ICRAF Science and Practice of Agroforestry 2

J. Burley

Global needs and problems of the collection, storage and distribution of multipurpose tree germplasm

Science and Practice of Agroforestry

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CONTENTS

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Thanks must also go to several secretaries at Oxford, to Miss Janet Stewart for assistance in final editing and proof-reading, and to the printers Messrs. Parchment (Oxford) Ltd. who bent all their usual rules to meet the deadlines for this document and for the full proceedings.

The large number of appendices include material (published and unpublished) from a range of authorities. These sources are duly acknowledged, of course, but they deserve special recognition for the extensive field and library work that these lists of species represent. The problem of scientific names and authorities was a major one; I have corrected obvious spelling errors and checked most names against Willis' "Flowering plants and ferns" (7th ed.) but it was not feasible to confirm all names in Index Kewensis.

Finally I would like to thank the Director of ICRAF, Dr. B. Lundgren, for his support and Mr. P. von Carlowitz (ICRAF and GTZ) for his unfailing enthusiasm and encouragement in the preparation of this document, the organisation of the entire workshop and the publication of the full proceedings.

FOREWORD

This is the second in what is intended to be a continuing series of booklets under the name "Science and Practice of Agroforestry". The range of topics that will be covered in these booklets is very wide. Practical handbooks and manuals, descriptions of research methods, species/genus monographs, analyses of specific agroforestry technologies (e.g. alley cropping, shelterbelts, etc.), geographical accounts of agroforestry practices and systems, reviews on special aspects of agroforestry (e.g. this volume), etc. are some of the types of topics covered by booklets which are already at different stages of preparation.

There will be three loosely unifying features of the series:

- the format, 80-120 pages each, will be the same,
- each booklet will stand by itself as a "complete" treatment of its subject,
- each booklet will be directly related to agroforestry and will be directed to practitioners, scientists and/or students of agroforestry.

Given the definition of agroforestry used at ICRAF — "all land use practices and systems where woody perennials are deliberately grown on the same land management unit as annual crops and/or animals" — the last feature will not be too much of a restriction.

Authors and editors of booklets will be drawn from ICRAF's scientific staff but may also be invited from outside ICRAF to write on topics of their speciality. In due course, as the series picks up momentum and becomes more well known, voluntary contributions from scientists and practitioners of agroforestry will also be welcome.

The present booklet comprises the base document prepared for a planning workshop to discuss international cooperation in multipurpose tree germplasm, organised by the International Council for Research in Agroforestry (ICRAF Nairobi), the Commonwealth Forestry Institute (CFI, Oxford) and the International Board for Plant Genetic Resources (IBPGR, Rome) and held at the National Academy of Sciences (NAS, Washington). The workshop was sponsored by ICRAF, IBPGR and the German Agency for Technical Cooperation (GTZ, Eschborn). The base document was prepared by Dr. J. Burley, Director of the Commonwealth Forestry Institute and Head of the Department of Forestry at Oxford University, who acted as the consultant for the workshop and, with Mr. P. von Carlowitz (ICRAF and GTZ), edited the proceedings.

In the document Dr. Burley examined the scope of multipurpose trees, providing an initial definition for the workshop to discuss, and indicated the problems caused by the large numbers of potentially useful species; a review of published and unpublished information revealed some 2000 species believed to have multiple uses. After reviewing the current international activities in germplasm research and development, he described the special characteristics of multipurpose tree germplasm and the major problems and issues in taxonomy, exploration, collection, evaluation, and conservation of species and populations. International needs for such germplasm and information were predicted, the legal and practical problems of germplasm distribution were outlined, and elements of possible international strategies for coping with the demands and problems were suggested; several of these were amplified at the workshop and are described in the full proceedings.

B. Lundgren
Director, ICRAF

EXECUTIVE SUMMARY

With increasing human and livestock 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 49 and Appendix 1). Of particular importance are fuelwood deficits (page 49 and Appendix 2). Equivalent plantation areas needed by the year 2000 are estimated at 100 million hectares; the current annual rate is 1 million hectares (Appendix 3) for 76 specified tropical countries.

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 49 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 50-52 and Appendix 7). Many hundreds of species have been considered to have multiple uses (pages 52-54, 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 (page 54 and Table 2). The major sources of such information are described (pages 55-56 and Appendices 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 57-61). 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 (pages 59-60 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 61-65). 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 66-67). 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 68-69).

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 71-72, 67-68); 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 72-73 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 73-74). The potential for and problems of breeding multipurpose trees are reviewed and the conclusion reached that considerable enhancement of national capabilities is required; strategies should be developed for resource sharing through internationally coordinated breeding pools and data banks (pages 74-75).

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 75-77).

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.

ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank, Manila, Philippines
AFOCEL	Association Forêt Cellulose, Nangis, France
AGRIS	Agricultural Research Information System, FAO, Rome, Italy
ANU	Australian National University, Canberra, Australia
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, Washington, USA, and FAO, Rome, Italy
CIAT	Centro Internacional para Agricultura Tropical, Cali, Colombia
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 für Medizinische Dokumentation und Information, Köln, Germany
DNA	Deoxyribonucleic acid
ESA-IRS	European Space Agency — Informational Retrieval System, 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
IDB	Inter-American Development Bank
IDRC	International Development Research Council, Ottawa, Canada
IITA	International Institute for Tropical Agriculture, Ibadan, Nigeria
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
TPI	Tropical Products Institute, London, UK
UN	United Nations, New York, USA
UNEP	United Nations Environment Programme, Nairobi, Kenya
UNESCO	United Nations Educational, Scientific and Cultural Organization, Paris, France
UNU	United Nations University, Tokyo, Japan
US	United States
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). Appendix 1 summarises references to the rates of regression of tropical moist forests, rates of desertification and the tropical lands with potential for reforestation that are commonly quoted.

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 in some 76 tropical countries 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, nor indeed for any tree 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 four 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 DISCUSSION 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 *Furcraca*; 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 timber, fuelwood and the so-called "minor forest products" such as 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 many diverse uses of trees and shrubs. Several major compilations of the performance of exotic forest trees include 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 multi purposes and various sites in one country (*e.g.* Appendix 8a, Bauer, 1982, Honduras; FAO/IBRD, 1978, Nepal), 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, 1980a; NAS, 1980), multiple purposes (Appendix 8k, Webb *et al.*, 1980) 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 with potential 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 Varmah 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 8, 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-legumineus 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 woody) 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 tepical 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.

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 summarises 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.

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1. Personal communications Dr J.A. Duke, Economic Botany Laboratory, USDA, Beltsville, Maryland, USA.

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 multipurpose 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 (Sastrapradja 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.

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 computerised 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).

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

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 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 since a large literature exists; Appendix 10a summarises the numbers of references located through DIALOG in preparing this document.

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 collection 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 paper by Turnbull to this Workshop (Annex 5.5).

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. However despite the

clear theoretical advantages of such centralised programmes, it is widely recognised that top priority in general research must be given to strengthening national institutional capability; such national institutions must be approached first to see if they are able and willing to make collections or give other support to networks of recipient countries. This is the approach taken in the FAO/IBPGR programme for arid species (FAO/IBPGR, 1980; FAO, 1981c). Further, many countries are becoming increasingly concerned at the exploitation of their genetic resources by others, particularly when commercial seed and breeding companies are involved; seed export may be forbidden to protect local trade. FAO is currently preparing documentation for an international agreement on germplasm distribution.

Among the seed suppliers is CSIRO and among the trial coordinators 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 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 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, especially 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 eight 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, Texas A and I University[1] for seed of American *Prosopis* species, and CATIE, Costa Rica, for such species as *Erythrina, Gliricidia* and *Inga*.

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

CFI

The Commonwealth Forestry Institute, Oxford, England, 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 assis..nce with analysis and interpretation, and the maintenance of a computerised bank for data and bibliography.

CSIRO

The Forest Tree Seed Centre of the CSIRO Division of Forest Research, Canberra, Australia, has been concerned with the collection and distribution of Australian trees since the early 1960's. It has cooperated with international organizations such as FAO and IBPGR to sample the gene pools of important or potentially valuable multipurpose trees including species of the nitrogen fixing genera *Acacia* and *Casuarina*. The CSIRO Seed Centre maintains a seed store of several thousand seedlots of *Eucalyptus, Acacia* and other Australian genera which are of interest for developing countries. All seedlots have origin data and are tested for germination before being distributed. The staff of the Seed Centre also carry out research into genetic variation and various aspects of seed testing and handling.

CTFT

The Centre Technique Forestier Tropical, Nogent-sur-Marne, France, is a French Government company created in 1950 to carry out research for tropical and sub-tropical regions. CTFT is currently collecting seeds of African hardwoods (*Acacia* spp., *Aucoumea klaineana, Terminalia* spp.) and it has been involved in the last ten years in several explorations and collections of provenances of tropical Australian hardwoods (about 150 species including more than 100 eucalypts) and an Indonesian *Eucalyptus (E. urophylla).*

In most countries where CTFT takes part in research activities, seed sources have been built up locally for the most important species *(Eucalyptus* spp., *Gmelina arborea, Pinus* spp., *Tectona grandis).* Improved seeds are produced in seed orchards for some species. Conservation stands have been established for important African hardwoods (*e.g. Terminalia superba* in the Congo).

Seeds are distributed every year to more than 25 countries, about half of them being in the African continent. Over 40 different countries received seed for provenance trials organized through FAO *(e.g. E. urophylla).* Such studies are carried out with the collaboration of the Laboratoire de Phanerogamie of the Museum National d'Histoire Naturelle and the Laboratoire du Physiologie des Organes Végétaux après Récolte (POVAR) of the Centre National de Recherche Scientifique (CNRS).

Permanent CTFT staff are involved in the research programmes of nine different countries. In all these countries a large number of species (both

native and exotic, industrial and multipurpose species) have been evaluated or are under evaluation (species/provenances/yield trials).

DFSC

The DANIDA Forest Seed Centre, Humlebaek, Denmark, is active in several topics related to this Workshop. It has been responsible for coordination of the establishment and evaluation of international provenance trials of *Tectona grandis, Gmelina arborea* and *Pinus merkusii*. DFSC collaborates with FAO and DANIDA projects involved in establishment of conservation stands of mainly tropical pines. Seeds are procured for research, *i.e.* for supplementary species/provenance trials, seed studies, *etc.* Seeds are also procured in "semi-bulk" quantities for future seed production stands, conservation and pilot plantations. The objective is to make available seed of provenances already identified as of high potential for planting in quantities adequate for the establishment of up to about 500 ha worldwide. In choosing species particular attention is paid to the needs of certain south Asian countries. DFSC will compile and distribute information on seed handling techniques, including the production of a guide for seed handling and separate species leaflets for selected 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 81.

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 DANIDA Forest Seed Centre, and taxonomic research is contracted to specialist institutions.

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 Coordinator and one or two Deputy Coordinators), 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 Coordinators, Deputy Coordinators 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 or 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, organizing training courses, and keeping scientists aware of global problems and progress through meetings and the publication of their proceedings.

The World Bank and UNDP have funded a special 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.

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, a problem that is common to all field experiments; another is the lack of planned centralised evaluation.

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 pays 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 Reports), sponsors workshops 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 has also been 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 agriculture, it has great value to other countries and its data bases should be maintained and extended.

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 relationship 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."

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 the 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/IBPGR, 1980; the FAO/IBPGR project plans to 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). Selfed seed may be inviable or seedlings less competitive.

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

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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.

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, including 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 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 potential 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 if resources permit 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 Annex 5.2 to this document on the activities of non-governmental organizations by Buck).

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 systems.

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 be 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 socio-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 of managerial problems (*e.g.* some of the sites in the NAS Sahel trials[1]. Another problem with lists of species is that they are of no value if no seed is available or there is no infrastructure for its procurement.

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); *Picus* 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.

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 "Germplasm certification" (see also Appendix 17) but far more data on seed origin are needed for evaluation experiments than for routine germplasm

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1. Personal communication, J.A. Gritzner, BOSTID, NAS, Washington DC, USA.

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 (Eckholm, 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, 1979). The International Union for the Conservation of Nature and Natural Resources (IUCN) has a Threatened 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 multipurpose 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 necessary 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 proportions (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 circular questionnaire discussed below (under "Demand") there were reported to be seed problems in 50% of the 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 for 76 countries in the tropics 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 Lanly, 1982; Turnbull, 1982; and Annex 5.5 to these Proceedings).

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. Eucalyptus 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. Fifty replies were received and over 200 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 species seed supply was considered adequate for only 71; for 26 the supplies were considered definitely inadequate. These 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 seed of trees used in forest production, with less emphasis on woody plants suitable for erosion control, ornamentals, game and wildlife management, shelterbelts, fodder, *etc.*, but these are included where seed was available in 1975.

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 these Proceedings. 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 characte- 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 these Proceedings). 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 of 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 offers a useful technique. For virus-infected material heat therapy of shoot tip cultures may be combined with virus indexing.

Tissue culture could also be valuable for genetic conservation as long as the in-culture mutation rate is not high. However, an expert committee within FAO's Agriculture Department felt that tissue culture will not be suitable for conservation until long-term techniques have been proved (Williams, personal statement at the Workshop). 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 US 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.*, 1980) and Burley (1980b) 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, *Triplochiton* 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 characteristics 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 whether national or international; that is the object of the Workshop and of the FAO Panel of Experts in Forest Gene Resources. 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.* CFI, CSIRO, CTFT, DFSC, FAO, IBPGR, 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, techniques or product) may economise on financial or skill resources. The coordination of such networks could be an activity of the IUFRO special coordinator for developing countries 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.* Radwanski, 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 impoverishment, 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. Sample sources of lists of multipurpose species

Authors	*Date*	*Scope*	*No. of genera or species*	*Appendix*
FAO	(In prep.)	Global fuelwood and other uses	65 genera 128 species	8a
Bauer	(1982)	Eight site types in Honduras	30 species 21 genera	
FAO/IBRD	(1978)	Nepal	91 species	
Koivisto	(1979)	Asia-Pacific	13 genera trees 5 genera bamboos 2 agric. industrial woody sp. 13 potential untested sp.	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	15 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 }	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	163 species, 116 genera	
Goor & Barney	(1976)	Arid	53 species	8h
Brewbaker *et al.*	(1981)	Tropical legumes in agroforestry	26 species, 12 genera	8i
Vergara	(1982)			
NAS	(1980)	Global firewood	60 species selected list	8j
Burley	(1980a)		650 source list	
Boland and Turnbull	(1981)		111 species and genera	
Lavoie	(1981)	Energy biomass	31 genera, 288 species	-
Webb *et al.*	(1980)	Global multipurpose	166 species	8k
Edwards	(1983)	Malawi multipurpose	69 species and/or genera	8l
Barrow	(1983)	Kenya multipurpose	57 species	
Owino	(1983)	Kenya nitrogen fixing and multipurpose	73 species, 46 genera	
NAS	(1982)	Sahel	84 species	8m
Lessard and Chouinard	(1980)	Bamboos	41 species, Malaysia 22 species, Indonesia	8n
Varmah and Pant	(1981)		Many species, A-P region Many species, India	
Le Houérou	(1980)	Browse species, North Africa	34 species	8o
Johnson	(1983)	Palms	4 species domesticated 19 species incipient	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
Kessler	(1981)	Fodder, Nepal	24 species	8r
Okafor	(1980)	Food and fodder, Nigeria	51 species	
Khosla		Himalayan multipurpose	31 species	8s

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				√	√	√	√	√		

1. Arboretum
2. Herbarium
3. Xylarium
4. National institutions
   - A. Seed bank
   - B. Forest department
   - C. Research institute
   - D. University
   - E. International support programme *e.g.* ANU, CFI, CTFT, 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.* AGRIS, 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* Dahnh.[1]	11 new provenances collected for project with special emphasis on arid zones.
	E. microtheca F. Muall.[1]	73 seedlots, grouped into 21 "provenance groups" for first-stage evaluation according to climatic conditions.
	Acacia aneura F. Muell. ex Benth.	5 provenances collected by early 1980
Chile	*Acacia caven* Mol.	
	Atriplex repanda Phil.	
	Prosopis tamarugo P. Philippi	
	Prosopis sp. ("Algarrobo")	May include several species, *P. atacamensis, P. siliquastrum, P. chilensis, P. burkartii.*
India	*Acacia nilotica* (L.) Willd. ex Del.	ssp. *indica*/var. *vediana* var. *jaquomontil* 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* (Porak) Hayne ssp. *raddiana* (Savi) Brenan)	
	A. tortilis Hayne	
	(syn *A. tortilis* Porak) Hayne ssp. *tortilis* (Hayne) Brenan)	
Mexico	*Atriplex canescens*	
	Prosopis sp. ("Mesquite")	May include several species, *P. juliflora; P. glandulosa, P. alba, P. torreyana.*
Peru	*Prosopis* sp. ("Algarrobo")	May include several species, *P. chilensis, P. limensis, P. juliflora.*
Senegal	*Acacia albida* De. 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. Dal.	"Land Race"
	A. senegal (L.) Willd.	
	A. tortilis Hayne	

1. Collections completed and distributed for evaluation.

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APPENDICES

Appendix I

Loss and Creation of Tropical Forests

Table 1.1 Regression of Tropical Moist Forests

(million hectares)

SUB-CONTINENT	Moist forest climate area	Moist forest actual area	Regression	Regression as percentage of climate area
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 × 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 × 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	56,587	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
2. All are in tropical moist forest areas
3. The area of Deforested Watersheds is only a rought estimate. It has been included in 'All Lands'.
4. Savanna and arid land.

