PN-AAZ-733

Forestry Networks

Proceedings of the First Network Workshop of the Forestry/Fuelwood Research and Development Project (F/FRED) held September 24-27, 1986 in Bangkok, Thailand

Edited by Norma Adams and Robert K. Dixon

Winrock International

Forestry Networks

Proceedings of the First Network Workshop of the Forestry/Fuelwood Research and Development Project (F/FRED) held September 24-27, 1986 in Bangkok, Thailand

1986
Winrock International Institute for Agricultural Development
Supported by the U.S. Agency for International Development

Forestry Networks is the proceedings of the first networks workshop of the Forestry/Fuelwood Research and Development Project (F/FRED) held September 24-27, 1986 in Bangkok, Thailand. It was conducted by the F/FRED Project team in association with the Winrock International Institute for Agricultural Development, prime contractor for the F/FRED Project. Financial assistance was provided by the U.S. Agency for International Development.

Planning Committee

Suree Bhumibhamon, Associate Professor, Kasetsart University Faculty of Forestry
Salleh M. Nor, Director General, Forest Research Institute of Malaysia
Khalid M. Siddiqi, Director, Forest Products Research, Pakistan Forest Institute
Somsak Sukwong, Dean, Kasetsart University Faculty of Forestry
Y.S. Rao, Regional Forestry Economist, Food and Agriculture Organization, Bangkok
Robert K. Dixon, F/FRED Species Network Specialist, Winrock International and Associate Professor of Forestry, Auburn University
William F. Hyde, F/FRED Land and Forest Management Specialist, Winrock International
Thomas C. Niblock, F/FRED Project Manager, Winrock International

Technical Editors

Norma Adams, Project Editor
Robert K. Dixon, F/FRED Species Network Specialist

Library of Congress Cataloging-In-Publication Data

Forestry/Fuelwood Research and Development Project.
Network Workshop (lst : 1986 : Bangkok, Thailand)
Forestry networks.

1. Forestry/Fuelwood Research and Development Project--Congresses. 2. Forests and forestry--Information services--Asia--Congresses. 3. Multipurpose trees--Information services--Asia--Congresses. 4. Forests and forestry--Research--Asia--Congresses. 5. Multipurpose trees--Research--Asia--Congresses. 6. Information networks--Asia--Congresses. 7. Forests and forestry--Information services--Developing countries--Congresses. 8. Multipurpose trees--Information services--Developing countries--Congresses. 9. Forests and forestry--Research--Developing countries--Congresses. 10. Multipurpose trees--Research--Developing countries--Congresses. 11. Information networks--Developing countries--Congresses. I. Title.
SD356.54.A78F67 1986 025'.066349'095 86-26682

Copyright © Winrock International Institute for Agricultural Development, 1986.

Contents

Foreword vii

Preface ix

Acknowledgements xi

Acronyms xiii

MPTS Networking

Introduction 3

Opportunities for MPTS Biotechnology Research Networking 5

MPTS Provenance Trials 15

Planning and Implementing MPTS Field Trials 25

Regional Opportunities for Networking: The FRIM Experience 33

Survey Methods to Determine Research Priorities: A Thai Case Study 41

Integrating the Social Sciences into MPTS Research Networking 53

Global Research Networking

Introduction 61

Overview of DBMS for MPTS 63

MPTS Data Base: Concepts, Contents, and Objectives 71

Hardware and Software Systems for Data Management in MPTS Research 79

Appendices

I Framework of the F/FRED Research Network 89

II Announcement of Establishment of a Research Network for MPTS 91

III Field Trip Summary 93

IV Participants 95

V Program 101

Foreword

The first Forestry Networks workshop held in Bangkok, Thailand September 24-27, 1986, established the F/FRED Research Network in Asia, a milestone moving toward the goal of identifying and providing improved species of multipurpose trees to benefit the rural poor and meet the needs of an expanding population for fuelwood, construction materials, and various other uses. This is a priority and shared goal not only of the U.S. Agency for International Development, which financed the workshop, and of Winrock International, but also of a sizable and growing number of Asian forestry departments, research and education institutions, and scientists. Interest by these groups was evidenced by the high level of workshop attendance, the high quality of the papers presented, and the active dialogue among participants.

Winrock International is proud of the opportunity to share in implementing the F/FRED Project and in exchanging experiences with the forestry community in Asia. We look forward to the many occasions that lie ahead to collaborate with our colleagues in Asia, the United States, and other countries as field trials are initiated, results evaluated, and information exchanged for improved projects and use of multipurpose trees.

It is a pleasure to introduce this volume of proceedings from the first Forestry Networks workshop.

Robert D. Havener
President
Winrock International

Preface

Rapid depletion of forest reserves and the growing scarcity of wood for cooking and tree products for other household uses have emerged in recent years as a growing concern of development planners and specialists in most countries and development institutions. In recognition of this, AID identified forestry research as one of its top four priorities for long-term commitment. AID coordinated closely with IUFRO, World Bank, and interested developing countries in preparing the F/FRED Project, which reflects close coordination and joint funding between the Bureau for Science and Technology, the Asia Near East Bureau, and other regional bureaus of AID. In the course of preparing background papers, the authors held many discussions with experts and scientists in developing countries, the United States, and elsewhere. Design of the F/FRED Project is largely derived from these studies and consultations.

In deciding to finance the F/FRED Project, AID was aware that tree species trials had been conducted for at least 100 years on selected commercial species, such as *Pinus* and *Tectona*. Yet, this research did not include MPTS intended to meet the needs of small farms and woodlots. Little systematic research and sharing of findings have been done for such trees. AID concluded that large benefits would flow from more systematic research to improve these neglected "low value" trees and from shared findings, i.e., networking between research institutions and concerned scientists.

Also recognized was the long and constructive record of the IUFRO in strengthening worldwide forestry research and, in recent years, heightening interest in MPTS. Indeed, the 1984 IUFRO-sponsored workshop held in Kandy, Sri Lanka, which identified priority species using an environmental zone approach, contributed to the development of the F/FRED Project.

As prime contractor to AID, one of Winrock International's first steps in developing a project framework was to create an ad interim steering committee, which met in Bangkok, Thailand June 24, 1986, to plan the first Forestry Networks workshop, whose objectives were to introduce to the Asian forestry research community F/FRED opportunities and activities, as well as the use of microcomputers in forestry research information exchange.

Held September 24-27, 1986 in Bangkok, this workshop brought together over 60 forestry research and information specialists from Asia and represented a milestone in moving toward the goal of identifying and providing improved MPTS to benefit the rural poor and meet the needs of an expanding population for fuelwood, construction materials, and other uses. Anticipating the benefits from improved management and systems for control and validation of experimental data from field trials, action was taken by the workshop participants to establish a research network for MPTS.

Known as the F/FRED Research Network, it builds on recommendations of the 1984 IUFRO-sponsored Kandy meeting and is also designed to complement other research networks and activities of various multilateral and bilateral agencies that assist forestry development programs in Asia. The workshop participants drafted and adopted an organizational framework for the network (see Appendix I) that extends membership and/or observer status to Asian forestry departments, forestry and agricultural research institutes, and to schools of forestry and agriculture. A steering committee serves as the governing body of the F/FRED Research Network and is composed of a representative from the lead institution of each participating country. A communique, issued at the close of the workshop, announced the formal establishment of the F/FRED Research Network (see Appendix II).

Winrock International is proud to share in facilitating the F/FRED Project and for the opportunity to share experiences with the forestry community. We look forward to the many occasions that lie ahead to collaborate with our colleagues in Asia, the United States, and other countries as field trials are initiated, results are evaluated, and information is exchanged for improving products and uses of MPTS.

The proceedings of the first Forestry Networks workshop is divided into two sections. Section I introduces MPTS networking from three perspectives--biotechnology research, provenance trials, and field trials. Papers presented by Asian scientists on the Malaysian experience in regional networking and surveys conducted in Thailand to determine research priorities are contained in this section. Also included is a paper on how the social sciences can support MPTS research networking. Section II introduces the global research networking component of F/FRED and includes three papers. The first is an overview of data base management systems, the second describes the MPTS data base at the ICRAF, and the third presents hardware and software systems applications for data management in forestry research.

Acknowledgements

Appreciation is expressed to all people who helped make the workshop and this publication possible. Credit for laying the groundwork for the workshop goes to the F/FRED Ad Interim Steering Committee, including Dr. Suree Bhumibhamon, Dr. Salleh M. Nor, Dr. Khalid M. Saddiqi, Dr. Somsak Sukwong, Dr. Y.S. Rao, Dr. Robert K. Dixon, Dr. William F. Hyde, and Mr. Thomas C. Niblock.

Also recognized is the logistical support provided by the F/FRED Coordinating Unit at Kasetsart University. We are grateful to staff assistants Mrs. Phatcharin Eiumnoh and Miss Leela Wuttikraibundit, who untiringly made administrative arrangements and coordinated workshop activities.

A special word of appreciation is expressed to the Kasetsart University staff, including Rector Areekul, for their courtesy throughout the workshop and for arranging a productive day-long field trip.

Finally, we would like to thank the U.S. Agency for International Development Offices of Rural and Institutional Development and Forestry, Environment, and Natural Resources within the Bureau for Science and Technology, as well as the Asia Near East Bureau, without whose support the workshop and this proceedings would not have been possible.

Acronyms

AAFTIP--ASEAN-Australia Forest Tree Improvement Program
ACIAR--Australian Centre for International Agricultural Research
ADAB--Australian Development Authority Bureau
AFOCEL--Association Foret Cellulose
AIMS--Australian Institute of Marine Science
ANOV--Analysis of Variance
ANZAP--ASEAN-New Zealand Afforestation Project
ARCB--Augmented Randomized Complete Block
ASEAN--Association of South East Asian Nations
AT--Advanced Technology
ATTC--ASEAN Timber Technology Centre
AVRDC--Asian Vegetable Research and Development Center
BM--Benchmark
CATIE--Centro Agronomico Tropical de Investigacion y Ensenanza
CGIAR--Consultative Group for International Agricultural Research
CHAMPS--Computerized Habitat Analysis and Multiple-use Prescription System
CIAT--Centro Internacional de Agricultura Tropical
CIMMYT--Centro Internacional de Mejoramiento de Maiz y Trigo
CSIRO--Commonwealth Scientific and Industrial Research Organization
CTA--Chief Technical Advisor
DBMS--Data Base Management System
DOS--Disk Operating System
ECU--European Currency Units
EGP--Effective Gene Pool
FAO--Food and Agriculture Organization
F/FRED--Forestry/Fuelwood Research and Development
FIO--Forest Industry Organization
FORS--Forest Resources Systems Institute
FRIM--Forest Research Institute of Malaysia
G x E--Genotype x Environment
GIS--Geographic Information System
GTZ--German Agency for Technical Cooperation
IARC--International Agricultural Research Centers
IBM--International Business Machines
IBSNAT--International Benchmark Sites Network for Agrotechnology
ICRAF--International Council for Research in Agroforestry
ICRISAT--International Crops Research Institute for the Semi-Arid Tropics
IDRC--International Development Research Centre
INCOFORE--International Council for Forestry Research and Extension
INSPIRE--Interactive Species Retrieval Program
IRRI--International Rice Research Institute
ITTA--International Tropical Timber Agreement
ITTO--International Tropical Timber Organization
IUFRO--International Union of Forestry Research Organizations
MAB--Man and Biosphere
MDS--Minimum Data Set(s)
MIS--Management Information System
MPTS--Mutipurpose Tree Species

MS--Multisite
NATMANCOMS--National Mangrove Committees
NFTA--Nitrogen Fixing Tree Association
OFI--Oxford Forestry Institute
PC--Personal Computer
R & D--Research and Development
REMIC--Regional Mangrove Information Centre
REMIN--Regional Mangrove Information Network
RFD--Royal Forest Department
RIC--Rattan Information Centre
RTF--Regional Task Force
SET--Species Elimination Trial(s)
SI--Self-Incompatibility
SPDC--Special Program for Developing Countries
SPOT--Systeme Probatoire d'Observation de la Terre
STAN--Statistical Analysis
TDRI--Thailand Development Research Institute
TPC--Thai Plywood Company
UNDP--United Nations Development Programme
UNESCO--United Nations Educational, Scientific, and Cultural Organization
UNIDO--United Nations Industrial Development Organization
USAID--United States Agency for International Development
USDA--United States Department of Agriculture

MPTS Networking

Introduction

The F/FRED research networks are a core group of institutions and scientists who share a common interest in improving the establishment, management, and utilization of MPTS by farmers in Asia. Research networking within the F/FRED project is defined as people who communicate in areas of common interest. MPTS include trees or shrubs that have multiple end uses, such as fuelwood, fodder, fiber, and food cultivated by resource-poor farmers.

For research networks to function, information must be shared. Thus, network members must agree on a standardized data set and methodologies for collecting, analyzing, and reporting information. The F/FRED global research team will work with network members to develop useful standardized data sets and micro-computer linkages. Priority MPTS networks and research needs established at the 1984 IUFRO-sponsored workshop, Increasing Productivity of Multipurpose Tree Species, held in Kandy, Sri Lanka, have been adopted by F/FRED network members.

The focus of the F/FRED MPTS research networks include both biological and social questions associated with the cultivation and use of MPTS by resource-poor farmers. Project scientists will foster network research activities through dissemination of research information, cooperative experiments, twinning relationships, state-of-the-art workshops, and graduate student training programs across the region. F/FRED network activities are designed to complement existing research programs in the Asia-Pacific region. Recently, F/FRED project cooperators defined network structure and function and a full range of activities has been initiated. Future network activities will be coordinated at the F/FRED office located at the Kasetsart University Faculty of Forestry in Bangkok, Thailand.

Opportunities for MPTS Biotechnology Research Networking

Robert K. Dixon

F/FRED Network Specialist, Winrock International, Bangkok, Thailand
Associate Professor, School of Forestry, Auburn University, Alabama

In recent decades, many forest and agriculture development programs have been modeled after successes realized in the so-called Green Revolution (Plucknett et al. 1983). These programs have been advocated due to the dramatic improvements in crop productivity. The failure of appropriate technologies to provide similar crop productivity improvements and the lack of meaningful land-reform programs have strengthened the desire of the rural poor to adopt energy and capital intensive rural development programs to increase crop production and meet basic needs (Buttel, Kenney, and Kloppenburg 1985). However, there is growing evidence that the substantial increases in forest and agriculture production attributed to the Green Revolution are reaching a plateau (Balandrin et al. 1985). Moreover, many analysts predict past levels of agriculture and forest production may be difficult to sustain due to the Third World debt crisis. These factors, coupled with a growing world population problem, have focused attention on recent advances in applied and molecular biology.

The group of emerging technologies generically known as biotechnology promises to revolutionize chemical production, plant breeding, energy generation, food and fiber processing, as well as pollution and waste management. The complexity of technologies has led some analysts to predict the effects of forest biotechnology as far in the future, particularly with regard to impact on farm forestry and the rural poor. In this paper, I will demonstrate that biotechnology will have increasingly significant applications to the establishment, management, and use of MPTS.

A broad definition of biotechnology is the management of biological systems for the benefit of humanity. In this sense, biotechnology had its infancy in the cradles of civilization when humans first domesticated plants and animals. Early farmers selected seed from the best performing plants to use for subsequent crops. Biotechnology matured considerably in the late 19th century, with the acceptance of genetic principles established by Charles Darwin and Gregor Mendel. Classical plant breeding techniques developed by these and other scientists fueled the Green Revolution in Asia and Latin America in the 1960s.

Until recently, manipulation of biological systems has been limited by the genetic constitution of organisms. Research culminating in the 1970s removed this barrier and a biological revolution is now underway. The new biotechnology has been defined as:

- The selection, isolation, and transfer of a gene from one organism to another.
- The technology of manipulating genetic material to create new products and processes.
- Using living organisms or their components to improve plants and animals.

FOREST BIOTECHNOLOGY

Forest biotechnology involves directly or indirectly all of man's uses of living organisms for the production of food, fuel, and fiber. This factor is particularly significant in tropical regions, which contain two-thirds of the world's approximately 4.5 million plant and animal species. This diverse pool of plants and animals has great potential value in all fields of biology, particularly forestry and agriculture (Balandrin et al. 1985).

Forest biotechnology applications encompass much more than genetic engineering. A broad range of new technologies and terminology has evolved (see Glossary, p. 14). In farm forestry, biotechnology applications encompass tree seedling production, fertilization, protection of plantations, wood processing, development of new forest products, wood by-products uses, and safe management of hazardous wastes. Biotechnology research and development can potentially alter many aspects of forest-based economies of nations worldwide.

APPLICATIONS

Germplasm Preservation

While MPTS crop yields have been generally increasing, the genetic base of most important tree crops has been rapidly narrowing (Plucknett el al. 1983). The adoption of high-yielding varieties over broad areas has resulted in subsistence farmers abandoning indigenous tree crops that were rich in genetic diversity. In the past two decades, for example, native MPTS in Southeast Asia have been abandoned after the introduction of *Eucalyptus*, *Casuarina*, and *Acacia* varieties from Australia.

When vast areas are dedicated to a single MPTS genotype (Burley and Stewart 1985), fodder, fuel, fiber, and fruit productivity becomes extremely vulnerable to factors that limit yields. As a result of the country's dependence on a single species, Dutch elm disease killed the majority of urban shade trees in the United States and triggered a mass replacement program. A similar problem exists with the widely planted multipurpose tree *Leucaena*. Infestation of plantations by the jumping plant lice has resulted in mass defoliation and decline of fodder yield and fiber growth. Wide dependence by farmers on *Leucaena* has exascerbated economic problems of the rural poor in developing countries in the Asia-Pacific region.

To counteract the genetic vulnerability of MPTS crops, foresters and agronomists must collect germplasm so that geneticists will have the resources necessary for biotechnology applications. Most gene banks (e.g., IRRI, CIMMYT, ICRISAT) currently store germplasm of major agronomic crops, but the germplasm of other important plants, such as MPTS, as well as nitrogen-fixing bacteria, actinomycetes, mycorrhizal fungi, and yeasts should also be safeguarded. Research and development organizations concerned with MPTS should develop mechanisms to meet this need. To exclude MPTS crops from germplasm collections is unwise since much of the developing world is dependent on them.

Developments in biotechnology are enhancing the value of gene banks (Balandrin et al. 1985). Scientists are rapidly developing new bio-processes and recombinant DNA techniques, and naturally-occurring genes serve as raw material and working models. Germplasm collections of MPTS in the humid and arid tropics need to be extensively evaluated and documented so that biotechnologists can fully cultivate the rich genetic diversity of the tropical latitudes. Currently, the phenotypic characters of accessions are identified rather than genes of the plants. Emerging biotechnologies associated with gene mapping, transfer, and storage will improve the utility of gene banks. Given the enormous benefits of MPTS, a global gene bank network should be established to provide scientists the genetic resources necessary for developing superior crops.

Production of Tree Seedlings

Trees of the future will be superior to those harvested today (Farnum, Timmins, and Kulp 1983). Classical tree-breeding techniques have already been used to improve several genera, such as *Eucalyptus*, *Leucaena*, *Acacia*, and *Alnus*. Improved straightness, vigor, disease resistance, and wood properties have resulted from selection and propagation of superior trees. Although effective, standard breeding and selection techniques are expensive and long-term; for this reason, few institutions in developing countries are able to invest (McCown 1985). Historically, IARCs and a

select group of universities in developing countries have spearheaded these activities (Buttel, Kenney, and Kloppenburg 1985).

Biotechnology will decrease the time required to identify and propagate superior trees. Currently, vegetative propagation from plant cuttings is used to clone trees with desirable traits (Figure 1). The success rate of vegetative propagation varies greatly with tree species. Although rooting of cuttings is a problem for some species, rapid production of selected clones of MPTS, such as *Eucalyptus*, is possible (McCown 1985). The major problem with vegetative propagation is selection of superior trees at maturity when propagation from cuttings is only partially successful.

Plant tissue culture may provide an alternative in cloning superior trees (Mott and Amerson 1981). Plant cells excised from meristem tissues of woody plants can be grown as cell suspensions or as callus. Cultured cells become organized and form plantlets following inducement by appropriate growth hormones. Currently, over 200 woody species have been established in callus culture, representing over 40 genera in 20 families. Differentiation of plantlets from tissue culture and genetic instability of some cell lines limit the application of this technology. Further research is needed to develop these techniques for a broad range of MPTS.

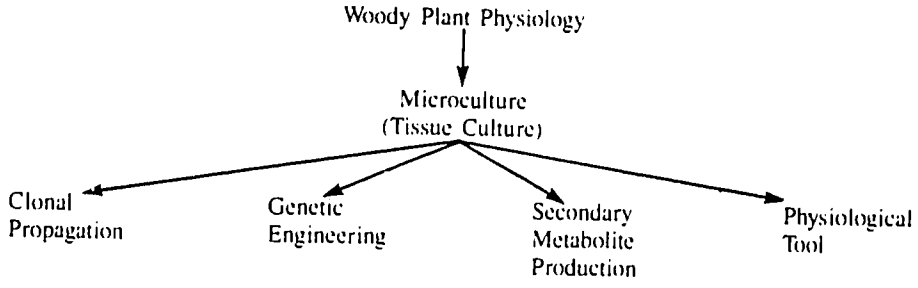


Figure 1. Alternative approaches in using tissue culture techniques for genetic improvement of MPTS.

In addition to cloning superior genotypes, tissue culture offers the potential for rapid screening of superior genotypes (Libby and Rauter 1984). With *Populus* species, the rate of tree growth under natural conditions was correlated with rate of callus production *in vitro*. *Pinus* species with abundant tissue culture bud production show a good correlation with rapid growth in the field (Mott and Amerson 1981). Desirable traits such as growth efficiency; photosynthetic efficiency; and resistance to disease, frost, drought, salinity, herbicides, and toxic soil chemicals may be screened using tissue culture techniques. Further fundamental research may elucidate biochemical traits of cultured cells that correlate with wood quality factors, such as specific gravity, lignin content, production of extractives, and fiber length (Burley and Lockhart 1985).

Selection of highly desirable traits using these techniques assumes their existence in the gene pool of a given species. Traditional breeding methods have relied on the broad natural variability of genotypes within breeding populations or the introduction of mutated genes (Durzan and Bonga 1987). New biotechnology methods include transfer of specific genes into the host plant, which involves introducing foreign DNA into the host cells. Several methods have been developed to accomplish this (Torrey 1985). Techniques such as protoplast fusion and multiple gene transfer are expected to be used in the future to improve agronomic and tree crops.

Commercial propagation of genetically superior forest trees has been successfully implemented at several locations in developing countries (Bylinsky 1985). The Unilever Company is actively

micropropagating oil palm, with superior planting stock distributed to rural farmers and used within their own intensively managed industrial plantations. Several corporations in Europe, Asia, and North America have also invested heavily in tissue culture research and produced limited planting stock (Buttel, Kenney, and Kloppenburg 1985). The National Chemical Company in Pune, India is distributing improved *Eucalyptus* and *Tectona* stock to establish plantations that will provide feedstock for chemical production. The French consortium AFOCEL is distributing *Eucalyptus* and some conifers to rural farmers in Africa. In Brazil, vegetative regeneration of *Eucalyptus* is being used in combination with other biotechnology applications to increase stemwood yields.

Manipulation of Soil Microbiology

Forest soils are often nutrient-poor. Although it is sometimes economical to use selected fertilizers such as phosphates, the high price of nitrogen fertilizer has curtailed its use even on certain food crops and is rapidly changing the way many crops are grown (Dixon and Marx 1987). In Southeast Asia alone there are 87 million hectares of saline, highly infertile, and drought-prone soil unsuitable for traditionally bred MPTS.

Biological fixation of atmospheric nitrogen can potentially offset the need for commercial nitrogen fertilizers. Symbiotic nitrogen-fixation is of special interest because it occurs in close proximity to the plant roots so that little fixed nitrogen is lost to competing organisms. Many examples are known with MPTS, including *Alnus* and *Casuarina* nodulated by actinomycetes (Brewbaker 1985) and leguminous trees nodulated by bacteria of the genus *Rhizobium*. In New Guinea, an *Ulmacea* species was recently found that is nodulated by *Rhizobium* and fixes nitrogen, offering the hope that a wider range of tree families can be nodulated.

It should be possible to develop nitrogen-fixing clones or varieties of the best tree species among those that already fix nitrogen (Torrey 1985). It may be possible to create hybrids between nitrogen-fixing species and other good MPTS, perhaps by protoplast fusion. Better strains of symbiotic nitrogen-fixing bacteria can also be developed. To create highly superior symbiotic nitrogen-fixing MPTS may require genetic engineering of both the tree and the bacterium and is a long-term prospect that, nevertheless, should not be discounted. Achievement of superior nitrogen fixation, drought resistance, and pest resistance in MPTS could reduce environmentally hazardous and expensive chemical inputs and have far-reaching consequences on fodder, fiber, and fruit yields. The current problem with the *Leucaena* jumping plant lice in the Asia region emphasizes this research need.

It is possible to use better methods of MPTS management to encourage free-living nitrogen-fixing microorganisms (Chatarpaul and Carlisle 1983). One alternative is to interplant nitrogen-fixing alders, leguminous trees, shrubs, or ground-covers with other MPTS crops. In some farm forests, decaying wood has been shown to be a rich site of nitrogen fixation. Correct management of MPTS litter may help ensure maximum rates of nitrogen fixation by these organisms, thus enriching the soil. It might even be possible to select and improve the dominant nitrogen-fixing microorganisms in forestry or agriculture.

Mycorrhizae

MPTS grow poorly unless their roots are colonized by symbiotic fungi that form root-fungus structures known as mycorrhizae. Mycorrhizae enhance nutrient uptake, especially of phosphorous and nitrogen. They also have been shown to increase disease resistance, reduce root shock in outplanted seedlings, and increase tolerance to drought, salt, toxicants, and pH extremes (Dixon and Marx 1987). Severalfold increase in the growth rates of MPTS seedlings in nursery and field situations--and frequently field survival itself--is observed after proper mycorrhizal fungus manipulation.

Even though the benefits of mycorrhizal associations to tree growth have been increasingly appreciated, little consideration has been given to mycorrhizae in MPTS nursery practices and plantation management. In many parts of the world, natural inoculum of MPTS is absent, and attempts to establish plantations or farm forestry programs failed until inoculum was provided. Because many mycorrhizal fungi species have varying benefits for a given tree on a given site, natural inoculation, where it does occur, may not provide the optimum association. Experiments on MPTS inoculation with selected strains of *Pisolithus*, *Cenoccocum*, *Hebeloma*, and other genera have dramatically increased survival and growth on adverse sites. Because progress toward commercial production of *P. tinctorius* inoculum has been rapid (Marx et al. 1984), this may well become the first fungus used for large-scale nursery inoculation. *P. tinctorius*, however, is only one of more than 3,000 species that can be exploited worldwide. Currently, one of the most serious bottlenecks in mycorrhizae research is the inability to culture the vesicular-arbuscular type mycorrhizal fungi free of their host plants. These fungi are responsible for mycorrhizae formation in many MPTS (Dixon and Marx 1987).

Protection of MPTS Plantations

Alternatives to chemical control of MPTS pests are abundant and are most effective when amalgamated into integrated pest management programs. Insect pathogenic microorganisms offer one solution for control. Many of the microparasites have merit, including viruses, bacteria, fungi, protozoa, and rickettsiae. Awareness is increasing that viruses may be an extremely powerful tool to control insect pests in MPTS.

