Improving Multipurpose Trees for the Humid Tropics of Asia: Providing Alternatives to Slash and Burn and to Rehabilitate Degraded Lands

Dennis P. Garrity
Systems Agronomist and Coordinator

Southeast Asian Regional Research Programme
International Centre for Research in Agroforestry
Jalan Gunung Batu No.5
P.O Box 161, Bogor 16001
Indonesia
Telephone (62-251) 315234
Fax: (62-251) 315567
E-mail: IN%"ICRAF-Indonesia@cgnet.com"

Paper presented at the International Seminar on "Conservation and Utilization of Multipurpose Tree Species for Rural Development and Food Security", Taiwan, Forestry Research Institute, Taipei, June 27-28, 1994.

Abstract

Multipurpose trees and shrubs (MPTs) are a key element in alleviating several of the most urgent environmental and poverty-related problems of the tropical developing countries. The inclusion of productive timber and fruit trees on small-scale farms, particularly on degraded lands, provides important sources of income while offering crucial environmental services. Multipurpose tree cultivation by small farmers can provide a superior means of reforesting large areas of degraded Imperata grasslands in Southeast Asia with ecologically- and socially-important species. At the same time, these trees may provide the major source of timber and fuelwood for countries whose stock of natural forests is now virtually exhausted.

As has been proven in crop plants, and in plantation forestry in the temperate regions, the genetic improvement of MPTs by the collection and domestication of the existing germplasm may provide cultivars with enormously greater (40-90%) productive potential than those currently available. Unfortunately, sustained attention to this aspect of tropical development has been greatly neglected.

In order to help realize some of the potential of the MPTs in the humid tropics of Asia, ICRAF proposes to initiate a research project in the region, as part of its Multipurpose Tree Improvement Programme (Programme 2). The project (the Multipurpose Tree Improvement Project for the Humid Tropics of Asia) will be a critical component of ICRAF's mission to mitigate tropical deforestation, land depletion, and rural poverty through improved agroforestry systems. The work will build upon the strong foundation of MPT improvement that the Network has achieved, and foster new intensity in this important work. The proposed work will advance the research carried out through the Network. It will initiate MPT improvement to address urgent current concerns related to sustainable natural resources management and the conservation of biodiversity through the identification and dissemination of tree germplasm suited to small-scale farmers in fragile environments on the margins of protected forests, in degraded grasslands, and in hilly, erodible farmlands.

The project will develop multipurpose tree cultivars that will provide profitable, sustainable, and ecologically-superior alternatives to slash-and-burn agriculture. It will also identify tree cultivars that enable small-scale farmers to effectively rehabilitate degraded grasslands and hilly farmlands in the humid tropics of Asia. It will place particular emphasis on the indigenous fruit, timber and fodder MPTs within each of the major eco-geographic zones of the humid tropics. The research will emphasize clonal selection and propagation systems that accelerate the identification and dissemination of improved cultivars to farmers. Such non-conventional systems are an efficient means to capture genetic variation for rapid dissemination of outstanding cultivars.

The strategy is to focus on two key eco-geographic regions within the humid tropics: The equatorial tropics represented by Indonesia, Malaysia, and southern Philippines; and the northern tropical belt represented by northern Thailand and adjacent countries (Vietnam, Laos, Myanmar and Southern China). Each has unique environmental and socioeconomic circumstances.

The work will involve the selection of several priority species based on an understanding of the key agroforestry systems in the threatened upland ecosystems. This will be followed by intensive collection of the germplasm of these species; evaluation and domestication of the most promising material, and the development and dissemination of the outstanding cultivars identified. Innovative improvement methods will be employed for evaluating and utilizing germplasm through seed or clonal propagation, depending upon the species.

Agroforestry in Southeast Asia: The Setting

An astounding array of agroforestry systems are observed in Asia, evolving in response to market changes, new technical options, and the inexorable pressure of more people on the land. Agroforestry systems were always there, particularly in the uplands. But until recently their potential to solve land use problems was not recognized by mainstream research and extension institutions, and consequently they were given very little notice but the situation has changed.