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	0	0	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	0	20	11.8	0	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	0	5	34.3	5	8.5
	Full irrigation	0	0	1	6.9	5	8.5
	Social forestry	0	0	20	137.0	60	102.0
	Rain fed plantations	20	140.4	15	102.8	0	0
	Dune planting	0	0	5	34.3	5	8.5
	Conservation	70	491.4	50	342.5	20	34.0

Source: Wood *et al.* 1982

Appendix 2

Areas of the Tropics with Fuelwood Deficits, 1980 and 2000

			Deficit (million m³)		*Equivalent Plantation Area* (ha × 10³)	
			1980	*2000*	*1980*	*2000*
Africa						
Acute Scarcity	(i)	Arid areas	-6	-10	1200	2000
	(ii)	Montane/island areas	-40	-70	8000	14000
Deficit	(i)	Savanna areas	-66	-185	6600	18500
	(ii)	High forest	-	-5		250
			-112	-270	15800	34750
Latin America						
Acute Scarcity	(i)	Andean plateau	-2	-4	400	800
	(ii)	Arid west S. America & densely populated areas	-9	-15	1800	3000
Deficit	(i)	Populated Semi-Arid areas & Andean zone	-36	-117	7200	23400
			-47	-136	9400	27200
Asia						
Acute Scarcity	(i)	Montane areas (mainly Himalayas)	-38	-60	7600	12000
Deficit	(i)	Plains (mainly Indo-Ganges)	-90	-146	9000	14600
	(ii)	Plains & Islands in SE Asia	-120	-265	6000	13200
	(iii)	Other growing areas with fast growing populations	-	-48		3200
			-248	-519	22600	43000
		ALL TROPICS	-407	-925	47800	104950

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

NB 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

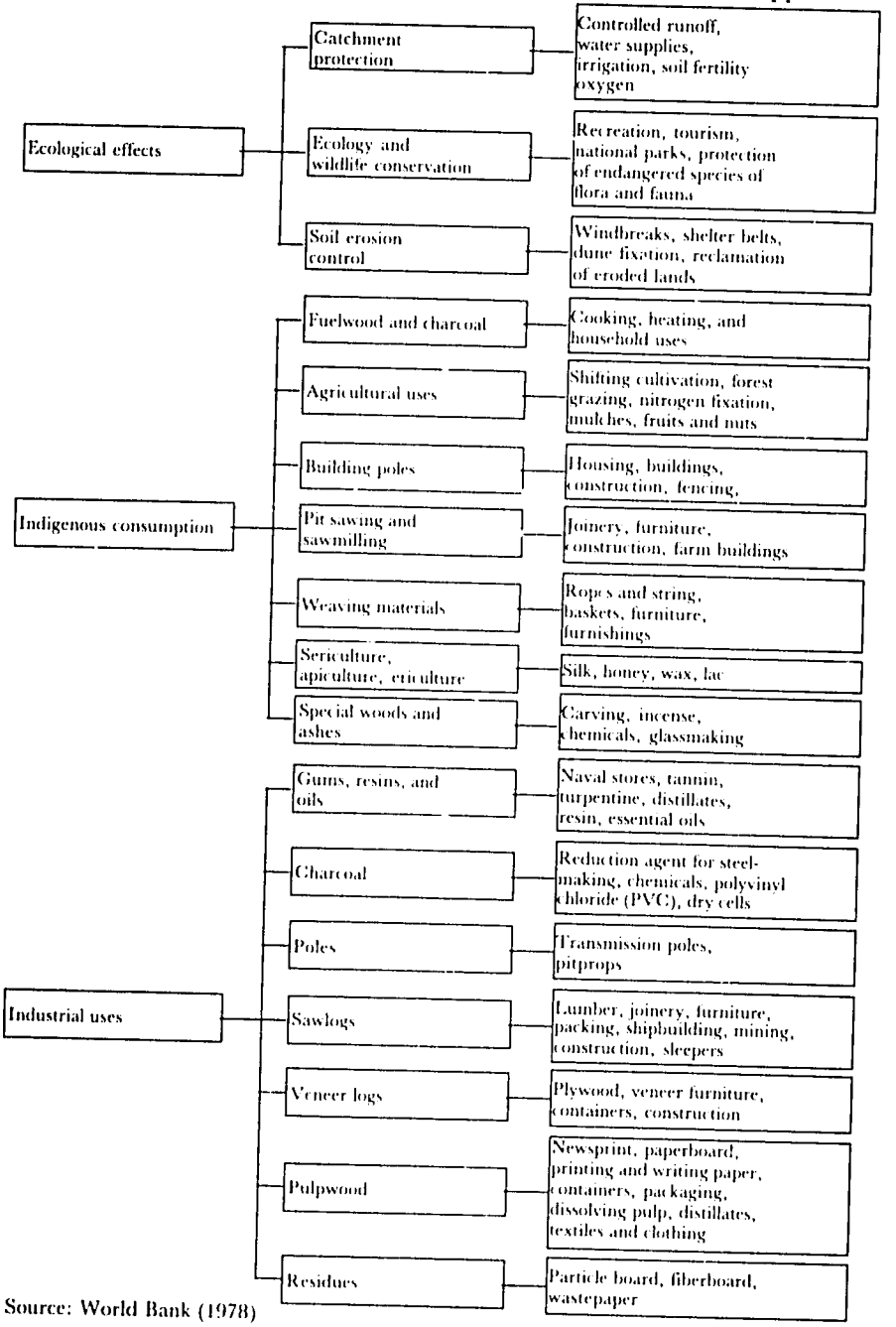
Areas of Tropical Forest Plantations 1980
(ha × 10^3)

	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)

Appendix 5

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 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 maximise range production
9. Least cost approaches to range improvement
10. Improvement of savanna 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 regeneration
4. Artificial enrichment

(D) Whole tree use

1. Harvesting
2. Utilization
3. Effects on site

(E) Use and marketing of secondary species

(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

National Priorities for Reforestation

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

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

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

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.

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)]

Environmental to afforestation of severely degraded/desertified arid lands. *Fuelwood* and *Fodder* to the establishment of plantations of multipurpose trees producing fuelwood and fodder respectively (or both).

Source: Wood *et al.* (1982)

Appendix 7

Definitions of Terms Associated with Social Forestry

Source: 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 it may or may not be used in social forestry.

Appendix 8a

Species of First Priority for Fuelwood and Other Uses.

(E = endangered in parts of range. * = some work in progress. 1-3 = priority order.)

	Industrial Wood	Fuelwood	Other Uses
Mexico			
Atriplex canescens	-	2	1
Ceiba pentandra	1	-	1
Cordia alliodora	1	-	1
Leucaena sp.	-	1	1
Pinus douglasiana	1	-	1
P. leiophylla	2	-	1
P. michoacana	1	-	1
P. montezumae	1	-	1*
P. oocarpa	1	-	1*
P. patula	1	-	1*
P. pseudostrobus	1	-	1*
P. strobus var. *chiapensis*	1	-	1
Prosopis juliflora	2	1	1*
Brazil			
(E) *Anadenanthera macrocarpa*	-	3	3
(E) *Aniba duckei*	-	-	3
(E) *Araucaria angustifolia*	2	2	-
Aspidosperma pyrifolium	-	3	3
(E) *Astronium urundeuva*	3	-	-
(E) *Bertholletia excelsa*	2	-	3
Caesalpinea paramidalis	-	3	3
Cassia excelsa	-	3	3
Dalbergia cearensis	-	3	3
(E) *Ilex paraguariensis*	-	-	3
(E) *Joannesia princeps*	3	-	3
(E) *Mimosa caesalpiniifolia*	-	3	3
M. scabrella	3	3	-
(E) *M. verrucosa*	-	3	3
Parkia platicephala	-	3	3
Pithecellobium parvifolium	-	3	3
Podocarpus lambertii	3	2	-
(E) *Schinopsis brasiliensis*	-	3	3
(E) *Tabebuia impetiginosa*	-	3	3
Torresia cearensis	-	3	3
(E) *Zeyheria tuberculosa*	3	3	-
Caribbean, Central and S. America (except Brazil and Mexico)			
(E) *Acacia caven*	-	1	1*
(E) *Alnus jorullensis*	3	-	1
(E) *Atriplex repanda*	-	1	1*
Capparis angulata	-	-	1
Cedrela odorata	1	-	1*
Cordia alliodora	1	-	1*
Leucaena leucocephala	-	1	1*

Source: FAO Panel of Experts on Forest Gene Resources, Fifth Meeting. Supplied by Miss C. Palmberg, FAO, Rome, Italy.

Pinus caribaea var. *bahamensis*	1	–	1*
P. caribaea var. *hondurensis*	1	–	1*
P. caribaea var. *caribaea*	1	–	1*
P. oocarpa	1	–	1*
P. pseudostrobuus/tenuifolia	1	–	1*
Prosopis atacamensis	–	1	1*
P. bourkartii	–	1	1*
P. chilensis	–	1	1*
P. juliflora	–	1	1*
P. limensis	–	1	1*
P. siliquastrum	–	1	1*
P. tamarugo	1	1	1*
Mediterranean, S. Europe, Near East			
(E) *Acacia albida*	–	1	1*
A. nilotica	–	1	1*
A. raddiana	–	1	1*
A. tortilis	–	1	1*
Cupressus sempervirens	–	–	1
Picea omorica	1	–	1
(E) *Pinus pinea*	2	–	1
(E) *Prosopis cineraria*	–	1	1*
Quercus suber	–	–	1*
Tetraclinis articulata	–	–	1
(E) *Ulmus wallichiana*	1	–	1
South/East Asia			
Acacia nilotica	3	1	1*
A. mangium	1	2	1*
A. senegal	–	1	1*
A. tortilis	–	1	1*
Albizia falcataria	1	3	1
A. lebbeck	1	3	1
Azadirachta indica	–	1	1
Bamboos (*Bambusa, Dendrocalamus, etc.*)	1	1	1
Bombax ceiba	1	–	1
Eucalyptus urophylla	1	1*	–
Gmelina arborea	1	2	–
Litsea sp.	–	–	1
Octomeles sumatrana	1	–	1
Palaquium sp.	–	–	1
Parkia sp.	1	–	1
Pinus kesiya	1	–	1*
P. merkusii	1	–	1*
Prosopis cineraria	3	1	1*
Rhizophora sp.	2	1	1
Santalum album	–	–	1
Sindora sp.	–	1	1
Syzygium sp.	–	1	2
Terminalia sp.	3	1	1
North, North-East and Central Asia			
Alnus nepalensis	1	1	1
Cedrus deodara	1	–	1
Cryptomeria japonica	1	–	1
Elaeagnus angustifolia	1	1	1
Fokienia hodginsii	1	–	1
Gmelina arborea	1	–	1*
Haloxylon ammondendron	–	1	1
H. persium	–	–	1
Illicium verum	–	–	1
Melia azedarach	1	–	1
M. toosendan	1	–	1

Mesua ferrea	1	–	1
Metasequoia glyptostroboides	1	1	1
Paulownia fargesii	1	–	1
P. tomentosa	1	–	1
Pinus kesiya	1	–	1*
P. koraiensis	1	–	1
P. massoniana	1	–	1
P. roxburghii	1	–	1
P. sylvestris var. *mongolica*	1	–	1
Pseudolarix amabilis	1	–	1
Toona sinensis	1	–	1
Africa			
Acacia albida	–	1	1*
A. nilotica	–	1	1*
(E) *A. raddiana*	–	1	1*
(E) *A. tortilis*	–	1	1*
A. senegal	–	1	1*
Irvingia gabonensis	–	–	1
Australia			
Acacia aneura	–	1	2*
A. auriculiformis	–	1	2
A. cyclops	–	2	1
A. saligna	–	1	2
Casuarina cunninghamiana	1	1	1
C. equisetifolia	1	1	1
Eucalyptus camaldulensis	1	1	1*
E. citriodora	1	1	1
E. cloeziana	1	1*	–
E. globulus ssp. *globulus*	1	1	2*
E. globulus ssp. *maidenii*	1	1	2*
E. microtheca	1	1*	–
E. radiata	–	–	1
E. tereticornis	1	1*	1

Selection of Species for Reforestation in Honduras.