The rhinoceros beetle (*Oryctes* sp.), indigenous throughout the tropics, is a serious damaging agent of *Cocos* sp. and *Elaeis* sp. Since the early 1900s, the Asian species *Oryctes rhinoceros* has been spreading through the Pacific and Melanesian Islands. The African species *Oryctes monoceros* is also spreading rapidly and severely defoliating plantations. Beetle control studies with baculovirus revealed that infection and release of virus-infected adults in coconut plantations in Malaysia was an effective method of controlling populations. Although extremely effective, these techniques should be extended to identify other biologically active agents usable as alternatives to chemical control. Genetic engineering can introduce new properties into biological control agents, such as enhanced virulence, broader host specificity, and longer shelf life.

The tussock moth of tropical pines is a serious global pest. A 1976 outbreak in Papua New Guinea destroyed 40 percent of the oldest stand of the Lapegu forest in the highlands. The termination of this outbreak was accompanied by presence of a virus. In 1982, viruses pathogenic to the tussock moth were released in New Guinea through aerial helicopter applications. The moth populations were decimated by viral populations. Papua New Guinea is applying for further research support to develop this biotechnology and to train local people in the application of biological control of insects.

Fiber Processing

The recognition of MPTS as important gene pools and sources of chemical and energy feedstocks has led to intensive efforts to develop appropriate technologies for harvesting and processing new products (Kirk, Jeffries, and Leatham 1983). Biotechnology will directly affect methods of processing because MPTS selection methods will alter the raw material (e.g., fodder, fiber, fruit). Historically, important MPTS in the chemical industry have included *Pinus* sp. (resin), *Elaeis guineensis* (oil palm), and *Hevea brasiliensis* (rubber). MPTS can be selected to overproduce resins or lignin. Biotechnology will also directly affect the MPTS fiber-processing industry through improved methods of papermaking or use of wood residues from harvesting or manufacturing (Kirk, Jeffries, and Leatham 1983). Small-scale technologies appropriate for the social, cultural, economic, and environmental conditions of developing countries have been developed in some regions (Burley and Lockhart 1985).

Certain microorganisms are able to partially delignify wood, suggesting a potential for MPTS biological pulping (Kirk, Jeffries, and Leatham 1983). For example, white rot fungi found worldwide are efficient lignin decomposers. Investigators in Sweden have discovered that selected varieties of white rot fungi are highly selective for lignin and selected cell-wall components. Removal of lignin from wood or mechanical pulp with these fungi dramatically reduces the energy required for mechanical refining. The time required for fungal treatment may be limited to a matter of hours if fungal strain and environmental conditions are optimized. Another potential application of microbial technology is biological leaching of pulp. The low cost and high efficiency of biological pulping are attractive to farm forestry programs in developing countries (Buttel, Kenney, and Kloppenburg 1985).

Development of New MPTS Products

Traditionally, the primary products derived from woody plants have been building materials, paper, and fuels. Because of their wide diversity in chemical composition, MPTS offer an excellent opportunity for expanding commercial production of useful products from a renewable resource (Burley and Lockhart 1985). The types of chemicals that may be derived from MPTS, in addition to lignin and cellulose products, include resins, phenolics, enzymes, waxes, flavorings, furfural, and pharmaceuticals. Other products of bioconversion may include fertilizers and protein for animal feed.

To fully exploit chemical use of MPTS, an intensive screening program of leaves, fruits, exudates, and whole tree chips is needed (Table 1). The biomass may be collected from farms, plantations, natural forests, or harvest residues. Currently, this resource is greatly underused in developed and developing countries. For example, tree-based oils from sandalwood (*Santalum album*) has an annual production of 150,000 tons in India. Oils derived from *Eucalyptus* in cottage and village industries are produced at a rate of 140,000 tons annually. There are over 100 other oil-bearing species in India of which less than a dozen are currently used. A review of the literature indicates that of some 300 MPTS, 5 produce waxes, 17 produce essential oils, 30 yield gums, 26 yield tannins and dyes, and 1 produces latex. One species, *Azadirachta indica*, which occurs in arid and semi-arid lands, yields at least one extractive in each plant component (roots, shoots, leaves).

Table 1. Types and uses of extractives and exudates from MPTS.

Types	Uses	Examples
xylem and phloem saps	food, drink, medicine	*Acer saccharum*
gums and mucilages	food industry, medicine, adhesives, inks, water color	*Acacia senegal*, *Commiphoraceae*
essential oils	perfumes, flavoring, medicine	*Eucalyptus*
fatty oils	industrial coatings, plastics, lubricants, food	*Butyrospermum paradoxum*
latex	rubber	*Hevea brasiliensis*
resins	paints, thinners, varnishes, adhesives, energy feedstock	*Pinus* sp.
tannins	tanning	*Acacia mearnsii*

MPTS BIOTECHNOLOGY DEVELOPMENT

Biotechnology can potentially benefit farm forestry in production and management of MPTS, wood and pulp processing, and development of new fodder or specialty chemical products. This technology has important implications for agriculture and forestry programs in developing countries. India, Philippines, Thailand, Malaysia, and other countries have established national biotechnology institutes and programs. UNIDO recently proposed the establishment of an International Center for Genetic Engineering and Biotechnology that would conduct research and transfer new biological technologies to developing countries.

Current and emerging biotechnologies will improve cultural methodologies and yield of MPTS in zones now favorable to intensive cropping. However, in contrast to the Green Revolution, biotechnology applications will greatly expand the geographic sphere in which technology and research can be used to simulate forest and agriculture production. Biotechnology will make possible extension of agroforestry to regions characterized by marginal edaphic and climatic factors, including those regions where subsistence commodity production by the rural population has persisted unchallenged. A principal feature of many new biotechnologies is the applicability of methodologies to a range of organisms.

The effects of biotechnology on forest and agriculture production will be equally profound in industrial and nonindustrial countries. Transnational forest product and chemical companies, genetic research firms, and university labs are developing improved crops or bio-processes to use MPTS (Bylinsky 1985). Principal research areas include yield improvement, achievement of nitrogen fixation in nonleguminous crops, enhancement of photosynthesis, manipulation of growth regulators, improved stress tolerance (e.g., temperature extremes, drought, soil toxicity), pest and pathogen resistance, plant architecture, and new products. Expansion of this research to a broad range of MPTS is urgent. In almost every aspect of MPTS culture and use there are strong prospects for biotechnology to enhance yields, renewable resource production, and human welfare.

A unique aspect of biotechnology applications that differs sharply with those of the Green Revolution is the tripartate relationship of government, universities, and private industry (Buttel, Kenney, and Kloppenburg 1985). This relationship is common in developing countries where capital is in short supply, new markets are emerging, and genetic resources abound. Biotechnology research, development, and production facilities are relatively expensive. The leading 50 genetic engineering firms have a capital investment of over $1 billion. Although the IARCs are moving to exploit new biological technologies, diminishing resources prohibit them from meeting the enormous challenge and responsibility of technology development and deployment. Thus, biotechnology applications may broaden the scientific and technological gap between developing and advanced industrial nations.

ELECTRONIC INFORMATION MANAGEMENT

Improvements in micro-computer hardware and software provide biotechnologists with a powerful tool to organize, store, analyze, model, exchange, and retrieve data (Rose and Cady 1986). For example, specific information on the many MPTS gene banks, strains of bacterial or fungal symbionts, or specialty chemical extracts are now easily managed. Summaries of key information on analytical laboratory techniques and tissue culture methodologies for specific research and development problems are now accessible via electronic transfer hardware. Moreover, raw data can be transformed using physiological simulation models and statistics to answer questions regarding plant structure, function, and yield. MDS, such as disease (e.g., virus) indexing of seeds or efficiency of *Rhizobium* sp. have been implemented by private industry in North America and Europe in recent years. The development of MDS for evaluating and managing biotechnology applications with MPTS (e.g., strains of superior mycorrhizal fungi, germplasm collections of rare chemical producers, or biological control organisms) should be accelerated.

Efficient technology transfer in the rapidly developing field of biotechnology is precluded by traditional scientific outlets, such as journal publications or books (Plucknett and Smith 1984). Emerging laboratory techniques, production methodologies, and the rapid expansion of organism gene banks require improved formats for reporting, transferring, and disseminating information. Establishment of biotechnology-oriented data bases in Asia will rapidly accelerate MPTS improvement programs as new knowledge is accessed. The standardized techniques and MDS associated with biotechnology research and development applications are well-suited to electronic networking with micro-computers. Information learned from biotechnology research and development can be easily transferred to network members, thus improving research planning and evaluation as well as accelerating industrial applications of new technology.

NETWORKS

Developing countries share many common forest-related problems, including a chronic shortage of fuelwood, rapid deforestation of landless rural people, and subsistence farming. Forest biotechnology applications could play an important role in solving these problems. Most Asian countries have facilities and resources too limited for conducting the forest biotechnology research that is required. Moreover, an urgent need exists to develop a mechanism to develop and deploy the benefits of MPTS biotechnology applications in developing countries. The transition from innovation to product marketing is expensive, and the expertise and financial capacity are concentrated in only a few companies and countries.

Biotechnology research networking within the F/FRED project can systematically organize the region's scarce forest biology research resources to attack some of the region's major forest resource and human problems. Most countries within South Asia share common basic problems with research infrastructure. Sharing resources through a coordinated program of research scientists, institutions, and countries can be more effective than an individual approach in marshalling resources, and can more quickly explore a wider range of optional solutions (Plucknett and Smith 1984). A coordinated approach using electronic information exchange is especially critical to successful fundamental research where the goal is to develop basic information to solve major problems of broad significance. Most Asian countries share common opportunities to apply emerging biotechnologies and could benefit from a coordinated, cooperative research program on forest biology problems conducted through informal or formal research networks that link up scientists and research institutions in different countries and different disciplines. Such linkages can:

- help organize a larger research effort to work on a fundamental biology problem with a range of skills, research methodologies, and facilities wider than any one country or institution could provide;

- allow countries with limited forest biotechnology research capabilities to exploit a wider range of scientific expertise and facilities through cooperative research programs;

- stimulate cooperative biology research with non-forestry scientists and specialized institutions;

- provide a large gene pool of MPTS and associated organisms for experiments;

- provide a wider data base for testing hypotheses and developing more general scientific principles and techniques;

- offer improved mutual training opportunities among collaborating scientists;

- link scientists to private industry and improve opportunities for their research and expansion of new technology;

- offer investment opportunities to donors and private industry in forest biotechnology research.

Current Asian forest biotechnology research capabilities cannot adequately support the intensive forest resource development planned for the region in future decades. Research networking offers an effective means of augmenting existing research personnel and facilities in the immediate future, and would substantially increase the level, productivity, and effectiveness of biotechnology applications in Asia within the next 10 years. Without exception, opportunities exist for biotechnology to enhance renewable resource-based production and human welfare throughout Asia.

REFERENCES

Balandrin, M.F., J.A. Klocke, E.S. Wurtele, and W.H. Bollinger. 1985. Natural plant chemicals: sources of industrial and medicinal materials. Sci. 8: 1154-1160.

Brewbaker, J.L. 1985. Leguminous trees and shrubs for southeast Asia and the South Pacific. In Forages in southeast Asian and South Pacific agriculture. eds. G.J. Blair, D.A. Ivory, and T.R. Evans, pp. 43-50. Canberra, Australia: ACIAR.

Burley, J.L. and L.A. Lockhart. 1985. Chemical extractives and exudates from trees. Ann. Proc. Phytochem. Soc. Eur. 26: 91-102.

Buttel, F.H., M. Kenney, and J. Kloppenburg. 1985. From green revolution to biorevolution: some observations on the changing technological bases of economic transformation in the third world. Econ. Devlop. Cult. Change 34: 31-52.

Bylinsky, G. 1985. Test-tube plants. Fortune 9: 50-53.

Chatarpaul, L. and A. Carlisle. 1983. Nitrogen fixation: a biotechnological opportunity for Canadian forestry. For. Chron. 59: 249-259.

Dixon, R.K. and D.H. Marx. 1987. Mycorrhizae. In Tissue culture methods in forestry, eds. D. Durzan and J. Bonga. The Netherlands: Martinus Nijhoff Pub.

Durzan, D. and J. Bonga, eds. 1987. Tissue culture methods in forestry. The Netherlands: Martinus Nijhoff Pub.

Entwistle, P. 1983. Viruses for insect pest control. Span. 26: 1-4.

Farnum, P., R. Timmins, and J.L. Kulp. 1983. Biotechnology of forest yield. Sci. 219: 694-702.

Kirk, T.K., T.W. Jeffries, and G.F. Leatham. 1983. Biotechnology: applications and implications for the pulp and paper industry. Tappi 66: 45-51.

Libby, W.J. and R.M. Rauter. 1984. Advantages of clonal forestry. For. Chron. 60: 145-149.

Marx, D.H., C.E. Cordell, D.S. Kenney, J.G. Mexal, J.D. Artman, J.W. Riffle, and R.J. Molina. 1984. Commercial vegetative inoculum of Pisolithus tinctorius and inoculation techniques for development of ectomycorrhizae on bare-root seedlings. For. Sci. Monogr. 25, 101 p.

McCown, B.H. 1985. From gene manipulation to forest establishment: shoot cultures of woody plants can be a central tool. Tappi 68: 116-119.

Mott, R.L. and H.V. Amerson. 1981. A tissue culture process for the clonal production of loblolly pine plantlets. N.C. Agric. Res. Serv. Bull. 271, 14 p.

Plucknett, D.L. and N.J.H. Smith. 1984. Networking in international agricultural research. Sci. 225: 989-993.

Plucknett, D.L., N.J.H. Smith, J.T. Williams, and N.M. Anishetty. 1983. Crop germplasm conservation and developing countries. Sci. 200: 163-169.

Rose, D.W. and F.B. Cady. 1986. Overview of data base management systems for multipurpose trees. In Forestry Networks. Proceedings of the first network workshop of the F/FRED project, eds. N. Adams and R.K. Dixon. Arlington, Virginia: Winrock International.

Thomas, T.L. and T.C. Hall. 1985. Gene transfer and expression in plants: implications and potential. BioEssays 3: 149-152.

Torrey, J.G. 1985. The development of plant biotechnology. Am. Sci. 73: 354-363.

Glossary of MPTS Biotechnology Terms

Asexual propagation. Vegetative, somatic nonsexual propagation of plant parts without fertilization.

Callus culture. Proliferation from a parental explant of many cells in protoplasmic continuity, but having no equivalence with any normal tissue. Same as tissue culture.

Cell differentiation. Internal chemical or ultrastructural changes preceding or accompanying specialization of function.

Clone. A strain of cells or organisms obtained from a single cell or organism genetically identical. Also, identical copies of genes.

DNA. A linear polymer of deoxyribonucleic acid, the sequence of which defines the genetic message.

Gene. A segment of DNA in a chromosome that codes for a functional product, either RNA or its translation product, a protein.

Genetic engineering. Altering the heritable genetic makeup of an organism by other than standard breeding techniques, usually adding genes from one organism to another. Other similar terms include gene-splicing, ligation, and recombinant DNA.

Genotype. The genetic constitution of an individual organism.

Mutation. A change in the DNA sequence of an organism, usually produced by irradiation or chemical treatment.

Plantlet. A small rooted shoot. Also, a piece of callus having both roots and shoots that are not connected together inside the callus.

Protoplast. A spherical cell without a wall, surrounded by a membrane.

Somatic. Referring to vegetative, or nonreproductive tissue.

RNA. Ribonucleic acid; similar to DNA but functioning in the expression rather than storage of genetic information.

Selection. Process whereby desired genotypes are isolated from a population of organisms.

Tissue culture. Cultures of cells from multicellular organisms outside the whole organism. Other similar terms include callus and cell culture.

Vegetative propagation. Asexual or nonsexual propagation.

MPTS Provenance Trials

James L. Brewbaker

Professor, University of Hawaii
President, Nitrogen Fixing Tree Association

The following assumptions have been made for this discussion of network trials involving MPTS provenances and progenies:

- A single species or EGP of MPTS has been selected for intensive study over a wide geographic region;
- Seeds are available from different provenances and/or single-tree progenies for further study;
- Network trials can be justified by evidence for genetic differences in yield, in site specificity, or in resistance to disease, pests, and/or stress.

BACKGROUND

Collaborative trial networks with plant species are customarily based on genetic variation that allows the identification of superior cultivars with specific local adaptability. Collaboration is requisite to regionwide recommendations, to reduction of work at each location, to the estimation of G x E interactions, and to the exploitation of specific capabilities at each location for intensive, narrowly-based inquiry (e.g., effects of a single disease race).

Network trials have been the basis for much genetic advance and for the recognition of extraordinary crop germplasm with wide adaptability, and may be expected similarly to undergird improvement of multipurpose, fast-growing tropical trees. Yields are recorded in such trials, of course, but are often a symptom rather than a cause for which the trials are networked and data combined. Typically, stable genetic resistance to a disease, stress, or pest is the basis for the trial. This is more imperative perhaps with annual crops, which are less tolerant than tropical trees to broad pest and disease. A few tropical examples of effective IARC experiences with networks are:

- IRRI--rice disease, pest, and stress tolerance
- CIAT--acid tolerance in pasture legumes, compatibility of beans with maize
- CIMMYT--yield and harvest index
- AVRDC--leafspot resistance in mungbean
- ICRISAT--grain yield and quality in pigeonpea, yield and pest resistance in sorghum and millet
- IITA--disease resistance in maize, cassava, and cowpeas

Long-sustained network collaboration usually reflects continuing inputs from breeding programs. Collaborative network trials grew out of the experience of crop breeders, with major design contributions from the Rothamstead Experiment Station (U.K.) and Iowa State University (U.S.) scientists. Temperate breeders of cereals and grain legumes have a narrow seasonal "window" of frost-free days. Maximal yields usually require that this window be filled, i.e., that integrated incident light be maximized from emergence to physiological maturity. Maturity classes finely distinguish such temperate cultivars, e.g., three classes in Iowa alone for soybeans or maize. Superior yielding crop varieties are identified only through repeated trials, usually involving 3-5 years at 10 or more

locations, and are based where possible on random model projections from identical replicated trials. In the tropics, collaborative food crop trials more often focus on disease, pest, and stress problems since these dominate the challenges facing plant breeders. In U.S. seed companies, for example, choice is predicated heavily on the consistency of performance above the mean of each trial, and costly variance and regression analyses are often left to scientists.

At least four features of annual, tropical crop trials distinguish them from proposed F/FRED trials:

(1) their small size, very short duration, and low cost
(2) involvement of many entries of breeders, often thousands of lines or hybrids
(3) rare questioning on site adaptability, local management methods, or differing local use
(4) inordinate focus of crop research on product quality and on disease and pest resistance

However, at least four features of temperate tree trials distinguish them boldly from proposed F/FRED trials:

(1) 30-80 years duration
(2) 10-20 years generation time
(3) restricted focus on end use of timber of good form or of pulp
(4) extensive prior experience to guide scientists in trial design

Given these comparisons, the trials with fast-growing trees in the tropics will be much more similar to crop network trials than to trials with the premier softwood timbers of temperate forests. Fodder and fuelwood trials will be the most similar, having 3 to 24-month harvest cycles, high population densities, and small plots.

EGP AS A CONCEPT OF SPECIES

A basic assumption for provenance/progeny trials is that SET have led to the focus on a single species for intensive study. Species for the F/FRED-type research is equated with an EGP. Improvement of tropical MPTS involves gene pools well beyond the confines of a single species of our present interest. The EGP of any species must include all species to which it may be crossed to produce fertile offspring. To be pragmatic, we can add that a gene pool is effective only if it can produce usable varieties within a reasonable time frame, e.g., 5-10 years for a tropical fuelwood or fodder tree.

Tropical fuelwood trees are genetically rich in that they breed rapidly, they represent species complexes with high morphological and ecological diversity, species complexes have high interspecific fertility, and the objective of "biomass in almost any shape or form" permits the breeder to thoroughly exploit the gene pool.

Food crop breeders are heavily constrained by human preferences in taste, color, shape, smell, etc. Although every major food crop has cross-fertile relatives, their use as a gene pool requires extensive backcrossing (six or more generations, reducing the non-recurrent parent contribution by $(1/2)^6$, to obtain a marketable food.

Fuelwood or total biomass, by contrast, provides the geneticist almost unlimited scope for use of an inter-fertile germplasm pool (Burley and von Carlowitz 1983). We have many familiar tree examples with mixed hybrids used for biomass, e.g., *Salix*, *Eucalyptus*, and *Populus*. This is an expanding family now including examples such as *Acacia* (*mangium* x *auriculiformis*), *Casuarina* (*junghuhniana* x *equisetifolia*), *Leucaena* (*leucocephala* x *diversifolia* and others) and *Prosopis* (*alba* x *chinensis*). I expect the EGP of all tropical fuelwoods to include two or more species. These will be

species that taxonomists view unequivocally as distinct in their morphology, and probably also in their ecology, physiology, and cytology.

It has been true historically that species hybrids routinely have exceptional biomass yields and fitness (e.g., wide site adaptability). The current use of *Eucalyptus* hybrids is illustrative, and cloning is the key to commercial exploitation. In the legumes, production of hybrid seeds based on SI is another option, notably cloning the SI parents as females for commercial hybrid seed production (Brewbaker 1986).

Provenances and single-tree, half-sib progenies within a single species constitute the major initial germplasm for F/FRED studies. I would suggest that genetic improvement should be a part of every study with short-rotation trees. At the end of an experiment, simple roguing can create a useful seed orchard; cloning can create an excellent one. Half-sib progenies can be taken from outstanding trees, or full-sib crosses made. In a selfing genera like *Leucaena*, any genetically variable trial becomes a potential reservoir of new pure-line germplasm. An early requirement for F/FRED studies is to identify the size of the EGP.

THE EGP OF *LEUCAENA* AND ASSOCIATED PSYLLIDS

The *Leucaena* psyllid (*Heteropsylla cubana*) has become a major pest in Asia within a short time, but is under predation and generally negligible in its Caribbean/Central American place of origin. *Leucaena* Research Reports, Vol. 7, reviews this problem in detail, and addresses options of biological and genetic control. The psyllid came to Hawaii in April 1984, and clearly illustrates the significance of EGP. Sorensson has shown that most if not all of the 12 *Leucaena* species can be hybridized with the commercial *L. leucocephala*. We consider some of these hybrids commercially useful. By having this gene pool well represented in Hawaii in April 1984, sources of resistance were immediately apparent, as seen in Tables 1 and 2 (Sorensson and Brewbaker 1986).

Table 1. Psyllid ratings for *Leucaena* sp.

Species	Rating	Provenances	Comments
L. collinsii	1-2	12	Immune
L. diversifolia 2n	3-7	32	Susceptible or tolerant
L. diversifolia 4n	4-8	39	Susceptible or tolerant
L. esculenta	1-7	51	Most immune; some susceptible
L. greggii	4-7	31	Susceptible or tolerant
L. lanceolata	5-8	35	Susceptible or tolerant
L. lanceolata sousae	4-6	7	Susceptible or tolerant
L. leucocephala	4-9	531	Susceptible or tolerant
L. macrophylla	4-7	13	Susceptible or tolerant
L. pallida	1-3	18	Immune
L. pulverulenta	6-9	16	Susceptible
L. retusa	2-4	15	Tolerant or resistant
L. shannoni	4-6	21	Susceptible or tolerant
L. trichodes	4-7	24	Susceptible or tolerant

1 = immune
9 = highly susceptible

Table 2. Psyllid resistance among interspecific *Leucaena* hybrids.

MALE	COL 52	DIV 32	DIV 104	ESC 52	GRE 56?	LAN 52	LNS 52	LEU 104	MAC 52	PAL 104	PUL 56	RET 56	SHA 52	TRI 52
L. collinsii	(1)					2	3							
L. diversif. (2n)	2	(5)	5			6	6	6					8	
L. diversif. (4n)			(6)			8	5	6		3			5	
L. esculenta				(2)				3					3	
L. greggii					(5)									
L. lanceolata	3	6				(7)	5						5	
L. lanc. sousae	3					5	(5)						4	
L. leucocephala	3		6	3		7		(7)		4	7	5	6	6
L. macrophylla									(5)					
L. pallida			3							(2)			5	
L. pulverulenta	3		2			9	8	9			(8)		6	
L. retusa	3		7	3				7		3	6	(4)	4	
L. shannoni		6				6						4	(5)	
L. trichodes						6	6							(6)
G.C.A.#	2.8	6.0	4.6	3.0	—	6.1	5.5	6.2	—	3.3	6.5	4.5	5.1	6.0

*General Combining Ability = average of all hybrids of this parent

1 = immune
9 = highly susceptible

Network trials coordinated by F/FRED and NFTA are proposed to help solve the psyllid problem. The trials are to be designed at a collaborative workshop entitled Biological and Genetic Control Strategies for the *Leucaena* Psyllid to be held by NFTA and F/FRED November 4-7, 1986. A major consideration here must be the EGP of the pest, of which only a sample of germplasm has reached Asia and the Pacific region.

SET VERSUS PROVENANCE TRIALS

Attempting to do too much too fast ruins many experiments. Political pressure and erratic funding lead to extensive misplantings of trees. This occurs frequently enough in developed countries, but is exascerbated with tropical trees where less background information is available and where fiscal/political factors are often so great. No better examples of the need for preliminary trials can be found than experience over the past decade with *Leucaena* sp. One such failure involved several hundred acres planted with bad seeds too late in the rainy season into an untested soil without *Rhizobium* from badly designed containers. A preliminary trial of only 100 trees the year before would have prevented this error.

SET are conducted largely to plan better provenance trials. They are especially important in preparing for large-scale developmental plantings. If carefully designed, they can in one year show:

- effective methods to establish and protect the trial (the major problem with most tree trials--animals, fire, humans, weeds)
- entries to exclude because of poor germination or growth
- treatments to exclude as ineffective, extreme, or too costly

SET of MPTS germplasm can involve unreplicated plots, or, on occasion, single trees. However, replication in SET permits statistical evaluation of the extent of useful replication, the most effective sample numbers, and plot sizes. These evaluations use variance components analyses and require that both replication and sampling within plots are practiced. SET should be encouraged because they provide useful information and are cost-effective.

BM AND MS TRIALS

Two basic types of trials are recommended for F/FRED provenance trials: 1) BM trials, normally at a single site or region and 2) MS trials at multiple sites and regions appropriate to the trial objectives.

Although the term *benchmark* has not been used by breeders, it usefully connotes a location or set of sites at which initial screening is made of the entire gene pool that might go into trials. Obvious MPTS rogues would include those with poor germination, poor seedling growth, or serious genetic defects. BM progeny trials will normally be conducted at the site where progenies are being generated under non-stress conditions (adequate water, pH, nutrition, etc.), and may involve small unreplicated plots of genetic materials. Traits to be assessed at a BM site are those believed to be environmentally stable, i.e., under genetic control with little G x E interactions. As examples, Waimanalo (Hawaii, U.S.) is an excellent BM site for *Leucaena* screening trials for psyllid resistance, and Sanford (Queensland, Australia) for tolerance of mild frost.

MS trials are indicated for all provenances and progenies of potential wide-scale interest. I propose that the ARCB design be considered for MS trials in the F/FRED networks.

G X E INTERACTIONS

G x E interactions are generated in trials with different genotypes at different locations (Brewbaker 1984). Almost every MS tree trial can be expected to generate statistically significant G x E interactions, but their practical significance can be much debated. Such interactions assume importance in two ways:

(1) associated G x E mean squares serve as an error term to judge the significance of genotype mean squares applying the random model, giving a more conservative view of the superior genotypes over some or all environments; and

(2) when significant components of the environment are known and quantified, G x E interactions may be directly interpreted, e.g., different races of a disease can be seen to distinguish different sources of genetic resistance.

More precise descriptions of environment through MS trials may help reveal the source of G x E interactions. However, this exercise may be only time-consuming and frustrating since trees integrate over the entire year the effects of many environmental parameters. Specific trials should be devised to determine precisely the regression of performance against specific environmental factors, e.g., pathogens, edaphic and climatic variables. These trials are to be viewed as an integral element in provenance/progeny networks, planned collaboratively by the proposed cooperators. Of greatest importance, the progress report data should be fully shared and preferably published annually in journals.