Upland Agroforestry Solutions. As the staple food production problems in the lowlands were successfully overcome, governments had breathing space to begin seriously grappling with the ecological and poverty crisis in the uplands. Widespread interest has mounted in implementing upland agroforestry development programmes, often involving non-traditional land tenure arrangements. In socialist (eg China and Vietnam) as well as in free-market economies (eg Philippines and Thailand) major programmes are evolving that essentially involve the transfer of millions of hectares of hilly land from government control to family farmers. Agroforestry has been popularized among decision- makers as a conservation farming solution to sustaining the productivity of these fragile lands. Consequently, there is an enormous demand for sound upland agroforestry technology. Improved cultivars or provenances of key multipurpose species are crucial to the success of agroforestry systems.

ICRAF's Mission in Multipurpose Tree Improvement

ICRAF's purpose is "to work towards mitigating tropical deforestation, land depletion, and rural poverty through improved agroforestry systems." The implementing guidelines for our research and dissemination activities include a determination to use appropriate indigenous knowledge to develop improved technologies, and a concern to ensure that agroforestry technologies simultaneously address the welfare of rural households and the conservation of natural resources for sustainable production.

The Southeast Asia Regional Research Programme. The institute established a regional programme in Southeast Asia in 1992. The basic objective of the Southeast Asian Regional Research Programme is to implement ICRAF's mission in the context of the unique agroecological and institutional circumstances of the nations of Southeast Asia (Garrity, 1993). Defined in ecological terms the region includes the continuum of humid tropical environments that stretches from Indonesia and the Philippines in the south and east, through Indochina and southern China, to Thailand, Myanmar, and the northeastern hill states of India.

This is an exceedingly diverse and dynamic region. It includes countries with immense areas of tropical rainforest (104 m ha in Indonesia) and many countries (eg; the Philippines and Thailand) dominated by denuded, hilly lands whose forest is only a memory.

The regional headquarters is located at the Forest Research and Development Centre in Bogor. The offices are adjacent to those of the Asia- Pacific Agroforestry Network (APAN), and the global headquarters of Centre for International Forestry Research (CIFOR). This location enables ICRAF to collaborate closely with APAN in agroforestry training and information

dissemination in 10 Asian countries. It also integrates ICRAF with the forest science community at CIFOR. And it places the institute in a position to link with the Indonesian forestry and agricultural science community centred in the many Bogor based research institutions.

The general themes of the Programme's activities are:

* **the development of alternatives to slash-and-burn agriculture in buffer zones, and**

* **the rehabilitation of degraded uplands, primarily those dominated by *Imperata cylindrica*.**

MPT improvement work will target ecosystems and agroforestry systems that focus on these major problems. ICRAF is the convening centre for the Global Initiative on Alternatives to Slash-and-Burn (Bandy et al., 1993). This effort links over 17 international and national research institutions to provide practical solutions to the problem of slash-and-burn agriculture on the three tropical continents. Improved MPTs are an essential component of alternative agroforestry systems for slash- and-burn. Therefore, we see very important linkages for the work envisioned here and the activities of the this global initiative in Asia.

ICRAF in Southeast Asia will focus on small-scale farmers and their agroforestry systems. It will encourage farmers to use improved germplasm of MPTs on their own farms. This is a critical component contributing to forest conservation, helping to alleviate the need to further destroy the dwindling natural forest stands in the region.

The Multipurpose Tree Improvement Programme

Multipurpose Tree Improvement is one of ICRAF's four research programmes[1]. This programme collaborates closely with ICRAF's other programmes to identify and improve multipurpose tree species which have the proven potential to produce food, fruit, fodder, fuelwood, timber, mulch, and other products. This is done through a systematic process of selection, evaluation, domestication and conservation.