ESPECIE	FAMILIA	Aptitud para las principales zonas de vida (1) bh-T	bs-T	bms-T	bmh-P	bh-P	bs-P	bh-MB	bmh-MB	Calidad de la madera (2) Lc	As	Po	Ch	Pu
Acacia auriculiformis	*Leguminosae*	X	X		X					+	O			+
Albizia falcata	*Leguminosae*	X			X						O		+	+
Albizia lebbeck	*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	X				+	O			
Leucaena leucocephala	*Leguminosae*	X	X	X	X					+ +	O	+		+
Pinus caribaea var. *hondurensis*	*Pinaceae*	X	X	X	X	X				O	+	+		+
Pinus maximinoi	*Pinaceae*				X	X		X		O	+			? +
Pinus oocarpa	*Pinaceae*	X	X	X	X	X	X	X		+	+	+		+
Sesbania grandiflora	*Leguminosae*	X	X	X	X					O				+
Swietenia macrophylla	*Meliaceae*	X	X	X	X	X					+ +		+	
Tabebuia pentaphylla	*Bignoniaceae*	X	X	X	X	X				+	+		+	
Tectona grandis	*Verbenaceae*	X	X	X	X	X				+	+ +	+	+	
Terminalia ivorensis	*Combretaceae*	X			X						+		+	O
Terminalia superba	*Combretaceae*				X						+		+	O

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

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

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

Source: Bauer (1982)

Appendix 8a

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	occasionally 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 sp.	1	Tingre salla			X	X	X	X	fT
Acer sp.	1, 2	Phangaru		X	X	X		X	LFt
Aesculus indica	1	Lampatte phangaru			X				LF
Albizia mollis	1	Siris	X	X					Lft
Alnus nepalensis	1	Utis		X	X			X	LFts
Artocarpus lakoocha	1	Badahar	X	X				X	ELIf
Arundinaria sp.	(3)	Nigalo (mountain bamboo)			X	X			LIS
Bassia butyracea	1	Chiuri	X	X				X	EfION
Bassia latifolia	2	Mahuwa	X	X	X			X	EfOIN
Bauhinia purpurea	2	Tanki	X	X			X		LiFgS
Bauhinia variegata	2	Koiralo	X	X			X		ELFigS
Betula utilis	2	Bhoj patra				X	X		LFImrSt
Brassaiopsis alpina	2				X	X			Lf
Brassaiopsis glomerulata	2, 3	Chuletro		X	X				Li
Buchanania latifolia	2		X				X		EgS
Buddleia sp.	2	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	EfId
Castanea sativa (N)	1	(chestnut)		X	X				EfT
Castanopsis hystrix	1	Patle katu		X	X		X	X	elFTs
Castanopsis indica	1	Dale katus		X			X	X	ElFTs
Castanopsis tribuloides	1	Musuri katus		X	X		X	X	elFTs
Cedrela toona	1	Tooni	X	X				X	FT
Cedrus deodara	1	Debdar			X		X	X	HT
Choerospondias axillaris	1	Lapsi	X	X	X		X	X	Etf
Cupressus torulosa	1	Dhupi		X	X	X	X		FIT
Dendrocalamus hamiltonii	(2)	Bans (bamboo)	X	X					elfIMS
Elaeocarpus sp.	1	Rudraksha	X	X					M
Erythrina arborescens	2	Phaledo	X	X			X	X	LFS
Eugenia jambolana	2	Jamun	X	X				X	EF
Euphorbia sp.	3	Sihundi, sija	X	X	X		X	X	Hs
Euria cerasifolia		Pate		X					L
Ficus elavata		Borulo godilo	X	X				X	L
Ficus glaberrima	1	Pakhuri	X	X				X	L
Ficus nemoralis	1	Dudhilo	X	X	X			X	L
Ficus roxburghii	1	Nemarro	X	X	X			X	LE
Ficus semicordata	1	Khanmim	X	X				X	Le
Fraxinus sp.	1	Lankuri		X	X			X	LTF

Latin Name	1 - Tree 2 - Small tree 3 - Shrub	*Nepali Name* (English name)	*Ecology*						*Utilization* (see legend)
			Upper Tropical	Sub-tropical	Temperate	Sub-alpine	Dry sites	Rich sites	
Grewia sp.	1, 3	Bhimal	X	X			X	X	EFLRIS
Hippopae sp.	3	Armalito		X	X		X		EHS
Ilex sp.	2	Bhokre		X	X		X	X	L
Juglans	1	Okhar		X	X	X		X	ETFM
Juniperus sp.	1, 3				X	X	X		tfS
Larix sp.	1	Langtang sallo				X	X	X	Tfs
Litsea citata	2	Sil timur		X	X		X	X	elFM
Litsea polyantha	2	Kutmiro	X	X			X	X	LFt
Machilus odorotissima	1	Ehate kaulo	X	X					LF
Melia azedarach	2	Bakaino					X	X	Ft
Michelia champaca	1	Champ, Tsampo	X	X				X	LTMo
Michelia doltsopa	1	Sated champ		X	X			X	LTF
Moringa pterygosperma (N)	2		X	X			X	X	ELOs
Morus alba	1	Oeshi kimbu	X	X					ELfG
Morus nigra	1	Kimbu	X	X					ELfG
Mucuna macrocarpa	1	Ba[illegible]dyangro	X	X					L
Olea cuspidata	2, 3			X	X		X		Ll(o)
Picea sp.	1	Jhule sallo			X	X	X	X	Tf
Pistacia integerrima	3					X	X		(e)lfs
Pteris ovalifolia	2		X	X			X		fS
Pinus excelsa	1	Pingre 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	tlFS
Premna barbata	2	Ginderi (?)		X			X		Lf
Princepia utilis	3	Dhatela		X	X		X		CSh
Prunus cerasoides	1	Painyo		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 sp.	2, 3	Lali gurans			X	X			F

Latin Name	1 - Tree 2 - Small tree 3 - Shrub	*Nepali Name* (English name)	*Ecology*						*Utilization* (see legend)
			Upper Tropical	Sub-tropical	Temperate	Sub-alpine	Dry sites	Rich sites	
Rhus javanica	2, 3	Bhakimlo		X	X				Lf
Rhus succedana	2, 3	Bhalayo		X	X		X	X	LfG
Salmalia malabarica	1	Simal	X	X				X	TFM
Salix sp.	1, 3	Bains		X	X	X	X	X	Lif
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	TIFm
Sorbus sp.	1, 2	Maile			X	X			LtF
Symplocos crataegoides	1	Lodh		X	X				LF
Tsuga dumosa	1	Tingre sallo			X	X	X	X	Tif
Viburnum coriaceum	3	Pitho char		X	X				L
Vitex negundo	2, 3				X				IIh
Woodfordia floribunda	2, 3					X	X		fS
Xylosma controversum	2	Maidallo		X					L
Ziziphus jujuba	2	Bayer, Jujube	X	X			X		ELHtFSmg

Appendix 8b

Species or Genera Recommended for Asia Pacific Region

Source: Koivisto (1979)

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 sp.

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

Aleurites spp.
Artocarpus utilis
Ceratonia siliqua
Durio zibenthinus
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 forest uses**

Cocos nucifera
Hevea brasiliensis

E. **Bamboos**

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

Appendix 8c

Species for African Savannas

Source: Laurie, 1974

1. Desert— ommitted 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 ca carata
C. glauca
C. intratropica
C. robusta
Cassia siamea
Eucalyptus camaldulensis
E. citriodora
E. cloeziana
E. grandis
E. pilularis
E. propinqua
E. tereticornis
Pinus caribaea
P. kesiya
P. merkusii
P. oocarpa

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
P. kesiya
P. merkusii
P. oocarpa
Tectona grandis

Appendix 8d

Hardwood Species for Lowland Tropics

Source: 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 robusta*
10. *Eucalyptus tereticornis*
11. *Eucalyptus torelliana*
12. *Eucalyptus urophylla* — not formally named
13. *Grevillea robusta*
14. *Melaleuca leucodendron*
15. *Maesopsis eminii*
16. *Octomeles sumatrana*
17. *Terminalia brassii*
18. *Terminalia calamansanai*
19. *Terminalia catappa*
20. *Terminalia ivorensis*
21. *Terminalia superba*
22. *Toona ciliata*
23. *Tetrameles nudiflora*

Appendix 8e

Plants for Arid and Semi-arid Lands

Source: Adams *et al.*, 1978

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
Albizia julibrissin
A. lebbeck
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
Albizia 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. redunca
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. guyoniana
E. mauritanica
E. nereifolia
Genista saharae
Haloxylon aphyllum
H. articulatum
H. persicum
H. salicornicum
Heliotropium dasycarpum
Ipomoea pes-caprae
Iris sisyrinchium
Lagerstroemia indica
Launea spinosa
Leptadenia 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
Zilla macroptera
Z. spinosa
Zygophyllum coccineum
Z. dumosum

Shrub and Ground Cover Plant Introductions

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

2 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 lanceformis, Phoenix dactylifera, Tamarix maris-mortiu, T. passerinoides*
35,000	*Atriplex nummularia, A. vesicaria, Juncus actutus, Prosopis stephaniana, P. tamarugo, Tamarix arcensis, 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 saxedeni, Tamarix nilotica*
18,000	*Acacia pendula, A. saligna, Casuarina glauca, Eucalyptus camaldulensis, E. sargentii, E. spathulata, Nerium oleander, Parkinsonia aculeata*
16,000	*Acacia farnesiana, A. saligna, 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, Albizia chinensis, Casuarina lehmanii, Clerodendrum inerme, Eucalyptus pimpiniana, Haloxylon salicornicum, Sesbania grandiflora*
12,000	*Acacia stenophylla, Nassia latifolia, Callitris glauca, Dodonea viscosa, Eucalyptus kruseana, Melaleuca paupertfolia, Melia azederach, Punica granatum, Thevetia nereifolia*
10,000	*Albizia lebbeck, Butea monosperma, Eucalyptus annulata, E. brachycorys, E. cornuta, E. melliodora, E. occidentalis, E. stricklandi Ficus carica, F. religiosa, Hakea laurina, Lagenaria pattersoni, Ricinus communis var. persicus, Salvadora oleoides, Thespesia populnea, Vitex agnus castus*
8,500	*Carvalpinia gilliesii, Calligonum comosum, Casuarina cunninghamiana, Dalbergia sissoo, Dodnonea attenuata, Eucalyptus cladocalyx, E. forestiana, E. grossa, E. lansdowneana, E. largiflorens, E. Le Souefii, E. robusta, E. salubris, E. spathulata, Inga dulcis, Terminalia arjuna*
8,000	*Brachychiton gregorii, Eucalyptus brockwayi, E. dundasi, E. intertexta, E. woodwardii, Ficus benghalensis, Myrtus communis, Prosopis spicigera, Schinus molle, Terminalia catappa*
6,000	*Acacia deani, 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, Albizia julibrissin, Ficus sycomorus, Robinia pseudoacacia, Salix alba*
2,500	*Acacia cyanophylla, A. cyclops, A. mellifera, A. raddiana, A. forestiana, A. gerrardii*
2,000	*Eucalptus tereticornis, Hyphoene thebaica, Poinciana (Delonix) regia, Duranta plumieri, Populus oblega*
1,000	*Azalea* spp., *Bougainvillea* spp., *Populus euramerica, P. thevestina*

Appendix 8f

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 sub-tropical 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 Venezuala, 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*.

Appendix 8g

Species of Trees and Shrubs for the Sahel
Source: Von Maydell (1981)

ALPHABETISCHE LISTE DER BOTANISCHEN NAMEN UND SYNONYMA

LEITNAMEN	*SYNONYMA*	
	Acacia adansonii Guill. et Perrott.	= *A. nilotica* var. *adansonii*
	Acacia adstringens (Schura. et Thonn.)	= *A. nilotica* var. *adansonni*
ACACIA ALBIDA DEL.		
	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 ATAXACANTHA DC.		
	Acacia buchanani Harms	= *A. macrothyrsa*
	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 dalzielli Craib	= *A. macrothyrsa*
ACACIA DUDGEONI CRAIB EX HOLL.		
ACACIA EHRENBERGIANA HAYNE		
	Acacia fasciculata Guill. et Perrott.	= *A. raddiana*
	Acacia flava (Forsk.) Schweinf.	= *A. ehrenbergiana*
	Acacia glauca Moench	= *Leucaena leucocephala*
ACACIA GOURMAENSIS A. CHEV.		
	Acacia gyrocarpa Hachat.	= *A. albida*
	Acacia hockii De Wild.	= *A. seyal*
ACACIA LAETA R. BR. EX BENTH.		
	Acacia lebbeck (L.) Willd.	= *Albizia lebbeck*
	Acacia leucocephala	= *A. albida*
ACACIA MAC ROSTACHYA REICHENB. EX BENTH.		
ACACIA MACROTHYRSA HARMS		
ACACIA MELLIFERA (VAHL.) BENTH.		
	Acacia nefasia Schweinf.	= *A. sieberiana*
	Acacia nilotica var. *adansoniana* (Dubard) A.F. Hill	= *A. nilotica* var. *adansonii*
ACACIA NILOTICA VAR. *ADANSONII* (GUILL. ET PERROTT.) O. KTZE.		
	Acacia nilotica var. *adstringens* (Schum. et. Thonn.) Choiv.	= *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 prorsispinnata Stapf	= *A. macrothyrsa*

ACACIA RADDIANA SAVI

Acacia ruprestris Stokes	= *A. senegal*
Acacia saccharata Benth.	= *A. albida*
Acacia samoryana A. Chev.	= *A. dudgeoni*
Acacia scorpioides (L.) W.F. Wight var. *nilotica* (L.) A. Chev.	= *A. nilotica* var. *nilotica*
Acacia scorpioides (L.) W.F. Wight var. *pubescens* A. Chev.	= *A. nilotica* var. *tomentosa*

ACACIA SENEGAL (L.) WILLD.

Acacia senegal (L.) Willd. ssp. *mellifera* (Vahl.) Roberty	= *A. mellifera*

ACACIA SEYAL DEL.

ACACIA SIEBERIANA DC.

Acacia singuinea 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*
Acacia tortilis Hayne	= *A. raddiana*
Acacia tortilis Hayne var. *pubescens* A. Chev.	= *A. raddiana*
Acacia trentiniani A. Chev.	= *A. laeta*
Acacia trispinosa Stokes	= *A. senegal*
Acacia verek Guill. et Perrott.	= *A. senegal*
Acacia verugera Schweinf.	= *A. sieberiana*

ADANSONIA DIGITATA L.

Adansonia sphaerocarpa A. Chev.	= *A. digitata*
Adenium arabicum Balf. f.	= *A. obesum*
Adenium coetaneum Stapf	= *A. obesum*
Adenium honghel A. DC.	= *A. obesum*

ADENIUM OBESUM (FORSK.) ROEM. ET SCHULT.

Agialida barteri Van Tiegh.	= *Balanites aegyptiaca*
Agialida senegalensis Van Tiegh.	= *Balanites aegyptiaca*
Agialida tombouctensis Van Tiegh.	= *Balanites aegyptiaca*

ALBIZIA CHEVALIERI HARMS

ALBIZIA LEBBECK (L.) BENTH.

ANACARDIUM OCCIDENTALE L.

Annona chrysophylla Boj.	= *A. senegalensis*

ANNONA SENEGALENSIS PERS.

Annona senegalensis var. *chrysophylla* (Boj.) 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*
Antelaea azadirachta (L.) Adelbert	= *Azadirachta indica*

AZADIRACHTA INDICA A. JUSS.

BALANITES AEGYPTIACA (L.) DEL.

Balanites ziziphoides Mildbr. et Schlechter	= *B. aegyptiaca*
Balsamodendron africanum Arn.	= *Commiphora africana*
Bassia parkii G. Don.	= *Butyrospermum parkii*
Bauhinia abyssinica Rich.	= *Piliostigma thonningii*
Bauhinia adansoniana Guill. et Perrott.	= *B. rufescens*
Bauhinia benzoin Kotschy	= *Piliostigma reticulatum*
Bauhinia glabra A. Chev.	= *Piliostigma reticulatum*
Bauhinia glauca A. Chev.	= *Piliostigma reticulatum*
Bauhinia pyrrhocarpa Hochst.	= *Piliostigma thonningii*
Bauhinia reticulata DC.	= *Piliostigma reticulatum*

BAUHINIA RUFESCENS LAM.

Bauhinia thonningii Schum.	= *Piliostigma thonningii*
Bombax andricui Pellegr. et Vuillet	= *B. costatum*
Bombax buanopozense P. Beauv.	= *B. costatum*

BOMBAX COSTATUM PELLEGR. ET VUILLET

Bombax houardii Pellegr. et Vuillet	= *B. costatum*
Bombax vuilletii Pellgr.	= *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 SENEGALENSIS (PERS.) LAM. EX POIR.

Boscia tenuifolia A. Chev.	= *B. angustifolia*
Brehmia spinosa (Lam.) Harv. ex DC.	= *Strychnos spinosa*
Brehmia spinosa ssp. *lokua* (A. Rich.) E.A. Bruce	= *Strychnos spinosa*
Butyrospermum paradoxum ssp. *parkii* (G. Don) Hepper	= *B. parkii*

BUTYROSPERMUM PARKII (G. DON) KOTSCHY

CADABA FARINOSA FORSK.

CADABA GLANDULOSA FORSK.

Cadaba mombassana Gilg et Benedict	= *C. farinosa*
Cathica dichrostachys Guill. et Perrott.	= *Dichroatachys 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. siamea*
Cassia kotschyana 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 lecananthum 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 punctanum Hook	= *C. paniculatum*
Combretum raimbaultii Heck	= *C. micranthum*
Combretum ramosissimum Engl. et Diels	= *C. paniculatum*

COMMIPHORA AFRICANA (A. RICH.) ENGL.

Commiphora calcicola Engl.	= *C. africana*
Commiphora pilosa Engl.	= *C. africana*
Conacarpus leiocarpus DC.	= *Anogeissus leiocarpus*

CRATEVA ADANSONII DC.