Based on my experience, G x E interactions should not be a major factor governing design of F/FRED trials since it is expensive and inefficient to replicate each variable at every site. Great genetic variability is expected with F/FRED tree species, and major differences will occur among MS trials. Since the G x E main effects are expected to be large, caution should be used in interpreting interactions. Let me cite a current experimental design problem we encountered in Hawaii. The experiment focused on G x E, with each trial replicated 4 times with 26 species in 36-tree plots at 2 x 2 m spacings. For two locations, this experiment (over 3 hectares) will cost about three times my annual tree research budget. In contrast, a few entries from this trial could be replicated at all locations, thus permitting some assessment of G x E, but other species of less interest left

unreplicated. The savings of cost and time would permit me to conduct other equally important trials. The design that permits this approach is discussed below.

ARCB

The ARCB is highly suited to many types of tree trials, and may be a useful tool for the F/FRED network. Particularly designed for trials with numerous entries or treatments, it is especially suited to provenance and progeny trials. As with all tree trials, much care must be given to minimizing border effects between plots, resulting from competition for light and water. SET are important for excluding, for example, excessively slow growers.

The augmented designs were developed in relation to sugarcane experiments by Federer (1956), in which newly bred varieties were to be compared with older, well-adapted ones. Sugarcane plots are large and long-term, and experimental costs and error variances are high, much as in our tree trials.

Tropical tree studies inevitably involve varieties or treatments at differing stages of evaluation. Some varieties have been tried before, and can be considered at an advanced level of evaluation. Their further comparisons require replication referred to here as treatments replicated (tr). Other varieties or treatments that are preliminary or exploratory in nature are impractical and costly to include in all replications at all experiment locations. They are referred to here as treatments unreplicated (tu). The ARCB puts both the tr and tu entries into the same trial, allowing direct, critical comparison. The average of tr entries in any block is treated as a baseline for comparison.

The ARCB design has proven versatile, and we have used it for most maize and tree trials at the University of Hawaii over the past 25 years. An academic example of simplified analyses is presented in Annex A (reprinted by Huxley, 1985). Analysis involves simple randomized complete block calculations of the tr plots, adjustment of tu plot values to the tr mean of the block in which they occur, and application for treatment comparisons of a set of four standard errors. In practice, our maize trials usually involve 20 tr in four replications and 60 tu entries at eight locations annually. The entries are changed slightly each year, with tu entries tested at least three years before discarding or advancing to tr status. *Leucaena* spacing trials involved four tr and eight tu in four replications at several locations (Van Den Beldt et al. 1982). A current *Leucaena* wood-yield variety trial involves about 30 tr and 30 tu in three replications. In practice, trials with numerous entries are conveniently combined and compared using data as percentages of the mean of the replicated entries of the trial.

REFERENCES

Brewbaker, J.L. 1984. Genotype-environment interactions and agrotechnology transfer. In A multidisciplinary approach to agrotechnology transfer, ed. G. Uehara, 26: 29-42. University of Hawaii HITAHR Ext. Ser.

Brewbaker, J.L. 1986. The search for self-incompatible L. leucocephala; theoretical considerations. Leucaena Res. Rept. 7: 114-116.

Burley, J. and P. von Carlowitz, eds. 1984. Multipurpose tree germplasm. Nairobi, Kenya: ICRAF.

Federer, W.T. 1956. Augmented (or Hoonuiaku) designs. Hawaiian Planters Record 55(2): 191-208.

Federer, W.T. and D. Raghavarao. 1975. On augmented designs. Biometrics 31: 29-35.

Huxley, P.A. 1983. Systematic designs for field experimentation with multipurpose trees. ICRAF Working Paper 12, 6 p.

_____. 1985. Methodology for the exploration and assessment of multipurpose trees. The scope and design of field trials. Nairobi, Kenya: ICRAF.

Sorensson, C.T. and J.L. Brewbaker. 1986. Resistance of Leucaena species and hybrids to psyllids. Leucaena Res. Rept. 7: 13-15.

Van Den Beldt, R.J., J.L. Brewbaker, Ta-Wei Hu, and B. Boontawee. 1982. International Leucaena population trials. Leucaena Res. Rept. 3: 96-98.

Annex A

Application of Augmented Designs in Field Crop Experiments

Tropical crop and tree investigations often involve treatments or varieties at two distinct stages of evaluation. Some treatments will be at a fairly advanced level and extensive replication is desired. Because other treatments are preliminary in nature, it would be expensive and time-consuming to include them in all replications at all locations of the experiment. An experimental design that conveniently incorporates both types of treatments is the augmented design of Federer (Federer 1956, Federer and Raghavarao 1975, Federer and Searle 1976).

The augmented design was first applied to varietal trials of sugarcane, in which new seedling varieties (referred to as tu) were being compared with older, well-adapted varieties (tr) (Federer 1956). Sugarcane plots are large and experimental expenses and errors high. The augmented design permits great reductions in block size, but still allows critical comparisons of numerous entries. The design has a convenient flexibility for use with any large set of varieties or treatments. This seems especially true for tropical crop experiments, such as those involving multiple cropping, soil amelioration, new varieties or new control measures. It has proved most effective and versatile for statewide trials of corn and fast-growing trees in Hawaii. These will involve, for example, 20 tr and 60 tu in small plots of maize or 5 tr and 10 tu in trials of trees.

A Simplified Example of the ARCB Design

Calculations and interpretations are applied to a set of data (Table 1) from a randomized complete block design with 3 tr in 3 replications. The design was augmented by including in each replication 2 tu. The experiment thus includes 15 plots, with 3 replications of 5 plots each. Randomization is practiced in all plots in each replication, with no subgrouping.

Table 1. Data from an ARCB.

	tr				tu				
Block	A	B	C	Sub-total					Block Totals
I	8	6	12	26	(D)	4	(E)	6	36
II	9	5	9	23	(F)	13	(G)	10	46
III	12	8	13	33	(H)	10	(I)	8	51

Preliminary Analysis of the Experiment

In most instances, the following ANOV and standard error calculations, using only the tr, should suffice for augmented designs (Federer and Raghavarao 1975). Adjustment of tu values is required. The basic ANOV (Table 2) ignores data from the unreplicated entries. The computed error variance is then applied in tests of differences among both replicated and unreplicated entries. The ANOV is traditional, using the data in Table 1 for replicated entries only (SS = Sums of Squares, corrected; CF = Correction Factor for the mean):

Sum x = 82, Sum x^2 = 808, CF = $(82)^2/_9$ = 747.11

SS Total = 808 - CF = 60.89

SS Block = $(26^2 + 23^2 + 33^2)/_3$ - CF = 17.56

SS Treatment = $(29^2 + 19^2 + 34^2)/_3$ - CF = 38.89

Table 2. ANOV of data in Table 1.

Source	DF	SS	MS	F
Treatment	2	38.89	19.45	17.51
Block	2	17.56	8.78	7.91
Error	4	4.44	1.11	

The ANOV results in an error mean square of 1.11. This should reflect directly the dispersion of the three replicated varieties included in the five plots of each block; i.e., this mean square would normally be smaller if the unreplicated entries were excluded. In normal practice, probably no more than half of each block should be occupied by unreplicated entries.

Adjustment of Tu Means

Before comparing means, it is necessary to adjust the tu values for the effect of the block in which each occurs. Letting tu represent the value of the unreplicated treatment in the ith block, the following adjustment must be made: treatment adjustment = tu - $x_{i.}$ + $x_{..}$, where $x_{i.}$ is the mean of all tr within the ith block, and $x_{..}$ is the mean of all tr in the experiment. These values are as follows, based on data in Table 1:

$x_{1.}$ = 26/3 = 8.67 $x_{3.}$ = 33/3 = 11.00

$x_{2.}$ = 23/3 = 7.67 $x_{..}$ = 82/9 = 9.12

Adjusted treatment values are then obtained as follows:

Treatment	Tu	Block no.	Block Mean	Treatment Adjustment
D	4	I	8.67	4.4
E	6	I	8.67	6.4
F	13	II	7.67	14.4
G	10	II	7.67	11.4
H	10	III	11.00	8.1
I	8	III	11.00	6.1

Standard Errors of Difference (SE_D) based on the Mean Square Error (MS_e) = 1.11 can be calculated to apply to all treatment comparisons as follows, where replication = 3 blocks, tr = 3 and tu = 6:

1. SE_D between any 2 tr:

   $(2MS_e/\text{replication})^{1/2} = 0.86$

2. SE_D between any 2 treatments in the same block:

   $(2MS_e)^{1/2} = 1.49$

3. SE_D between any 2 tu not in the same block:

   $[2\ MS_e\ (1 + 1/tr)]^{1/2} = 1.72$

4. SE_D between tr (averaged over all blocks) and tu:

   $[MS_e\ (1 + 1/\text{replication} + 1/tr - 1/[\text{replication} \times tr])]^{1/2} = 1.32$

As an example of further calculations, least significant difference values were obtained by the formula:

5% least significant difference = treatment at degrees of freedom error ($df_e = 4$) x SE_D

For the four comparisons above, treatment = 2.78 and the least significant differences are:

1. 2.39 2. 4.14 3. 4.78 4. 3.67

Applying these values (2.39 to replicated, 4.78 to unreplicated), significant differences are evident:

C	11.3a	F	14.4a
A	9.7a	G	11.4ab
B	6.3b	H	8.1bc
		E	6.4c
		I	6.1c
		D	4.4c

Discussion

The ARCB design provides a welcome flexibility to block designs where not all treatments appear to warrant full replication. By reducing numbers of replicated entries, the size of blocks is reduced and experimental errors should also be reduced.

Great care is encouraged in choosing tr for long-term tropical crop trials. Preliminary evaluation in unreplicated plots (phase I trials) that can be compared visually and statistically with tr as controls permits better choice of treatments for study in advanced trials. Augmented designs might also include tu such as those suggested by junior investigators, extension workers and farmers, or treatments chosen for demonstration purposes or those representing extremes of treatment combinations. A major advantage of the design is that such treatments, no matter how discrepant their values, do not contribute to experimental error (except as they may introduce undesirable border effects, an important consideration). In a replicated experiment, the unwise choice of an extreme treatment may greatly increase the experimental error, thereby damaging the entire experiment.

REFERENCES

Federer, W.T. 1956. Augmented (or Hoonuiaku) designs. Hawaiian Planters Record 55 (2): 191-208.

Federer, W.T. and D. Raghavarao. 1975. On augmented designs. Biometrics 31: 29-35.

Federer, W.T. and S.R. Searle. 1976. Model considerations and variance component estimation in augmented completely randomized and randomized complete block designs. Biometrics unit memo series, Cornell University.

Planning and Implementing MPTS Field Trials

Kenneth G. MacDicken

Species Network Specialist, Winrock International, Bangkok, Thailand
Vice President for Development, Nitrogen Fixing Tree Association

Research networking is based on the key assumption that research information exists that can be shared or networked. For a network to grow and thrive, it must have a continual flow of experimental data. One of the objectives of the F/FRED project is to support Asian foresters and agriculturalists to more effectively generate and use research on MPTS.

The ultimate goal of MPTS research is to improve the productivity or profitability of growing or using MPTS through individual and institutional field experimentation. These experiments are often conducted without the benefit of knowledge about experiments in other countries or regions because of the obstacles of language, distance, tradition, and the expense of modern communication technologies. The lack of effective exchange of research information can result in duplication of expensive efforts and reduction of scientific advance.

Networking cooperation between researchers and institutions can improve the efficiency and effectiveness of MPTS research. To collect and analyze enough data on a single MPTS to determine its site requirements, growth rates, and usage requires more effort than any single institution or individual can provide. However, when this effort is shared among various network participants, the amount of total effort can increase dramatically while the amount of work required of any one participant is reduced. Improvements in research output can result from increased experimental planning, improvements in methodology due to increased communications, and combined analysis or modelling, which is only possible with multi-location experiments. Data from network field experiments can be pooled, combined for analysis, or used in constructing models that may more efficiently use research data and be more cost effective.

Data, motivation, and technical and financial resources are critical requirements for successful networking (Plucknett and Smith 1984). This paper will cover some of the steps required to begin cooperative field trials to generate MPTS data through the F/FRED project. Much of the material found in this paper is adapted from an excellent manual on species and provenance experimentation compiled by Burley and Wood (1976).

TYPES OF COOPERATIVE MPTS EXPERIMENTS

The IUFRO Kandy meeting report (Shea and Carlson 1985) identified 21 major research goals or activities. Seventy-eight percent of these goals focused on four major areas of MPTS research: choice of species, genetic improvement, improved biomass yields through silviculture/management, and agroforestry systems design. The research interests expressed at the IUFRO meeting and in subsequent discussions with potential F/FRED cooperators suggest two primary types of MPTS trials might be encouraged for F/FRED networks: 1) species and provenance trials and 2) management trials.

SET AND PROVENANCE TRIALS

SET and provenance trials are types of research in which international agreement and collaboration are of vital importance to all participants (Burley and Wood 1976). While SET and provenance trials have been conducted in Asia since the 1800s, nearly all of them have been designed

to collect information on conifers or hardwood timber species for industrial plantation use. Very few trials exist for trees for multiple uses. For example, little work has been done to compare wood and foliage yields of promising MPTS or provenances under the kinds of management used by farmers. In addition, few promising MPTS have been tested in comparative species and provenance trials. Little is known of the environmental requirements of some MPTS, such as the lesser-known Australian Acacia sp. or how their performance compares with better-known Leucaena sp. or Eucalyptus camaldulensis.

Network trials can be categorized into two general phases: SET and provenance trials. Set allow the mass screening of many potentially usable species for short periods of time. The amount of time required for SET of fast-growing MPTS might be as little as one year. The most promising species from these tests are carried into the provenance phase. At this stage, larger plots would be used for longer periods of time, perhaps two-four years for short-rotation MPTS. This stage further tests species under plantation or small-farm management, and is intended to confirm the suitability of a few species.

SET are generally conducted for the primary purpose of comparing species growth rates and characteristics, such as form, pest and stress resistance, quality of wood and/or foliage, and suitability to local cultural practices. This type of experiment helps identify a range of sites to which a species is adapted. It is essential that these sites be described fully to permit their incorporation into a network, including soil characterization and analysis, as well as climate data (e.g., temperature and rainfall) during the experimental period. Many tree SET have been conducted in Asia, but few of them are accompanied by complete site descriptions.

The priority species identified (MacDicken et al. 1986) have been compared in SET in many sites in Asia. For these species, larger plot experiments of the provenance stages are more appropriate. Species x management trials that compare the priority species under two-three simple management treatments, such as spacing or lopping, would provide more information relevant to small-farm MPTS use than simple species trials.

SET might be used to compare relatively well-known species with untested ones. For example, there are various promising Australian Acacia sp. (e.g., Acacia cincinnata) that have not yet been compared with MPTS such as Acacia auriculiformis or Leucaena leucocephala.

Provenance trials are progeny test of populations of the same species but of different provenances (geographical area and environment). Populations tested in provenance trials should represent the location and environment in which the parent trees grew and in which their genetic constitution has been developed. It is critical to know and record the place of origin for all planting materials used in provenance tests. Vital to any network provenance trials is careful collection, documentation, and distribution of seeds.

Provenance tests can also be classified into three phases: range-wide provenance sampling, restricted provenance sampling, and provenance proving. Limited provenance trials have been conducted in Asia for Acacia mangium, Dalbergia sissoo, Eucalyptus camaldulensis, Leucaena leucocephala, Tectona grandis, and several pine species. An early network activity might be to summarize the present status of these trials and, from this summary, determine how to proceed with network provenance trials.

The three main activities in MPTS and provenance research relevant to network efforts in Asia include (Burley and Wood 1976):

1. Review of literature, correspondence, and knowledge of distribution and variation of species. Coordination with other international or regional programs.

2. Choice of species and provenances to test from parent stands in natural forests or plantations. This includes seed procurement, processing, and dissemination.

3. Design, layout, and analysis of species and provenance experiments. This involves the assessment and selection of sites and management systems and the planning, design, analysis, and reporting of experiments.

It might be assumed that statistical ANOV within provenances would normally be done by each participating country and only summary data, such as the means and variances, would be used in network-wide analysis. These data may be extracted and used in statistical analysis of G x E interaction and in summaries of overall provenance or species performance (Burley and Nikles 1973).

The effort required to conduct truly cooperative network species or provenance experiments and effectively pool data should not be underestimated. Network decisions are needed at each step in this process, followed by detailed planning on how to accomplish specific objectives. However, given the ability and willingness of scientists and institutions in Asia to conduct effective MPTS research, I am optimistic about the chances for successful network SET and provenance trials.

IMPORTANCE OF COORDINATED, PHASED TRIALS

SET and provenance trials are often dealt with sequentially--species are first compared, followed by provenance tests of promising species. Field programs are often based on the initial results of SET without an adequate understanding of the variation within the species. One likely consequence of this error is the elimination of a species from further testing because of poor performance by a single provenance or seed source.

Identification and selection of experimental sites must be done on an ecological basis rather than a national one. The results from trials in the same climatic zone and on similar soils in different countries will likely be more useful in combined analysis than those from ecologically different sites within the same country. The critical importance in standardizing methods cannot be over-emphasized if the results of trials in one country are to be readily interpreted elsewhere.

MANAGEMENT TRIALS

Management trials, which include spacing, intercropping, and lopping or coppicing treatments are critical to understanding MPTS. A key assumption in MPTS usage by small farmers is that the trees provide more than one important product or service. Yet most MPTS experimentation has assessed growth rates of trees under single-purpose management (e.g., biomass or firewood yields). Studies of wood and fodder yields under different types of lopping or coppice management commonly practiced by small farmers are virtually nonexistent for most MPTS. As a result, while we know that a species like Acacia nilotica has more than one important small-farm use, we do not understand how best to manage the tree for optimal production of more than one product.

Various fast-growing trees, such as Acacia mangium, may grow rapidly and are clearly adapted to particular stress environments, but they may not be truly multipurpose in terms important to small farmers. If they are to be truly effective, management trials must be designed to directly address the questions important in small-farm management.

Trials might be designed to combine small-farm management practices, such as lopping for fodder with species or provenance trials. This would provide a comparison of priority species or provenances under multipurpose management regimes. It is highly probable that species x treatment interactions will be significant (i.e., species will respond differently to management treatments). For example,

while the height and diameter growth of Acacia mangium is greater than for Gliricidia sepium when the two species are not lopped for fodder, Gliricidia is probably much better suited to lopping and would most likely be a better MPTS to recommend for small-farm use. Experiments that compare both promising species or provenances and important management treatments would be more complex, but would provide more information in a shorter period of time than a series of species trials followed by management trials.

SETTING GOALS AND OBJECTIVES

The first step in planning network trials is to set goals and objectives. Research goals need to be relevant to important farmer problems, agreeable to network participants, and attainable. It is important that goal setting be done by those who are close enough to field activities to understand the problems of importance to farmers. Since a large body of relevant forestry and agricultural research already exists in Asia, an effort should be made to identify gaps in the present knowledge of the priority MPTS. Research goals and objectives can then be established to help focus research efforts on generating data to fill those gaps.

PLANNING NETWORK EXPERIMENTS

Once goals have been set, several critical planning decisions must be made to coordinate and plant field experiments.

Defining MDS

This primarily involves defining data to be collected. Careful thought given to MDS helps avoid missed opportunities for data collection. General categories of data for the MDS are tree growth and site assessment variables.

Most forestry researchers are familiar with tree growth and survival data. Height, diameter, form, vigor, and survival are all familiar measurements. However, MPTS frequently provide non-wood products, such as fodder, green manure, or food. The wood may also be used as firewood for which the traditional definitions of form and wood volume to a merchantable top diameter are of little value. THe measurements required for MPTS MDS need to reflect the end uses of the research data and uses by the farmers.

Site assessment data are required to describe selection of experimental sites and to correlate environmental factors with tree growth of species or provenances. Greaves and Hughes (1976) cite climate data that should be collected (in order of priority):

1. mean annual total rainfall
2. mean monthly rainfall
3. mean annual temperature
4. mean monthly relative humidity
5. mean monthly temperature
6. mean daily minimum temperature of coldest month
7. absolute minimum temperature recorded
8. mean daily maximum temperature of hottest month
9. absolute maximum temperature recorded
10. mean range of temperature
11. mean monthly wind speed at 2m above ground level

Soils at the site should be described by profile, and data should primarily focus on physical properties. Prediction of tree growth has been most successful using soil physical characteristics, such as depth and texture, and not chemical content.

Experiment Design

Cooperators will need to select experimental designs that meet their own research objectives, aid combined analysis of data, and are as simple as possible. To ensure precise and accurate experimental estimates, network trials should consider the following general components of design (Wright and Andrew 1976):

- choice of a suitable experimental site
- adequate replication
- control of external influences, blocking
- randomization
- simplicity

Germplasm Collection and Distribution

A key to understanding the genetic variability and environmental requirements of trees is to test known germplasm in known environments. These field plantings will not likely have significant long-term value without standard supplies of well-documented MPTS germplasm.

Each F/FRED MPTS network should be based on collection, increase, and distribution of germplasm. MPTS seed are currently collected and stored by a wide variety of institutions around the world. Cooperative efforts need to be made with these institutions to evaluate and share collections on a broader scale.

While the F/FRED project has a limited lifespan with no permanent facilities, institutions such as CSIRO, OFI, and CATIE have well-established MPTS seed collections. Thus, it is critical that the networks actively seek to cooperate with these and other institutions in identifying, collecting, processing, and disseminating germplasm for network trials. The general steps required to ensure that adequate germplasm is available for network trials include:

- Identification of germplasm resources, including summaries of the quantities, sources, and availability of MPTS germplasm. This effort has been initiated through several institutions and directories of seed sources found in publications on forest-tree seed resources by FAO, CSIRO, and ICRAF. The detailed inventory of germplasm sources could be done through a network-sponsored contract with network members to be completed prior to the design of network experiments.

- Design of network trials as discussed above. Only when trials are designed and an estimate of the seed requirements is made can germplasm collection and distribution be adequately planned.

- Development of a germplasm collection and distribution action plan, which would provide the basis for the actual assembling and distribution of seed to network cooperators. This plan might be developed by a working group of network participants following completion of the initial experimental design process.

Data Collection and Analysis Methods

Unless care is taken to establish common data-collection procedures and analysis methods, it will be very difficult to summarize and analyze data from network trials. Critical tasks to consider include determining procedures for collecting, summarizing, analyzing, publishing, and sharing research data.

This involves defining responsibilities of cooperating institutions and individuals and defining standards.

Establishment and Maintenance

Establishment of cooperative trials demands more time, care, and precision than does the establishment of single-site experiments. For example, in network species trials, seedlings must be grown from the same seedlots whenever possible, using standardized nursery, site preparation, and outplanting techniques. Planning of such experiments can be a complicated, time-consuming process that needs to be done carefully to ensure success.

TYPES OF NETWORK PARTICIPATION

Intensive Collaborative Trials

This is the most intensive category of network cooperation in which experiments are carefully planned and coordinated for the purpose of model development. The IBSNAT and CATIE fuelwood projects are examples of this type of collaboration. Cooperators at this level of effort would need:

- complete characterization of soil and climate
- well-established sites
- trained staff for coordination and data measurement
- adequate equipment for climate monitoring and data collection
- willingness to conduct trials of common design
- well-controlled, common methods and germplasm
- extensive MDS

A major objective of these trials might be to develop prediction models in cooperation with scientists at CATIE in Latin America and at ICRAF in Africa.

Cooperative Trials

This level of participation would be less intensive than that described above, and would involve trials of common or similar design. Objectives of these experiments might include distribution and evaluation of common germplasm on a wide variety of sites and the further definition of the range of site requirements for each of the priority species. Cooperative trials would be designed for simplicity and flexibility, and should require limited additional effort for most scientists. Cooperators at this level would need:

- basic data for rainfall, temperature, and soil properties
- common or similar experiments with few required measurements for network use (e.g., height and diameter at breast height)
- common source of germplasm

Network of Existing or Completed Trials

This effort would be directed at the recovery and sharing of unpublished or raw data. Data could perhaps be assembled, summarized, printed, and distributed by a working group of F/FRED cooperators. This effort would provide a solid understanding of what already exists and would help identify specific gaps that need to be filled by additional research. A serious effort to examine and summarize data from previous or ongoing MPTS trials would be required.

SUMMARY

Research networking is a means of enhancing the generation and use of MPTS research. Scientists and research administrators in Asia have identified various research goals that could be attained through SETS, provenance, and management trials. Trials that compare priority species under multipurpose management are particularly unique, and could provide exciting network research opportunities. The critical importance of standardized methods cannot be overemphasized. The F/FRED project can facilitate network trials and the sharing of common methodologies and experimental results.

REFERENCES

Burley, J. and D.G. Nikles, eds. 1973. Tropical provenance and progeny research and international cooperation. Oxford: Commonw. For. Inst.

Burley, J. and P.J. Wood. 1976. A manual on species and provenance research with particular reference to the tropics. Tropical For. Papers, No. 10.

Burley, J., P.J. Wood, and R. Lines. 1976. A guide to field practice. In A manual on species and provenance research with particular reference to the tropics, eds. J. Burley and P.J. Wood. Tropical For. Papers, No. 10.

Greaves, A. and J.F. Hughes. 1976. Site assessment in species and provenance research. In A manual on species and provenance research with particular reference to the tropics, eds. J. Burley and P.J. Wood. Tropical For. Papers, No. 10.

MacDicken, K.G., M.R. Dove, J.L. Brewbaker, and W. Hyde. 1986. Multipurpose tree species networks for the Forestry/Fuelwood Research and Development Project: recommendations. Arlington, Virginia: Winrock International.

Plucknett, D.L. and N.J.H. Smith. 1984. Networking in international agricultural research. Sci. 225: 989-993.

Shea, K.R. and L.W. Carlson. 1985. Increasing productivity of multipurpose tree species: a blueprint for action. Washington, D.C.: USDA Forest Service.

Wright, H.L. and I.A. Andrew. 1976. Principles of experimental design. In A manual on species and provenance research with particular reference to the tropics, eds. J. Burley and P.J. Wood. Tropical For. Papers, No. 10.

Regional Opportunities for Networking: The FRIM Experience

Salleh Mohd. Nor and Chan Hung Tuck

Director-General and Research Officer, respectively, Forest Research Institute of Malaysia

Increasingly, it is becoming more critical for scientific researchers to share their learning experiences. More institutions and scientists are pursuing research, resources available to scientists are limited, problems are becoming more difficult and finding solutions more urgent, advanced communication systems allow sharing of information and experiences and mechanisms are now established to promote and encourage such sharing.

IUFRO, one of the oldest scientific institutions (established about 1890), is designed specifically to promote sharing of experiences between scientists in the field of forestry. It now comprises 100 member countries, some 500 member institutions, and over 15,000 member scientists. A non-governmental organization, IUFRO promotes research collaboration within a loosely-knit family where scientists are encouraged to contribute and participate through their own resources.

Notwithstanding the commendable efforts of IUFRO, forestry science has lagged behind the agricultural sciences in international linkages, especially those within the developing countries. The CGIAR, with its 13 affiliated IARC, has an annual budget of over U.S. $200 million that supports agricultural research. While the reasons for the proliferation and success of international agricultural collaboration can be well understood, there is no reason why forestry scientists should not emulate agriculture in this regard, adapting its models to forestry needs.

FACTORS FOR SUCCESS

While the concept of networking and international collaboration appears straightforward, the path is full of hazards, especially when the linkage is between countries of different regions with people of different cultural and religious backgrounds, attitudes, and training. In addition, the linking institutions might have widely contrasting backgrounds with varying resources. The problem could further be heightened if the institutions are inflexible with their own programs.