The MPT Germplasm Resources Unit. Globally, some 2000 MPT species have been identified. ICRAF focuses only on several priority species within its MPT Improvement Programme. The Centre's MPT Germplasm Resource Unit, located in Nairobi, will be the global focal point for multipurpose tree germplasm: Supplying seed and vegetative material for research, and information about species characteristics and accessions using ICRAF's MPTS database, which currently holds details on some 1100 species.

The Centre will conserve priority species; the domestication project deals with scores of species; while tree improvement work will focus on but a few. ICRAF 's MPT improvement work in

---

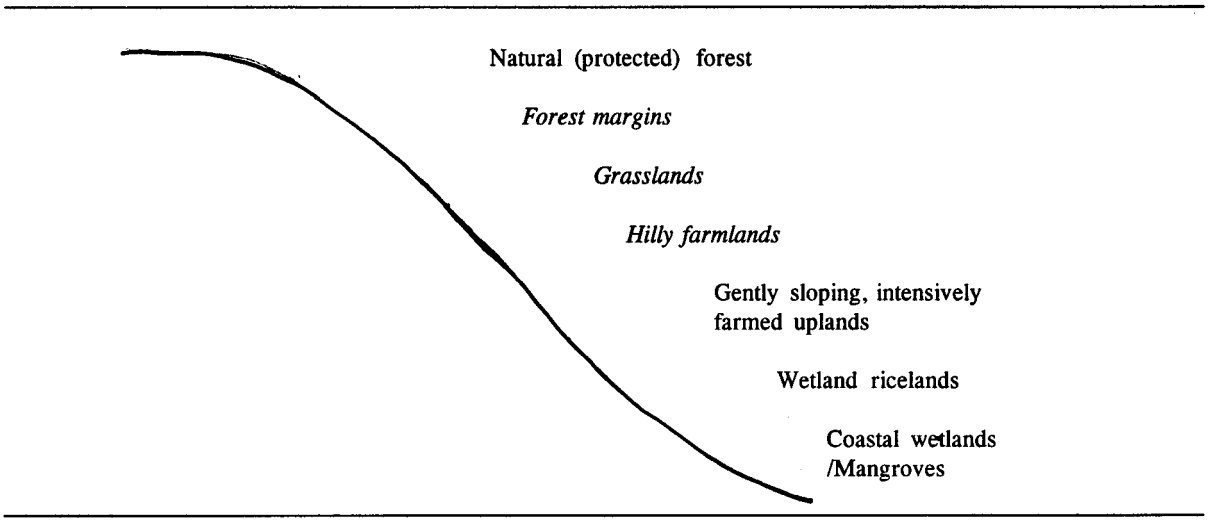
[1]The other three ICRAF research programmes are: Characterization and Impact, Component Interactions, and Systems Improvement.

Southeast Asia will be carried out in collaboration with regional and national tree seed centres and gene banks, and with CIFOR. It focuses on those MPTs that can play dominant roles in key agroforestry systems. These are determined through a process of identification that proceeds directly from the ecosystem targets and systems hypotheses that the entire ICRAF team will focus on.

The MPT programme has developed training packages on MPT improvement methods and techniques. Over 100 researchers and field technicians from collaborative institutions in Africa have participated in this type of training. Similar training packages will be developed for Southeast Asia in collaboration with national and international institutions.

The Ecosystem Focus

The landscape ecology of much of Southeast Asia follows a broadly similar pattern along a decreasing elevational gradient. In a 'typical' watershed the land use pattern may be characterized as:



This simplified pattern is useful in conceptualizing the ecosystems and their interactions for research and development planning.