Crateva religosa Forst.	= *C. adansonii*

DALBERGIA MELANOXYLON 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*
Elayuna biloba Raf.	= *Piliostigma reticulatum*

ENTADA AFRICANA GUILL. ET PERROTT.

Entada sudanica Schweinf.	= *E. africana*
Entada ubanguensis De Wild.	= *E. africana*
Entadopsis sudanica (Schweinf.) Gilbert et Boutique	= *E. africana*

ERYTHRINA SENEGALENSIS DC.

EUCALYPTUS CAMALDULENSIS DEHNHARDT

Eucalyptus rostrata Schlecht.	= *E. camaldulensis*

EUPHORBIA BALSAMIFERA AIT.

Euphorbia rogeri N.E. Br.	= *E. balsamifera*
Euphorbia sepium N.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 sassandensis A. Chev.	= *F. iteophylla*
Ficus senegalensis Miq.	= *F. vogelii*
Ficus spragueana Mildbr. 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 N.E. Sr. = *G. bicolor*
Grewia quazumifolia 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 populifolia Vahl = *G. tenax*
Grewia salvifolia Heyne ex Roth = *G. bicolor*

GREWIA TENAX (FORSK.) *FIORI*

Grewia venusta Fres. = *G. mollis*

GREWIA VILLOSA WILLD.

GUIERA SENEGALENSIS J.R. GMEL.

Gymnosporia dinturi Loes = *Maytenus senegalensis*
Gymnosporia senegalensis (Lam.) Loes = *Maytenus senegalensis*

Heudelotia africana A. Rich. = *Commiphora africana*

HYPHAENE THEBAICA (L.) MART.

KIAYA SENEGALENSIS (DESR.) A. JUSS.

LANNEA ACIDA A. RICH.

Lannea djalonica A. Chev. = *L. microcarpa*

LANNEA MICROCARPA ENGL. ET K. KRAUSE

LEPTADENIA PYROTECHNICA (FORSK.) DECNE.

Leptadenia spartium Wight = *L. pyrotechnica*
Leucaena glauca (Moench) Benth. = *L. leucacephala*

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. *adansonii*
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*
Podoria senegalensis (Pers.) Lam. ex Poir = *Boscia senegalensis*
Poupartia birrea (A. Rich.) Aubr. = *Sclerocarya birrea*

PROSOPIS AFRICANA (GUILL., PERROTT. ET RICH.) TAUB.

Prosopis chilensis *siehe* *Prosopis juliflora*
Prosopis dubia Guill. et Perrott. = *Acacia sieberiana*
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*

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*
Sodada 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 laxa Solered. = *S. spinosa*
Strychnos lokua A. Rich. = *S. spinosa*

STRYCHNOS SPINOSA LAM.

Strychnos spinosa var. *pubescens* Bak.	= *S. spinosa*
Strychnos volkensi Gilg.	= *S. spinosa*
Swietenia senegalensis Desr.	= *Khaya senegalensis*
Sycomorus gnaphalocarpa Miq.	= *Ficus gnaphalocarpa*

TAMARINDUS INDICA L.

TAMARIX SENEGALENSIS DC.

Terminalia adamauensis Engl.

TERMINALIA AVICENNIOIDES GUILL. ET PERROTT.

Terminalia chevalieri Diels	= *T. macroptera*
Terminalia dawei Rolfe	= *T. macroptera*
Terminalia dictyoneora 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. macropte .*

Uncaria inermis Willd.	= *Mitrogyna inermis*
Urostigma dekdekena Miq.	= *Ficus iteophylla*
Urostigma ingens Miq.	= *Ficus ingens*
Urostigma vogelii Miq.	= *Ficus vogelii*

Vintricena flavenscens (Juss.) Burret	= *Grewia flavescens*
Vitellaria parodoxa Gaertn	= *Butyrospermum parkii*
Vitex chariensis Chev.	= *V. doniana*
Vitex cienkowski Kotschy 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 mitis A. Rich.	= *Z. mucronata*

ZIZIPHUS MUCRONATA WILLD.

Ziziphus orthocantha DC.	= *Z. mauritiana*

ZIZIPHUS SPINA-CHRISTI (L.) DESF.

Appendix 8g

Species Under Trial for Plantations in Dry Tropical Africa

Source: Delwaulle (1979)

(* = not promising)

Adansonia digitata
Adenanthera pavonina
* *Adenium obaesum*
Afzelia africana
Ailanthus malabaricum
Albizia adianthifolia
Albizia chevalieri
Albizia lebbeck
* *Alluaudia procera*
Alstonia congensis
Anacardium occidentale
* *Anogeissus leiocarpus*
* *Antiaris africana*
* *Araucaria columnaris*
Atriplex sp.
* *Aucoumea klaineana*
Azadirachta indica
Balanites aegyptica
* *Bauhinia cunninghamii*
* *Bauhinia rufescens*
Bombax costatum
Borassus aethiopium
* *Breynia nivosa*
Butyrospermum paradoxum
Caesalpinia pulcherrima
* *Callistemon rigidus*
* *Callitris* sp.
Calothamnus gilesii
* *Canarium australianum*
* *Carissa edulis*
* *Cassia auriculata*
* *C. fistula*
* *C. glauca*
* *C. glutinosa*
* *C. notabilis*
* *C. oligophylla*
* *C. plurocarpa*
C. siamea
* *C. sieberiana*
* *Casuarina decaisneana*
C. equisetifolia
* *C. glauca*
* *Catalpa* sp.
Ceiba pentandra
Cedrela sp.
* *Celtis integrifolia*
* *Chukrasia tabularis*
* *Combretum* sp.
* *Commiphora africana*
* *Copernicia cerifera*
* *Cordia sinensis*
* *Cordyla pinnata*
* *Crotalaria cunninghamii*
* *Cupressus lusitanica*
Dalbergia melanoxylon
D. sissoo
Daniellia oliveri
* *D. thurifera*
* *Delonix regia*
* *Detarium* sp.
Dichrostachys cinerea
Diospyros mespiliformis
* *Dodonea viscosa*
Entada africana
* *Erythrina senegalensis*
Erythrophleum guineense
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[1]
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

[1] Editors' footnote: synonymous with *Acacia albida*.

- *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. calappa*

T. ivorensis
T. mantaly
T. superba

Thevetia peruviana

- *Thuja orientalis*
- *Vitex doniana*
- *Ximenia americana*
- *Ziziphus mauritiana*
- *Z. mucronata*

Appendix 8h

Species Recommended for Arid Zones
Source: 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

x 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

Appendix 8i

Tropical Tree Legumes of Special Significance as Fuelwood
Source: 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

Appendix 8j

Firewood Species Described by NAS
Source: NAS (1980)

FUELWOOD SPECIES FOR HUMID TROPICS

Acacia auriculiformis
Calliandra calothyrsus
Casuarina equisetifolia
Derris indica
Gliricidia sepium
Gmelina arborea
Guazuma ulmifolia
Leucaena leucocephala
Mangroves
Mimosa scabrella
Muntingia calabura
Sesbania bispinosa
Sesbania grandiflora
Syzygium cumini
Terminalia catappa
Trema spp.

FUELWOOD SPECIES FOR TROPICAL HIGHLANDS

Acacia mearnsii
Ailanthus altissima
Alnus acuminata
Alnus nepalensis
Alnus rubra
Eucalyptus globulus
Eucalyptus grandis
Grevillea robusta
Inga vera

FUELWOOD SPECIES FOR ARID AND SEMIARID REGIONS

Acacia brachystachya
Acacia cambagei
Acacia cyclops
Acacia nilotica
Acacia saligna
Acacia senegal
Acacia seyal
Acacia tortilis
Adhatoda vasica
Albizia lebbeck
Anogeissus latifolia
Azadirachta indica
Cajanus cajan
Cassia siamea
Colophospermum mopane
Emblica officinalis
Eucalyptus camaldulensis
Eucalyptus citriodora
Eucalyptus gomphocephala
Eucalyptus microtheca
Eucalyptus occidentalis
Haloxylon aphyllum
Haloxylon persicum
Parkinsonia aculeata
Pinus halepensis
Pithecellobium dulce
Prosopis alba
Prosopis chilensis
Prosopis cineraria
Prosopis juliflora
Prosopis pallida
Prosopis tamarugo
Tamarix aphylla
Zizyphus mauritiana
Zizyphus spina-christi

(b) **Master List of Firewood Species Prior to Selection of 60 Species**
Source: 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. aulacocarpa
A. crassicarpa
A. flava
A. koa
A. leucophloea
A. polyacantha
A. stamensis
A. tomentosa
Acrocarpus fraxinifolius
Adansonia digitata
Adina cordifolia
Afzelia africana
A. xylocarpa
Aglaia spp.
Albizia falcata
*A. lebbeck**
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.
Baphia kirkii
Bauhinia malabarica
B. tomentosa
Bischoffia javanica
Bocageopsis multiflora
Bombax spp.
Bruguiera spp.•
Caesalpinia sappan
Cajanus cajan•
Calliandra calothyrsus•
C. surinamensis
Calliticarpa arborea
Caloncoba gilgiana
Cananga odorata
Capparis spp.
Carapa guineensis
Cariniana 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.
Chlopsis linearis
Chlorophora tinctoria
C. excelsa
Chloroxylon swietenia
Citrus spp.
Cocoloba sp.
Cocos nucifera
Coffea spp.
Combretum spp.
Connocarpus erectus
Cordia spp.
C. alliodora
Cratoxylon spp.
Crescentia cujete
Croton spp.
Cupressus lusitanica
Cynometra cauliflora
Daniella oliveri
Dendrocalamus strictus
Derris microphylla
Detarium senegalense
Diolium guineensis
D. ovoideum
Dichrostachys glomerata
Dillenia spp.
Diospyros spp.
Diphysa robinioides
Dinizia excelsa
Duabanga grandiflora
D. moluccana
Elaeriospermum spp.
Enterolobium cyclocarpum
Erythrina spp.
Erythrophleum spp.
Eschweilera mexiana
Eucalyptus 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
Hymenaea acida
Inga spp.
I. alba
I. edulis•
I. laurina
I. vera•
Inocarpus edulis
Intsia bijuga
Iryanthera hostmani
Khaya senegalensis
Kydia calycina
Laguncularia spp.
Lantana spp.
Leucaena leucocephala•
Labichbia corymbosa
Lucania spp.
Lundackeria 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. pendunculariis
Q. sapotaefolia
Rhamnus spp.
Rhizophora apiculata
R. candelaria
R. mangle•
R. mucronata•
Salix humboldtiana
Salvadora persica
Samanea saman
Schleichera oleosa
Schizolobium parahyba
Securinega virosa
Serialbizia splendens

Sesbania aegyptica
S. grandiflora•
Sterculia urens
Swartzia spp.
S. fistuloides
S. madagascariensis
Swietia brachystachya
Swietenia macrophylla
S. mahogani
Symphonia globulifera
Syzygium cumini•
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
Ziziphus 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 excelsea
Amorpha fruticosa
Aristotelia chilensis
Araucaria spp.
Aspidosperma quebracho-blanco
Baeckea frutescens
Bambus 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•
E. tereticornis
E. trabutii
E. viminalis•
E. wandoo
Eugenia sp.
Ficus palmata
F. salicifolia
Fraxinus sp.
Gleditsia triacanthos
Grevillea robusta•
Greuia 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. lutakunensis
A. longifolia
A. macracantha
A. melanoxylon
A. modesta
A. mollissima•
A. nilotica•
A. nilotica ssp. *adansonii*
A. nilotica var. *tomentosa*
A. oswaldii
A. pallacantha
A. peuce
A. planifrons
A. polyacantha ssp. *campylacantha*
A. pycnantha
A. raddiana•
A. senegalensis
A. seyal•
A. siamensis
A. tomentosa
A. tortilis•
A. victoriae
Albizia lebbeck
Anogeissus leiocarpus•
A. pendula•
Argania sideroxylon
Artemisia herba-alba
A. monosperma
A. scoparia
Aspidosperma quebracho-blanco
Atriplex bracteosa
A. canescens
A. leuoclada
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 sengalensis
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 ssp. *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 crassefolia
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**
Poponax 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 Multi-use) in Humid Tropics, Tropical Highlands and the Sub-tropical Arid/Semi-arid Regions

Source: Boland and Turnbull (1981)

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1. Humid tropics

Acacia aulacocarpa +
A. auriculiformis +
A. bakeri
A. cincinnata
A. crassicarpa
A. hylonoma
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. +
Commersonia 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 hunsteinii**
Backhousia anisata
Callicoma serratifolia
Callistemon salignus
Callitris macleayana
Casuarina cunninghamiana +
C. glauca
C. torulosa
Choricarpa subargentea
*Diploglottis australis**
Flindersia bourjotiana
Grevillea robusta
G. hilliana +
G. pinnatifida +
Macadamia spp.*
Mallotus paniculatus
M. philippensis
M. tetranoides
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.*

Appendix 8k

Species for Tropical Plantations

Source: Webb *et al.* (1980); and to be included in second edition, 1984

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 ssp. *raddiana*
Acrocarpus fraxinifolius
Agathis dammara
Albizia falcataria
Albizia lebbeck
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
Casaurina 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 ssp. *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 septum
Gmelina arborea
Grevillea robusta
Haloxylon aphyllum
Hieronyma chocoensis
Jacaranda copaia
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 merkusii (Continental Provenances)
Pinus merkusii (Island Provenances)
Pinus michoacana
Pinus montezumae
Pinus occidentalis
Pinus oocarpa
Pinus palustris
Pinus patula ssp. *patula*
Pinus patula var. *tecunumanii*
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

Appendix 8l

Trees and Bamboos for Integrated Landuse Systems in Malawi
Source: Personal communication, I.D. Edwards, Forestry Research Institute of Malawi

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

Appendix 8l

East Pokot Agricultural Project: Tree Planting Summary 1978-1982

Source: 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*	°*Balanites orbicularis*	
Acacia aneura	*2,3,4*	*Leucaena leucocephala* K8•	*1,4,5*
Acacia salicina	*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*	
Eucalyptus citriodora		°*Salvadora persica*	
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*	
Eucalyptus 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		*Bombax* spp.	
(Israel, Ben Gurion)	*1,3,4,5*	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, PO 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

Appendix 81

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 buchananii
Newtonia paucijuga
Parkia filicoidea
Adenocarpus mannii
Cordyla africana
Craibia brownii
Dalbergia melanoxylon
Dalbergia microcarpa
Erythrina abyssinica
Erythrina burtii
Erythrina excelsa
Indigofera arrecta
Lonchocarpus bulei
Milletia dura
Milletia usambarensis
Mundulea sericea
Ormocarpum kirkii
Sesbania sesban
Tephrosia elata
Tamarindus indica
Trachylobium verrucosum
Julbernardia magnistipulata
Erythrophleum guineense
Cynometra webberi
Delonix elata
Calia petersiana
Brachystegia spiciformis
Bauhinia tomentosa
Afzelia quanzensis
Acacia gerrardii
Acacia kirkii
Crotalaria laburnifolia
Piliostigma thonningii

MULTIPURPOSE SPECIES

Adansonia digitata
Anacardium occidentale
Balanites aegyptiaca
Borassus aethiopium
Casuarina equisetifolia
Chlorophora excelsa
Chrysophyllum albidum
Commiphora africana
Commiphora throthae
Cordia abyssinica
Cordia milleni
Eurphorbia tirucalli
Ficus sycomorus
Markhamia hildebrandtii
Markhamia platycalyx
Markhamia zanzibarica
Moringa 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.

Source: J. Gritzner, NAS, Washington, DC, USA.