In discussing networking in international agricultural research, Plucknett and Smith (1984) identified seven factors for success:

1. The problem should be clearly defined and a realistic research agenda proposed.

2. The problem must be widely shared.

3. There must be strong self-interest.

4. The participants are willing to commit resources, such as personnel and facilities.

5. Outside funding is available to develop the network and keep it running for at least the first few years.

6. The participants must be sufficiently trained and experienced to make a contribution.

7. The network must be guided by strong and efficient leaders who have the confidence of the participants.

In addition to these important factors, institutions aspiring to participate in networking should also have flexible research programs to accommodate the needs of the network, whose goals might not always coincide exactly with their own programs or priorities.

FRIM'S EXPERIENCE

The Forest Research Institute, Kepong, established in 1929 as a division of the Forestry Department Peninsular Malaysia, was in 1985 transformed into FRIM, an autonomous statutory body. While the physical facilities of FRIM can be considered adequate, the scientific human resources are fairly limited. Nevertheless, FRIM has benefited from participating in numerous international programs through networking arrangements. Descriptions of some of these programs are cited below.

ASEAN

Formed in 1967, ASEAN promotes economic, social, cultural, scientific, technical, and administrative collaboration between member nations, which comprise Brunei, Darussalam, Indonesia, Malaysia, Philippines, Thailand, and Singapore. Collectively, these countries cover a land area of 3.1 million km^2, a forest area of 160 million hectares (51%), and contain a population of 282 million.

ASEAN-Australia Cooperative Program

The ASEAN-Australia Cooperative Program on Living Coastal Resources with Emphasis on Mangrove and Coral Reef Ecosystems was initiated in 1985 with a series of workshops at AIMS. A total of about Australia $3 million was funded by the ADAB to create an awareness of the ecological importance of shallow-water coastal ecosystems. The objectives of the program are to generate quantitative, management-relevant baseline information on community structure and distribution of recognized resources within mangrove, coral, and nearshore soft-bottom ecosystems; to generate data on carbon, energy, and nutrient budgets of these ecosystems with particular emphasis on intersystems dependence in the coastal environment; and to develop scientific and technical expertise within the ASEAN region to ensure long-term capability in acquiring management-relevant baseline information and applying it to the development of coastal-zone management policies.

ASEAN-Canada Forest Tree Seed Centre

The proposal to establish an ASEAN Forest Tree Seed Centre was first introduced at the third meeting of ASEAN forestry experts held in Manila October 13-14, 1977. Canada agreed to finance the project during the second ASEAN dialogue held in Ottawa October 31-November 1, 1977. The memorandum of understanding between Canada and Thailand (on behalf of ASEAN) was signed in Ottawa on May 1, 1981. With a contribution of Canada $1.5 million, the Centre was established in Mauk-Lek, Thailand and completed in September 1982. The Centre provides training in seed research, develops forest tree seed production areas in ASEAN countries by providing an adequate supply of quality seeds of selected species used in afforestation and reforestation, and strengthens technical competence in nursery and forest plantation research and development in each of the ASEAN countries.

Phase I of the project ended September 1985. Pending an agreement for Phase II, Canada provided an additional Canada $300,000 for the interim phase through December 1985 and has agreed to a one-year extension.

ASEAN-New Zealand Afforestation Project

ANZAP began in November 1979 with a contribution of New Zealand $2.6 million. The project was located in an area of about 10,000 hectares of low but steep hill country in the Tarlac Province of the Philippines. The two principal objectives of the project are to 1) establish a forest nursery and pilot plantation to demonstrate effective afforestation measures on a site with characteristics similar to others requiring afforestation in other ASEAN countries, using techniques adapted from New Zealand and ASEAN countries and 2) to use the pilot plantation for practical on-the-job training for foresters from ASEAN countries. A three-year second phase began in October 1984 with a budget allocation of New Zealand $1.4 million.

ASEAN-Australia Forest Tree Improvement Program

AAFTIP, a proposed three-year program, will be located in Thailand. It aims to assist in the exchange and use of tree improvement information, methodology, expertise, and germplasm within the ASEAN region and to identify and overcome constraints to progress in tree improvement programs of ASEAN countries through appropriate training and inputs from experts. It is envisaged that the program will require funding of about Australia $2.4 million.

The proposed program would be implemented through a series of identified projects of national and regional significance. A collaborative working group would be formed to review the progress of the projects and to assist communication between tree breeders in the region. The nine projects identified are:

1. breeding improved *Eucalyptus*
2. breeding improved *Acacias*
3. breeding improved *Tectona*
4. management for production of improved seeds
5. breeding and propagation of improved *Gmelina arborea*
6. breeding improved *Albizzia falcataria*
7. species and provenance introduction
8. applied research on reproductive biology
9. conservation of indigenous forest gene resources

ASEAN-U.S. Watershed Project

This project was approved for implementation in January 1984, with USAID funding of U.S. $500,000 per year for five years. The project headquarters, based in Los Banos, Philippines, has the following functions:

- to collect, collate, and disseminate research knowledge and information relevant to the ASEAN watershed;

- to collaborate with national watershed institutions and researchers in the identification, design, and implementation of priority watershed conservation and management research programs;

- to develop and organize specific watershed conservation and management training programs for mid-level scientists and technicians; and

- to prepare, promote, and disseminate watershed conservation and management guidelines useful to management and extension personnel.

The center operates through technical advice provided by the ASEAN-COFAF Coordinating Group on Forestry and guidance from a program steering committee.

ATTC

This project is intended to strengthen applied research, training, and technical information services available to the timber-processing industry in the ASEAN region. The ASEAN Timber Technology Centre, established in Kuala Lumpur, serves the timber-processing industry in the region by providing technical assistance to research and training institutes and timber-processing and trade associations and by disseminating training and information materials at the regional level. A regional research program is also being formulated to promote better use of timber and timber industry development.

The project cost has been estimated at about $13 million ECU. The Malaysian Government, as the host country, will contribute in-kind inputs of $2.4 million ECU. The project, which began in March 1985, has a five-year duration. ATTC implementation is guided by a project steering committee appointed by COFAF. Collaboration with FRIM has not yet begun.

ASEAN Institute of Forest Management

The memorandum of understanding for this five-year project was signed in February 1985. Steps are currently being taken to establish the Institute in Kuala Lumpur. Canada will provide expert services, equipment, training, and other inputs with a total value of Canada $7.3 million. Malaysia (through its Forestry Department) will provide infrastructure and other facilities with a value of Canada $0.95 million, as well as 18 professional, technical, and support staff and related operating costs totalling Canada $1.25 million. The Institute is aimed at providing training to foresters in the ASEAN region in the use of forest DBMS, inventory methods and procedures, and forest management planning systems. Collaboration with FRIM has yet to be initiated.

UNESCO/UNDP PROGRAMS

Regional Research and Training

The Regional Research and Training Program on Mangrove Ecosystems in Asia and the Pacific was started in September 1982 with UNDP funding of U.S. $1.2 million. It aims at training scientists, technicians, and regional managers in understanding the nature and functioning of mangrove ecosystems and in formulating appropriate managerial guidelines. In addition, the program is developing a regional network between institutions and countries. NATMANCOMS formed in the participating countries and the RTF, comprised of national project leaders of chairmen of the various NATMANCOMS, assist the CTA, appointed by UNESCO, in coordinating and implementing program activities. A total of 11 countries participated in the program.

Phase II of the above program will begin in January 1987 and will have a duration of five years. It will be expanded geographically to include Japan, China, New Zealand, Fiji, Truk, Burma, and Vietnam. The scope of Phase II will be broadened to include other coastal ecosystems, such as seagrasses, seaweeds, coral reefs, estuaries, and nearshore waters.

Demographic Study on Lowland Dipterocarp Forest

This study, being carried out in Pasoh, Malaysia under UNESCO's MAB program, is a collaborative research effort among FRIM, Harvard University's Arnold Arboretum, and the University of Iowa. It was initiated in June 1985. Data on the population structure and spatial patterns of distribution of all woody plants of 1 cm diameter at breast height and above is being collected in a 50-hectare plot at the Pasoh Forest Reserve in Negri Sembilan. The long-term goal is to assess the plot at regular intervals and to record directly the patterns of recruitment, growth, and mortality of trees in relation to gaps and microsites to understand the silvicultural requirements of commercial species.

Ecological Effects of Human Activities on Forest Ecosystems

The MAB Program on Ecological Effects of Increased Human Activities on Tropical and Subtropical Forest Ecosystems has as its framework the comparison of dynamics of natural forest ecosystems with adjacent manipulated and replacement systems. It is aimed at elucidating key processes that accompany changes, which in turn determine future yield and stability. In a given field project, study areas might range from natural forests to diverse forest exploitation and management practices, to plantations. Funded by UNESCO, the research projects under the program are carried out by the various national MAB committees. The research projects range from intensive studies on the sociological and environmental impacts of agricultural settlements and rainforest manipulation in a pilot study in East Kalimantan, Indonesia to small, specialized studies on the structure and nutrient cycling in tropical forests in Malaysia, to extensive integrated studies on forest ecology and watershed management in Thailand and the Philippines.

IDRC PROGRAMS

RIC

Following an agreement by IDRC to finance the project for the first three years, RIC was established at FRIM in March 1982. The functions of the Centre are to 1) develop a comprehensive collection of rattan literature, 2) set up a document storage and retrieval system, 3) publish a comprehensive annotated bibliography on rattan, 4) translate articles upon request, 5) prepare and publish state-of-the-art reports on special topics, 6) perform specific searches upon request, 7) make copies of documents available for dissemination to those interested, 8) compile a directory of ongoing research projects, and 9) issue a quarterly news bulletin and occasional papers on rattan.

REMIN

The need for a REMIN in the Asia-Pacific region was proposed during the Asian Regional Workshop on Mangrove Information held in Manila April 30-May 2, 1984. A formal project proposal was prepared by the Philippine NATMANCOM by workshop delegates. The IDRC agreed to provide financial assistance to support REMIN in developing its operational structure during the first three years.

The project includes establishment of a REMIC that will institutionalize, develop, and implement a mangrove information system. the Centre will screen, select, analyze, and store mangrove information in a central library, which will be made available to users in the format suited to their individual requirements. The project also seeks to strengthen the national mangrove information systems in each of the participating countries so that they can function as sources of local information and recipients of services available at REMIC. In addition, REMIC will update the mangrove bibliography and prepare a regional newsletter, state-of-the-art reports, and a directory of mangrove experts in the region.

ROYAL SOCIETY (U.K.)

Southeast Asia Rainforest Research Program

This collaborative program began in 1984 with the signing of a memorandum of understanding between the Danum Valley Management Committee (chaired by the Sabah Forest Department) and the Royal Society. The program allows for brief reconnaissance and research visits by British participants to Southeast Asia and by Southeast Asian collaborators to Britain.

The program's broad research theme is the recovery of tropical forests following disturbance. The primary aim is to understand the influence of created gaps of various sizes and kinds on hydrological parameters, soil processes, fauna and flora, plant successional processes of these gaps, and on animal-plant interactions vital for forest regrowth.

The Danum Valley Conservation Area, which covers about 438 km of lowland rainforests, has been selected as the study site. A field study center was established in June 1985. The Royal Society has agreed to provide a grant equivalent to U.S. $15,000 per year for three years to assist with operational costs and has also offered to equip the field laboratory.

USAID

F/FRED Project

This collaborative project, one of the first outside the U.N. system addressing itself specifically to regionwide research collaboration, is designed to meet the basic needs of developing countries for fuelwood and other tree products through enhancing forestry/fuelwood research and research capabilities. It functions to 1) improve formulation, planning, and management of forestry/fuelwood and agroforestry research; 2) support and develop networks of scientists and institutions in less developed countries to focus on the assessment, improvement, and management of fuelwood/MPTS; and 3) enable less developed countries to address their forestry/fuelwood needs through more effective use of forestry and agriculture-related research information. USAID is providing funds of U.S. $40 million over 10 years for implementation in Asia, Africa, and Latin America. The first phase is being carried out in Asia.

F/FRED's three components are research planning and management, network development research, and global research support. Research areas identified include multipurpose/fuelwood tree selection and improvement, biotechnology, environmental models, socio-economic methods and tools, and socio-economic research.

The contract for implementing Phase I was awarded to the Winrock International Institute for Agricultural Development. USAID funding is about U.S. $9 million for five years. The field staff headquarters is based at Kasetsart University in Bangkok, Thailand.

ITTO

The ITTO, which governs the ITTA, has its headquarters in Yokohama, Japan. ITTA currently has 41 producer and consumer members. Its objectives are as follows:

- provide an effective framework for cooperation and consultation between tropical timber producing and consuming members with regard to all relevant aspects of the tropical timber economy;

- promote the expansion and diversification of international trade in tropical timber and the improvement of structural conditions in the tropical timber market by considering the long-term increase in consumption and continuity of supplies, prices remunerative to producers and equitable for consumers, and improving market access;

- promote and support research and development to improve forest management and wood utilization;

- improve market intelligence to ensure greater transparency in the international tropical timber market;

- encourage increased and further processing of tropical timber in producing member countries to promote their industrialization and thereby increase their export earnings;

- encourage members to support and develop industrial tropical timber reforestation and forest management activities;

- improve marketing and distribution of tropical timber exports of producing members; and

- encourage the development of national policies aimed at sustainable use and conservation of tropical forests and their genetic resources and at maintaining the ecological balance in the regions concerned.

As this organization has recently been established, collaboration has not yet been initiated.

TROPENBOS

Tropenbos is the program launched by the Netherlands to create an international framework for conservation and development of tropical forests. It has been designed as a network of research sites that can act as crystallization points and growth centers for expansion. The program is directed toward providing efficient answers to practical problems. It has identified locations in Brazil, Ivory Coast, Colombia, Gabon, and Indonesia. The Netherlands Government has provided U.S. $4 million for the period 1986-1989, and Tropenbos hopes to obtain additional financial support. FRIM is preparing a proposal for consideration by Tropenbos.

IUFRO

FRIM participates in various IUFRO activities, particularly the Tropical Forest Silviculture Subject Group and other working groups relevant to FRIM's research program. FRIM actively participated in IUFRO's program for developing countries (SPDC). In its last congress in Ljubljana, Yugoslavia (September 7-21, 1986), IUFRO endorsed the establishment of an INCOFORE as another step in assisting forestry research in developing countries. INCOFORE hopes to strengthen national forestry research and extension capabilities, encourage high-quality research on important and timely problems, accumulate and interpret existing forestry research information, and deliver the information to primary users (Buckman 1986). FRIM hopes to maintain contacts within IUFRO and to participate in INCOFORE activities.

BENEFITS AND DRAWBACKS

The extent of FRIM's involvement in the above programs varies. Within the ASEAN program, FRIM plays a minimal role while in some UNESCO/UNDP and IDRC programs it serves as a leader. Nevertheless, FRIM must provide funds and resources, particularly manpower, to participate in these programs.

FRIM has reaped definite benefits from involvement in these international programs. Directly, there has been an inflow of small sums to supplement or complement its own resources. The main advantage of such funds is that they are not governed by the usual cumbersome, internal fiscal regulations, which helps purchasing and out-of-budget expenditures. Another benefit has been the increasing number of short-term, specialized training courses, which offer research staff the opportunity to travel overseas and which can be used to reward performance. FRIM's staff has also been able to develop outside links with senior scientists working in common research fields. Such links are especially important with younger and less experienced staff.

To collaborate fully, FRIM has to sacrifice time and human resources. Often, this happens at the expense of its own programs and activities. While some programs need little administrative support, others require close monitoring and frequent reporting, especially when financial support is involved.

CONCLUSION

In general, most of the cooperative forestry research programs in the ASEAN region have clearly defined objectives and well-documented and easily interpreted project management and implementation plans. Often, each project has its respective project steering committee to guide the host countries in implementing identified and planned tasks and activities. Close cooperation and collaboration between researchers and institutions involved are essential to ensure sharing of research information, approaches, and methodologies, as well as effective use of available technical and financial resources. The establishment of an effective network of project managers, planners, scientists, and appropriate institutions is therefore important. Finally, active participation and commitment of time and effort by respective member countries and organizations, whether national or international, are required to produce the expected outputs and to meet the goals of the various programs.

REFERENCES

Buckman, R. 1986. Bringing forest sciences to bear on socio-economic problems of the developing world. IUFRO Congress, September 1986, Yugoslavia.

Plucknett, D.L. and N.J.H. Smith. 1984. Networking in international agricultural research. Sci. 225: 989-993.

Survey Methods to Determine Research Priorities: A Thai Case Study

Suree Bhumibhamon

Associate Professor, Kasetsart University Faculty of Forestry, Bangkok, Thailand

The depletion of forest resources in Thailand, as in most tropical developing countries, has been caused primarily by the continuous misuse and mismanagement of forest area. The over-exploitation and shifting cultivation practices of forest resources are closely linked with agricultural development and land encroachment.

The annual depletion rate of forest resources in Thailand decreased from 9.9% during 1963-1973 (Wacharakitti et al. 1973) to the present rate of 3.2% or 0.5 million hectares. Between 1961 and 1982, the forest area diminished from 27.36 million hectares to 15.66 million hectares. The environmental and socio-economic evaluation of the deforestation was previously reported by Bhumibhamon (1986). In the natural resource profile of Thailand, deforestation issues and possible ways to resolve them were also outlined by TDRI (1986). However, the existing forest areas are scattered throughout the country. Presently, there are 10 provinces (mostly in the central plain) where the forest area was long ago converted to farming. The stand density of the remaining forest varies according to forest types. Highest and lowest stand density are found in pine forest (46.71 m3/hectare) and dry dipterocarp forest (5.60-19.91m3/hectare), respectively. However, the stand density in all forest types has decreased by 10.31-56.45%. In 1978, the total growing stock in Thailand was about 185 million m3. The decreasing trend of stand density has greatly limited the allowable cut from 3.1 million m3 in 1979 to 1.8 million m3 in 1983. This allowable cut could provide only 10% of the annual need. The other 90% of the country's wood consumption was mainly from illegally smuggled wood.

There is no indication that the present forestry situation can be improved unless tree planting in its different forms is conducted continuously and effectively. As for securing wood supply for the needs of the industrial sectors, Thailand cannot avoid importing wood from its neighboring countries. The over-exploitation of forest resources has also limited people's ability to gather minor forest products for food and additional income as they once did (Mungkorndin 1981). It is thought that additional farmer income from illegal cuttings and from gathering minor forest products has decreased (Panpiamrat 1984).

CURRENT ATTITUDES

The attitudes of different social groups on forest resources have been surveyed (Bhumibhamon 1983). Senior forest administrators or directors reviewed factors affecting forest resources, including lack of forest policy, poor cooperation among government institutions, and the possibility of local officers and politicians benefiting from illegal cutting and land encroachment. However, senior forest officers recommended conserving more forest area and strict control of illegal cutting in the natural forest to prevent social problems. Moreover, they recommended forest extension as the means to solve the problem and encouraged the setting up of more training programs on nature conservation for both adults and young people.

The survey was also conducted for regional and provincial forest officers who identified similar factors on depleting forest resources (Bhumibhamon and Atipunampai 1983). Moreover, they indicated other actions that also disturb forest resources, including wood-carving promotion, illegal tree felling for fuelwood and charcoal burning, as well as dam construction. This administrative group emphasized the need to promote and control tree farming. It also recommended alternative extra-

income sources for farmers, such as apiculture, growing other agricultural crops, and establishing *Bambusa* plantations or livestock farms. In managing forest resources, they suggested the necessity of establishing community forests, particularly in the form of agroforestry.

Bhumibhamon, Vajirajutipong, and Viriyaratanaporn (1984) interviewed 50 village chiefs in northern provinces who live close to forest areas. The chiefs mentioned that most forest destruction was caused by shifting cultivation, followed by direct or indirect action by tobacco kiln owners and some local officers. To earn extra income, village chiefs indicated that people within their domains had to cut down trees mainly to build and repair their homes and for fuelwood. They also collected medicinal plants and other minor forest products.

Results of a survey carried out in 50 villages in northern Thailand showed the need for forest cover in the watershed areas (Bhumibhamon et al. 1983). Listed were groups of people similar to those indicated by the chiefs who were involved in forest destruction. To prevent this problem, villagers recommended conserving part of the forest areas but allowing exploitation of a certain portion. They claimed that natural regeneration would compensate for forest exploitation. Nevertheless, farmers needed more land.

Based on the above attitudes on forest resources, different social groups pointed out that lack of forest policy allows various active groups to misuse natural resources. Common forest property still requires further evaluation before management recommendations can be made.

FOREST POLICY VERSUS FOREST RESOURCES

The major causes of deforestation in Thailand include shifting cultivation practices, illegal cutting and processing, infrastructure development, settlement, and natural disasters. State and private companies, private entrepreneurs, and peasants are directly engaged in the deforestation process. Politicians, traders, cash crop promoters, and tourist promoters are indirectly involved. Forest destruction has had serious ecological (climate, soil condition, soil erosion, water balance, salinity), economic, and social effects (Bhumibhamon 1986). To overcome these problems, many social groups have emphasized the need for drafting forest policy. A draft forest policy document was later presented for criticism. Based on public opinion, the completed draft was accepted by the Cabinet in December 1985.

To protect against further genetic erosion of the natural forest, national forest policy indicates the need to preserve 15% of the total area as conserved forest, including that on steep-sloping areas. The current policy indicates the need for an action plan to solve the existing problem of shifting cultivation and forest fire. It calls for serious control of tree conservation forest and development of an additional 25% of land area into economic forest for sustainable exploitation. (The economic forest is meant to provide wood to meet the needs of all industrial wood-using sectors as well as fuelwood needs.) It was additionally recommended to use the selection system or clear-cut system wherever applicable. If the clear-cut system is used, immediate replanting of the area is recommended.

Land-use zoning is needed because land use does not meet with land capability, and forest land has been continuously converted into agricultural land. The policy claims to identify and control city expansion as well as the expansion of agricultural land into forest area, the remaining area being converted into green area. To secure needed land for settlements, it calls for more cooperation.

The policy pointed out that application of scientific knowledge and technical know-how to increase cash-crop production could indirectly prevent further shifting cultivation activities. Reducing constraints to land use requires emphasis on the relationships between forest and other resources, including land, water, minerals, and wildlife.

The interrelationship of resources allowed the government to organize the National Forest Policy Committee to draw up policy, control, and administration of forest resources. Improving the forest law that prevents possible forest development is also needed. At the same time, the policy indicates the need to develop education-related social groups through forest extension programs.

To secure the wood required by all social groups, forest policy emphasizes the need for incentives for people who would establish tree farming or fuelwood plantations on any possible sites. The policy also recommends forming an integrated wood-industry network and searching for other materials suitable as substitute wood products.

NEED FOR A REFORESTATION PROGRAM

Regarding experimental trials, the first plantation was established in 1906. *Tectona* was planted in association with upland rice in the so-called form of agroforestry. To date, the RFD has successively established man-made plantations, with a total planting area of 0.3 million hectares. The FIO has three main types of planting programs--i.e., based on the FIO budget, by concession fee of FIO, and by provincial forest company budget. FIO has 35 plantation units, with an annual planting area of 5,600 hectares. The total planted area of FIO was 50,176 hectares in 1982. The Thai Plywood Company, a state-owned enterprise, has planted about 2,700 hectares in five plantation units. There are also other forms of tree planting created by other government organizations (see Table 1).

Table 1. Tree planting by Thai government agencies through 1983

	Type of tree planting (ha)			
Year	Industrial plantation	Environmental plantation	Replanting in poor conserved forest	Planting by using concession fee
1978	99,083.52	33,312.80	29,976.16	30,980.00
1979	22,543.52	11,855.20	14,447.04	13,393.92
1980	38,795.68	12,880.00	15,833.60	13,887.04
1981	15,153.60	11,808.00	14,541.44	11,216.80
1982	9,004.80	5,600.00	4,896.00	12,883.68
1983	8,975.20	5,600.00	4,816.00	12,862.72

Due to the shortage of fuelwood and wood supply for industry, farmers can expect to earn more by actively planting tree species on any available land.

CHOICE OF TREE SPECIES

Generally, the trees selected for planting should be based on native species grown in various parts of the country (Table 2). Evaluation of existing plantations revealed that the number of native and exotic trees planted was 88 species (Table 3). Types of tree planting were also indicated, including those planted for multiple uses. However, many of these tree species have been rejected due to slow growth, poor form, or susceptibility to biotic injury.

In exceptional cases, trees have been selected for planting because of easy and cheap seed collection, and in some cases, good growth. The question of how to use the end product effectively still remains unsolved. It was also found during the course of study, with the exception of *Tectona*, *Eucalyptus*, and *Pinus*, that most tree species have been planted on a small scale and scattered over the planted areas. This has limited the possibility of managing the plantations for industrial purposes.

Table 2. Highly commercial tree species from natural forests in Thailand.

Species	Regions
Afzelia xylocarpa	N, E, NE, C
Ailanthus fauveliana	N, E, C, S
Chukrasia velutina	N, C, S
Dalbergia cochinchinensis	E, NE, C, S
D. cultrata	N, NE, C, S
D. dongnaiensis	N
D. siamensis	N, NE, C, S
Dipterocarpus	N, E, NE, C, S
Fagraea frangrans	N, E, NE, S
Hopea sp.	N, NE, C
Intsia bakeri	E, S
Manglietia garrettii	N
Mesua ferrea	N, E, NE, C, S
Michelia sp.	N, E, NE, C, S
Millettia leuchantha	N, C, S
Pinus kesiya	N, NE, C
P. merkusii	N, NE, C
Shorea curtisii	S
S. henryana	E, C, S
S. obtusa	N, E, NE, C
S. parvifolia	S
S. siamensis	N, NE, C
Sindora coriacea	S
Tectona grandis	N, E, NE, C, S
Xerospermum intermedium	E, NE, S

C = central
E = east
N = north
NE = northeast
S = south

Table 3. Trees selected for planting in Thailand.

Species	Type	Form of planting				
		Industrial plantation	Farm wood-lots	Environmental plantation	MPTS	Other
Acacia auriculaeformis	E	*	*	*		
A. catechu	N		*		*	
A. mangium	E	*				*
A. siamensis	N		*	*		
Adina cordifolia	N					*
Afzelia bakeri	N					*
A. xylocarpa	N					*
Albizia falcataria	E	*				
A. procera	N					*
A. lebbek	N					*
Aleurites montana	N	*			*	
Alstonia macrophylla	N	*				
Anacardium occidentale	E				*	
Anthocephalus chinensis	N	*				
Azadirachta indica	N	*			*	
Bambusa arundinaceae	N				*	
Bauhinia sp.	N					*
Bombax insignies	N	*			*	
Broussonetia papyrifera	N	*			*	
Butea monosperma	N					*
Calophyllum inophyllum	N					*
Calotropis gigantea	N					*
Cassia fistula	N					*
C. siamea	N		*		*	
Casuarina equisetifolia	E	*	*	*		
C. junghuhniana	E	*	*	*		
Ceriops roxburghiana	N	*			*	
Chichona ledgeriana	E				*	
Corypha umbraculifera	N				*	
Cotylelobium lanceolatum	N					*
Dalbergia cochinchinensis	N	*				*
Delonix regia	E			*		
Dipterocarpus alatus	N	*				
D. obtusifolius	N	*				
D. turbinatus	A	*				
Eucalyptus camaldulensis	E	*	*	*	*	
E. deglupta	E	*	*	*	*	
E. tereticornis	E					*
E. citriodora	E					*
E. alba	E					*
Fagrea fragrans	N	*				*
Garuga pinnata	N					*
Gliricidia septum	N				*	
Gmelina arborea	N	*			*	

E = exotic
N = native

Table 3. Continued.