The remnants of old growth forest are generally present only at the highest elevations (eg old growth is seldom observed at less than about 800 m elevation in the Philippines). The boundary of the forest margin moves upward due to forest conversion processes, accelerated by slash-and-burn. Below the forest margins are extensive grasslands. They evolved following prior cultivation, and are maintained in a fire climax. These lands are used (depending on the area) for cattle grazing, hunting, or shifting cultivation. At lower elevations closer to the roads, the hilly lands are more densely occupied. Here, rotation-fallow systems are gradually evolving into more permanent cropping systems. This zone grades into more gently sloping, intensively farmed uplands. Wetland rice is produced in the alluvial valleys from the uplands to the broad

lowland river basins. Agroforestry is important in the rice-growing areas as home gardens and bund planting. The coastal wetlands include large areas of mangroves, which allow for unique forms of agroforestry.

ICRAF's target ecosystems in Southeast Asia will be limited to the uplands, and will encompass three ecosystems: The forest margins, grasslands, and hilly farmlands. Each of the prospective research sites for the 'alternatives to slash-and-burn initiative' have been selected to sample these landscape components.

Agroforestry Systems Hypotheses

Our research in the target ecosystems is based on three agroforestry systems hypotheses. One hypothesis guides the efforts in each target ecosystem.

Systems Hypothesis 1. On the forest margins, complex agroforestry systems or 'agroforests' provide a superior alternative for small-scale farmers to either food crop systems or monoculture plantations of perennials. Complex agroforests increase production sustainability, increase biodiversity, reduce production risks, and increase returns to labour when compared to continuous food crops or monoculture plantation crops models as alternatives to slash-and-burn.

There have been two predominant models promoted for sustainable settlement of the forest margins in Southeast Asia. The first might be termed the 'continuous food crops model'. It was based on the premise that with appropriate soil and crop management practices, continuous annual cropping could be practised sustainably on humid, infertile Ultisols and Oxisols based.

An alternative model, given particular emphasis during the past decade, is the 'monoculture estate crops model'. This model involves the development of 'nucleus' estates to replace natural forest and/or slash-and-burn farming. Concerns have arisen with this model, particularly the high degree of price risk farmers face because their source of livelihood is dependent on a single commodity. Other instabilities observed are the loss of biodiversity in the production system, and the likelihood of increased pest infestation, threatening dependence on pesticide inputs.

A mounting body of studies on the agroecology of the farming systems of indigenous communities on the forest margins in Southeast Asia has now provided strong indications that there is a 'middle ground' between continuous annual cropping and monoculture plantations.

Solutions involving the development of agroforests, or complex agroforestry systems, have been quietly occurring in some rural communities on the forest margins. 'Agroforest' models that exemplify these solutions include: The 2.5 million hectares of 'rubber agroforests' in Indonesia, the cultivation of dipterocarp timber trees in several types of agroforestry systems (including the damar systems), and the diverse array of fruit agroforest systems.

These systems have now been described and documented. Our systems improvement team is building a sustained effort to better understand their agroecology, to predict their extrapolability, and construct agronomic and silvicultural improvements that will expand their productivity.

The potential of such systems to intensify production in the buffer zones of protected forests and national parks is now being recognized. The Multipurpose Tree Improvement team will strive to infuse improved germplasm into complex agroforestry systems.

We will focus on:

* **key species of fruit trees** with excellent prospects as timber, fodder, and fuelwood producers. Examples of such species include jackfruit (Artocarpus heterophyllus) and durian (Durio zibethinus), and Gnetum gnemom.

* **key species of timber trees** are cultivated in mixed agroforestry systems by small-scale farmers for their fruits of industrial importance. Examples include the Dipterocarps damar (*Shorea javanica*) and illipe nuts (*Shorea macrophylla*, *S. stenoptera* & others). The damar agroforests of Sumatra provide a regular income from resin tapping in addition to quality timber. Illipe nuts provide an important internationally-traded oil.

A scientific understanding of these systems has only begun. The prospects for building upon indigenous knowledge is only gradually being recognized by the scientific community.