8.	*A. aneura*	Nulga	CSIRO, Australia	12791	New South Wales, Australia	Currently out of stock.
*9.	*A. bolandieri*	Buajillo	Texas Department of Health		McNullen 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	Bomdia area, Senegal	Fuel, construction, fodder, tannin, gum.
15.	*A. nilotica* var. *tomentosa*		ISRA/CNRF, Senegal	82/597	Nayobe region, Senegal	Fuel, living fences and windbreaks, fodder, tannin, gum.
16.	*A. raddiana*	Umbrella Thorn	ISRA/CNRF, Senegal	82/599	Nayobe 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. tumaida*		CSIRO, Australia	11495	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 mate and paper.
22.	*Anogeissus leiocarpus*		ISRA/CNRF, Senegal	82/571	Boulai, Senegal	Fence posts, construction and wood-working, ashes, yield potash.
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		Wester, Texas	Browse, ground cover.
25.	*A. nummularia*	Oldman Saltbush	Western Australia Dept. of Agriculture	Acc WA-/1981	Western Australia	Browse, ground cover.
26.	*Balanites aegyptiaca*	Desert Data	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*	Yeab	Baobab Farm, Kenya		Mombasa, Kenya	Currently out of stock.
32.	*Desmanthus virgatus*		CSIRO, Australia	65947	Salinas, Equador	Currently out of stock.
33.	*Eucalyptus brockiwayi*	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	11738	New South Wales, Australia	Fuel, shelterbelts.
38.	*E. melanophloia*	SilverLeaved Ironbark	CSIRO, Australia	13158	Queensland, Australia	Fuel, honey production.
39.	*E. microtheca*	Flooded Box	CSIRO, Australia	12846	Queensland, Australia	Fuel, poles and posts, conservation.
40.	*E. microtheca*	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. olecea* var. *olecea*	NarrowLeaved 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*	CoralFlowered Gum	CSIRO, Australia	10106	Western Australia	Ornamental plantings, honey production.
*46.	*Geoffroea decorticans*		SACOE, CUILE	EE-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	Marida, 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/CHRF, Senegal	106	Keur-Nactar, 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.	*Stylosenthes hanata*		CSIRO, Australia	Verano	Coastal South America	Browse shrub.
80.	*S. scabra*		CSIRO, Australia	Q10042	Rahia, 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.	*Tarchomanthus camphoratus*	Camphor Bush	Bolus Herbarium		Bloenfontein, South Africa	Fuelwood, fodder, windbreaks, termite-resistant wood, medicinal uses.

Species and Uses of Bamboos in Asia
Source: Lessard and Chouinard, 1980

Table 1

Uses, local names, and location of some species in Malaysia.

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	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	—	—
B. ventricosa	—	—	Originally from China
B. vulgaris	Furniture, paper, pulp, shoots, landscaping	Buloh minyak aao/ aro/beting/pan	All over Malaysia
B. wrayi	—	Buloh sumpitan	Perak-Gunong Inas (1500-2000 m)
Dendrocalamus asper	Laminated trays, plywood, vencer, bridges, fences, water vessels, racks, tables, chairs, cages, fish traps, shoots	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
Dinochloa scandens	Rope making	Buloh akar	Perak
Gigantochloa sp.	Structures	—	—

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. scortechenii			Buloh semantan, telur/rayah/Pa-aao/ gala/seremai	Kedah, Penang, Perak, Selangor, N. Sembilan, Kelantan, Pahang
G. wrayi		—	Buloh beti	Kedah, Pahang, Province Wellesley, Perak, Selangor
Schizostachyum aciculare	Handicrafts		Buloh padi/akar	Johore, Selangor, N. Sembilan, Melaka
S. brachycladum		—	Buloh nipis/lemang/ padi/urat/rusa/ pelang	Kedah, Penang, Perak, Pahang, Johore
S. gracile		—	Buloh rapen/akar	Johore; Selat Teberau, Kota Tinggi, Segamat, Sg. Sedili; Melaka: Bukit Tungal, Air Panas Selangor; Sungai Labu; Pahang; Kuala Bera, Pekan
S. grande	Rims for large baskets		Buloh semeling/ semenyeh	Kedah; Grik; Perak; Cameron Highland; Pahang; Kuala Lipis, Kelantan, Selangor
S. insulare		—	—	Pulau Langkawi, Kedah, Penang, Johore
S. jaculans	Wind instruments, handicrafts		Buloh sumpitan/ temiang/kerap/ tikus	Pahang, Selangor, Melaka, Johore, Singapore, Perak
S. longispiculatum		—	—	In all states except Perlis, Kedah, P. Pinang, Trengganu, Province Wellesley
S. terminale		—	—	Kedah; Inchong Estate, Sg. Kenan
S. zollingeri	Handicrafts, baskets, traps, hats, woven wares, rafts, floors, walls, patitions cooking vessels		Buloh telor/pelang nipis/dinding/kasap/ lemang/aur	Perak, Selangor, N. Sembilan, Pahang, Johore

Table 2

Species of bamboos and their uses in Indonesia

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	•		•	•	•	•	•	•		•	•			
Dinochloa scandens					•		•							
Gigantochloa apus	•	•	•	•	•	•	•	•	•		•			
G. atter	•		•	•	•	•	•	•		•	•			
G. aff. *atter*	•		•	•	•		•	•		•	•			
G. verticillara	•		•	•	•		•	•		•	•			
Nastus elegantissimus	•	•												
Phyllostachys aurea					•									•
P. nigra														•
Schizostachyum blumei	•	•			•	•	•			•	•			
S. brachycladum	•	•	•	•	•	•	•			•	•			
S. caudatum	•								•					
S. lima	•				•	•	•			•	•			
S. zollingeri	•		•	•	•	•	•	•		•				
Thyrsostachys siamensis							•							

Table 3

Consumption (%) of bamboos in 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 Housing	Construction Others	Rural uses	Packaging	Pulp manufacture	Other uses
Bangladesh	50	10	20	5	10	5
Burma	33	32	32	5	-	!
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. nutans (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

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 capittatum (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)
Cephalostrachyum 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)

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)
Thyrsostachys 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)
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 (Ja, 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 mitsukayamensis (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)

Country tiles
Bambusa arundinacea (In)

Pan trays
Neohouzeoua dulloa (In)
Teinostachyum dulloa (Bu)

Seed drills
Dendrocalamus strictus

Containers to administer medicine to animals
Bambusa arudinacea (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)

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)
B. 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 elegantissimis
Schizostachyum lima (Ph)
S. brachycladum
S. blumei (Ind)
All bamboos (Th)

Sprayers
Bambusa blumeana (Ph)

Polo mallets
Bambusa blumeana (Ph)

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)

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

Appendix 8n

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

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: *Lambusa blumeana, Bambusa vulgaris.*

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

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

Bows and arrows: *Bambusa arundinacea, Cephalostachyum capitatum, Cephalostachyum pergracile, Dendrocalamus 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, Neohauzeaua dullooa, Oxytenanthera stocksii, Teinostachyum beddomei, Thyrsostachys oliveri.*

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 seriptoria.*

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.*

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

Lattle shats: *Dendrocalamus strictus, Ochlandra* species.

Loading vessels: *Neohauzeaua dullooa.*

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 dullooa, Ochlandra strictorica, Ochlandra travancorica, Oxytenanthera nigrociliata, Teinostachyum dullooa.*

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, Cephalostachyum pergracile, Dendrocalamus giganteus, Phyllostachys aurea, Oxytenanthera monadelpha, Thyrsostachys siamensis.*

Pandals for shade: All bamboos.

Pan trays: *Neohauzeaua dullooa.*

Paper and Pulp: An idea about the changes in the utilisation pattern of bamboo in the production 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 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 dullooa, Ochlandra brandsii, 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 membranaceus, Thyrsostachys oliveri, Thyrsostachys siamensis.*

Pea sticks: *Thamnocalamus spathiflora.*

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

Polo mallets: *Bambusa blumeana* (Basal portion of culm).

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

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

Rickshaw 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.*

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.

Stabilising 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.*

Walking sticks: *Arundinaria armata, Dendrocalamus strictus, Ochlandra travancoria, 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 sikkimensis, Gigantochloa aspera, Gigantochloa levis, Melocanna baccifera.*

Appendix 8o

Ecological Requirements of Some Artificially Established Browse Species in North Africa

Source: Le Houérou, 1980

Species	Rainfall in mm	Mean minimum January temp. in °C	Soils
Acacia cyanophylla	> 250	> 3	Deep sandy
Acacia ligulata	> 150	> 3	Deep sandy
Acacia salicina	> 150	> 3	Deep sandy
Acacia victoriae	> 150	> 3	Silty to sandy
Artemisia herba alba	> 150	>-2	Silty, shallow
Atriplex canescens	> 200	>-5	Sandy to silty
Atriplex glauca	> 150	> 1	Silty to clayey, saline EC < 30 mmhos
Atriplex halimus	> 150	> 1	Silty to clayey, saline EC < 30 mmhos
Atriplex 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
Elaeagnus angustifolia	> 300	>-2	Various
Fraxinus oxyphylla	> 500	> 1	Various
Gleditsia triacanthos	> 400	>-5	Various
Haloxylon aphyllum	> 80	>-10	Silty-clayey
Haloxylon 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	> 1	Deep sandy
Opuntia fusicaulis	> 200	> 1	Deep sandy
Opuntia inermis	> 200	> 1	Deep sandy
Periploca laevigata	> 100	> 3	Shallow
Prosopis juliflora	> 200	> 2	Sandy
Vitis berlandieri	> 200	>-5	Various

Vitis riparia	> 200	>-5	Various
Vitis rupestris	> 400	>-5	Various
Vitis vinifera	> 200	>-5	Various

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 100mm mark.

Appendix 8p

Masterlist of Woody Species under Consideration as Nitrogen-fixing Trees

Source: Halliday and Nakao, 1982

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 (PO Box 0, 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 aduncа
Acacia alata
Acacia albida
Acacia anceps
Acacia aneura
Acacia arabica (nilotica)
Acacia arenaria
Acacia armata
Acacia aroma
Acacia aspera
Acacia ataxacantha
Acacia aulacocarpa
Acacia auriculiformis
Acacia baileyana
Acacia berlandieri
Acacia berteriana
Acacia bidentata
Acacia biflora
Acacia blakelyi
Acacia bonariensis
Acacia borlaea
Acacia brachybotrya
Acacia brachystachya
Acacia burkei
Acacia buxifolia
Acacia byoneana
Acacia caffra
Acacia calamifolia
Acacia caleina
Acacia cambagei
Acacia cana
Acacia cardiophylla
Acacia catechu
Acacia cavan
Acacia cavenia
Acacia celastrifolia
Acacia chariessa
Acacia cognata
Acacia colletoides
Acacia complanata
Acacia confusa
Acacia constricta
Acacia crassicarpa
Acacia cultriformis
Acacia cunninghamii
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 glaucoptera
Acacia glomerosa
Acacia goetzii
Acacia grandicornuta
Acacia granitica
Acacia greggii
Acacia hakeoides
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 kempeana
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 luederitaii
Acacia lunata
Acacia macrantha
Acacia macrthyrsa
Acacia mangium
Acacia mearnsii
Acacia melanoxylon
Acacia mellei
Acacia mellifera
Acacia microbotrya
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 orfota
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 ruhida
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 stulmanii
Acacia suavolens
Acacia subcaerulea
Acacia suffructescens
Acacia sulcata
Acacia swazica
Acacia tamminensis
Acacia tennispina
Acacia tetragonocarpa
Acacia tomentosa
Acacia tortilis
Acacia triptera
Acacia tucunanensis
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 schweinfurthii
Albizia acle
Albizia adianthifolia
Albizia amara
Albizia anthelmintica
Albizia antunesiana
Albizia brevifolia
Albizia carbonaria
Albizia chinensis
Albizia distachya
Albizia edentula
Albizia falcateria
Albizia forbesii
Albizia glaberrima
Albizia gummifera
Albizia harveyi
Albizia julibrissin
Albizia katangensis
Albizia lebbeck
Albizia lebbeckoides
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 fruticosa
Alnus glutinosa
Alnus hirsuta
Alnus incana
Alnus jorullensis
Alnus maritima
Alnus mollis
Alnus multinervus
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
Aphanocalyx cynometroides
Apoplanesia paniculata
Aprevalia floribunda
Apuleia praecox
Arthrocarpus 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 hirsuta

Bauhinia blakeana
Bauhinia candicans
Bauhinia carronni
Bauhinia corymbosa
Bauhinia cumingiana
Bauhinia diphylla
Bauhinia excisa
Bauhinia galpinii
Bauhinia kirkii
Bauhinia kochiana
Bauhinia kunthiana
Bauhina macrantha
Bauhinia malabarica
Bauhinia megalandra
Bauhinia nonandra
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
Brongniartria podalyroides
Brownea ariza
Brownea capitella
Brownea coccinea
Brownea crawfordii
Brownea grandiceps
Brownea latifolia
Browneopsis ucayalina
Brya ebonus
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 h. ematocephala
Calliandra haematoma
Calliandra humilis
Calliandra inaequilatera
Calliandra parvifolia
Calliandra selloi
Callinadra 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
Ceonothus americanus
Ceonothus azurens
Ceonothus cordulatus
Ceonothus crassifolius
Ceonathus cuneatus
Ceonothus delilanus
Ceonothus divaricatus
Ceonothus diversifolius

Ceonothus fendleri
Ceonothus foliosus
Ceonothus fresnensis
Ceonothus glabra
Ceonothus gloriosa
Ceonothus greggii
Ceonothus griseus
Ceonothus impressus
Ceonothus incana
Ceonothus integerrimus
Ceonothus intermedius
Ceonothus jepsonii
Ceonothus leucodermis
Ceonothus microphyllus
Ceonothus oliganthus
Ceonothus ovatus
Ceonothus parvifolius
Ceonothus prostratus
Ceonothus rigidus
Ceonothus sanguineus
Ceonothus sorediatus
Ceonothus thyrsiflorus
Ceonothus 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
Curdia gabonensis
Crudia parvoa
Cyclobium brasiliense
Cyclolobium vecchi
Crudia gabonensis
Cyobosepalum baroni
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 oliveri
Daniellia thurifera
Dansera procera
Delaportea armata
Delonix baccal
Delonix elata
Delonix regia
Denistophytum madagascariense
Derris indica
Detarium senegalense
Dewevrea bilabiata
Dialium engleranum
Dialium pachyphyllum
Dialium zenkeri
Dichrostachys cinerea
Dichrostachys glomerata (D. cinera)
Dichrostachys spicata
Dicorynia guianensis
Dicraeopetalum stipulare
Dicymbe altsoni
Dicymbe corymbosa
Didelotia africana
Dimorphandra davisii
Dinizia excelsa
Diphysa floribunda
Diphysa robinoides
Diplotropis purpurea
Dipteryx odorata
Dipteryx trifoliata
Diptychandra epunctata
Discaria toumatou
Distemonanthus 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 cyometroides
Elizabetha durissima
Elizabetha princeps
Erdertia spectabilis
Englerodendron usambarense
Entada abyssinica
Entada phaseoloides
Entada sudanica (E. africanum)
Enterolobium cyclocarpum
Enterolobium schomburghii
Enterolobium timbouva
Epetua falcata
Epetua jensani
Epetua 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
Eurypetalum batesii
Eurypetalum tessmannii
Exostyles venusta
Eysenhardtia amorphoides
Eysenhardtia peninsularis
Eysenhardtia texana
Ferreirea spectabilis
Fillaeopsis discophora
Fissicalyx fendleri
Fordia cauliflora
Gagnebina tamariscina
Genista sp.
Geoffroea decorticans
Geoffroea spinosa
Gilbertiodendron demonstrans
Gilletiodendron klaineanum
Gleditsia amorphoides
Gleditsia caspica
Gleditsia japonica
Gleditsia sinensis
Gleditsia triacanthos
Gliricidia ehrenbergii
Gliricidia lambii
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 feuilei
Inga laurina
Inga oerstediana
Inga paterna
Inga vera
Inocarpus edulis
Instia acuminata
Instia bakeri
Instia bijuga
Instia palembanica
Instia plurijuga
Instia retusa
Isoberlinia schefflera
Isoberlinia angolensis
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
Lebrunodendron 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 schomburghii
Macroberlinia bracteosa
Macrozamia communis
Macrozamia riedlei
Maniltoa grandiflora
Maniltoa scheffera
Marmaroxylon racemosum
Martiodendron excelsum
Melanoxylon brauna
Michelsonia microphylla
Microberlinia brazzavillensis
Milbraediodendron excelsum
Millettia dubia
Millettia grandis
Millettia laurentii
Millettia rubiginosa
Millettia stuhleannii
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 pennsylvanica
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 micranthus
Oleiocarpon panamense
Olneya tesota
Ormosia coccinea
Ormosia hosei
Ormosia monosperma
Ostroyoderris gabonica
Ostryoderris stuhlmannii
Ougeinia oojeinensis
Oxystigma mannii
Oxystigma msoo
Pachyelasma tessmannii
Pahudia galedupa
Pahudia rhomboidea
Piloue guianensis
Paloveopsis emarginata
Panurea longifolia
Paramachaerium schomburgkii
Paramacrolobium caeruleum
Papiptadenia rigida
Paraponia andersonii
Parsponia 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 diphyllus
Peltogyne catingue
Peltogyne densiflora
Peltogyne excelsa
Peltophorum adnatus
Peltophorum dasyrrhachis
Peltophorum pterocarpus
Peltophorum vogelianus
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 carahoboense
Pithecellobium cauliflorum
Pithecellobium collinua
Pithecellobium dulce
Pithecellobium flexicaule
Pithecellobium jiringe
Pithecellobium lobatum
Plagiosiphon discifer
Plathymenia reticulata
Platycelyphium cyananthua
Platycyamus regnellii
Platycyamus uleı
Platymiscium dimorphandrum
Platymiscium pinnatum
Platymiscium trinitatis
Platymiscium ulei
Platypodium elegans
Platysepalue vanhouttei
Platysepalum violaceam
Platysepalum violouttei
Podopetalum ormondii
Poecilanthe effusa
Poeppigia procera
Pogocybe entadoides
Polystemanthus dinklagei
Pongamia pinnata
Prioria copaifera
Prosopis africana
Prosopis alba
Prosopis articulata
Prosopis chilensis
Prosopis cineraria
Prosopis dulcis
Prosopis glandulosa
Prosopis juliflora
Prosopis kinzeie