Species	Type	Form of planting				
		Industrial plantation	Farm wood-lots	Environmental plantation	MPTS	Other
Homalium damronggianum	N					*
Hopea odorata	N	*				*
Hydnocarpus anthelmintica	N					*
Intsia bakeri	N	*				*
Irvingia malayana	N	*				
Jacaranda filiafolia	E			*		
Lagerstroemia calyculata	N			*		
L. macrocarpa	N			*		
L. tomentosa	N			*		
Lannea grandis	N	*		*		
Leucaena leucocephala	E	*	*		*	
Litsea grandis	N					*
Mangifera indica	N	*			*	
Melaleuca leucadendron	N				*	
Melia azedarach	N	*		*	*	
Mesua ferrea	N					*
Millingtonia hortensis	N					*
Parashorea stellata	N	*				
Parkia speciosa	N				*	
Peltophorum inerme	N	*	*			
Pinus caribaea	E	*			*	
P. kesiya	N	*			*	
P. merkusii	N	*			*	
P. oocarpa	E	*				
Pterocarpus indicus	E	*			*	
P. macrocarpus	N	*			*	
Rhizophora sp.	N			*		
Samanea saman	E	*	*		*	
Sandoricum indicum	N				*	
Semecarpus curtissii	N					*
Sesmania grandiflora	N				*	
Shorea talura	N					*
Sindora siamensis	N					*
Spondias pinnata	N				*	
Sterculia foetida	N				*	
Swietenia macrophylla	E	*				
Tabebuia pentaphylla	E			*		
Tamarindus indica	N				*	
Tectona grandis	N	*				
Terminalia catappa	N			*		
Tetrameles nudiflora	N	*				
Thyrostachys siamensis	N	*		*	*	
Xylia kerrii	N	*				
Zollingeria dongnaiensis	N					*

E = exotic
N = native

Table 4. Species selected by 24 regional forest offices in Thailand.

Species	Rank
Eucalyptus camaldulensis	17
Tectona grandis	15
Acacia auriculaeformis	15
Leucaena leucocephala	12
Gmelina arborea	11
Pterocarpus macrocarpus	10
Melia azedarach	8
Peltophorum dasysachis	6
Anacardium occidentale	5
Acacia catechu	5
Azadirachta indica	5
Xylia kerrii	4
Afzelia xylocarpa	4
Rhizophora sp.	3
Casuarina equisetifolia	3
Dipterocarpus alatus	3
Parkia javanica	3
Acacia mangium	2
Cassia siamensis	2
Bombax sp.	2
Hopea odorata	2
Dalbergia cochinchinensis	2
Swietenia macrophylla	2
Pinus kesiya	2
Chukrasia velutina	2
Parkia speciosa	2
Cassia garrettiana	1
Fagraea fragrans	1
Bruguiera cylindrica	1
Litsea grandis	1
Alstonia macrophylla	1
Ceriops sp.	1
Albizia procera	1
Spondias pinnata	1
Pithecellobium dulce	1
Sindora siamensis	1
Mangifera indica	1
Ailanthus triphysa	1
Casuarina junghuhniana	1
Pinus merkusii	1
Intsia palembanica	1
Calamus caesius	1
Delonix regia	1

As the number of trees selected for planting was relatively high, questionnaires were sent to 24 regional forest offices for the purpose of listing the 10 most favored species for plantation establishment (see Table 4). A study was also conducted on the tree species selected for research by 81 foresters and scientists directly or indirectly responsible for tree planting (see Table 5).

Table 5. Top 10 species selected for research by 81 foresters/scientists.

Species	Rank	
	Present	1986-91
Eucalyptus camaldulensis	48	37
Tectona grandis	32	20
Acacia auriculaeformis	32	24
Leucaena leucocephala	27	10
Melia azedarach	27	20
Pinus kesiya	18	18
Azadirachta indica	15	22
Bambusa	14	13
Dipterocarpus alatus	14	29
Acacia mangium	13	16

Based on Tables 4 and 5, there is a similarity in choice of tree species by those who work in theoretical and practical fields. However, foresters and related scientists still wish to maintain trees of interest. *Eucalyptus camaldulensis* was the major selected tree species. Surprisingly, 29 researchers selected *Acacia mangium* as a promising species for the next five years.

MPTS

The Asian regional workshop, Increasing the Productivity of Multipurpose Tree Species, held in Kandy, Sri Lanka in 1984, recommended a list of priority species for moist/wet, arid/semi-arid, and mountainous zones. Of the 10 species networks proposed, the following are of interest to Thailand: *Acacia*, *Bambusa*, *Albizia*, *Leucaena*, *Eucalyptus*, *Azadirachta*, and *Melia*. As reviewed by 81 Thai scientists, the *Acacia* species network received highest priority, followed by *Eucalyptus*, *Azadirachta*, *Melia*, *Bambusa*, *Albizia*, and *Leucaena*.

PLANTATION ESTABLISHMENT PROBLEMS

Land Availability

Land availability for large-scale tree planting is limited because of land encroachment. Foresters responsible for tree planting must confront the rural poor, who need more land for growing cash crops and staple foods. There are still 0.5 million landless families and another 1 million families that rent land for growing farm products. There are also indications that trees are being cut by the rural poor in the conserved forest and plantation areas to clear land for growing cash crops to meet basic needs.

Regional forest officers indicated that villagers in some areas still prefer growing fruit or rubber trees to growing economical or fast-growing trees. Moreover, the available land for tree planting is infertile and involves severe environmental or political problems.

The provincial forest companies established plantations, using the logging concession fees. However, these companies are still faced with the problems of land availability for their annual planting programs.

The Sixth National Economic and Social Development Plan recommends leasing larger areas of poorly-producing forest land to tree farmers. The plan also recommends growing trees on any available land, particularly on the edges of farm area and in backyards. The planting of trees to improve poor soil, good site preparation by tractors, and the application of nitrogen fixing trees, as well as compost and chemical fertilizer, are the main tasks to be carried out to solve land problems.

Budget

It was found that the budget for tree planting was generally inadequate, as claimed by most regional forest officers. The annual planting budget provided by the government is sometimes irregular and often prevents good planning. The bureaucratic system also affects proper management of existing plantations. Researchers characterized the budget supporting research and development programs as relatively small. They strongly recommended that donors support practical research programs.

Provincial forest companies mentioned that they had no budgeting problems. When land is not available for planting, they deposit in a bank the concession fee for tree planting.

Tree farmers asked the responsible agencies to ease the planting program by providing them with incentives, particularly soft loans. The rural poor require free seedlings and often inquire about price guarantees and the marketing of end products.

Seed Used

Since species selection is not taken into serious consideration, seeds used have been collected from unclassified seed sources. Some regional forest officers claimed to have no problems in seed used, but the evaluation was based mainly on quantity rather than quality. Some did have problems of recalcitrant seed and did not preserve genetic material in the form of seedlings. Buying seed form other agencies maintains the confusion about seed quality.

Based on a survey of the existent problems at 44 nursery centers, results showed that seed used was collected primarily from unclassified seed sources.

Sixteen provincial forest companies obtained seed by buying from forest agencies (38.10%), the private sector (23.81%), by direct collection (33.35%), and by importing from foreign seed companies (4.76%). Researchers recommended mass selection and collection of seed [illegible] qualified seed sources. Knowledge on seed processing and storage is needed.

Seedlings are usually grown in plastic bags, preferably made of black polyethylene. Seedling containers are now being introduced into the market so that cheap and healthy seedlings can be produced. The soil medium varies according to the availability of materials at the nursery sites. Sand, forest topsoil, ash, burnt rice husks, and rice straw are commonly used. Further research on seedlings and cuttings is sorely needed.

Management of Planting Area

Lack of machinery prevents foresters from better managing planting areas. This is common to most state-owned plantations. Limited budgets also constrain proper management programs because, five years after planting, the budget for plantation maintenance is terminated. This is one of the major reasons why tree farmers grow superior plantations.

The main problems affecting the existing plantations were identified as forest fire, poor site, damage caused by several biotic enemies, and lack of silvicultural knowledge and qualified personnel.

MPTS RESEARCH PRIORITIES

Forestry research needs in developing countries have been summarized by the World Bank and FAO (1981). The four research priority areas identified were forestry in relation to: agriculture and rural development, energy production and use, management and conservation of existing resources (mainly natural forest), and industry. Callaham and Buckman (1981) also listed key areas needing future research programs, with more emphasis on lesser-known species, critical forest types, reforestation in leftover areas, growth and yield of natural forests and fast-growing trees, logging and use of waste during processing, etc. High-priority research areas recommended by USAID at the Asia/Forestry/Fuelwood Research and Development Planning Conference in Bangkok (1984) were (in order of priority): species trials, nursery techniques, provenance trials, genetics, spacing trials, reclamation of wastelands, establishment techniques, grazing/fodder, shelterbelts, nitrogen-fixing trees, and biomass productivity. At the 1984 IUFRO meeting at Kandy, high-priority research activities were identified in more detail (Shea and Carlson 1985, Burley and Stewart 1985). These research topics were ranked according to highest-to-lowest priority and included silvicultural and management research, genetic improvement of MPTS, choice of species, design of agroforestry systems, cost-effective techniques for nursery-stock production, use of nitrogen-fixing organisms with MPTS, cost-effective techniques for tree establishment and maintenance, pest-management systems, and utilization studies.

In the present study, 81 researchers were interviewed on the major ongoing research programs and those to be conducted in the next five years (Table 6).

Table 6. High-priority research conducted by 81 Thai scientists.

Rank	Research priorities	
	Present	1986-91
1	Planting techniques	Wood utilization
2	Growth and yield	Physiology
3	Seed	Agroforestry
4	Seedling	Tree improvement
5	Agroforestry	Seedlings
6	Plantation management	Biomass
7	Weed control	Fuelwood
8	Fertilization	Seed
9	Biomass	Growth and yield
10	Fuelwood	Genetics
11	Tree improvement	Wood properties
12	Wood utilization	Planting techniques
13	Soil	Logging and transportation
14	Biotic enemies	Anatomy
15	Wood properties	Urban planting
16	Physiology	Biotic enemies
17	Logging and transportation	Soil
18	Genetics	Fertilization
19	Conservation plantations	Conservation plantations
20	Urban planting	Weed control

Currently, most Thai forest scientists are satisfied with research activities. However, 20 of them claimed that the present research system is unsatisfactory. They stressed that forest research policy is inconsistent and undirected, resulting in research programs with widely varying aims and difficulty in practical application of research results. They acknowledged that researchers have been active in the

programs but claimed that support from official organizations is relatively low. Researchers lack funds and teams capable of tackling the problems. Because they have limited contact with related organizations, dissemination of information is prevented. The majority of researchers considered it necessary to improve the scientific atmosphere in forestry research programs.

REFERENCES

Bhumibhamon, S. 1983. Present views of senior forest administrators on forest resources conservation. Mimeograph, 12 p.

_____. 1986. The environmental and socio-economic aspects of tropical deforestation. Bangkok: Kasetsart University Faculty of Forestry, 105 p.

Bhumibhamon, S. and L. Atipunampai. 1983. Present views of regional forest officers and provincial forest officers in northern area on forest resources conservation. Mimeograph, 12 p.

Bhumibhamon, S., T Vajirajutipong, and T. Viriyaratanaporn. 1984. Present views on natural resources conservation of chiefs of villages in some northern areas. Conserv. 7: 52-59.

Bhumibhamon, S., T. Vajirajutipong, T. Viriyaratanaporn, A. Parnnakapitun, L. Atipunampai, and S. Changtragoon. 1983. Present views of villagers on the natural resources conservations in the northern area. Mimeograph, 21 p.

Burley, J. and J.L. Stewart. 1985. Increasing productivity of multipurpose species. Vienna: IUFRO, 560 p.

Callaham, R.Z. and R.E. Buckman. 1981. Some perspectives of forestry in the Philippines, Indonesia, Malaysia, and Thailand. USDA Forest Service, 66 p.

Mungkorndin, S. 1981. Forests as a source of food to rural communities in Thailand. FAO Regular Programme No. RAPA, pp. 52-69.

Panpiamrat, K. 1984. Thai rural areas: progress and reverse development. (In Thai.) Bangkok: Saengrung Press, 291 p.

Shea, K.R. and L. W. Carlson. 1985. Increasing productivity of multipurpose tree species: a blueprint for action. Washington, D.C.: USDA Forest Service, 100 p.

TDRI. 1986a. Forest and mangrove resources. In Thailand natural resource profile. Mimeograph, 67 p.

_____. 1986b. Land resources. In Thailand natural resource profile. Mimeograph, 141 p.

USAID. 1984. Asia/Forestry/Fuelwood Research and Development Planning Conference. Draft final report. Bangkok, 65 p.

Wacharakitti, S., P. Boonnorm, P. Sangvantam, A. Boonsaner, C. Silapatong, and A. Songai. 1979. The assessment of forest areas from LANDSAT Imagery. For. Res. Bull. 60, 22 p.

World Bank and FAO. 1981. Forestry research needs in developing countries--time for a reappraisal. 17th IUFRO World Congress. Kyoto, 50 p.

Integrating the Social Sciences into MPTS Research Networking

William R. Bentley

Senior Program Officer/Agroforestry, Winrock International

Integrated or multidisciplinary research often is advocated among both agricultural and forestry professionals. Few successful cases can be cited, however, because of the difficulty of researchers agreeing on a common set of problems. Improvement of this process may be the major payoff of integrating the social sciences into MPTS research networking.

The social sciences are concerned with understanding people, their behavior, and the consequences of their activities. The traditions, methods, and results of various kinds of social science inquiries are at least as varied as those of the natural sciences. Economics often draws upon classical physics for its models, and theory tends to precede empirical work. Fields such as anthropology, sociology, and social psychology have a less defined body of accepted hypotheses, and therefore generally start with observations before reaching theoretical constructs.

The richest research, as might be expected, integrates disciplines and methodologies. A common ground of almost all fruitful social science, however, is that inquiry is as much concerned with social processes as with social consequences. How markets work is thought to affect market consequences; the procedures of a political system are hypothesized to affect political consequences; household processes are believed to affect the distribution of material goods and power among household members. One lesson of this common ground is that the way we conduct MPTS research probably affects the quality of our results. That is the essential premise of all discussions on research methodology or process.

PRIMARY CLIENTS

MPTS improvement is an applied field of research defined by the clients who will use the results. Resource-poor farmers are the group most interested in MPTS. In general, wealthier farmers, industrial owners, and public agencies are more concerned with single-purpose crops, forage, or timber species. The resource-poor household, which usually is composed of a mix of subsistence and cash activities, will benefit most by substantial improvement in MPTS productivity (Chambers 1983, Bentley 1985).

The problems of the resource-poor household can be defined in several dimensions. First, because capital is quite scarce, it is difficult to invest. Trees are a useful form of investment because the initial cost is relatively low, growth accumulates and is readily stored, and the overall technology is relatively simple and generally understood by rural people.

Second, labor is relatively more abundant than capital, but time is often the limiting factor, especially for women. The addition of a new set of activities--tending and harvesting MPTS--often requires giving up some other activities. Where tree scarcity has led to long hours of fuelwood or fodder gathering, adding MPTS can result in a net saving of time that can be allocated to other tasks. However, in many cases, an initial consequence of MPTS improvement will be a net increase in total time requirements that likely falls disproportionately on particular household members. Where MPTS are subsistence crops, women are likely to be responsible for tending and harvesting; where MPTS produce cash, men by tradition may be responsible.

Third, resource-poor householders, who are more severely affected by adverse events than are better off rural people, are used to managing complexity. Even small farmers have many crops and activities to provide for the subsistence and cash necessities. Consequently, complexity may be an advantage for the poor.

Fourth, resource-poor farmers often can be described as "marginalized people on marginalized lands." Beyond the capital, labor and complexity characteristic of being economically and politically marginalized, the most severe constraint usually is the marginal productivity of their lead resources as measured by food crop output per hectare. Improvements in productivity require careful definition in terms of current and prospective client needs and resources.

Worldwide we observe tropical deforestation and degradation of former grasslands and forests that are now under subsistence farming. Population growth, common-access property rights, archaic timber sale laws, and traditional perceptions of trees as public property are among the many factors that contribute to this downward spiral in the productivity of marginal agricultural lands. MPTS and other agroforestry components are a means of stopping this degradation and initiation of a rehabilitation process. Where markets are allowed to function reasonably well, growing scarcity of wood, fodder, and other tree-based products alone may provide the necessary incentive to grow MPTS. The social values of farm forestry, in many cases, justify public subsidies of seedlings and other inputs, especially information.

At the macro or policy level, the institutional context is set for the resource-poor farmer. This context often includes vague property rights for private lands and disproportionate dependence on common access to public lands for grazing, fuelwood, and other necessities. Credit may be limited by class, caste, or other factors that have little impact on financial risk. Input subsidies and extension/outreach programs may serve the rural rich much better than the rural poor. Changes there and other adverse factors in the context of resource-poor farmers require policy analysis and political choices.

To understand the resource-poor household and its context, social science research is needed to define client problems and to conduct effective applied research to solve problems. A MPTS research effort to increase fuelwood productivity is of little use if fodder is the scarce household resource. MPTS research to improve subsistence productivity will not help households well into the cash economy. And the reverse examples are equally true.

The social sciences will not only assist the biological sciences in defining a more relevant research agenda, but will lead to a more specific social science research agenda as well. Clearly, improved MPTS productivity will help resource-poor farmers, and understanding the resource-poor household will lead to more targeted biophysical resource and outreach programs. Given the social complexity of rural poverty, especially in ecologically stressed areas and marginal lands, social changes in micro and policy factors are even more likely to improve the consequences of MPTS productivity.

RESEARCHERS

Standardized MPTS network research improves methodology and results. Applied research is especially demanding in terms of methodology or process. The critical questions of scientific method are honed further by pragmatic considerations that are relevant and valuable to particular clientele. Consequently, there is an interplay between questions of cause and effect and those of decision criteria and responses of alternatives. Agroforestry research and problem solving, especially by people with different disciplinary skills and perspectives, is complex. Effective group process is seldom taught in the highly competitive training crucibles that produce most MPTS scientists. However, it is the disciplined group question-answer skills that are especially valuable to MPTS research methodology.

Along with the many research methods of the biophysical disciplines, various social science methods can add to the total "kit of tools" available to MPTS scientists. Economics, with its strong conceptual base, provides some useful frameworks for design and interpretation of results. The production function--the physical output responses and manipulating inputs, including time--is a conceptual device that enables researchers to measure technical efficiency and separate it from economic efficiency. And it forces the research design to yield results that are useful to the client.

Applied anthropology and rural sociology seldom assume knowledge about the household or village. Design of instruments--from participant observation, to ethnographic measures, to questionnaires for measuring specific household perceptions and behaviors--is a critical skill set of these fields. The most successful social forestry programs, such as community forestry in Nepal and farm and energy forestry in Pakistan, are based on rigorous analysis and interpretation of primary social data gathered by using such instruments.

Although it is so commonly accepted as to sound trivial, the progress of science is dependent upon the sharing of results. Sharing ensures that research builds on itself and, perhaps more critically, constantly checks itself for error and objectivity. Networking is a means of facilitating sharing results and the social benefits of applied science.

OUTREACH PROFESSIONALS

Perhaps the most obvious secondary clients are extension or outreach professionals. Transfer of technologies and other research results is most effective if information is packaged in terms of the primary clients' perception of their problems. For example, because resource-poor people are risk adverse, MPTS information must include risks of seedling mortality, low growth, and poor yields (fruit, fodder, etc.). Also, understanding the client will lead to more effective selection and use of media. For example, demonstrations and other visual media generally communicate better than verbal media.

Social marketing--the use of mass marketing techniques for socially desirable goods and services, such as oral rehydration therapy and family planning--has yet to be used for social forestry. Social marketing may be especially useful in convincing farmers to adapt more productive agroforestry land-use practices and to gain general public support for policy changes that favor small landowners in marginal areas.

POLICY MAKERS

Because MPTS are grown at the household and garden-plot level, it is not obvious to many MPTS researchers and outreach professionals that the critical problems may be at the macro or policy levels. The symptoms of deforestation and land degradation are most easily seen at the micro level--e.g., local overgrazing, specific poor timber harvesting practices, etc.--but these causal mechanisms are social institutions, such as timber sale policies, grazing rights or other tenurial issues. Diagnosis of institutionally-caused problems, design of improvements, and predictions of the consequences of policy changes are results of social science research of use to policy makers.

POLICY DIAGNOSTICS

An example of macro or policy diagnostics would be the cause of India's wasteland problems (Romm 1979, Bentley 1984). Out of 266 million hectares in rural India, 100-150 million are seriously degraded. The symptoms are serious reduction of actual annual productivity relative to potential, soil losses, and water runoff.

In some cases, the obvious cause is mismanagement of irrigation water with consequent water logging or salinization. Woody perennials often are part of effective rehabilitation of these 20-30 million hectares. However, most of the causes are more complex and subtle. Some areas have been traditional grazing commons for decades if not centuries, but many were scrub jungle or high forest within living memory. Some were cleared for cultivation or to avoid losing title to the state as Famidar estates were taken over after independence. Others were initially harvested by contractors for the commercial timber and then grazed and exploited for fuelwood. A factor common to almost all these degraded lands is overgrazing, at least in the fallow season. Indeed, that is the critical clue to the institutional cause of India's wastelands--common-access property rights. The standard understanding of common property problems is that overharvesting occurs. While that is true, the more critical point is that neither public nor private investment for future productivity occurs. Few land-use systems maintain productivity over time without both control of harvest rates and reinvestment for future output.

The design of better systems to manage common-access properties is not easy. In some cases, the solution is tied to technology, such as dry-season irrigation or intercropping patterns that extend the crop growing season. In other cases, local organizations can be created to control use and make investments. In a few cases, transfer of lands from public commons to private ownership is a feasible solution. In all cases, some shift in policy, at least at the interpretive level, is needed.

MPTS, no matter how desirable, will be not be planted and tended if peasants cannot expect to reap the benefits of their efforts. Common-access rights affect far more activities than MPTS, but unless researchers and policy makers deal with property rights issues, MPTS will not be useful to resource-poor farmers in South Asia.

VILLAGE DIAGNOSTICS

Several social forestry projects in Asia have either been ineffective or slow to take hold because forestry departments have not discovered villagers' preference for tree species. MPTS improvement is, in fact, a learning response about the needs of villagers. In specific areas, however, the MPTS selected by researchers may not be what the villagers want or think they want. Thus, the social science instruments useful for understanding the primary client are specifically useful for diagnosing the local MPTS needs. Improved understanding of time allocation (Bennett 1983) often will help direct research toward the MPTS values of greatest potential benefit. Fuelwood is critical where much time is spent gathering fuelwood; fodder where animal ownership and use is constrained by dry-season protein needs; etc.

As with the macro or policy level, the purpose of social science diagnostics is to understand causal forces. The failures of social forestry to date have resulted from professionals treating symptoms rather than causes.

SUMMARY

Social scientists can help MPTS research teams in several ways. First, they can help select the most important problems as defined by the resource-poor farmers. Second, they can help improve the research process and management. Third, they can provide information to accelerate and improve the quality of research transfer to the primary clients. Finally, they can help policy makers improve the institutional context for MPTS growing and harvesting.

REFERENCES

Bennett, L. 1983. Preliminary analytical framework for proposed study on the role of women in income production and intrahousehold allocation of resources as a determinant of child health and nutrition. Draft paper prepared for WHP/UNICEF Seminar on Determinants of Infant Feeding Practices, December 5-9, 1983. Geneva, 22 p.

Bentley, W.R. 1984. The uncultivated half of India: problems and possible solutions. Ford Foundation Discussion Paper No. 12. New Delhi (in press).

_____. 1985. Future forest design: economic aspects. In Attributes of trees as crop plants. eds. M.G.R. Cannell and J.E. Jackson, pp. 527-544. Huntington, U.K.: Institute of Terrestrial Ecology, Natural Environmental Research Council.

Chambers, R. 1983. Rural development: putting the last first. London: Longman, Inc., 246 p.

Romm, J. 1979. The uncultivated half of India. New Delhi: Ford Foundation, 47 p.

Global Research Networking

Introduction

The global research component will help develop, collect, analyze, and synthesize research information of the F/FRED network and will develop data bases for technology assessments and research models. Through global linkages with CATIE, ICRAF, and other organizations, an integrated informational data base will also be developed.

Principle activities include assistance in research design of network trials, data base management training and regional coordination. These activities will be carried out under subcontracting arrangements between Winrock International, prime contractor, and the University of Hawaii.

In a broad sense, data base management involves information collection and knowledge generation; information storage, retrieval, and knowledge preservation; and knowledge transmission and utilization. F/FRED's microcomputer DBMS is conceptualized as: an experiment data base resulting from the network trials, where standardized methodology is used and the same MDS is collected; and an informational data base that incorporates several sources of information, such as literature, syntheses of past research results from other data bases, and observations of MPTS specialists globally.

The major activity of the global research component will be research dealing with F/FRED network collaboration and related data bases. The concept of a MDS will be used to standardize the collection, input, and analysis of collaborator research data. This experiment data base will provide collaboration with an analysis of network data on MPTS performance and BM site data for longer-term development of computer models. Weather, soil, and socio-economic data will be combined with MPTS performance data and MPTS information from other regions to constitute a comprehensive data base adequate for technology assessments and predictive modeling. The results will form the basis for development of relevant guidelines, state-of-the-art manuals, and training materials with a focus on key topical areas, such as species selection for priority use, application of DBMS and modeling.

From the viewpoint of an F/FRED collaborator, the DBMS can be seen as an information and decision support system with the ability to input, organize, and store data; retrieve, display, and analyze data; develop and validate prediction models; and assess MPTS technology transfer. The user-friendly support system will allow timely decision making based on available research data and other supporting information. The system and the specialized materials developed from and in support of it will be used in implementing a series of workshops to focus on data base management, modeling feasibility, and evaluation and exchange of model information.

Coordination with Asian collaborators and other regional counterparts will assist in designing minimum standards for data collection, the development of systematic methodologies, and a global information data base. The long-range goal is an enhanced range and distribution of environmental gradients and a reduced need for external site-specific experimentation.

Overview of DBMS for MPTS

Dietmar W. Rose and Foster B. Cady

Professor, University of Minnesota College of Forestry, St. Paul and F/FRED Research and Development Director, respectively

Successful forestry research and development projects require readily available, easily accessible, and precisely analyzed experimental information from well-planned experiments. Such an information support system is part of the F/FRED effort to develop DBMS and scientific networks that would facilitate the efficient exchange and transfer of information on forestry and MPTS research among scientists and regions of the world (Rose 1984). The first phase of this information exchange is the development of an Asian network. The development of integrated data bases from coordinated experiments and other MPTS information is one key aspect of the F/FRED Project. The ideas presented in this paper are offered to begin a constructive dialogue among Asian scientists, administrators, and practitioners about approaches to coordinate research planning, experimentation, and transfer of technology resulting from this research.

DBMS CONCEPTS

General

Advances in microcomputer and electronic information transfer technology and associated software developments, especially spreadsheet and data base management packages, have raised the awareness of planners and analysts to questions of efficiency and effectiveness in generation, storage, and retrieval of data and information. This new technology permits efficient organization of data and information exchange. These advances in hardware and software do not eliminate the need for structuring data and information.

Timely and efficient access to organized information improves decision making. Information must be relevant to management decisions in MPTS production systems and must be transferrable efficiently to the various users, including project managers, scientists, extension agents, practitioners, administrators, and policy makers. Efficient transfer means transfer of timely information in a form that makes understanding and implementation easier. Technology transfer is aided by using condensed, well-organized, and readily accessible summaries of key information relevant to a specific problem and aimed at previously identified end users. Technically, this is best accomplished by developing a MIS. According to Hicks (1984), a MIS is a formalized, computer-based system able to integrate data from various sources to provide the information necessary for management decision making. One of its key components is a DBMS, a program serving as an interface between applications programs and a set of coordinated and integrated physical files called a data base (Hicks 1984).