It is essential to target the research to two types of situations:

* Mature communities with promising agroforest solutions, and

* Pioneer communities facing the challenge of how to proceed toward sustainable systems.

We will employ a farmer-participatory land use systems research methodology, complemented by vigourous researcher-managed investigations. A collaborative research team of international and national researchers will tackle the issues from the social, economic, agroecology, agronomic and silvicultural perspectives. The ICRAF research team will be composed of a social scientist, forest ecologist, ethnobotanist, systems agronomist, and soil fertility specialist, with germplasm contributions from the multipurpose tree specialist.

National teams are also now forming to understand, promote, and improve agroforest models for their specific agroecosystems.

Systems Hypothesis 2. The rehabilitation of *Imperata* grasslands through small-scale agroforestry systems will be superior to plantation reforestation in terms of production, equitability, and participation objectives.

The *Imperata cylindrica* grasslands of Southeast Asia represent a vast underutilized natural resource, covering an aerial extent of 20 to 50 million hectares. Most grasslands (known as *alang-alang, cogon*, and *lalang* in local languages) in the region were derived through slash-and-burn cultivation, linked with logging activities, and maintained through the frequent occurrence of fire. Plantation forestry, particularly the many projects sponsored by forest departments, has had a disappointing history. There is increasing interest in focusing on land use alternatives for the grasslands that feature the active participation of local people.

Little systematic knowledge exists concerning the rehabilitation of degraded grasslands. Largely ignored is the reality that the presence of Imperata grasslands is symptomatic of a complex interaction of human and environmental factors. A more holistic understanding of the agroecosystem is essential in developing truly practical and comprehensive ways of managing and exploiting the potential of these lands.

Agroforestation. Timber prices are increasing rapidly in Southeast Asia. This incentive is inducing small-scale farmers to grow trees for sale (van den Beldt et al., 1994). Hundreds of farmers in the southern Philippines are widely planting such species as *Gmelina arborea*, *Peraserianthes falcataria*, and *Acacia mangium*. They are intercropping the trees in contour lines with their annual field crops often in lieu of practicing a grass fallow-rotation (Garrity and Mercado, 1994). Unfortunately, the genetic quality of the seed they used is poor, and the lack of diversity in the species planted is alarming.

Preliminary observations indicate that the establishment of timber trees by small-scale farmers has several unique advantages:

1) land preparation and weeding costs in the initial years are charged to the annual crops, making tree establishment and maintenance cheap and effective compared to large-scale plantation methods,

2) the cropped alleyways between trees provide fire breaks that drastically reduce wildfire damage, and

3) small farmers' more intensive field management better insures that the trees will make it to harvestable age.

The premise is that small-scale farmers may be effective agents for reforestation in the future, by integrating trees into their farming systems. Strategically designed tests of this hypothesis will provide a basis for further action. ICRAF proposes to attack this issue most promising by selection and propagation of improved germplasm of the most promising MPTs with research on improved production systems.

The Hilly Farmlands. In the third target ecosystem, hillslope farmlands, there are several pathways to sustainable small-scale farming. Annual crop farming is common on millions of hectares of hilly land in nearly every country in Southeast Asia. Much of this land is on slopes that range from 15-90 %, with documented rates of soil erosion that typically range from 50-300 t/ha/yr (Garrity, 1993). If urgent efforts to stabilize these soil resources are not successful, the resulting land degradation and wasted farms will further exacerbate settlement pressure on the forest margins.

Contour hedgerow systems provide distinct advantages as a superior, least cost foundation upon which to build agroforestry-based conservation farming. The production of timber and fruit trees in such systems provide the family with competitive income while it also obtains the service functions of the trees in soil conservation and nutrient cycling through the leaf litter produced.