Prosopis nigra
Prosopis pallida
Prosopis ruscifolia
Prosopis tamarugo
Prosopis velutina
Pseudosamanea guachapele
Pterodendron spinosum
Pterocarpus angolensis
Pterocarpus blancoi
Pterocarus echinatus
Pterocarpus inducs
Pterocarpus marsumpium
Pterocarpus officinalis
Pterocarpus podocarpus
Pterocarpus rotundifolius
Pterocarpus santaloides
Pterocarpus sericeus
Pterocarpus soyauxii
Pterocarpus stevensonii
Pterocarpus vidalianus
Pterodon emarginatus
Pterogyne nitens
Pynaertiodendron congolanum
Ramorinoa girolae
Recardoxylon amazonicum
Robinia hispida
Robina neomexicana
Robinia pseudoacacia
Robinia viscosa
Sabinea florida
Sakoanaia madagascariensis
Samanea pedicellaris
Samanea polycephala
Samanea saman
Samanea saminiqua
Sophora tomentosa
Sopropis palmeri
Spirotropis longifolia
Stachyothyrsus staudtii
Stahlia maritina
Steinbachiella leptoclada
Stemonocaleus micranthus
Storkiella vitiensis
Strombocarpa strombulifera
Xanthocercis zambesiaca
Xeroderris stuhlmannii
Xylia evansii
Xylia ghesquierei
Xylia xylocarpa
Yucaratonia brenningii
Zenia insignis
Zenkerella citrina
Zenkerella citrina

Appendix 8q

Economically Important Nitrogen-fixing Tree Species "A" List

Source: Brewbaker and Styles, 1982

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 30 m, spreading
2. Fuelwood; pulpwood; .68 sp.gr.; 15 m^3/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; tannin; 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 m^3ha/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 m^3/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 m^3/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 LEBBECK (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 m^3/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 m^3/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 500 m
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 3000 m, 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. 1000 mm), cooler (above 500 m?); to 40 m^3/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
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

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 PEOPPIGIANA (WALPERS) O.F. COOK (PAPILIONOIDEAE; LEGUMINOSAE)
1. S. America to Panama; to 40 m
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; live fence; to 8 m^3/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 (CAESALPINIOIDEAE; 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

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 m^3/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 (ROX.) 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. Fuelwood; fodder (leaves); oil (seeds); pest control (leaves); shade tree; medicine
3. Mesic tropics (min. 600 mm); saline tolerant; to full height in 5 yrs.
4. Aggressive spreading roots; also known as *Derris indica* (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 m^3/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 m^3/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 m^3/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. (MIMOSIDEAE; LEGUMINOSAE)

1. Chile; to 15 m
2. Firewood; forage (pods, leaves); 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 20 m^3/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 S.E. Asia; to 10 m, slender
2. Pulpwood; forage (leaves, pods); food (flower, leaves, young pods); ornamental; sp.gr. .42; to 22 m^3/ha/yr; large nodules
3. Moist tropics (1000 mm min.), on to poor soils
4. Genetic variability; soft wood; borer susceptibility 2n = 14,24

Appendix 8q

Economically Important Nitrogen-fixing Tree Species "B" List

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
Adenanthera 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

Appendix 8r

Fodder Trees for Nepal Hills
Source: Kessler (1981)

Albizia 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 citrata
L. polyantha

Morus alba

Prunus cerasoides

Quercus incana
Q. lamellosa

Salix spp.

Saurauria napaulensis

Schima wallichii

Appendix 8r

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*	Anacardiaceae			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 eurycoma*	"				X				
15.	*Daniallia oliveri*	"	X							
16.	*Detarium microcarpum*	"			X	X				
17.	*Dialium guineense*	"			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*	"								
29.	*Ficus capensis*	Moraceae	X		X					
30.	*Ficus polita*	"			X					
31.	*Moringa oleifera*	Moringaceae	X				X			
32.	*Syzygium guineense* var. *macrocarpum*	Myrtaceae			X					
33.	*Borassus aethiopum*	Palmae			X	X		X	X	X
34.	*Elaeis guineensis*	"			X	X			X	X
35.	*Phoenix reclinata*	Palmae			X					X
36.	*Raphia sudanica*	"			X					X
37.	*Pterocarpus santalinoides*	Papilonaceae	X							
38.	*Ziziphus mauritiana*	Rhamnaceae			X					
39.	*Ziziphus spina-christi* var. *spina-christi*	"			X					
40.	*Gardenia erubescens*	Rubiaceae			X					
41.	*Nauclea latifolia*	"			X					
42.	*Aphania senegalensis*	Sapindaceae			X					
43.	*Blighia sapida*	"			X					
44.	*Zanha golungensis*	"			X					
45.	*Butyrospermum paradoxum* ssp. *parkii*	Sapotaceae			X				X	
46.	*Pachystela 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 5: Fruit 7: Flowers 9: Oil

4: Bark 6: Seeds 8: Roots 10: Local beverage

Appendix 3s

Multipurpose Trees for the Himalayan Region

Source: Personal communication, Professor P.K. Khosla, HPKVV, Solan, HP, India

Scientific name (common name)	Distribution	Uses
1	5	6
Acacia catechu (Khair)	Up to 3500'	Fuel, Shelterbelts, Fodder, Katha, Soil conservation
Acer caesium (Maple)	7000-10000'	Fuel, Fodder, Timber
Acer oblongum (Maple)	Up to 6000'	-do-
Ailanthus excelsa (Maharukh)	Up to 2000'	-do-
Adina cordifolia (Haldu)	Up to 3500'	Packing material, Fuel, Timber
Aesculus indica	4000-9000'	Fuel, Timber
Anogeissus latifolius (Chall)	Up to 3000'	Fuel, Fodder, Agr. implements
Albizia lebbeck (Kalo Siris)	Up to 4000'	Fuel, Fodder, Soil conservation, Shelterbelts
A. procera (Safed Siris)	Up to 3500'	Fuel, Fodder
Alnus nitida (Kosh)	6000-9000'	-do- Soil conservation
Azadirachta indica (Neem)	Up to 2000'	Fuel, Medicinal, Shelterbelts
Bauhinia variegata (Kachnar)	2000-5000'	Fuel, Fodder, Medicinal, Shelterbelts
Cassia fistula (Amaltas)	Up to 4000'	Fuel, Ornamental
Celtis australis (Khirak)	2000-8000'	Fuel, Fodder, Agric. Impl.
Toona serrata (Darli)	4000-8000'	Fuel, Fodder
Toona ciliata (Toon)	Up to 4000'	Fuel, Fodder, Timber
Dalbergia sissoo (Shisham)	Up to 4000'	Fuel, Soil conservation, Timber, Shelterbelts
Emblica officinalis (Amla)	Up to 4500'	Fuel, Fruit, Ornamental
Grewia optiva (Beul)	Up to 6000'	Fuel, Fodder, Agric. Impl.
Moringa oleifera (Sanjna)	Up to 3500'	Fodder, Fruits, Medicinal, Pulp and Paper
Morus alba (Toot)	4000-9000'	Fuel, Fodder, Sports
Populus ciliata (Pahari pipal)	4000-10000'	Fuel, Fodder, Packaging
Quercus leucotrichophora (Ban oak)	4000-8000'	Fuel, Fodder
Q. dilatata (Mohru)	7000-10000'	Fuel, Fodder
Q. semecarpifolia (Kharsu)	8000-12000'	-do-
Robinia pseudoacacia (Robinia)	4000-7000'	Fuel, Fodder
Salix spp. (Beuns)	2500-15000'	Fuel, Fodder
Sapindus mukorossi (Ritha)	Up to 5000'	Fuel, Fruits, Ornamental
Shorea robusta (Sal)	In valleys of foot hills, Up to 3000'	Fuel, Timber, Fodder
Terminalia tomentosa (Sain)	Up to 4000'	Fuel, Fodder, Timber
Alnus wallichiana	3500-10000'	Fuel, Fodder, Soil conservation

Appendix 9

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 IRS & 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 & FERTILIZERS
WEED CONTROL

The equipment

To search CAB ABSTRACTS, you will need a computer terminal to access a host computer via a 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 host's 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, UK
Tel: Farnham Common 2281 Telex 847964
Cables COMAG, SLOUGH.

Appendix 10a

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

Appendix 10b

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 its 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 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*.

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

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

Information sources

At ICRAF:

- *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 practising 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

Subject scope

- 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
  PO 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 documents. The originator of the request identifies the ones wanted.

- a *computerized printout* of references for analysis by the originator. In some cases, depending on the 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 consulted to provide advice. This depends on the availability of the staff.

- *photocopied documents*. These are provided when requested or when it is thought they will be useful 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.

Appendix 11a

Periodicals, Bibliographies and General References to NFT

Source: Duke and Brewbaker (1982)

(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 largely 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. Periodicials 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 Institution, Washington, DC (Taxonomically oriented; includes lists of specialists)

BNF Bulletin. NiFTAL, PO Box "0", Paia, Maui, Hawaii 96779. (Published 3 times annually; focussed on biological nitrogen fixation)

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

ICRAF Newsletter. Internatl. Council for Research in Agroforestry, PO 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 notes, announcements of publications and meetings)

Leucaena Research Reports. J.L. Brewbaker, Ed. Nitrogen-Fixing Tree Association, PO 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, PO 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, PO Box "0", 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, DC.

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, DC.
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 Services, PO 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, DC.

ACACIA MEARNSII WILLD. 2,3,4,5,6,10
Sherry, S.P. 1971. The black wattle (*Acacia mearnsii* de Wild.). 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 LEBBECK (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, DC.

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

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

CASUARINA GLAUCA SIEB. EX SPRENG. 3,10

CASUARINA JUNGHUHNIANA 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, Costa 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

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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, Rajasthan, India

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(Includes *P. pallida* (Humb & Bon ex Willd) and *P. juliflora* (Swartz) DC)

Simpson, B.B. 1977. Mesquite: Its biology in two desert ecosystems. Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pa.

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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2. Webb, *et al.* Guide to Species Selection, Commonwealth Forestry Institute, S. Parks Rd., Oxford, UK.

3. National Academy of Sciences (NAS). 1980. Firewood Crops. Shrub and tree species for energy production. NAS, Washington, DC. 237 p.

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Appendix 11b

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. (1979). Amazonian oil palms of promise: a survey. Econ. Bot. 33 (1), 11-28.

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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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HAWKES, J.G., WILLIAMS, J.T. and HANSON, J. (1976). A bibliography of plant genetic resources. AGPE: IBPGR/76/4, CGIAR/IBPGR, FAO, Rome, Italy, 179 p.

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Agroforestry (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 Forêts 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
Forest Genetic Resources Information (Rome, Italy)
Indian Forester (Dehra Dun, India)
International Tree Crops Journal (Berkhamstead, England)
Kew Bulletin (London, England)
La — Yaaren (Hanoth, 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)

C. 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)

Appendix 12

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, CSIRO 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 wtih 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 Instituto Sperimentale per la Selvicoltura, Florence.

(d) Additional exploration/collection of Australian species by Division of Forest Research, CSIRO, 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 US 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 activities 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 have 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 possible 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 its 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 countries.

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 UK 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, CSIRO Canberra and *noted* the wide range of species and provenances collected since its last sessiuon 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 US 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.

Appendix 13

US National Research Council Grants Approved for Fast-growing, Nitrogen-fixing Trees

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 *Albizia 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.

Appendix 14

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*

Appendix 15

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 programme 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 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 referees having specific knowledge of their qualifications for this position.

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

Professor Dr. Dusan Mlinsek	Dr. Robert E. Buckman
IUFRO President	Vice President, IUFRO
Biotechnical Faculty	USDA Forest Service
Krekov trg 1	PO Box 2417
61000 Ljubljana	Washington, DC 20013
Yugoslavia	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.

POSTSCRIPT: since the Workshop in Washington the post has been filled by Mr. O. Fugalli (Italy) formerly with FAO.

Appendix 16

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* set 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 insufficent to prevent pollination because there are almost always other inflorescences on the same plant at various stages of development.

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Appendix 17

Seed Certification, Provenance Nomenclature and Genetic History in Forestry

Source: N. Jones and J. Burley
Reproduced with permission from Silvae Genetica 22(3), 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 together 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 identify, 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 USA 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 Norrthwest Territory and the Yukon (Wang and Sziklai, 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 not state or national systems operating. The State Forest Services have usually maintained records of origin of seed lots on a voluntary basis (Turnbull, 1973; pers. comm.)

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, USA. 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 to 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, 1963a, 1963b; 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 Developing (OECD, 1971; see also Barner in FAO, 1971). First accepted in 1967 after several years' preparatory work and meetings, this latest version is still subject to discussion and amendment. OECD 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.

The FAO Panel of Experts on Forest Gene Resources recommended that countries should model their own national seed certification schemes on that of the OECD, even though varying conditions from country to country will make complete standardisation impossible (FAO, 1971). The OECD scheme is also compatible with that of the European Economic Community (EEC, 1966).

The OECD scheme

The OECD scheme has not been widely publicised outside Europe and North America although it is open, on a voluntary basis, to all member countries of the Organization and to member countries of the United Nations or its specialised agencies. Although participation is voluntary, it entails complete acceptance of the rules of the scheme, including the designation of competent authorities to issue the relevant certificates. The scheme refers to all reproductive parts of plants, not just seed. The following terms are defined: — stand, indigenous stand, selected stand, seed orchard, clone, cultivar, provenance (location of seed source), origin, region of provenance, and designated authority. Barner (1972), who is the forestry consultant to the OECD scheme, has considered in detail the implications of the scheme for seed orchard classification and certification.

In essence the OECD (1971) scheme recognised three categories of reproductive material: source-identified, selected and certified.