Justification for MPTS Data Base Establishment

Efficient technology transfer is precluded by many standard forms of information distribution, e.g., unpublished, in-house reports or scientific publications. The former are often overburdened with technical detail and background information; the latter are often aimed only at a small, highly-trained audience or reach only a small audience because of the style of presentation. Improved formats for reporting, transferring, and disseminating information need to be developed.

Specific reasons for supporting data base development:

- Reduces the cost of information retrieval and transfer over traditional systems
- Makes information available on a more timely basis
- Forces abstraction of important information from available sources for efficient storage and transfer
- Helps identify major gaps in information and direct research and data collection efforts into high priority areas
- Facilitates systematic analysis of major problems and questions
- Standardizes data collection and reporting of research findings
- Improves data quality control through standardized procedures, including error checking programs
- Supports integrated planning activities and integration of different types of information, e.g., socio-economic and biophysical
- Helps coordinate related research and development projects
- Expedites appropriate management decisions and reduces likelihood of poor, uninformed decisions
- Avoids duplication of research and data collection efforts
- Enhances networking, training, and technical backstopping
- Reduces language communication problems and translation costs
- Reduces risk of information being lost

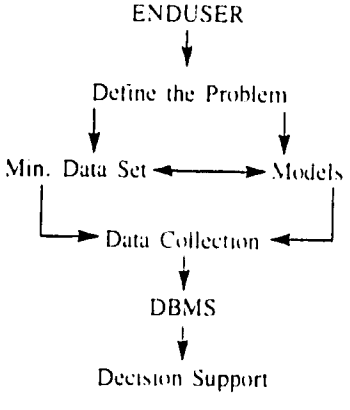
Many of these considerations are relevant also for any rational project management approach. Data base management and rational project management, therefore, are synergistic and complementary.

Data Base Organization

In organizing the MIS/DBMS, various tasks need to be implemented. Guidelines for assembly and organization of available data relevant to specific resource development problems need to be developed. Only after these guidelines have been established can the process of identifying additional inventory needs begin. Data collection must be problem-driven and never an end in itself.

A MIS must begin by defining the "necessary and sufficient" conditions for the data, and it should also specify the requirements of its structural format. Raw data become the inputs into models for prediction and explanation. The types of models desired by decision makers and other users need to be identified before determining which data need to be collected. Thus, collection of MDS of raw information is requisite for modeling. The types of models to be developed, on the other hand, determine the MDS that is needed (Figure 1). A MDS is the essential weather, soil, socio-economic, and MPTS information needed to model performance.

Figure 1. Linkage between MDS and modeling.



Whether organizing existing information or information to be generated in new research, a logical structure greatly helps this task. Distinct frameworks for data organization need to be developed since information is required at different levels of decision making.

Research Coordination for MPTS

Since the bulk of scientific knowledge is being generated at the individual project level, the major responsibility of data organization must be with project leaders. Projects should emphasize immediate analysis of data to make information available quickly. This will help plan future work by identifying important variables and relationships (Figure 1) and avoid duplication of work, especially if information can be shared.

Data are transformed into information for decision making using scientific methods and models, e.g., simulation, statistics, and economics. The outputs to be developed by research need to be clearly identified before setting up experiments and before identifying the variables that need to be measured for developing predictive and/or explanatory models. The key end uses of growth and yield models for MPTS are 1) matching species and sites to improve survival and growth and 2) quantifying the trade-offs between management systems.

It is therefore necessary to understand the relationship between key dependent and independent variables before setting up experiments. Once these outputs are known, a MDS needs to be developed, i.e., the variables that need to be observed and measured in the field. Data recorded in the field should be directly transferred to the data base for the MPTS network.

For accelerating the development of predictive models for the major outputs of MPTS systems, scientists should agree to common standards for experimentation, including a minimum set of measurement variables. They also should coordinate their experiments to cover the extreme sites for which information is especially s[illegible] coordination will also be required to ensure that research focus on the most important species and management approaches and that less emphasis be placed on SET. An adequate range of management treatments need to be covered, such as properly controlled spacing trials, pruning, coppicing, and lopping trials. A better range of trials will be needed on arid sites and in higher altitudes, and genetic improvement and good provenance selection are needed. To increase the efficiency of experimentation, SET and provenance trials can be combined via efficient experimental designs. There must be a common core of germplasm, treatments, and response data common to the cooperators to which each institution can add other species and treatments.

MDS

A clear frame of reference is needed to identify the gaps in current information and to coordinate the efforts that could fill these gaps in the shortest possible time through coordination and cooperation among Asian scientists. Uniform standards for implementing MPTS experiments need to be established to permit global exchange and transfer of scientific information on MPTS. These standards and MDS should be developed jointly by network participants of cooperating countries to ensure production of useful information and to gain acceptance of these standards. Detailed technical guides for the establishment, measurement, analysis, and model development of MPTS production systems need to be developed and distributed. The development of MDS and field guides is one of the central tasks of the F/FRED network.

The formulation of MDS, the appropriate forms and formats for recording data, and the design of the logical data structure for eventual linkages of all relevant data are the most time consuming and crucial steps in developing DBMS and MIS. Project staff, scientists, and practitioners should contribute to the design by formulating questions, analyzing what information is required to solve specific problems, and identifying the users of this information and the form in which it should be

made available. Since information related to the biological, economic, and social components of MPTS is needed, MDS will ultimately include a broad array of variables.

The F/FRED Project represents an early opportunity to open a dialogue on MDS for MPTS research among Asian scientists. The final MDS needs to reflect the specific needs of the region and the level of coordination acceptable to the network participants. Questions that will ultimately determine the type of research, the level of cooperation and coordination, and the possible research outputs in the form of various models useful to decision makers include:

1. What are the objectives of individual research programs?
2. What kind of experiments are being carried out (SET, provenance trials, management trials, etc.)?
3. What MPTS outputs or response variables are being measured (fuelwood, fodder, food, etc.)?
4. Are these outputs measured directly or indirectly?
5. Are environmental variables described? If so, which and how?
6. Is there already a conceptual MDS being used?
7. Can MDS be coordinated between countries?

The Central American Fuelwood Project at CATIE and F/FRED are pioneering experiment-based data bases, DBMS, and decision support systems for MPTS (Rose 1985, Rose and Ugalde 1985). MDS, field forms, procedures, and prototype DBMS are expected to be ready in the near future. Four general functional requirements of the decision support system being developed by these projects are: 1) to input, organize, and store all data; 2) to retrieve, analyze, and display the data; 3) to estimate and validate MPTS models; and 4) to assess the prospects for MPTS technology transfer.

At CATIE, experimental MPTS data has been collected in six Central American countries over a wide range of environmental and site conditions and a variety of MPTS production systems (SET, provenance, and management trials and agroforestry systems). This project has worked with over 150 MPTS, of which 15 have been identified as major species for more intensive experimentation. A good set of data exists for about five of them.

Another source of information for development of MDS and field forms is the USAID-supported IBSNAT Project, which has generated a DBMS to support decisions for agrotechnology transfer (IBSNAT 1986 a,b). Information from IBSNAT accelerates the flow of agrotechnology from its original site to new sites with similar environments. Each BM site is capable of generating the MDS for one or more crops. The network of BM sites then provides the range of environmental conditions needed to develop and validate crop models.

Past Versus Current Research

A question that needs to be raised before developing a DBMS for the MPTS network is the desirability of including existing collected information. The answer is complex and depends on the availability of resources, and, more importantly, on whether past data collection efforts conform to established standards for measurement and analysis, including the availability of a MDS. In the case that information is lacking on some variables, the answer depends on the ability to obtain these additional data efficiently. Experience suggests that most information collected in the past for MPTS experiments does not meet MDS standards needed for environmental modeling. This information is therefore not usable for comparative analyses between sites without additional information being collected. The establishment of standard procedures for MPTS experiments will prevent the occurrence of these cases in the future.

If only limited amounts of easily obtainable data are missing to complete the MDS for ongoing or completed experiments, a strong argument can be made for capturing existing data since they often

represent experiments that were established in the past. Such experiments can yield information that new experiments will generate only after several years. The earlier experimental data that meet MDS requirements can be assembled, the earlier it will be possible to develop predictive models that can aid project planning and decision making.

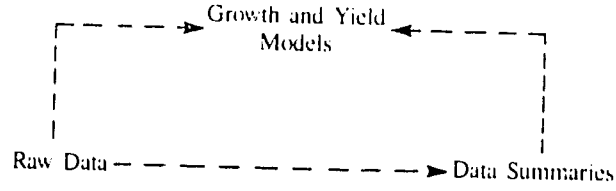
Categories of Data Bases

Information based on measurements and analysis of formal experiments is termed *experiment data base* and is ideally suited for comparative studies of species performance as long as uniform standards for measurement are applied and information is based on standardized geographic and physical descriptions of the site. The experiment data base should be the primary type of data base for F/FRED since it complements the goals of a scientific research network.

Depending on the level of abstraction of information gained from formal experiments, all information at some point could enter into another data base that summarizes, in a highly condensed form, key information on MPTS. We term this an *informational data base.*

In the experiment data base, scientists have access to the experiment data in raw form, i.e., the plot data, including replication of treatments in comparative trials. The possibilities of analyzing subsets of the total data base and of data aggregation and comparison for model development are excellent. In the informational data base, abstraction would have already led to models for prediction of species behavior that have been subjected to rigorous testing and that have been found reliable. Recorded observations on individual demonstration plots located in farmers' fields or plantations might also be included in an informational data base. There is no absolute dividing line between these two types of information systems, and data bases might be made up of elements from both types (see Figure 2).

Figure 2. Possible range of data bases that may be developed.



Only in the ideal case is the informational data base solidly founded on scientific experimentation using standardized, repeatable procedures. Informational data bases exist that are founded not on experiment data but on personal observations, literature surveys, and questionnaires. The role of these more general informational data bases for development and estimation of growth and yield models needs to be carefully studied.

Various special-purpose informational data bases for microcomputers are maintained or are presently being developed by interested organizations. For example, the NFTA data base contains information from the literature on taxonomy, environmental requirements, utilization, silviculture, and wood and forage characteristics for some MPTS. ICRAF maintains a worldwide inventory data base of trees and shrubs useful for multiple land-use systems with special emphasis on agroforestry (von Carlowitz 1986). An ambitious effort designed for minicomputers is being undertaken by Australian researchers at ACIAR. The INSPIRE program, written by the Forestry Department at Oxford University (U.K.), is a user-friendly program for selecting species for inclusion in the initial phase of forest species trials for tropical and subtropical climates. Species data are stored under a total of 21 main features, e.g., rainfall and temperature. Selections are made by successively applying users' requirements and site conditions to any of the features until a final choice is achieved (Webb et al. 1980).

Environmental Description and Modeling

Any information system dealing with a biological production system, such as agriculture or forestry, requires an environmentally or geographically-based reference system. Without the latter, scientific information on performance of specific plant production systems cannot be compared or transferred between locations. An environmental data base relates different kinds of information in forestry, agriculture, and agroforestry research to a common basis of environmental information. For example, soil taxonomy has provided the common language for communicating soil and climatic information to scientists in widely separated countries (MacDicken et al. 1985).

The proposed MPTS data base is organized around three environmental zones: humid tropics, arid and semi-arid tropics, and tropical highlands. The purpose of this environmental data base is to relate different kinds of information on MPTS experimentation to a common basis of environmental information. Information variables in such a system may include location, geology, land form, climate, hydrology, soils, vegetation, fauna, disease, and land use.

Several environmental models that attempt to integrate climatic conditions with existing vegetational patterns exist. The utility of such models is transfer of germplasm and/or cultural techniques from one part of the world to another with a predictable measure of success. A general discussion of these models is presented by McFadden (1984). ICRAF uses the Koppen system in its environmental data base for agroforestry (Young 1983, 1984). The fuelwood project at CATIE is using the system developed by L.R. Holdridge (1947) designed to determine worldwide plant formations from simple climatic data (Ewell and Whitmore 1973).

Based on the experience of the IBSNAT Project with agronomic crops (Silva 1985), propagation and cultural technology associated with MPTS can be expected to be more easily transferred within than across climatic regions. Statistical models can be used to describe the relationship between soil, climate, and management variables, and forestry or agricultural crop yields. Such environmental models may be used to analyze, expand, and transfer MPTS technology.

Multiple Outputs of MPTS Systems

One important feature of MPTS production systems is the ability to produce a variety of outputs, depending on the management objectives. Wood products typically include the commercial stem of a tree, secondary branches cut into posts and fuelwood, and tertiary branches that may serve as an energy source. Leaves may be used as green manure or as cattle feed. Seeds and fruits from the trees are an important source of nutrition for local populations.

While the quantification of the commercial stem of trees on the basis of tree diameter, height, or form is well-established, other components are difficult to quantify because they have not played an important commercial role. F/FRED network participants need to develop the methodology to quantify all components of MPTS production systems that are used by rural populations to help compare and rank alternative tree species and production systems.

Many analyses completed for MPTS systems have involved classical statistical methods, including calculation of statistical descriptors, correlation and regression analysis, and ANOV. Some of the outputs produced from these analyses have been volume tables for the commercial and biomass portion of trees. Growth models also have been produced for some species. Additional information on desirable outputs, i.e., measurement variables and models, needs to be assembled to support the design of the MDS. Field methodologies should be designed to measure these different outputs and related variables so that predictive and possibly explanatory models for decision support can be developed.

BENEFITS

The use of MDS and standardized procedures for measuring necessary variables will ensure that the absolute minimum information for model development and end-user decisions is collected. Principal investigators will be able to carry out data analysis and modeling on larger aggregated data sets and to compare different experiments. Such analyses will produce better models and help MPTS management decision making and information transfer.

One of the main objectives of a DBMS is to provide relevant data summaries of information for making decisions at different levels. The F/FRED DBMS will permit the retrieval of any or all information maintained in the experiment and informational data bases that are being developed.

Establishment of MPTS information data bases will help improve all phases of forest management, e.g., seed procurement and species selection for environmental zones. It should elucidate climatic, biophysical, and social constraints in tree seedling production and establishment and improve nursery operation and stand-management techniques.

Through the development and acceptance of standardized procedures, MPTS research can be coordinated to avoid duplication of effort and to emphasize research of species and ecological areas that have not been adequately covered. Uniformity of data standards will permit the pooling of data for improved modeling of species responses to site and treatment. Information gained from experimentation can be easily transferred and shared among network members. Those who will benefit most from improved MPTS output models will be the network participants that are coordinating their research and agree to share information. With the early availability of such models, research planning should become more efficient and duplication of effort greatly reduced.

Once fully implemented, the decision support system will help researchers in planning future project work. Information retrieved from the data base can identify priorities for species, soils, environmental zones, and end uses not currently covered adequately by experiments and avoid generating already existing information. The ease of transferring information will help plan new trials that will complement existing information.

REFERENCES

Ewell, J.J. and J.L. Whitmore. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. USDA Forest Service Research Paper ITF-18, 72 p.

Hicks, J.C., Jr. 1984. Management information systems--a user perspective. New York: West Publishing Company, 645 p.

Holdridge, L.R. 1947. Determination of world plant formations from simple climatic data. Sci. 105: 367-368.

IBSNAT. 1986a. Decision support system for agrotechnology transfer. Agrotechnology Transfer No. 2, 6 p.

_____. 1986b. Experimental design and data collection in procedures for IBSNAT (The minimum data set for systems analysis and crop simulation). Technical Report 1, 2nd ed.

MacDicken, K.G., D.A. Berger, J.L. Brewbaker, B.G. Cagauan, Jr., P.C. Ching, C.A. Jacob, R.G. Manuelpillai, A. Moukam, M.E. Raymundo, Ir. Soleh, and R.J. Van Den Beldt. 1985. Performance of nitrogen-fixing trees in benchmark environments. In Soil-based agrotechnology transfer, ed. J.A. Silva, pp. 140-148. Benchmark Soils Project. Hawaii Institute of Tropical Agriculture and Human Resources, University of Hawaii.

McFadden, M.W. 1984. A report to USAID/S&T/FNR to support development of a project for the Forestry/Fuelwood Research and Development Project. Annex D, 40 p.

Rose, D.W. 1984. Report to USAID/S&T/FNR to support development of a project paper for the Forestry/Fuelwood Research and Development Project: I. data base management component. II. tropical forest management component. III. biotechnology component. Washington, D.C.: USAID, 58 p.

_____. 1985. Report to USAID/ROCAP to support development of a project paper for the Tree Cropping and Fuelwood Production Project-data base and management information system component. Washington, D.C.: USAID, 27 p.

Rose, D.W. and L. Ugalde. 1985. Effective information management in forestry. An application to fuelwood research. Costa Rica: CATIE/INFORAT, 12 p.

Silva, J.A., ed. 1985. Soil-based agrotechnology transfer. Benchmark Soils Project. Hawaii Institute of Tropical Agriculture and Human Resources, University of Hawaii, 269 p.

von Carlowitz, P.G. 1986. MPTS data base: concepts, contents, and objectives. In Forestry Networks, eds. N. Adams and R.K. Dixon. Arlington, Virginia: Winrock International.

Webb, D.B., P.J. Wood, J.P. Smith, and G.S. Henman. 1980. A guide to species selection for tropical and sub-tropical plantations. Oxford Commonwealth Forestry Institute. Tropical Forestry Papers No. 15, 2nd ed., 256 p.

Young, A. 1983. An environmental data base for agroforestry. ICRAF Working Paper No. 5, Nairobi, Kenya, 62 p.

_____. 1984. An environmental data base for agroforestry. Supplement to ICRAF Working Paper No. 5, Nairobi, Kenya, 53 p.

MPTS Data Base: Concepts, Contents, and Objectives

Peter G. von Carlowitz

Forester, International Council for Research in Agroforestry

During the last 10-15 years, a gradual shift has taken place in land-use concepts from a monopurpose to an integrated, multi-component approach, particularly in developing countries. As a result, MPTS that had previously attracted little or no attention from foresters came into focus. This emphasis on trees and shrubs as major components in agroforestry and other multiple land-use systems has created a need for information. The sudden increase in the demand for the germplasm of these species is difficult to satisfy. Moreover, we have little silvicultural knowledge about the majority of these MPTS.

OBJECTIVES

If MPTS are to make a substantial economic and/or ecological contribution to a production system, answers to the following questions must be found:

- What are their actual and potential production and service uses?
- What are their biophysical requirements and tolerances?
- What are the species-specific characteristics, not only in terms of phenology, morphology, and reproduction, but also in terms of the problems associated with planting certain species?
- What is the species-specific capability to respond to tree manipulation and management, bearing in mind that woody plants in agroforestry systems are often associated with non-woody plants?

Most of the above questions are answered through expensive and time-consuming but necessary research. Much of the information so urgently required is contained in literature that is not easily assessed. Even more difficult is acquiring unpublished information. Consequently, our knowledge is accumulated by finding ways and means of accessing the information and then compiling and collating it in a logical and easily retrievable system.

In this process, the many species constitute a particular problem. The compilation of a master list of MPTS in connection with the publication of a MPTS seed directory yielded about 1,400 different species. This number increases almost daily through ICRAF's data collection activities involving more species that by definition qualify for inclusion in the master list and the MPTS data base. However, considering the time and cost involved in developing species by selection and breeding to a production level comparable to the one already achieved by other more conventional components of agroforestry systems, any number exceeding 30-40 species becomes unmanageable and too costly. These considerations call for establishing priorities on the basis of sufficient, objective information and data (von Carlowitz 1984).

The overall objectives of ICRAF's MPTS data base can be summarized as follows:

- Collect and systematically store existing information on MPTS of the tropics and subtropics.
- Assess the biophysical range of MPTS.
- Arrive at as complete an assessment as possible of noncommercial uses, e.g., timber.
- Provide the basis for the economic assessment of MPTS (yield data on fodder, food, and other products) to aid the economic analysis of agroforestry systems.

- Help select priority MPTS for further development.
- Identify information gaps and research needs.
- Develop an information system that can help pre-select MPTS by matching biophysical site conditions, making possible the response to other inquiries on MPTS.
- Assist in publishing MPTS crop sheets.

COMPUTERIZATION

The hardware presently available to ICRAF's MPTS data base project consists of a WANG PC, 768 KB RAM; one floppy disk drive (360 KB); 30 MB built-in hard disk; and a FX Epson and Epson LQ Matrix Dot printers. The software consists of a MS DOS operating system and KnowledgeMan relational DBMS, in addition to software developed in-house.

INFORMATION SOURCES AND DATA COLLECTION

The information and data contained in the MPTS data base are divided into site-specific information and those that have been extracted from relevant literature. With the intended focus on MPTS uses vis-a-vis biophysical conditions, site-specific records form the backbone of the data base. This approach sets apart ICRAF's MPTS data base from other similar ones.

The focus on site-specific information requires special efforts to access field data. Therefore, a MPTS data sheet was designed to obtain information and data from people working in the field or having access to those with site-specific knowledge about MPTS.*

In the early phase of establishing the data base, information retrieval was restricted to voluntary contributions. Data sheets printed in English, French, and Spanish were distributed in large numbers to suitable informants. While rate of response was encouraging, it did not reach a satisfactory level. Therefore, as of early 1985, special MPTS data collection missions were mounted by hiring junior researchers or undergraduate degree students as consultants. To date, three such missions have been successfully completed in Asia, West Africa, and Latin America.

Both the voluntary contributions and results of the data collection missions have produced numerous records on a correspondingly large number of species. Consequently, the multi-location information coverage of individual species is relatively low. To overcome this shortcoming, those informants whose contribution showed an outstanding level of information value and conscientiousness in completing the MPTS data sheets were selected form the computerized reference list. They are offered small contracts according to which they are requested to fill in 15-20 data sheets for the area with which they are familiar. By contracting many informants in different locations, the project is likely to receive many records on any individual species, thus enlarging the basis for gauging their biophysical range. As no substantial travelling is involved in this kind of small-scale operation, the cost-benefit ratio will be more favorable when compared to the larger data collection missions.

Another simultaneous activity is the screening of literature, such as research reports, species monographs, and compendium-type books, whose relevant information and data are extracted and loaded onto the computer. Because much of this information contains summary descriptions of species, this activity is considerably valuable.

---

*MPTS data sheet is available from P.G. von Carlowitz at ICRAF, P.O. Box 30677, Nairobi, Kenya.

STRUCTURE AND FORMAT

The data base deliberately restricts itself to MPTS information. Although some descriptors used and the respective information received permit the relating of species to their place and role in the system, it is not the intention to extend information and data collection to a systems approach in general. It would require a completely different set of descriptors, or, if included in this data base, would increase its contents to an unmanageable size. The inclusion of systems-oriented aspects would involve such topics as tree-crop interface effects and socio-economic considerations. Other projects and information systems, such as ICRAF's Agroforestry Systems Inventory Project, are more suited to placing MPTS more deliberately into a systems perspective.

Even with this self-imposed restriction of ICRAF's MPTS data base, it is not recommended that a single individual or institution attempt to cover all aspects of MPTS collection, interpretation, and dissemination of information and data. The vast and comprehensive information that is needed on species potentially useful in agroforestry systems calls for a division of labor.

Considering the generally low level of knowledge on the majority of MPTS, a logical first step was to aim at an overview of available knowledge on as many species as possible. Consequently, ICRAF's data base was designed as an inventory data base as opposed to a specialized one, such as the East-West Center/University of Hawaii data base on pest-control properties of woody perennials (Grainge et al. 1985).

Biophysical data, particularly climatic data and uses of MPTS (products and services) are considered core information. Therefore, special emphasis is placed on the collection of the respective data. Additional information on phenology, morphology, reproduction, and tree management/manipulation is collected.

Site-specific information form the backbone of the data base. In the early stages of establishing the data base, contributions from informants working in the field were the prime source of information. To secure a reasonable percentage of returns, completed data sheets had to be brief and "user-friendly." Therefore, the number of descriptors was limited to those considered essential for describing woody perennials in an agroforestry context.

Each description of a particular species in one site or area forms one record, identifiable in the data base by a unique "keyfield number." The number of records on any particular species and the biophysical and use range covered by it determine the information value. Climatic data, as obtained from informants, or literature on specific species are converted by a computer sub-routine program into discrete climate classes, which then constitute a major descriptor for conditional searches.

EVALUATING INFORMATION

The evaluation process starts at the simple level of checking and judging incoming completed data sheets for their information value, the taxonomic nomenclature, and on logic and authenticity of their contents. Once stored in the data base, information from site-specific collections and that obtained from literature can be evaluated and retrieved separately as it is coded differently.

The most important form of evaluation is the numerical assessment of accessions. At any time, checks can be carried out on the geographic coverage, exposing regions or ecological zones for which only a few records or none have been received. Similarly, any other subject-related, substandard information coverage can be exposed and steps taken to eliminate such shortcomings by directing further information collections accordingly.

Although activities are still concentrated on information collection and storage in order to quickly increase the volume of the data base, occasional evaluations have been conducted and may serve as examples. Checks on the number of records received from individual countries showed an under-representation of Latin American countries. Consequently, a MPTS data collection mission was mounted in this region, which produced 150 records. When screening the data base for yield data contained in individual records, it turned out that only 16 percent of the indications of production uses mentioned were accompanied by yield data (von Carlowitz 1986). This check further revealed that in most cases these quantitative data are incomparable as no circumstantial descriptions were given as to how they had been obtained. As a consequence, the terms of reference for data collection missions were amended, placing particular emphasis on the importance of yield data and providing standards for explanatory notes to accompany the yield data.

Other examples of evaluation opportunities offered by the descriptors and the format used are:

- The preference of certain products or services from individual species reflects their economic or ecological value in certain locations or areas. Repeated high ranking of certain uses associated with specific species in a wider geographic range may aid priority species selection.

- Certain species-specific morphological attributes, such as depth of root system or density of canopy, can indicate the probable suitability of species for tree-crop mixtures in an agroforestry situation.

- The comparison of climatic data (distribution of rainfall) and canopy architecture will permit conclusions on the capability of certain tree species to close fodder gaps.

- The information reliability requested will indicate research needs if certain aspects of tree characteristics and features are repeatedly met by a low ranking of reliability.

- Certain recorded service uses, tree management features, and tree characteristics may indicate species-specific potential suitability for certain agroforestry systems, such as alley cropping, shelterbelts, or live fences. For example, a species potentially suitable for alley cropping should coppice freely, respond to pollarding, and preferably be able to fix atmospheric nitrogen.

PRESENT STATUS

At present, the data base contains about 1,800 records on more than 700 species. About 50 percent of the records carry site-specific information. Printouts on all records can be produced on request. In response to the many requests received, selective searches based on biophysical data provided by requesters and/or on uses required can be conducted; these will produce lists of species matching the sites described and the uses demanded. These species lists are printed out as a result of a menu-driven search of the data base according to a single condition or a string of conditions.

Drafts of so-called MPTS summary sheets have been designed and can be printed out on any species contained in the data base. They combine all accessions/records on any species in tabular form (e.g., Table 1: geographic distribution, Table 2: climate, Table 3: phenology, Table 4: uses, etc.). However, these summary sheets require further editing and improvement with regard to format and have therefore not yet been released.

The computerized reference list is divided into three sections:

(1) compendium-type literature;
(2) specialized literature, research results, and species monographs;
(3) names and addresses of individual informants (site-specific records).

In addition to the MPTS data base, another set of data bases has been established that deals with various aspects of MPTS germplasm, e.g., the addresses of seed suppliers (including other related information) and a list of species for which seeds and relevant information are reportedly available. This exercise has been conducted in preparation for the publication of a MPTS seed directory, which is in press.