Building on the MPTS Network Foundation

The MPTS Network was founded through the support of USAID as part of the Forestry/Fuelwood Research and Development Project (F/FRED). The Network has made substantive progress in understanding the comparative performance of important exotic species of fast-growing hardwoods across the humid/subhumid zone of Southeast Asia. Two sets of multilocational international humid/subhumid trials have been conducted in the humid/subhumid ecologies. They included such species as *Acacia mangium*, *Acacia auriculiformis*, and *Leucaena spp*. They have provided the best tropical genotype-environment data on these species performance ever obtained. These species have become quite popular in reforestation projects in many parts of the region.

Proposed ICRAF collaboration with the MPTS Network would build upon this knowledge of popular fast-growing species performance by attempting to identify species that may further diversify the alternatives for small-scale farmers. Emphasis will be placed on species that are adapted to the fire-prone and nutrient poor grassland environments, forest margins, environments, and sloping infertile farmlands.

The choice of species for improvement will in future be focussed more on a regional basis within countries, a somewhat different model than reliance on a few species with presumed wide inter-country extrapolation. Such a shift in emphasis may allow tree improvement to better cope with the diversity of ecological conditions and market realities across Asia.

Key Elements of the MPTS Strategy

1. The target beneficiary of improved MPTS germplasm is the small-scale farmer, in contrast to the situation in tree improvement programmes for industrial forestry. Therefore, farmer preference surveys and farm-level adoption and impact studies is the critical first stage in the research. Some of this work has already been done through the F/FRED MPTS Network.

2. Germplasm collection will be vigorously implemented to sample and conserve the full range of genetic variability to be found in natural and domesticated populations. ICRAF's MPT Germplasm Unit will backstop the efforts in Southeast Asia. The ICRAF Multipurpose Tree Improvement Programme will be linked with the major germplasm conservation institutions within and outside the region.

3. The time and investment required for the improvement of the many useful multipurpose tree species through conventional tree improvement methods is unrealistic in the present circumstances. Unconventional methods will be required. We will emphasize the use of vegetative multiplication of varieties and the use of low-tech clonal propagation systems. Arrangements will be made for the timely flow of improved germplasm to national programmes for evaluation, multiplication, and distribution to farmers.

4. Many tropical forest and multipurpose trees produce recalcitrant seed. Little is known of their breeding systems and genetic variation. The project will engage the substantial expertise resident in the Southeast Asia region to develop practical ways of overcoming recalcitrant seed problems in key species.

5. A team effort is essential. The species selection process, and the subsequent evaluation of identified germplasm, are to be considered part of the overall agroforestry systems research process in which social scientists, silviculturists, and agronomists make collaborative contributions.

6. ICRAF's comparative advantage is in fitting MPTs into agroforestry systems. The promising systems are identified through the involvement of the ICRAF Systems Improvement Programme. Scientists in this programme provide the framework for species selection by establishing the priority agroforestry systems and new technologies into which improved germplasm can best be fitted. Germplasm evaluation will be done to conform to the requirements of the management systems.

Capacity Building through Training and Information

A major objective of ICRAF MPT improvement will be to enhance the capacity of national researchers as well as extension workers and farmers through short-term training, fellowships and better access to relevant information. Responsibilities in this area include:

- identification of priority training and information needs in each country and development of comprehensive training programmes;
- establishment and maintenance of contacts with national, regional and international institutions active in MPT research, training, education and development;
- insurance of a dynamic collaboration among relevant institutions in training and information aimed at meeting the needs of the MPT programme.