The two requirements for *source-identified* reproductive material are (a) the region of provenance where the reproductive material is collected and the nature of the origin of the reproductive material (which may be indigenous or non-indigenous) shall be defined and registered by a Designated Authority; (b) the seed shall be collected, processed and stored or plants shall be raised under the control of a Designated Authority. For *selected reproductive* material the same requirements apply but in addition the scheme outlines special criteria for the isolation, uniformity, population size and properties of selected stands. For *certified* reproductive material there is the additional requirement of genetic superiority, demonstrated by provenance or progeny tests.

As indicated earlier, this latter term *'certified'* is unfortunate because in English it simply means the provision of a certificate; the other two categories are also provided with certificates. The term *'tested'* is currently being considered although, again in English, this does not imply superiority. Terms such as *'passed'*, *'qualified'*, *'certified superior'*, *'proved'* might be better although any one would be acceptable if an adequate definition is given.

However, the results of tests in one environment must be interpreted with caution when applied to another because of the interactions of the genotype with the new environment. At its meeting in March, 1973, the OECD proposed the inclusion of a fourth category. "Reproductive material from untested seed orchards". This category additionally requires approval by the Designated Authority of the objectives, design, components, isolation, location and management of the seed orchard.

Other schemes

Some countries recognised subclassifications of their local seed sources, before progeny testing showed their genetic value, *e.g.* the plus, almost plus, normal and minus categories of Great Britain (Larsen, 1960, 1961); or the plus, normal and minus stands of Sweden (The Royal Board of Private Forestry of Sweden, 1950); or the standard plus, standard superior, and standard grades suggested for Western American conifers by Isaac (1960).

However, none of these systems offers adequate information on the genetic history and probable variability of the material. It has long been known that, for most tree species, the source and parentage of a seed sample influence the survival, adaptability, variability, productivity and value of the resultant

plantation. The number of potential parents varies with species from densities of one to several hundred trees per acre. To determine the optimum seed source for a given site type or region, comparative experiments are necessary, commonly termed seed source trials or provenance trials. Various definitions of provenance (provenience) and seed source are available.

Current definitions of provenance

Published definitions

Probably the earliest widely accepted English definitions have been:

(i) *"The geographical source or place of origin from which a given lot of seed or plants was collected; the material from such a source or origin; often restricted to imply material from a specific race."* (Empire Forestry Association, 1953).

(ii) *"The original geographic source of a lot of seed (or pollen)."* (Wright, 1962).

These definitions were commonly associated with studies of variation in naturally widespread species that demonstrated ecotypic, clinal or random variation between populations; thus, although they did not specifically exclude nonnative populations (*i.e.* exotic plantations) they were often taken as referring to natural populations. This is specifically stated in the first of two definitions of provenance given in the Terminology of Forest Science (Society of American Foresters, 1971):

Provenance (i) = *provenience*
The geographical area and environment, to which the parent trees, etc. are native, and within which their genetic constitution has been developed through natural selection.

Provenance (ii) = *source, origin, provenience*
The geographical source, i.e. place of origin, of a given seed lot or pollen.

However, the SAF Terminology defines seed source as:

Seed source = *seed origin*
The locality where a seed lot was collected.
Note: *if the stand from which collections were made was exotic, the place where its seed originated is the original seed source.*

However, these do not coincide exactly with the Southern Forest Experiment Station's revision of a Society of American Foresters' Glossary for Forest Tree Improvement Workers (Snyder, 1972):

Provenance.
The original geographic source of seed, pollen or propagules.

Seed source.
The locality where a seed lot was collected; also the seed itself. If the stand from which the collections were made was in turn from non-native ancestors, the original seed source should also be recorded and designated as the provenance.

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 OECD proposed a slight amendment: *The place in which any stand of trees is growing. The stand may be indigenous or non-indigenous.)*

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.*

Whichever definiton of provenance is used, it is desirable to compare different seed lots in designed experiments called provenance tests. Indeed the *'certified'* category in the OECD scheme requires proof of superiority to be shown by provenance or progeny tests. Currently proposed amendments for the OECD 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 reasonable 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 nomenclature 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 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 of 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 be taken from commercial collections or purposely collected for research. In most commercial collections many parents are represented although unfortunately there is still a tendency in some areas to collect from easily climbed, accessible trees with poor phenotype and, presumably, frequently poor genotype. (The OECD *source-identified* category allows this; the category *selected* is applied to seed from stands that are superior to the accepted mean for the prevailing ecological conditions. Inferior phenotypes must be removed

from selected stands.) The number of parents represented in small research lots clearly influences the deductions that can be made from a comparative trial or the use that can be made of the material for further selective breeding.

The year of seed collection is also important. Annual changes in the environmental factors that influence flowering and seed production cause different trees to be represented as the male or female parents in different years. Although little can be done to influence this, the year of collection may have some effect on the use of the resultant trees for further breeding. The genetic constitution of a plantation changes with age as thinnings are carried out.

Classification of genetic histories

In a classification of genetic histories *(Table 1)* the main division is between seed collected in a natural stand ("natural provenance") and in a plantation ("derived provenance"). Even if the plantation is within the natural range of the species there are sufficient differences between natural or artificial selection in natural forests and plantations to merit separate discussion.

For both gregarious and non-gregarious species, natural provenances may be classified dichotomously by the degree of human interference *(Table 1A)*. Both dysgenic and eugenic treatment may reduce genetic variability, and both of these may have caused the development of new local races. Similarly a forest population invading or reinvading a deforested area may develop new genetic structure.

Seed collected from trees in a plantation (derived provenance) may be classified according to whether or not the provenance of the parents of the plantation trees is known; the provenance of the parents may itself be natural or derived *(Table 1A)*.

Seed collected in natural forests

In the case of natural provenances *(Table 1B)* the poorest category is the bulked commercial collection made over a wide area with imprecise information on seed source and without any check on the collection. The lowest category to which an OECD certificate could be applied is the *source identified* class in which seeds are collected from representatives of a well defined region of provenance. The region of provenance is defined as the area or group of areas subject to sufficiently uniform ecological conditions on which are found stands showing similar genetic or phenotypic characters. However, it would be better to obtain information on a stand basis.

A higher category would require bulked collection from random representatives of a well defined stand sufficiently uniform in composition and arrangement to be distinct from adjacent populations. The next category in the OECD system *(selected)* is the bulked collection from random representatives of a selected stand which is superior to the accepted local mean. In these three classes random checks should be made on the seed collection process and on the extraction data. (The OECD *selected* category also includes seed from untested seed orchards based on superior individual trees — see below.)

A further important category in this group is the completely supervised collection of seed from specially selected representatives, usually superior phenotypes, with the seeds from each parent kept separate. This category is

often termed 'plus tree seed' in indigenous forest; it is intended for research and is not referred to in the OECD scheme for seed certification. Nevertheless it would be important to have this information about a seed lot if further selection were planned in the resultant plantation.

When the genetic superiority of any of these seed lots over some standard has been proved by properly conducted provenance tests the OECD category *certified* (or *tested*) is applicable.

Seed collected in plantations

If seed is collected in existing plantations there are again several categories that influence the genetic uniformity and value of resulting plantations *(Table 1C)*. The lowest category, which is frequently used, is seed from small plots such as arboreta or introduction trials. Here the numbers of trees represented as male and female parents are low and there is a possibility of deleterious self-pollination or of unwanted hybridization with other provenances or species.

Seed is commonly collected in commercial plantations that have received degrees of silvicultural treatment, hopefully eugenic. These range from virtually untreated stands (which suffer only local natural selection) to seed stands and seed production areas (which receive heavy silvicultural selection and special cultural treatment).

The ultimate step in the production of improved seed is the creation of seed orchards. These may comprise seedlings or vegetative propagules from superior individual phenotypes and may be untested (OECD *select* grade) or tested; (see Barner, 1972). If found genetically superior to an acceptable standard sample they are graded *certified* (or *tested*). The use of such material over several generations in a commercial plantation programme may produce land races (see de Vecchi Pellati, 1969). Seed orchards may be based on parents with good general combining ability or good specific combining ability or they may be intended for hybridization between species or provenances.

Few tropical and subtropical countries, apart from some in the Pacific, Mediterranean and central American regions, will establish major industrial plantations from indigenous species. Therefore the development of national seed zone systems may not be urgent. Nevertheless such a system is desirable. It is absolutely essential that all countries insist on some form of seed source identification and control for all seeds used, particularly imported seed. It is recommended that control is based on the OECD system.

As all countries progress from seed source experiments to selection of individual phenotypes and tree breeding, it will become necessary to adopt more informative categories than *source-identified*. The indiscriminate use of seed of allegedly 'correct' species and provenance may be dangerous. The *selected* and *certified* categories of the OECD scheme are valuable but more details of the genetic history of a given seed lot should be obtained; in particular the provenance (natural or derived) and the potential number of parent trees must be known.

Abstract

Demands for forest tree seed are continually increasing throughout the world. Improvement programmes have revealed a paucity of information on the parentage of seed. Seed certification schemes have been developed in some

countries to control the quality of seed and provide some of the required information. The Organization for Economic Cooperation and Development has proposed a scheme to control reproductive material moving internationally. This scheme is compatible with the scheme accepted by the European Economic Community. Various definitions of provenance exist. However, these definitions and schemes have limitations particularly for tree improvement programmes. This paper draws attention to additional information required for rational tree improvement. A classification of genetic histories is tabulated which emphasizes the potential parental differences between seed collections made in natural forests and those made in plantations.

Key words: Provenance, origin, seed source, seed certification, nomenclature, selection, seed trade.

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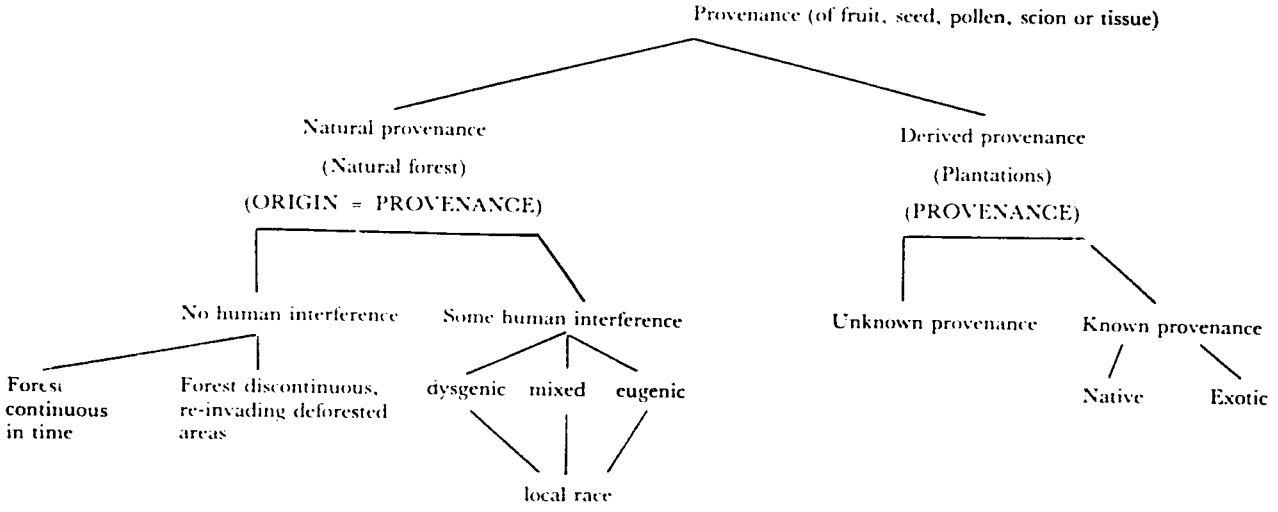
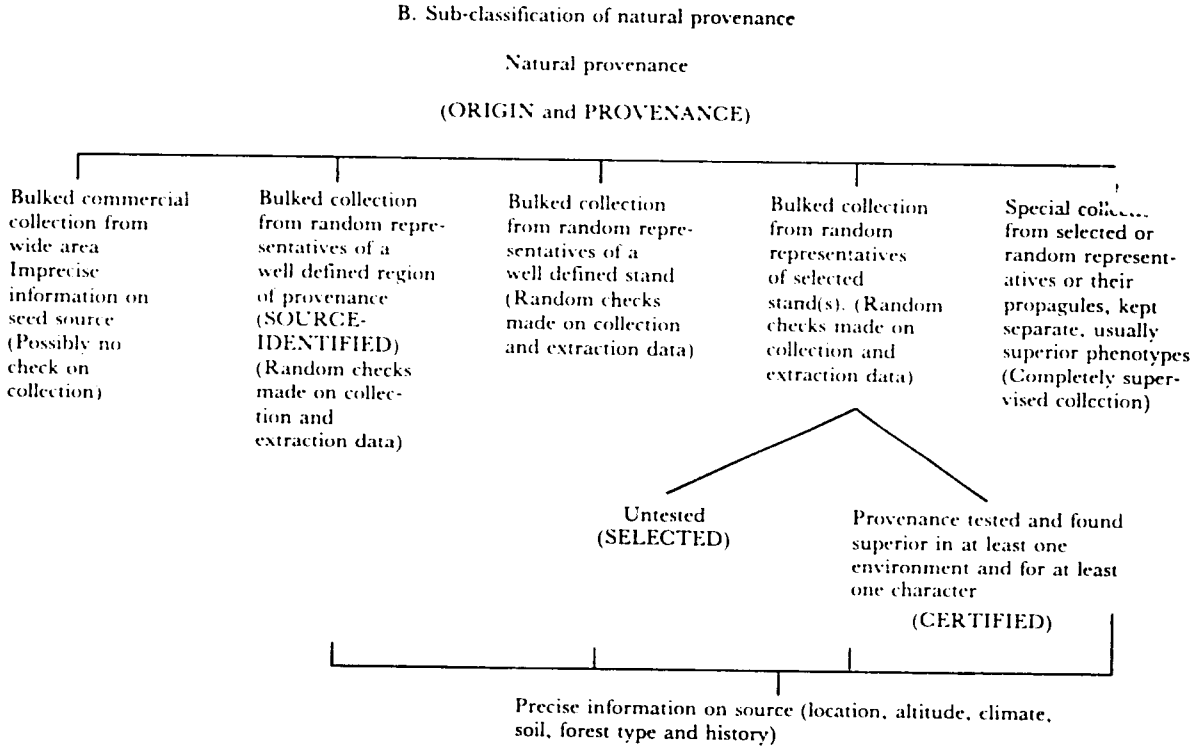
Table 1. A stylised classification of genetic history

A. Classification into natural and derived provenances



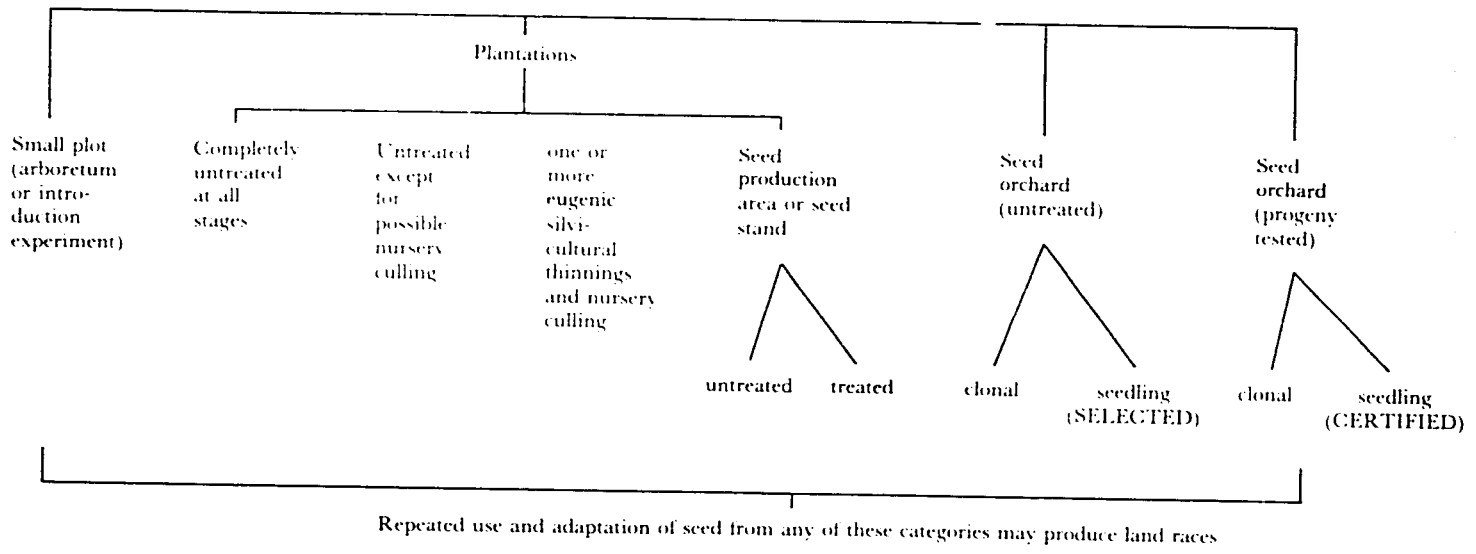
NB The entire system or any level of it could be repeated for parentages of 1 parent tree, 2-10 parent trees, or more than 10 parent trees; similarly by year of collection. Equivalent terms from the OECD system are given in capital letters in brackets.