One section of the germplasm data bases is a master list of MPTS. At present, it contains about 1,400 species, which are described by their currently valid scientific species names and authorities. In addition, reported major uses for each species are listed. A more complete taxonomic nomenclature will shortly be achieved by adding family names and synonyms with the assistance of the Royal Botanic Garden, Kew, U.K.

The master list of MPTS also serves as a link to the MPTS data base by checking new species against the master list. Likewise, data collection information or literature searches will be added to the master list. A summary of the MPTS data base process is depicted in Figure 1.

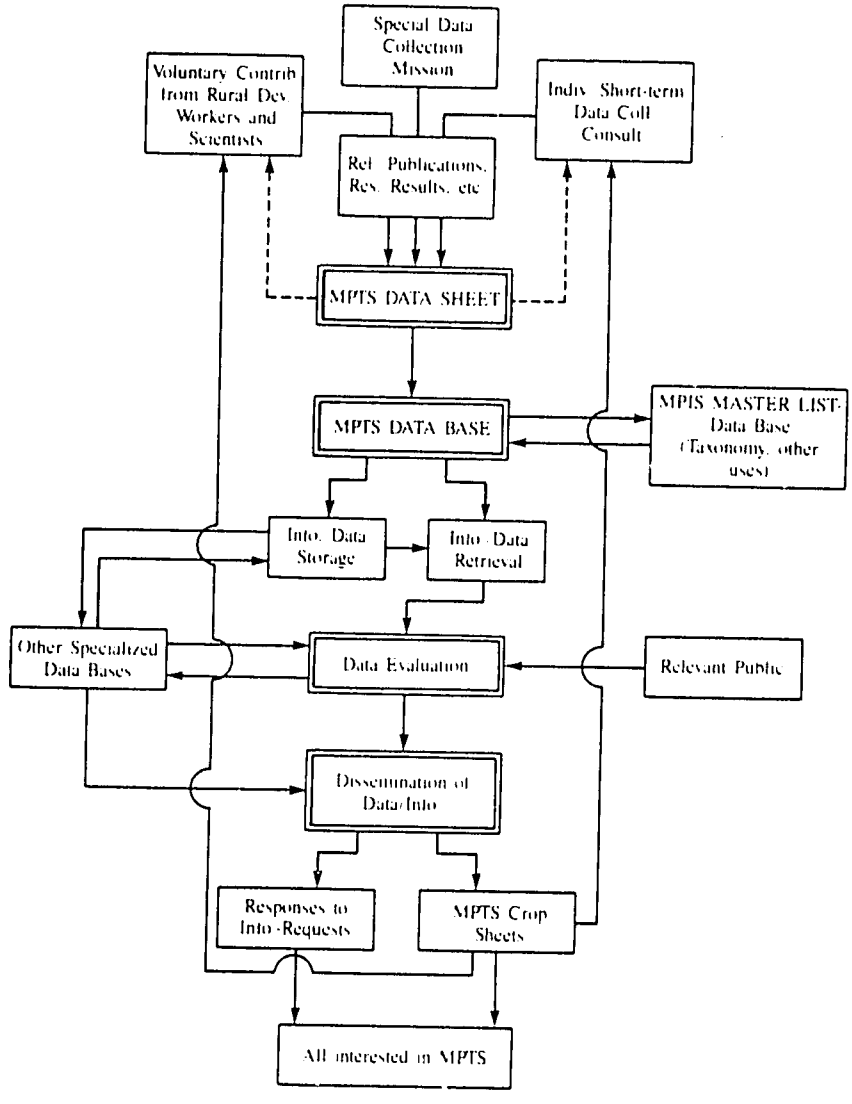


Figure 1. Summary of operational procedure for MPTS data base.

LIMITATIONS

A distinction has to be made between self-imposed restrictions and those based on current information, which is continually changing.

Self-imposed Restrictions

- response of MPTS to tree-crop interface situations,
- socio-economic aspects of MPTS (other than indications obtained from evaluating related descriptors/information),
- details on fuelwood production (yields) of MPTS, and
- qualitative and quantitative growth performance of individual MPTS.

The most important reason for these intentional omissions is that dealing with such aspects at a reasonably comprehensive level would far exceed the inventory scope of a data base such as this one. Specialized supplementary data bases, with different sets of descriptors, would be required to obtain satisfactory coverage.

In the case of fuelwood production, many additional descriptors that cover circumstantial information would be needed to provide meaningful yield data (e.g., initial spacing, rotation period, minimum stem/branch diameter, etc.). Furthermore, yield data on many species grown in plantations or woodlots are already accessible (Webb et al. 1980).

Descriptors relating to the growth performance of individual species were not feasible. Because the growth performance of species with a wide ecological range will differ according to site conditions, it can therefore only be rated in relative comparison with other associated trees at any given site. There was good reason to assume that, with this prevailing complication, the response to respective questions would be confusing and of doubtful informational value.

Current Information Restrictions

- The number of species contained in the data base include only a partial sample and exclude others of actual or potential multiple uses.
- For many species, only one or two records have been received and/or entered. Consequently, the biophysical range that is given is often inadequate.
- Yield data provided for products from particular MPTS (other than those grown for fuelwood) often cover a wide range.

ONGOING AND FUTURE ACTIVITIES

Enlarging the contents of the MPTS data base will remain the primary activity of the project. Efforts will be made to increase site-specific data representing a broad environmental range. Editing the MPTS data sheet and the MPTS profiles will also receive high priority. These activities are expected to be completed by early 1987. Additional future project activities include designing and publishing MPTS crop sheets (these will be updated and improved as needed), establishing a computer program for the application of the rapid appraisal methodology for selecting priority MPTS by linking up and using information in the MPTS data base (von Carlowitz 1984), and developing standard methods for assessing MPTS yields for selected agroforestry subsystems.

With the increasing number of MPTS-related data bases that have been established in recent years, duplication is increasing. Often these data bases have been established in isolation by individuals and institutions unaware of similar activities elsewhere. Usually, no coordination has taken place with regard to the types of hardware and software employed, the descriptors used, and format and structure adopted.

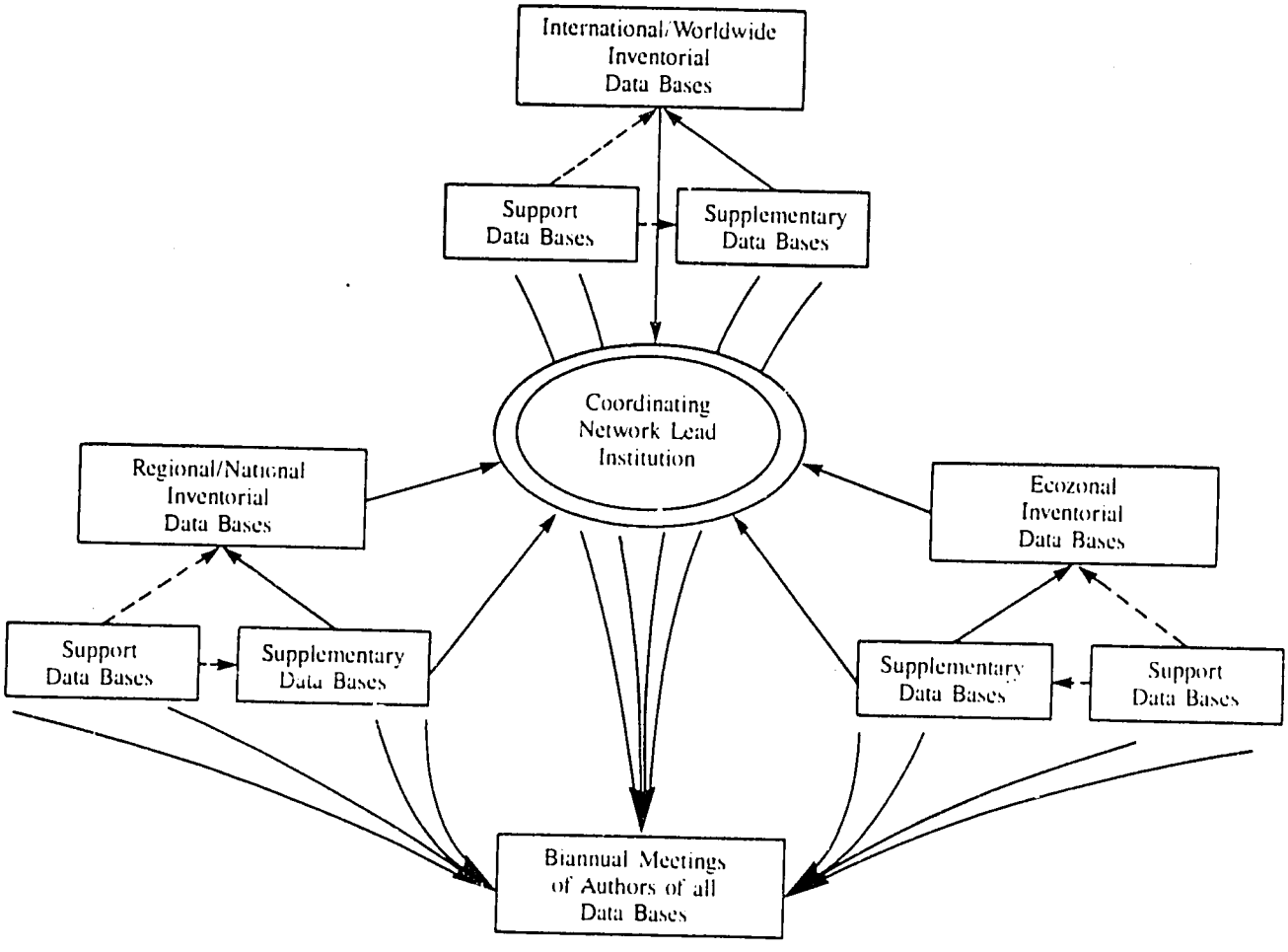


Figure 2. Proposal for a MPTS data base network.

This situation calls for initiatives to improve and coordinate present and future developments in data collection and management. Therefore, ICRAF's MPTS data base project, with the financial assistance of the GTZ, attempts to link together interested authors and operators of MPTS-related information data bases (see Figure 2). It is hoped that members of such an interest group will meet for annual workshops that would include:

- presentations and demonstrations of data bases by the respective authors/operators,
- discussions on improving the compatibility of data bases,
- highlights on enhancing efficient access to various data bases,
- exposing information gaps both in geographic and subject terms that are currently not covered by existing data bases,

- identifying individuals and/or institutions capable of closing such gaps by setting up new data bases, and
- discussions on adopting standardized models for data collection, storage, and retrieval (Hackett 1983).

REFERENCES

Burley, J. and P. von Carlowitz, eds. 1984. Multipurpose tree germplasm. Nairobi, Kenya: ICRAF.

Grainge, M., S. Ahmed, W.C. Mitchell, and J.W. Hylin. 1985. Plant species reportedly possessing pest-control properties--an EWC/UH data base. Honolulu: East-West Center Resource Systems Institute.

Hackett, C. 1983. Plant description modules: an aid to the compilation, storage, and retrieval of tabular descriptions of the qualities of plant species. CSIRO Divisional Report (83/2). Canberra, Australia.

Von Carlowitz, P. 1984. Rapid appraisal methodology for selecting priority MPTS species and criteria for determining status and research needs. In Multipurpose tree germplasm, eds. J. Burley and P. von Carlowitz. Nairobi, Kenya: ICRAF.

_____. 1985. Some considerations regarding principles and practice of information collection on multipurpose trees. Agroforestry Systems 3: 181-195.

_____. 1986. Multipurpose tree yield data–their relevance to agroforestry research and development and the current state of knowledge. Agroforestry Systems, in press.

Webb, D.B., P.J. Wood, J.P. Smith, and G.S. Henman. 1980. A guide to species selection for tropical and sub-tropical plantations. No. 15, 2nd ed. Oxford, U.K.: Oxford Commonwealth Forestry Institute.

Hardware and Software Systems for Data Management in MPTS Research

Terence W. Linkletter

F/FRED Information Systems Specialist, Weyerhaeuser Company

In agroforestry, we depend on recorded observations of natural phenomena to develop and validate theory that can be applied to human well-being. We protect the data's maturation and transformation into useful information as we work with it to discover and explain its relationships with other data in our analyses. We protect the resulting models, recording all their assumptions and results, so that decisions can be based on what is not known as well as what is known.

Whether you only process raw observations into models or go on to develop policy proposals, it is an intricate manufacturing process like any other. But this one requires a high degree of human intellectual insight, agreement, and flexibility.

DATA MANAGEMENT TOOLS

As scientists, technicians, and managers of agroforestry production and applications, whose raw material is data and product useful information, we need the most appropriate tools for data processing, analysis, and information management: computer hardware and software. These tools do not automate analysis, validation, model development, and decision making; however, because they ease the mechanics of handling the quantity of work, we can spend more creative effort on the quality of those processes.

Computer hardware and software help develop a good relationship between you and your data. They help your data mature into useful information, and help you understand and communicate to others its meaning. Computer hardware is dormant until, by loading software into it, you awaken it with a personality. If you choose older, poorer software, your computer's personality will be hard to deal with. But with carefully chosen software, the same computer will be surprisingly useful and flexible, helping you manipulate data in any way you choose.

Computer software transforms your hardware into any number of instruments (see Figure 1). With a statistical analysis package, your computer functions as a microscope and an x-ray machine for seeking the underlying relationships in data. When the DBMS is in control, the computer acts like a sonar search device and a skillful surgical tool. As a word processor, it becomes a notepad, idea organizer, automatic spelling dictionary, and a typewriter where no erasure is ever seen and where cutting and pasting is fast and seamless. With a communications package (and a phone line and some hard currency), your computer is your link to forestry researchers worldwide. With a spreadsheet or other modeling software, the computer can become a powerful tool to evaluate 20 years of stand growth or map an agroforestry system, showing the flow of individual expenditures and earnings.

Today, most useful computer tools are micro-based and truly compact, i.e., inexpensive, the size of notebooks, and battery operated. A micro-computer configuration appropriate for most forestry research work costs a few thousand U.S. dollars.

The role of the mainframe computer is fast changing. It is becoming a machine with which your personal computer can communicate when a query to a large, current data base is required (e.g., a bibliographic search) or when a complex calculation would take too long to do locally.

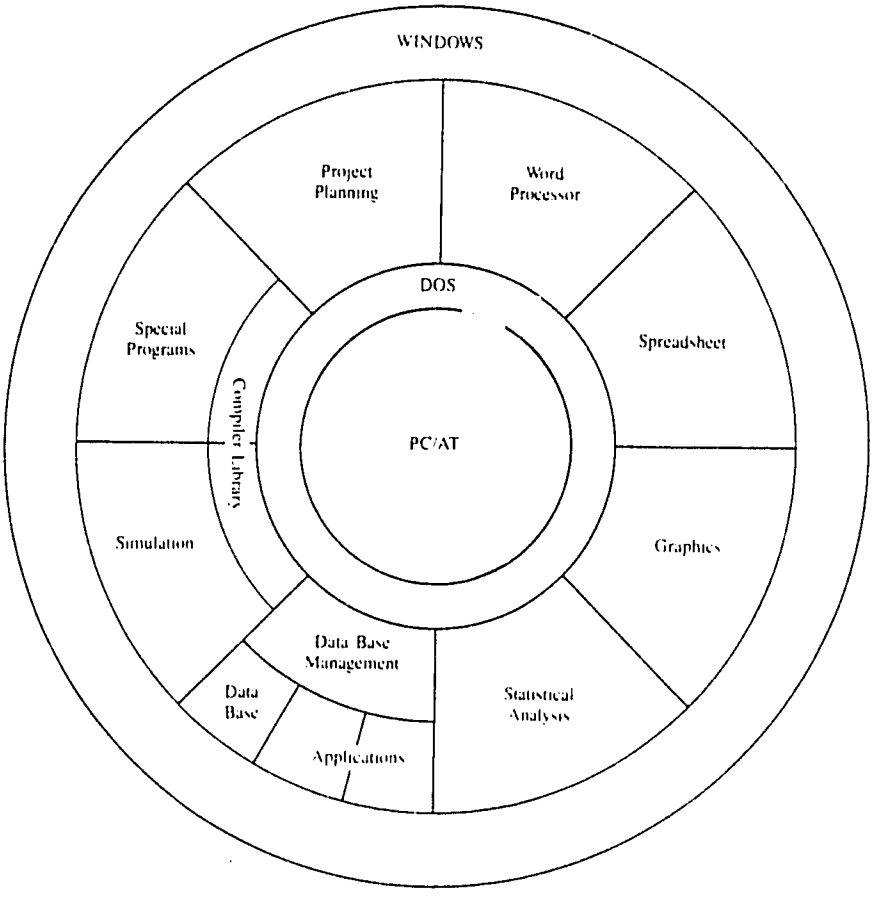


Figure 1. Layers of computer personality.

Market forces and micro-computer flexibility have encouraged major investment by developers in compatible hardware and software that is powerful, easy-to-learn, and enjoyable to use. In contrast to mainframe computers, the software tends to work cooperatively on a given micro. Statistical packages, such as STAN, work directly with data from the most popular DBMS and with the most popular spreadsheet modeling facility even though all are produced by different firms.

The computer can help us in measuring, recording, verifying, reducing, and analyzing our data. It makes it easier for us to keep our work organized. It gives us a means of quickly communicating data and results to colleagues and decision makers. It lets us effectively develop and validate models of interest and then perform sensitivity analysis on different variables under our control. Using software packages, we can show our results in graphic form automatically. We can quickly change the form and content of the displayed results. The effect on our research and its application is revolutionary.

DATA TRANSFORMATION

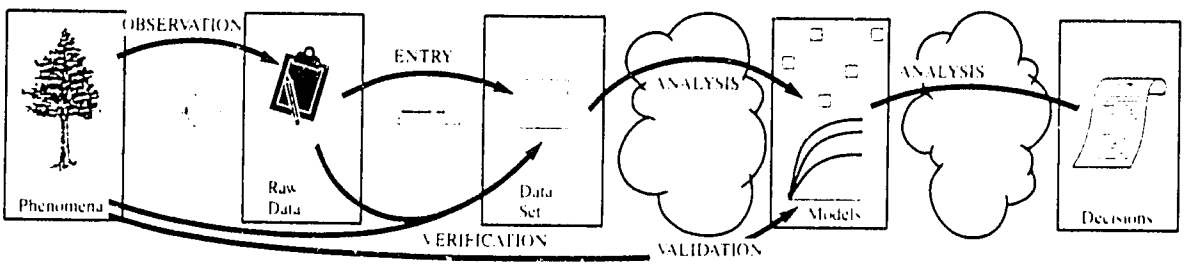


Figure 2. Data transformation process.

Observing and Recording Phenomena

Most forestry observations must be done by humans without the help of computers. Still, automatic microprocessor-based data real-time measurements systems do receive a fair amount of use from tropical zone forest services and forest products firms for such things as stream-flow measurements and hygrometric humidity measurement. About once each week, a forester will extract the nicely recorded data cassette from the measurement, put in a fresh cassette, and replace batteries. Back at the office, the recorded cassette will be read into a computer for interpretation, and its data placed in the ongoing monitor file. Similarly, those researching the micrometeorological effects of sunlight on the growing tree (and effects of the tree's shade on surrounding plant life) use automatic photoelectric equipment to measure changes in intensity and quality of light during the day.

There is also the automatic measurement from satellites of the earth's reflectivity of visible and infrared electromagnetic frequencies. This data is transmitted to earth where it is recorded, organized, and made available to clients wishing to purchase it. By using sophisticated but easily applied computer analysis techniques and ground verification surveys, foresters can reliably interpret the slight reflectivity variations measured by satellite as indicating tree cover, kind of tree, and even tree health.

GIS technology based on this constantly updated global information bank is now available even for micro-computers for such uses as timber inventory and stand management or land-use mapping. Previously, the approximately 75-meter resolution of the U.S. Landsat satellites was insufficient for many applications. But this year France's SPOT satellite was launched and has begun scanning the earth at 10-meter resolution. Agroforestry and MPTS studies may benefit. Devine and Field (1986) discuss GIS technology based exclusively on hand input of information from maps.

A more common form of computer-assisted data collection is the use of hand-held microprocessor equipment to help record and sometimes even measure data. Available for general use are watertight, single-handed keypads on which numbers can easily be entered in the field. Software is available that can be loaded into these hand-held recorders in the office and started when the site is reached.

One such software program, developed by the Ontario Ministry of Natural Resources (1986) first asks for plot number and the repetition number for the first plot in the trial, then asks for the heights and diameters of individual trees. If a number entered is not within a reasonable range, the program will ask if the operator made an error in measurement or in entering the number, then accepts the operator's correction. Similar programs can be written for any given data-collection activity. It is also possible to plug into the hand-held recorder a pair of large calipers for diameter measurement so that the measurement is automatically entered into the recorder's memory when a button on the calipers is pushed. At the end of the day, data is transferred from the hand-held recorder's memory to files or a data base on the computer where the field data is stored for analysis.

This use of technology is fascinating, but in many cases impractical. Wherever we rely on field personnel to record data on clipboard forms, training is extremely important. Not only must the observation methodology and measurement techniques be well-understood and carefully executed by each technical assistant, but so must the data-recording process. Completeness, correctness, and consistency at this stage are the keys to any future useful analysis.

Verification

At this stage, we ensure that the data is in computer-usable form (e.g., that it is recorded on a computer disk file). We assure that the data is properly organized for analysis and reporting. (this usually means the data is placed in tables, with a row [or record] for each observation and a column [or field] for each variable in the observation.) We also make certain that the data values have been verified.

If we are fortunate enough to use tools whose main job is data collection, they probably also organize and verify data, along with recording it in computer-usable form. The consequent increase in data reliability is often the most valuable reason for using such equipment.

However, most forestry observations are entered by pencil on printed forms. Back at the office, they must go through a separate data entry phase where errors can creep in. When errors that occurred in the observation phase are discovered during verification, it is much harder to find out what the correct values should have been. But there is good technology now available for minimizing these problems. No longer does the key board entry person have to get numbers right-justified in certain columns. No longer is an out-of-range number discovered only long after it has been entered.

Good DBMS now provide flexible data entry capabilities. They display on the screen a form to be filled in. When the data-entry person mistakenly attempts to place a disallowed character in any field (as determined by the data base administrator), the computer complains and waits for a correction. And the data base administrator can see that range checking is done on the input values, both with absolute ranges (e.g., to make sure an unreasonable diameter is noted) and with value relationships (e.g., to make sure a diameter is reasonable with respect to the corresponding height).

The statistics package we recommend works well with the DBMS to extract the newly entered data set and permit the researcher to perform a scattergram display so that outliers can be investigated before the data is granted confidence. In the end, it is the researcher who owns the data set. And although the verification stage is tedious, it is the key to successful analysis.

Model Analysis

The goal of model analysis is data synthesis. Whether the result is an inventory data base containing a useful abstraction of timber holdings, an equation set that reliably predicts tree taper from a few dimensions, or a continuous simulation of nutrient cycling during stand life cycles, the computer at this stage has long been essential, even when the only choices were large and expensive.[1]

Looking more specifically at the global MPTS model that could be developed, cooperators may determine here that the appropriate goal is a product-yield model showing growth over time as a function of species (and in some cases provenance), soil, climatic conditions, and management/treatment.

This can be accomplished in each country by entry of the different streams of data through screen-based forms to tables in a DBMS, local analysis of data and in common with a compatible statistical analysis system, and model development under the DBMS or using a programming language. The F/FRED networks could organize the software and means of communication and sharing of information at all levels using micro-computers.

Analysis for Decision Making

Ideally, this model could be coupled with a farmer's actual soil, climate, and projected product needs to derive recommended species, quantity, and management strategy. On a macro level, it could be coupled with nationwide GIS information to help a nation determine its land-use policy.

A large U.S. forest products company has for over a decade maintained an up-to-date, computerized inventory data base of its holdings, relating spatially the stand and land-use status information to site characteristics and legal, mineral, transportation, topographic, and other overlays of interest. By itself, the data base is only a model of the status quo, a carefully digested collection of

[1] See the referenced FORS 1986 literature for information on software packages available for general and specific forestry-related modeling in all disciplines.

of interest. By itself, the data base is only a model of the status quo, a carefully digested collection of static information. But using the surrounding communication/reporting/mapping capabilities, it has been a useful MIS.

This company recently joined this GIS to a complete economic model of stand product cost and value, forming a true decision support system. This model subsumes and uses the results of more detailed models of merchandiser decisions, log-to-lumber conversion, production models of plywood/composite product and pulp mill operations, a transportation distance/cost model, a harvesting time/cost model, a nursery and planting model, and growth/yield models. As a result, any predicted mix of market demand for products can actually be traced back to appropriate stands for meeting the demand. Near- and mid-term harvest and timber purchase planning can be globally optimized. Strategic decisions on planting, mill construction, and land purchase can be analyzed directly based on different geographic market scenarios.

This complex model runs on a mainframe computer, but has summarized spin-offs on micro-computers for specific kinds of analysis. It delivers one clear warning to scientists: keeping this model up-to-date with the state of knowledge in the many research disciplines is as important as keeping the inventory data base up-to-date. Results of new research in all areas are periodically placed within the model, which then organizes this knowledge. Specially selected harvests are periodically accounted for, with every piece of each tree traced to graded lumber or other products or to hogfuel or waste so true yield can be measured by tree and location on the tree.

A decision support system need not be this complicated. The simple, flexible, row-and-column spreadsheet (with the proper data and function calculations) can allow quick graphic comparison of the potential results of different decision options (see Figure 3).

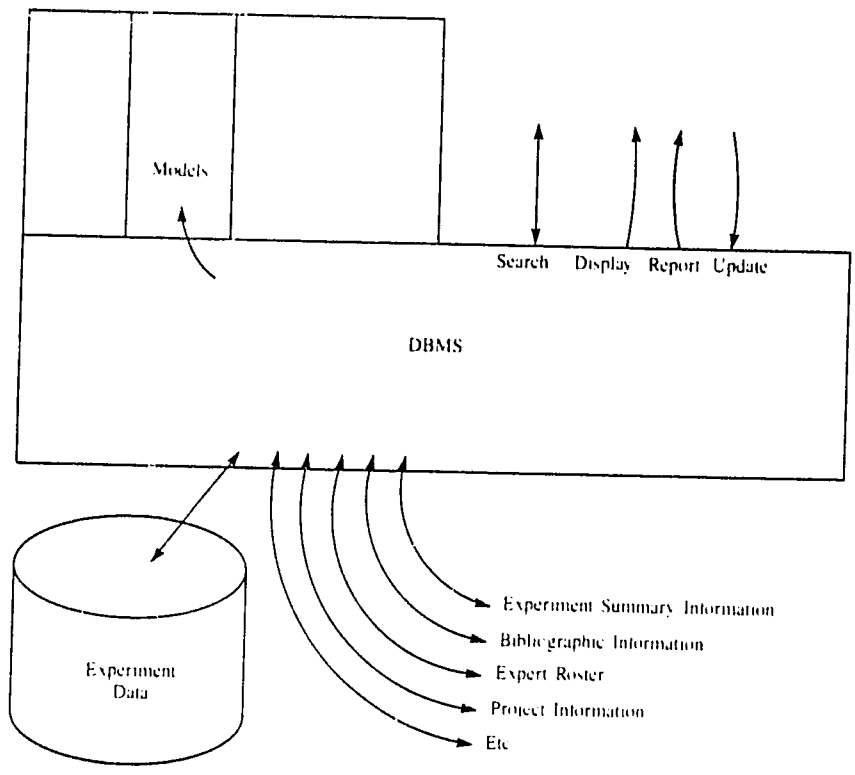


Figure 3. Decision support system.