Activities

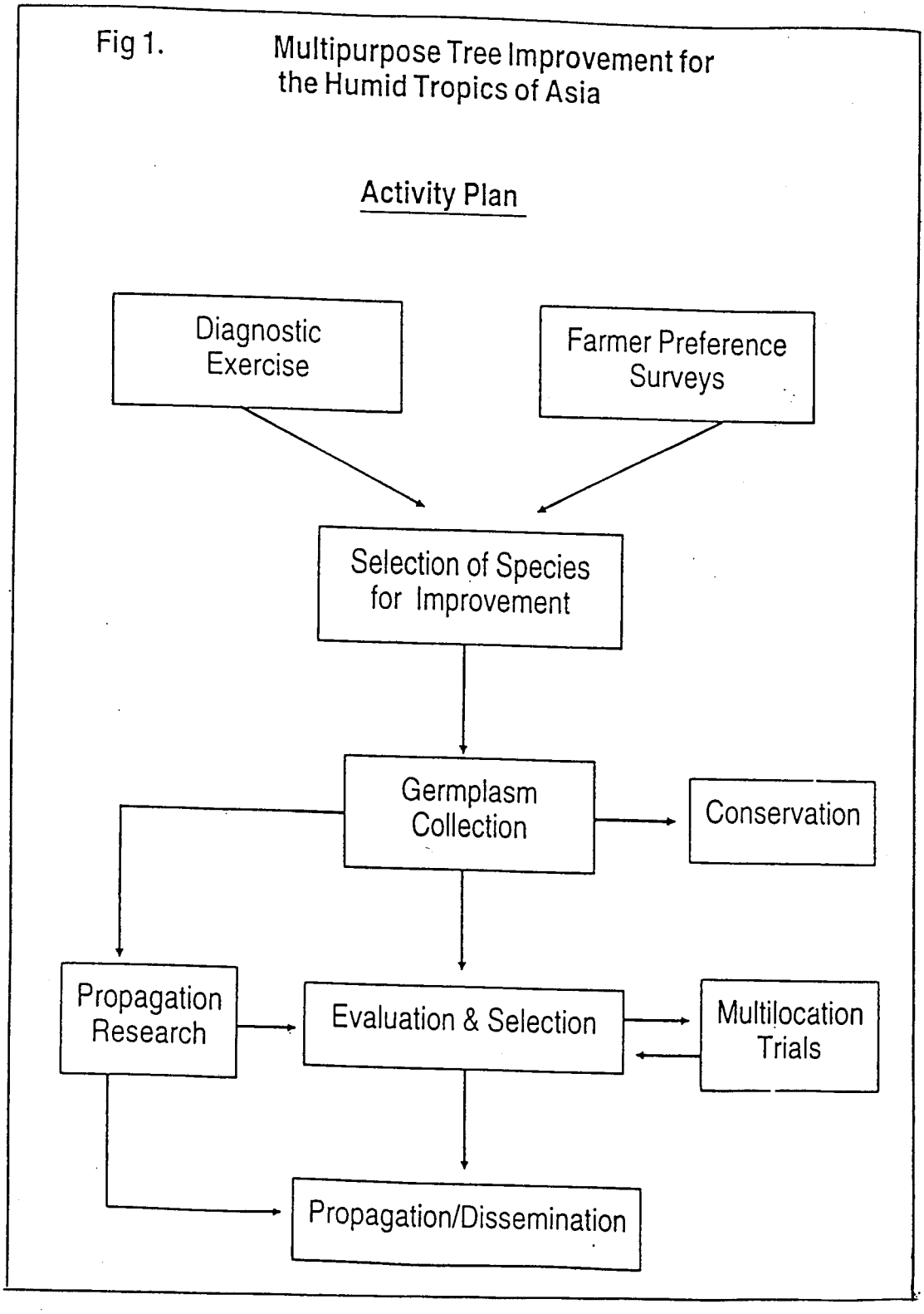
The proposed activities in MPT improvement are diagrammed in Figure 1. They will focus the promising indigenous MPT species in the major eco-geographic zones of Southeast Asia.

First, **diagnostic exercises and farmer preference surveys** will be conducted in both of the humid Southeast Asian target eco-geographic regions (equatorial and mainland tropical hilly lands). This work will culminate in a formal process of MPT species prioritization and selection. A regional workshop will help finalize consensus.

Second, **intensive germplasm collection** will be carried out to assemble the widest genetic variation possible for each target MPT species. This germplasm will be conserved in various international gene banks, and shared among all participating countries. Collection will be done in each eco-geographic region as a collaborative team activity with national scientists of the Humid/Subhumid component of the MPTS network.