B. Sub-classification of natural provenance



NB Information, value and uniformity increase from left to right.

C. Sub-classification of derived provenance



NB Information, value and uniformity increase from left to right

Appendix 18

Questionnaire on Multipurpose Tree Germplasm (Including trees, bushes, palms, bamboos and vines)

Please type your answers to the following questions for each species used for multiple purposes in your country. You do not need to repeat the entire question, just show the number or fit your reply on to copies of this page if only one species.

1. Your name and official address.
2. Species Latin name and authority
3. Local common names
4. To your knowledge are there any taxonomic difficulties in this species?
5. In your country what are the approximate limits of the natural distribution of the species (latitude, longitude and altitude)?
6. Have any systematic attempts been made to explore and sample the natural range (for seed, herbarium materials or other samples)? If so, by which organisation?

USES (Answer YES or NO)

7. Unprocessed roundwood, poles, including rattan. Yes/No
8. Sawn timber Yes/No
9. Firewood Yes/No
10. Charcoal Yes/No
11. Fodder Yes/No
12. Fruit Yes/No
13. Pulp and paper Yes/No
14. Extractives Yes/No
15. Herbal, medicinal Yes/No
16. Honey Yes/No
17. Silk Yes/No
18. Shelter (shelterbelts, windbreaks, shade trees) Yes/No
19. Soil stabilisation, watershed protection Yes/No
20.A Soil improvement Yes/No
20.B Others Specify

PLANTATIONS (Estimate annual plantings in whole country)

21. Pure blocks (hectares)
22. Intercropped lines (number of trees)
23. Isolated trees (number of trees)
24. Has any silvicultural research been conducted on this species?
25. Is tree breeding practised with this species?
26. Are plantings established from seed or vegetative propagules?

SEED SUPPLY

27. Approximate number of seeds per kilogram.

28. Approximate annual total weight collected by (a) farmers and other individuals (b) Government agencies (c) Commercial collection.

29. Names and addresses of commercial collectors.

30. Does the current seed supply meet the demand?

31. Are there any problems that need special treatment? (a) seed storage (b) seed germination

PUBLICATIONS

32. Please list all your publications and reports dealing with any of the above aspects for this species.

PLEASE RETURN YOUR REPLY TO -

Dr J. Burley
Commonwealth Forestry Institute
South Parks Road
OXFORD
OX1 3RB
ENGLAND

Multipurpose trees identified in 1983 questionnaire

(As far as possible the author has corrected the spelling of specific names as submitted by the respondents).

Species	*No. of uses*	*Others*	*Total*
Acacia albida	6		6
A. aneura	6	2	8
A. arabica	11		11
A. aulacocarpa	4		4
A. auriculiformis	8	1	9
A. auriculiformis	7		7
A. cambagei	4	1	5
A. catechu	4	1	5
A. confusa	3		3
A. coriacea	4	2	6
A. coulteana	2		2
A. cyanophylla	1	1	2
A. estrophiolata	3	2	5
A. holosericea	5		5
A. latzii	2		2
A. mangium	5		5
A. mearnsii	9		9
A. nilotica	10	1	11
A. nilotica/indica	11	1	12
A. oswaldii	3	1	4
A. pendula	5	3	8
A. planifrons	7		7
A. salicina	4	2	6
A. salicina	5	1	6
A. saligna	5	1	6

A. scorfoides	3		3
A. shirleyi	2		2
A. stenophylla	4	3	7
A. tortilis	5	1	6
A. victoriae	2	1	
Acer caesium	3		3
Acer campbelli	1		1
Acer oblongum	3		3
Acrocomia sclerocarpa	4		4
Adina cordifolia	2		2
Aesculus indica	2		2
Agathis robusta	4		4
Ailanthus excelsa	3	1	4
Ailanthus grandis	7		7
Albizia falcataria	5		5
A. lebbeck	4		4
A. lebbeck	3	1	4
A. lebbeck	7	1	8
A. marginata	8		8
A. procera	3		3
A. procera	2		2
Alnus jorullensis	3		3
A. jorullensis	4		4
A. nepalensis	9	1	10
A. nepalensis	8		8
A. nitida	3		3
Alnus wallichiana	3		3
Anacardium occidentale	4		4
A. occidentalis	6		6
Aniba sp.	2		2
Anogeissus latifolia	2		2
Anthocephalus cactamba	8		8
Arecastrum romanzoffianum	3	1	4
Artocarpus altilis	3		3
A. chaplasha	8		8
A. heterophyllus	4		4
A. heterophyllus	10		10
A. integer	4		4
A. sp.	3		3
A. sp.	3		3
Astrocaryum sp.	3		3
Astrocaryum sp.	2		2
Atriplex canescens	3	1	4
A. halimus	3		3
A. linearis	3		4
A. nummularia	3	1	4
Aucoumea klaineana	3		3
Azadirachta indica	5		5
A. indica	9		9
A. indica	3		3
A. indica	4		4
Araucaria augustifolia	10		10
Bactris gasipaes	4		4

B. gaspiaes	3		3
Bagassa guianensis	8	2	10
Bauhinia retusa	9	1	10
B. variegata	4		4
Bertholletia excelsa	8	1	9
B. excelsa	5		5
Betula cylindrostachys	7		7
B. pendula	6		6
B. pendula	6		6
B. pubescens	6		6
B. pubescens	6		6
Bombax ceiba	5		5
Bucklandia populnea	7		7
Buddleia corzaceae	4		4
B. coriaceae	4		4
Byrsonima coreacaea	7		7
Caesalpinia spinosa	4		4
Calliandra calothyrsus	8		8
Callitris glauca	4	1	5
Carapa guianensis	3		3
C. guianensis	3	1	4
Caryocar spp.	3		3
Caryocar sp.	3		3
Caryodendron orinocense	6	1	7
Caryodendron sp.	2		2
Cassia emarginata	4	1	5
Cassia fistula	1	1	2
C. siamea	3	1	4
C. siamea	7		9
C. siamea		1	1
C. siamea	4	4	8
C. sturtii	3	1	4
Casuarina cristata	5	1	6
C. cristata	5	3	8
C. cunninghamiana	5	3	8
C. decaisneana	4	3	7
C. equisetifolia	2		2
C. equisetifolia	3		4
C. equisetifolia	5		5
C. equisetifolia	4	1	5
C. equisetifolia	6		6
C. equisetifolia	7		7
C. glauca	4	3	7
C. junghuhniana	4	1	5
C. littoralis	4	3	7
C. luehmannii	5	3	8
C. obesa	1	1	2
C. spp.	8		8
Cedrela odorata	7		7
C. odorata	3		3
C. odorata	3		3
Cedrelinga catengeformis	2		2
Ceiba pentandra	3		3

Celtis australis	2	1	3
Ceratonia siliqua	7		7
Chukrasia tabularis	8		8
Chrysophyllum cainito and *C. albidum*	2		2
Chorisis sp.	3		3
Cinnamomum cecidodaphne meissa	8		8
Cocos nucifera	8		8
Copaifera multijuga	2		2
Cordia alliodora	2		2
C. alliodora	2		2
C. goeldiana	7	1	8
Couepia longipendula	2		2
Couma macrocarpa	3		3
C. macrocarpa	4		4
Coumarouna sp.	3		3
Cryptomeria japonica	5		5
Cupressus cashmeriana	5		5
Dacryoides edulis			4
Dalbergia sissoo	4		4
D. sissoo	8	3	11
D. sissoo	8		8
D. sissoo	4		4
D. sissoo	3		3
D. lamillonii	7		7
D. sikkimensis	6		6
D. strictus	5		5
D. strictus	7		7
Didymopanax morototoni	7	2	9
Dipteryx odorata	3		3
Dodonea attenuata	3	1	4
Emblica officinalis	2	1	3
Entandrophragma angolense	4		4
Erythrina arborescens	7		7
E. indica	4		4
E. poeppigiana	5		5
Eucalyptus alba	3	1	4
E. argophloia	4	2	6
E. camaldulensis	5		5
E. camaldulensis	5	2	7
E. camaldulensis	6	1	7
E. citriodora	4	3	7
E. cloeziana	5	2	7
E. crebra	5	2	7
E. deglupta	4		4
E. drepanophylla	4	1	5
E. exserta	4	3	7
E. gamophylla	3	1	4
E. globulus	7		7
E. globulus	7		7
E. grandis	6		6
E. grandis	3		3

E. intertexta	5	2	7
E. maculata	5	3	8
E. melanophloia	5	2	7
E. melliodora	5	2	7
E. microtheca	4	2	6
E. microtheca	4		4
E. occidentalis	5	1	6
E. ochrophloia	4	2	6
E. orgadophila	1	1	2
E. pauciflora	4		4
E. papuana	3	2	5
E. rubida	3		3
E. saligna	4		4
E. saligna	4		4
E. sideroxylon	5	2	7
E. tereticornis	4	2	6
E. tereticornis	8		8
E. tereticornis (*Mysore gum hybrid*)	7		7
E. thozetiana	3	2	5
E. urophylla	3		3
E. viminalis	4		4
E. spp.	5		5
Eugenia malaccensis	5		5
E. stipitata	3	1	4
Euterpe oleracea	8	1	9
Euterpe spp.	2		2
Gliricidia spp.	3		3
G. sepium	9	1	10
Gmelina arborea	5		5
G. arborea	6		6
G. arborea	3		3
Grevillea robusta	5		5
Grewia optiva	2	1	3
Gustavia sp.	3		3
Hardwickia binata	7		7
Hevea spp.	6		6
Hibiscus tiliaceus	2		2
Hymenaea coubaril	4		4
H. coubaril	6		6
Ilex paraguariensis	3	1	4
Inga venosa	5		5
Inga spp.	6		6
Inga sp.	3		3
Iryanthera sp.	3		3
Jessenia sp.	2		2
Juglans neotropica	4		4
Khaya senegalensis	6		6
Khaya ivorensis	4		4
Lagerstroemia flostoginae	6		6
Lecythis spp.	2		2
Leucaena leucocephala	4		4
L. leucocephala	4		4

Leucaena leucocephala	9	1	10
L. leucocephala	9		9
L. leucocephala	13		13
L. leucocephala	5		5
L. leucocephala	4		4
L. leucocephala	4		4
Liquidambar styraciflua	6		6
Litsaea polyantha	10		10
Machilus edulis	8		8
Mammea americana	5	1	6
Mangifera indica	5		5
M. indica	2		2
M. indica	7		7
Manilkara bidentata	6		6
M. huberi	3		3
Manilkara sp.	3		3
Mauritia sp.	3		3
Mauritia flexuosa	3		3
Melaleuca glomerata	3	1	4
Melaleuca lasiandra	3	1	4
Melia azadirachta	10		10
Melicoccus bijugatus	7		7
M. scabrella	8		[illegible]
Mimosa scabrella	4		4
Modhuca longifolia	7		7
Moringa oleifera	4		4
M. oleifera	5		5
Morus alba	9		9
M. alba	2	1	3
Myrciaria paraensis	4	2	6
Nauclea diderrichii	5		5
Ochroma sp.	3		3
Opuntia ficus indica	5	1	6
Orbignya sp.	5		5
Ormosia sp.	2		2
Pachira aquatica	5		5
Peltophorum dasyrachis	8		8
Phyllanthus emblica	8		8
Pinus caribaea	5		5
P. caribaea	8		8
P. caribaea	3		3
P. caribaea	6		6
P. caribaea var. *hondurensis*	4		4
P. eldarica	8		8
P. oocarpa	8		8
P. occidentalis	3		3
P. patula	3		3
P. radiata	2		2
P. radiata	5		5
P. roxburghii	8		8
P. wallichiana	6		6
Pithecellobium dulce	5	1	6

Platonia insignis	9	1	10
Podocarpus lambertii	4		4
Polylepsis racemosa	5		5
Pongamia pinnata	9	2	11
Populus ciliata	2	1	3
Poraqueiba sp.	3		3
Prosopis chilensis	4		4
P. cineraria	9		9
P. cineraria	7		7
P. juliflora	2		2
P. juliflora	9		9
P. juliflora	6	1	7
P. juliflora	6		6
P. pallida	8		8
P. spp.	1	1	2
Prunus nepalensis	10		10
Pterocarpus indicus	2		2
P. santalinus	6		6
Quercus dilatata	2		2
Q. leucotricephora	2		2
Q. petraea	10		10
Q. robur	10		10
Q. semicarpifolia	2		2
Rhizophora racemosa	7		7
Rhizophora sp.			
Robinia pseudoacacia	7		7
R. pseudoacacia	2		2
Salix capraea	4		4
S. cinerea	4		4
Salix sp.	2		2
Samanea saman	6	1	7
S. saman	6		6
Santalum album	5		5
Schima wallichii	9		9
Schinus molle	5		5
Schizolobium amazonicum	2	1	3
Schizolobium parahyba	4		4
Sesbania grandiflora	2	1	3
S. grandiflora	9		9
Shorea robusta	3		3
S. robusta	10		10
Shorea spp.	3		3
Simarouba sp.	2		2
Spindus mukurossii	2	1	3
Spondia sp.	3		3
Spondias dulcis	1	1	2
S. lutea	3	1	4
S. mombin	9	1	10
Spondias sp.	4		4
Swietia brachystachya	4	1	5
Swietenia macrophylla	8		8
S. macrophylla	4	1	5
S. mahogani	4	1	5

Syzygium jambolanum	10		10
S. cumini	8		8
Tamarindus indica	8	1	9
Tectona grandis	4		4
T. grandis	2		2
T. grandis	6		6
Terminalia arjuna	8		8
T. crenulata	8		8
T. chebula	7		7
T. ivorensis	6	6	6
T. ivorensis	3		3
T. myriocarpa	8		8
T. superba	3		3
T. superba	2		2
T. tomentosa	3		3
Tetragostris sp.	4		4
Theobroma grandifolia	2		2
Thyrsostachys siamensis	4		4
Toona ciliata	3		3
T. ciliata	3		3
T. serrata	2		2
T. serrata	2		2
Treculia africana	2		2
Triptochiton scleroxylon	6		6
T. scleroxylon	1		1
Tristania conferta	3		3
Virola spp.	3		3
Vismia sp.	3		3
Ziziphus mauritiana	5		5

ANNEX 1.

Table of contents of "Multipurpose tree germplasm"; Proceedings of a planning workshop to discuss international cooperation, Washington DC, USA, June 1983. Editors J. Burley and P. von Carlowitz, ICRAF, Nairobi, Kenya, 1984.

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