At the University of Florida, Duane Dippon has neatly integrated the simple-to-use spreadsheet technology with an economic model of timber yield and wildlife management developed at the Tennessee Valley Authority. The theoretical model provides economic results for alternative management regimes of the user's choice. The spreadsheet takes these and makes comparison clear, optimizing the overall objective of the decision maker. A neatly interactive knowledge-based decision support system currently being developed at North Carolina for forest management is the CHAMPS (Rauscher, Saha, and Robert 1986).

The decision support system is but a tool. The human still must identify the problem to be solved, conceive and formulate alternative solutions, and determine the criteria by which the "best" solution can be recognized. From here, it may be possible to build expert systems that embody the human expert's reasoning on those issues. Expert systems do currently exist outside forestry in specific, complex areas, which piecemeal are well-understood (e.g., configuring a mainframe computer system to meet a given customer's requirements).

Two difficult areas in expert systems development are 1) defining a tractable problem area for which human expertise is to be captured and reproduced so that the area has both clear boundaries and solutions free of political influence and 2) knowledge transfer--translating the expert's knowledge into logical rules of sufficient completeness. The well-defined computer configuration system referred to above took two years and hundreds of thousands of dollars to reach a satisfactory level of reliability. Computer scientists now have better knowledge transfer systems in different stages of experimentation. But in forestry, most decisions involve some intangible, subjective elements and are surprisingly hard to quantify completely. This is especially true in the public sector. For the present, forestry can treat expert systems as a potential for the private commercial forest products industry, and there only within decision areas of narrow scope.

CHOOSING A COMPUTER

At this point in the history of computer tools development, I can personally make this strong recommendation: the best choice for a general-purpose forestry research computer for the immediate future is the IBM PC/AT compatible.* This often-heard term refers to any computer that can run the same software, accept the same hardware additions, and interact with the user in the same way as does the IBM PC/AT. Many are available from manufacturers in various countries for under U.S. $2,000.

A good second choice would be one of the IBM PC compatibles. This older design is now extraordinarily inexpensive--many such computers cost well under U.S. $1,000. These machines currently use the same DOS software environment as the PC/AT compatibles. But they do have important limitations that will prevent them from using the next generation of software environment. Even then, it will still be relatively easy to transfer data between these computers.

If you need a very fast PC/AT compatible, you may consider the new computers based on the Intel 80386 processor. But these are expensive, and their potential hardware performance is not expected to be fully tapped by software until the end of this decade. By then the hardware price will have fallen considerably. For many specific purposes, there are other quite different computers considerably better than the IBM compatibles. It is advisable to study the options as your requirements become clear.

You must select those software packages that fit your computer needs and additional hardware items, such as a printer, disk drives, graphics output device, and a monitor with the kind of screen you

* This is the author's opinion and does not necessarily reflect policies of Winrock, F/FRED, USAID, CATIE, or Weyerhaeuser.

need. Refreshing is the fact that no nation has a monopoly on compatible computer technology. For example, my own personal computer was made in Korea using chips and components made in Malaysia, Taiwan, and Japan.

Ask us for recommendations in these areas, and we will be glad to help. Your data is your raw material. To be productive, you have to correctly manage that data. By knowing your needs, we can suggest the tools to make your job easier--one of the goals of the F/FRED global research component.

REFERENCES

Collier, J.N. and J.G. Massey. 1985. Public software for microcomputers. J. of For. Aug. 1985, 486-489.

Cooney, B.A. 1986. Representing knowledge through expert systems. The Compiler. Winter 1986. 5-8.

Cooney, T.M. 1985. Omnitali, an inventory program for all regions. J. of For. Jan. 1985, 13ff.

_____. 1985. Portable data collectors, and how they're becoming useful. J. of For. Jan. 1985, 19-23.

_____. 1985. Programs for analyzing forest management investment strategies. J. of For. March 1985, 138-139ff.

_____. 1985. Projecting the future forest. J. of For. May 1985, 269ff.

_____. 1986. Decision support systems. J. of For. Jan. 1986, pp. 13-14.

_____. 1986. Timber cruising, surveying, and engineering software. J. of For. Feb. 1986, 13-16.

_____. 1986. Automatic record-keeping with database management software. J. of For. June 1986, 14-16.

_____. 1986. Forestry database applications. J. of For. July 1986, 12-13.

Cooney, T.M. and J.G. Massey. 1985. How to get forestry software. J. of For. July 1985, 420-425.

Devine, H.A. and R.C. Field. 1986. The gist of GIS. J. of For. Aug. 1986, 17-22.

Fleury, J. 1986. Macro--solutions on microcomputers. The IDRC Reports. April 1986, 9-10.

FORS. 1987. Proceedings, Data Management Issues in Forestry, Computer Conference and 3rd Annual Meeting of the Forest Resources Systems Institute, April 7-9, 1986. Atlanta, Georgia.

Ontario Ministry of Natural Resources. 1986. Electronic Data Collection-User's Guide and Technical Reference.

Rauscher, H.M. and T.M. Cooney. 1986. Using expert-system technology in a forestry application: the CHAMPS experience. J. of For. March 1986, 14-17.

Rauscher, H.M., H. Saha, and P. Robert. 1986. Computerized habitat analysis and multiple-use prescription system (CHAMPS). The Compiler. 11-14.

Van Roessel, J.W. 1985. New computer systems applied to forestry. In Proceedings of the IX world forestry congress. Mexico.

Appendices

Framework of the F/FRED Research Network

Para 1: Membership

1.1 Membership in the F/FRED Research Network, hereafter referred to as the Network, shall be open to Asian forestry departments, forestry and agricultural research institutes, schools of forestry, forestry or agricultural colleges or universities that have signed or have expressed the intention of signing a Memorandum of Understanding (MOU) with Winrock International Institute for Agricultural Development (hereafter referred to as Winrock) or which participate in any F/FRED research activity through the Lead Institution in a country. A sample MOU is attached.

1.2 Observer status in the network is open to institutions that are invited to attend meetings of the network or to exchange information with network members.

Para 2: Organization

2.1 The governing body of the F/FRED Research Network is the Network Steering Committee. The Steering Committee is composed of a representative from the Lead Institution from each participating country. A Lead Institution is a member institution from a country chosen by the member institutions from the country to represent them.

2.2 The Lead Institution in each country shall act as a coordinator of F/FRED activities within the country, and keep all member institutions in the country informed on F/FRED activities.

2.3 Other member institutions could be invited to be members of the Network Steering Committee, if considered necessary.

2.4 The F/FRED Research Network shall be deemed established when six (6) institutions have signed the MOU.

2.5 The Steering Committee could invite specialists to advise the Steering Committee as and when considered necessary.

2.6 The Steering Committee shall oversee the activities of the Network through Research Committees which shall be formed by the Steering Committee as and when necessary. Initially, there shall be two Research Committees, namely the Multipurpose Tree Species (MPTS) Research Committee and the Land and Forest Management Research Committee.

2.7 The Steering Committee shall appoint appropriate scientists from member institutions to be members of Research Committees, taking into consideration country representations and expertise required.

Para 3: Rules and Terms of Reference of the Steering Committee

3.1 The Steering Committee shall meet annually or as needed. Meetings of the Steering Committee shall be called by the Network specialists at the F/FRED Coordinating Unit at Kasetsart University in Bangkok.

3.2 The Steering Committee shall elect a Chairman for each meeting from among its Asian members. The F/FRED Coordinating Unit shall provide secretarial support.

3.3 Decisions of the Steering Committee shall be by a majority of at least two thirds of members present at any meeting.

3.4 The Steering Committee shall:

a) plan Network programs
b) review progress of Network activities
c) guide and assist the Network specialists in Network activities
d) promote Network programs and activities
e) establish Research Committees and be responsible for their performance
f) approve annual Network activity reports
g) promote linkages with other related networks
h) carry out other functions as deemed necessary to implement F/FRED programs

3.5 Network specialists at the Network Coordinating Unit shall be members of the Steering Committee.

3.6 Chairmen of Research Committees shall be members of the Steering Committee.

Para 4: Rules and TOR of Research Committees

4.1 Research Committees shall report and be responsible to the Steering Committee.

4.2 The Chairmen of Research Committees shall be appointed by the Steering Committee.

4.3 Research Committees shall meet regularly as and when required.

4.4 Research Committees shall (for their own fields):

a) plan research studies
b) review and approve research studies
c) coordinate research and other related activities
d) ensure that standard methodologies are used in research and other activities
e) ensure that research reports are submitted when due
f) carry out any other functions as deemed necessary to ensure that success of F/FRED activities

Para 5: National Policies

The implementation of the F/FRED Research Network framework shall take cognizance of national policies.

Para 6: Changes to the Network Framework

The Steering Committee may make changes to the Network Framework as and when considered necessary.

Annoucement of Establishment of a Research Network for MPTS

More than 60 forestry research and information specialists from 10 countries of Asia and the United States, meeting at the Ambassador Hotel in Bangkok, Thailand September 24-27, took action to establish a research network for MPTS. They did this after reviewing benefits expected to arise form such networking. Anticipated benefits include improved information management and systems for control and validation of experimental data form field trials.

The network, to be known as the F/FRED Research Network, came into being as participants in this week's workshop witnessed the sixth cooperating Asian research institute sign a Memorandum of Understanding adhering to membership.

The network was recommended by an ad interim planning group of Asian forestry research scientists. That group, along with international agencies active in forestry research, have proposed expanding productivity and availability of improved fast-growing tree species for fuelwood and other household and commercial uses by rural framers.

Winrock International, a U.S.-based not-for-profit technical assistance institute for agricultural development, provides secretariat, technical, and staff support and administers a small grants program to facilitate network activities. Funding for this has been provided for an initial five-year period by the Agency for International Development (AID), Washington.

Network membership and/or observer status is open to Asian forestry departments, forestry and agricultural research institutes, and schools of forestry and agriculture. This week's workshop participants drafted and adopted an organizational framework for the network.

A Steering Committee was created to provide overall direction and plan network programs. The network offices, staff and communications facilities are located on the campus of Kasetsart University in Bangkok, the host institution for headquarters of the network.

Much of the work of the inaugural meeting was devoted to defining the research agenda, adopting tree species appropriate for network research and examination of techniques for collection storage, sharing and utilization of the large volume of data to be processed through the network. The network will make use of state-of-the-art micro-computer hardware and software to support a DBMS designed for the network.

With due regard to proprietary interests, data is to be shared on a global basis with other national and international organizations, and to provide ready access to many established data bases of interest to network members. Expertise for design of data sets and information management systems is being provided by specialists form the University of Hawaii. Implementation of research network activity is expected to draw upon consultants from the Asian region, as well as from cooperating U.S. schools of forestry.

A full day of the workshop was devoted to coordinating experimentation for developing predictive growth models. Equipment and computers for the demonstrations of computer application were made available courtesy of IBM Thailand.

Activities of the network will be carried out through research committees designated by the Steering Committee. Dr. Salleh Nor, Director General of the Forest Research Institute of Malaysia, was elected as the first chairperson of the Steering Committee.

The Steering Committee designed two Research Committees: Multipurpose Tree Species (MPTS) Research Committee and the Land and Forest Management Research Committee. These committees focus attention respectively on the biophysical and the socio-economic dimensions of achieving the network objectives.

Future activity of the Land and Forest Management Research Committee will be concerned with application of biological improvements through village-level outreach and extension programs. This will require multidisciplinary interaction between biological and social scientists and economists based on a broad knowledge of sites and local conditions. In addition to developing a better understanding of conditions under which local communities and private individuals will choose to adopt the improved MPTS species, this group will examine the environmental implications and benefits of various MPTS species.

Next steps in implementing the network program will be a meeting of the MPTS Research Committee scheduled to be held in Kepong, Malaysia in December of this year. At this meeting, final decision will be reached on the data sets to be used for experimental trials and arrangements will be considered for selection and processing of germplasm and other requirements for field trials in 1987.

A field trip to MPTS provenance trials and community forestry sites in Thailand was useful in constructing plans for the F/FRED network trials. On a day's visit to these sites, the workshop participants were able to review a large selection of multipurpose tree field trials involving species of interest to the new research network (see Appendix III).

The new research network builds upon work by the International Union of Forestry Research Organizations (IUFRO). Specifically, a set of recommendations arising from a meeting of IUFRO members in Kandy, Sri Lanka in 1984 has provided the basis for network activities. The new network is also designed to complement other research networks and activities of a number of multilateral and bilateral agencies that provide assistance in forestry development programs in the Asia region.

Field Trip Summary

The Forestry Networks workshop included a one-day field trip to MPTS provenance trials and community forestry sites in the Chachoengsao Province of Thailand, which helped in constructing plans for the F/FRED network trials. Workshop participants were able to review a large selection of MPTS field trials involving species of interest to the new research network. Observations were made of a *Casuarina* plantation; multispecies agro-ecosystems; private-sector *Eucalyptus* plantations and nursery production technology; a community forestry program with *Eucalyptus*, *Leucaena*, and *Acacia*; and a home garden and living fence with over 30 MPTS. Provenance trials of *Acacia mangium* and *Eucalyptus camaldulensis* were observed as was the coppicing ability of *Eucalyptus camaldulensis* after different periods of harvesting. Lectures were presented on private and community forestry programs by members of the Kasetsart University Faculty of Forestry.

Participants

Ms. Norma Adams
Project Editor
Winrock International
1611 N. Kent St.
Arlington, Virginia 22209
USA

Dr. Pimchai Apavatjrut
Assistant Professor
Chiang Mai Faculty of Forestry
Chiang Mai University
Chiang Mai 50002, Thailand

Dr. Kamis Awang
Dean/Associate Professor
Faculty of Forestry
University of Pertanian Malaysia
43400 Serpang
Selangor, Malaysia

Dr. Ramon C. Barba
Professor/Associate Research Director
PLANTEK International Ltd.
Unite 59-A, Block 1
Science Park Drive
Singapore 0511

Mr. Kirtland M. Barker
Assistant Project Manager
Winrock International
1611 N. Kent St.
Arlington, Virgnina 22209
USA

Dr. Alberto T. Barrion
Department of Entomoloy
International Rice Research Institute
P.O. Box 933
Manila, Philippines

Dr. William R. Bentley
Senior Program Officer/ Agroforestry
Winrock International
1611 N. Kent St.
Arlington, Virginia 22209

Dr. Suree Bhumibhamon
Associate Professor
Faculty of Forestry
Kasetsart University
Phaholyothin Road
Bangkok 10903, Thailand

Dr. Nantakorn Boonkerd
Acting Director
BNF Resource Center
Division of Soil Science
Department of Agriculture
Bangkhen, Bangkok
Thailand

Dr. James Brewbaker
President, NFTA and
Professor, University of Hawaii
P.O. Box 680
Waimanalo, Hawaii 96795
USA

Dr. Foster B. Cady
Research and Development Director
F/FRED Global Research Team
University of Hawaii
P.O. Box 186
Paia, Hawaii 96779
USA

Dr. Cai, Mantang
Research Institute of Tropical Forestry
Chinese Academy of Forestry
Longdong, Guangzhou
China

Mr. Pravit Chittachumnonk
Chief, Biotechnology and Biochemistry Lab
Central Forest Research Lab and Training Center
c/o Division of Silviculture
Royal Forest Department
Phaholyothin Road
Bangkok 10900, Thailand

Mr. Douglas Clark
Agricultural Development Officer
Office of Technical Resources
USAID/Thailand

Dr. Reynaldo E. de la Cruz
Associate Professor
University of the Philippines
at Los Banos
College of Forestry
College, Laguna 3720
Philippines

Dr. Wilfredo D. Cruz
Executive Director
Center for Policy and
Development Studies
University of the Philippines
at Los Banos
College, Laguna
Philippines

Dr. Marcelino Dalmacio
Director
Forest Research Institute
College, Laguna 3720
Philippines

Mr. Donald L. DeVivo
Assistant Regional
Representative, UNDP
UN Building, 12th Floor
Rajadamnern Avenue
Bangkok, Thailand

Dr. Robert K. Dixon
Associate Professor
Department of Forestry
Auburn University
Auburn University,
Alabama 36849

Dr. Apisit Eiumnoh
ARRSTC
Asian Institute of Technology
P.O. Box 2754
Bangkok 10501, Thailand

Mr. John Eriksson
Mission Director
USAID/Bangkok
APO San Francisco 96346

Dr. I.D. Esteban
Bureau of Forest Development
P.O. Box 2363
Manila, Philippines

Dr. Barin N. Ganguli
Senior Forestry Specialist
Asian Development Bank
P.O. Box 789
Manila, Philippines 2800

Mr. Donald G. Gibson
CIDA Project Consultant
Canadian Embassy
P.O. Box 2090
Bangkok 10501, Thailand

Dr. John Grayzel
Acting Director,
Rural Development
S&T Bureau, USAID
Washington, D.C. 20523
USA

Mr. Raj Gujral
Senior Technical Advisor
FAO Regional Office for Asia
Maliwan Mansion
Phra Atit Road
Bangkok, Thailand

Mr. Charles R. Hatch
Forestry Advisor
USAID, American Embassy
New Delhi, India

Dr. Ong Seng Heng
Wood Technologist
Forest Research Centre
P.O. Box 1407
Sandakan 90008, Sabah
E. Malaysia

Dr. Hu, Ta-Wei
Professor
Department of Forestry
Chinese Cultural University
Yang-Ming-Shan
Taipei, Taiwan

Dr. William F. Hyde
LFMN Specialist
c/o Faculty of Forestry
Kasetsart University
Bangkok 10900, Thailand

Dr. Robert Ichord
Chief, Energy and Natural Resources
Bureau for Asia and Near East
Office of Technical Resources
USAID
Washington, D.C. 20523
USA

Dr. K. Ishizuka
Central Forest Research Lab and Training Center
Royal Forest Department
Phaholyothin Road
Bangkok 10900, Thailand

Dr. D.A. Ivory
Forage Research Project
Balai Penelitian Ternak
P.O. Box 123
Bogor, Indonesia

Dr. K. Jayaraman
Statistician
Kerala Forest Research Institute
Peechi 680653, Trichur District
Kerala, India

Dr. Tawee Kaewla-Iad
Lecturer
Faculty of Forestry
Kasetsart University
Bangkok, Thailand

Mr. Masakazu Kashio
Forestry Officer
FAO Regional Office for Asia and the Pacific
Maliwan Mansion
Phra Atit Road
Bangkok, Thailand

Mr. Ryosuke Kato
Chief Advisor
The Research and Training in Re-Afforestation Project, II
Central For. Res. Lab and
Royal Forest Department
Bangkhen, Bangkok 10900
Thailand

Dr. S.A. Khan
Forest Researcher
FRI OTG, Bangladesh
P.O. Box 273
Chittagong, Bangladesh

Mr. Choob Khemnark
Associate Professor and Head, Department of Silviculture
Faculty of Forestry
Kasetsart University
Bangkhen, Bangkok 10903
Thailand

Mr. William Knowland
Natural Resources and Environment Advisor
USAID
37 Soi Somprasong 3
Bangkok, Thailand

Mrs. Patricia Koshel
Energy and Environment Advisor
PPC/PDPR/SP 3894B NS
USAID
Washington, D.C. 20523
USA

Dr. Celso B. Lantican
Dean, College of Forestry
University of the Phlippines at Los Banos
College, Laguna 3720
Philippines

Dr. Terence Linkletter
Information Systems Specialist
7170 CATIE
Turrialba, Costa Rica

Mr. Kenneth G. MacDicken
F/FRED Network Specialist
c/o Faculty of Forestry
Kasetsart University
Bangkok 10900, Thailand

Dr. T.B.S. Mahat
Social Forestry Specialist/ Forestry Scientist
ICIMOD
GPO P.O. Box 3226
Kathmandu, Nepal

Dr. Max W. McFadden
Program Director
Eastern Hardwoods Research
Cooperative
USDA Forest Service
NE Forest Experiment Station
Broomall, Pennsylvania
USA

Dr. Ian G. Morison
Senior Forestry Research
Advisor and F/FRED Project
Officer and Manager
S&T Bureau, USAID
Washington, D.C. 20523
USA

Dr. V.R. Nanayakkara
Chief Conservator of Forests
Forest Department
P.O. Box 509
Colombo 2, Sri Lanka

Mr. Thomas C. Niblock
F/FRED Project Manager
Winrock International
1611 N. Kent St.
Arlington, Virginia 22209
USA

Dr. Cesar Nuevo
Chief, FRO, Institute of
Forest Conservation
University of the Philippines
at Los Banos
College, Laguna 3720
Philippines

Mr. Swat Nitcharat
Director, Division of
Silviculture
Royal Forest Department
Bangkok 10900, Thailand

Dr. Salleh M. Nor
Director General
Forest Research Institute
of Malaysia
Kepong, Selangor
52109 Kuala Lumpur, Malaysia

Dr. Pan, Fuh-Jiunn
Silviculturalist
Taiwan Forest Research
Institute
53 Nan-Hai Road
Taipei, Taiwan 10728

Dr. Eric L. Pang
Data Base Manager
F/FRED Project
University of Hawaii
P.O. Box 186
Paia, Hawaii 96779
USA

Dr. J. Kathy Parker
Social Ecologist
Food and Renewable Resources
Program
Office of Technology
Assessment, U.S. Congress
Washington, D.C. 20510
USA

Ms. Iris Patrizii
Researcher
ASEAN Dormitory
Kasetsart University
Bangkok 10900, Thailand

Mr. Mark Poffenberger
Program Officer
Ford Foundation
P.O. Box 2030
Jakarta, Indonesia

Mr. Kedar Prasad Prajapati
Dean, Institute of Forestry
Tribhuban University
Tripureswar
Kathmandu, Nepal

Miss Srisamorn Quengdaeng
Central Forest Research Lab
and Training Center
Royal Forest Department
Phaholyothin Road
Bangkhen, Bangkok 10900
Thailand

Dr. Romeo S. Raros
Head/Associate Professor
Department of Forestry
Visayas State College of
Agriculture
Baybay, Leyte
Philippines

Dr. Dietmar Rose
F/FRED Gloabl Research Team
University of Minnesota
College of Forestry
110 Green Hall
1530 N. Cleveland Avenue
St. Paul, Minnesota 55108

Dr. Uthaiwan Sangwanit
Lecturer
Dpeartment of Forest Biology
Faculty of Forestry
Kasetsart University
Bangkok, Thailand

Dr. Setijati Sastrapradja
Director
Centre for Research in
Biotechnology
Jalan Juanda 18
Bogor, Indonesia

Mr. Eka Raj Sharma
Chief, Forest Survey and
Research Division
Forest Department
His Majesty's Government
of Nepal
Babar Mahal
Kathmandu, Nepal

Dr. Somkid Siripatamadilok
Assistant Professor
Department of Forest Biology
Faculty of Forestry
Kasetsart University
Bangkok, Thailand

Dr. Komar Soemarna
Director
Forest Research and
Development Centre
Ministry of Forestry
P.O. Box 66
Bogor, Indonesia

Mr. Hendi Suhaendi
Forest Research and
Development Centre
Jl. Gunung Batu 5
P.O. Box 66
Bogor, Indonesia

Dr. Somsak Sukwong
Dean, Faculty of Forestry
Kasetsart University
Phaholyothin Road
Bangkok 10900, Thailand

Dr. John D. Sullivan
Director; Office of
Forestry, Environment
and Natural Resources
S&T Bureau, USAID
Washington, D.C. 20523
USA

Dr. Sompon Tanhan
Forest Technician
Surveying and Mapping
National Forest Land
Management Division
Royal Forest Department
Bangkok, Thailand

Dr. George F. Taylor
Agricultural Development
Officer, USAID/Nepal
Rabi Bhawan
Kathmandu, Nepal

Mr. Henry Tucker
Regional Planning Advisor
UNDP Project
c/o Bappeda Dati I
Jl. Flamboyan No. 2
Mataram, NTB
Indonesia

Dr. John W. Turnbull
Forestry Program Coordinator
ACIAR
P.O. Box 4008 QVT
Canberra ACT 2600
Australia

Dr. Batuk Prasad Upadhya
Forestry Institutional
Consultant
USAID
Kathmandu, Nepal

Mrs. Yenehai Vasujat
Chief of Soil Microbiology
Research Group
Department of Agriculture
Rhizobium Building
Kaset Klang Bangkhen
Phaholyothin Road
Bangkhen, Bangkok 10900
Thailand

Mr. Cor P. Veer
Rural Sociologist
GCP/RAS/III/NET
c/o FAO/RAPA
Maliwan Mansion
Phra Atit Road
Bangkok, Thailand

Dr. K. Vivekanandan
Chief Research Officer
Forest Department
P.O. Box 509
Colombo 2, Sri Lanka

Dr. Sathit Wacharakitti
Associate Dean
Faculty of Forestry
Kasetsart University
Bangkhen, Bangkok 10900
Thailand

Mr. Pisal Wasuwanich
Director, ASEAN-Canada
Forest Tree Seed Centre
Muak-Lek
Saraburi
Thailand

Dr. Kovith Yantasath
Senior Research Officer
Thailand Institute of
Scientific and Tech.
Research
196 Phaholyothin Road
Bangkok 10900, Thailand

Mr. Chanchai Yarwudhi
Head, Department of Forest
Engineering
Faculty of Forestry
Kasetsart University
Bangkok, Thailand

F/FRED Forestry Networks Workshop

Program

Wednesday, September 24

Welcome and Introduction

8:30- 8:40 am	Welcome (Rector Sutharm Areekul)
8:40- 9:00 am	F/FRED Project Overview Planning Leading to F/FRED (Ian Morison) Development of F/FRED in Asia (Robert Ichord)
9:00- 9:20 am	Steering Committee Reports (Salleh M. Nor)
9:20- 4:40 am	LFM Network Update (William Hyde)
9:40-10:00 am	MPTS Network Update (Robert Dixon)
10:00-10:20 am	Global Research Team Update (Foster Cady)
10:20-10:40 am	Coffee Break
10:40-11:20 am	Regional Opportunities for Networking: The FRIM Experience (Salleh M. Nor)
11:20-12:00	Survey Methods to Determine Research Priorities: A Thai Case Study (Suree Bhumibhamon)
12:00- 1:30 pm	Lunch
1:30- 2:00 pm	Planning and Implementing MPTS Field Trials (Kenneth MacDicken)
2:00- 2:30 pm	MPTS Provenance Trials (James Brewbaker)
2:30- 3:00 pm	Opportunities for MPTS Biotechnology Research Networking (Robert Dixon)
3:00- 3:30 pm	Coffee Break
3:30- 4:00 pm	Integrating the Social Sciences into MPTS Research Networking (William Bentley)

Thursday, September 25

Electronic Information Management

8:30- 9:15 am	Overview of DBMS For MPTS (Dietmar Rose and Foster Cady)
9:15- 9:45 am	Hardware and Software Systems for Data Management in MPTS Research (Terence Linkletter)
9:45-10:00 am	Coffee Break
10:00-12:00	Small Group Discussion Questions
12:00- 1:30 pm	Lunch
1:30- 3:00 pm	Small Group Reports
3:00- 3:30 pm	Coffee Break
3:30- 5:00 pm	Small Group Discussion of MDS Needs and Methodologies

Friday, September 26

7:00- 6:30 pm	Field Trip to Review MPTS Provenance Trials and Community Forestry Program

Saturday, September 27

8:30- 9:00 am	Memorandum of Understanding (Robert Dixon)
9:00-10:00 am	Documentation Center Establishment (Norma Adams)
10:00-10:30 am	Coffee Break
10:30-12:00	Network Implementation Procedures Small Grant Guidelines (Robert Dixon, William Bentley, and Kenneth MacDicken)
12:00- 1:30 pm	Lunch
1:30- 2:00 pm	Establishment of MDS (Foster Cady)
2:00- 3:00 pm	Planning Sessions for Future Network Activities
3:00- 3:30 pm	Coffee Break
3:30- 4:00 pm	Summary