Third, **the germplasm will undergo intensive domestication**. Promising material will be shared among all interested cooperating institutions for evaluation. Some evaluation may be done in monoculture. The work will,however, emphasize germplasm evaluation in on-farm trials within

Fig 1. Multipurpose Tree Improvement for the Humid Tropics of Asia



the context of the target agroforestry systems. Thus, silviculturists and agronomists will play a key role in germplasm evaluation. Multi-location trials will be initiated to ensure uniform evaluation methods, based on the experience of F/FRED.

Fourth, **more efficient propagation methods** will be developed for the target MPT species. Emphasis will be given to clonal propagation methods where they are appropriate. For this work a modest clonal propagation project research unit will be established. In species where this is not the best route, research on overcoming recalcitrant seed problems will be undertaken.

Finally, as improved germplasm becomes available for wider scale distribution and cultivation by farmers, **methods of larger-scale propagation and dissemination will be developed and tested.**

Linkages

The key linkages to be developed in this project will be between the scientists participating in the MPTS Network itself. But the work will also be linked with a number of ongoing efforts to improve tree germplasm and agroforestry systems in Asia and globally. It will work closely with CIFOR in its areas of tree improvement that may complement our efforts. We will take advantage of the current collaboration between the MPTS Network and the Canada-ASEAN Tree Seed Centre in Thailand, and will explore continued collaboration in germplasm collection, conservation, and the exchange of seed material in multi- location trials. We will also identify and link with the major groups with experience in clonal propagation in the region. To connect the germplasm improvement efforts of this project with the wider role of identifying improved agroforestry systems, we will closely link the MPT germplasm evaluation efforts with the research teams and key sites of the global Alternatives to Slash-and-Burn (ASB) Project.

Outputs

We anticipate the following outputs from this collaborative work:

* A carefully prioritized choice of MPT species for major research in two eco-geographic regions of the humid tropics of Asia.

* Comprehensive collections of the target MPT species from sites throughout their range, well-characterized, and conserved for use by any interested research institution.

* Results on the evaluation of the selected germplasm of the target MPTs in major agroforestry systems, with the information published and distributed to all collaborating centres.

* Capture of genetic variation of outstanding individuals, with methods made available to interested researchers.

* A continuing, dynamic MPT research network for the humid tropics of Asia that links researchers from the various national programmes in the exchange of germplasm, experience, and scientific progress.

* Human resource capacity developed at the institutional and community levels.

In the medium term, we anticipate that the practical outputs of our work will guide the efforts of governments and development banks in designing programmes that better support the efforts of small-scale farmers to produce trees for market demand, family, consumption, and hillslope sustainability. In Asia, the small-scale farmer may in future be the most effective forester, producing much of the timber and fuelwood through profitable and adaptable agroforestry systems. This project will build toward that eventuality.

References Cited

Bandy, D.E., D.P. Garrity, and P.A. Sanchez. 1993. The worldwide problem of slash-and-burn agriculture. Agroforestry Today 5(3):2-6.

Garrity, D.P., and A.R. Mercado Jr. 1994. Reforestation through agroforestry: Smallholder market-driven timber production on the frontier. *In* Raintree, J. and H. Fernandez (eds) Marketing Multipurpose Tree Species in Asia. Winrock, Bangkok (forthcoming).

Garrity, D.P. 1993. ICRAF Southeast Asia: Implementing the Vision. International Centre for Research in Agroforestry, Bogor, Indonesia. 19 p.

van den Belt, R., C. Hatch, C. Sastry, J. Raintree, S. Ghosh, N.C. Saxena, and D.P. Garrity. 1994. Farm forestry comes of age: The emerging trend in Asia. Farm Forestry News, F/FRED, Bangkok, Thailand. pp. 1-4.