PN-AAP-781/22

SECOND DRAFT
April 28, 1981

ISN: 39256

FORESTRY RESEARCH NEEDS IN DEVELOPING COUNTRIES

- TIME FOR A REAPPRAISAL?

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World Bank
Washington, D.C.
U.S.A.

and

FAO
Rome
Italy

Paper for 17th IUFRO Congress
Kyoto, Japan
6-17 September, 1981

ABSTRACT

Following a review of global forestry research in the last decade and of the numerous organizations conducting or supporting research at national and international levels, changing emphases in developing country forestry programs are detected and new priorities for research are identified. These are directed towards the contribution of trees and forests to agriculture and rural welfare (including socioeconomic and environmental aspects), to the increased production and more efficient use of wood-based energy, and to the conservation and management of existing forest resources. Strategies advocated for ensuring more intensive research in these areas and for meeting technical and physical research needs are, principally, strengthening national research institutions in the developing countries themselves and more effective 'twinning' of national agencies with some 90 existing research agencies identified in the paper which are already carrying out research in these priority areas.

FORESTRY RESEARCH NEEDS IN DEVELOPING COUNTRIES - TIME FOR A REAPPRAISAL?

Table of Contents

Page No.

ABSTRACT

EXECUTIVE SUMMARY

CONCLUSIONS AND MAIN RECOMMENDATIONS 1

1. OBJECTIVES OF PAPER

2. DEFINITIONS AND CLASSIFICATION OF RESEARCH AND ECONOMIC RETURNS

   Definitions and classification of research
   Economic returns from forestry research

3. CURRENT SOURCES OF FORESTRY RESEARCH

   National level
      Governmental organizations
      Universities and polytechnics
      Non-governmental organizations (NGOs) and national societies
      Forest research sponsored by the private sector

   Regional level

   International level
      International institutes funded through the CGIAR
      UN agencies and organizations
      Other agencies and commissions
      National research institutes in developed countries with programs of relevance to developing countries
      Foundations, trusts, religious and charitable organizations
      International societies

   Role of the donor community

Page No.

4. RESEARCH ACHIEVEMENTS OF THE LAST DECADE

Monitoring and inventory of natural forest

Utilization of secondary species

Industrial utilization
- Reduced industrial scale
- Mixed tropical hardwood pulp
- Reconstituted wood
- Laminated wood structures

Logging methods
- Mechanized logging
- Harvesting

Plantation forestry
- Species/population variation and genetic conservation
- Tree breeding
- Vegetative propagation including tissue culture
- Nursery techniques
- Land preparation and planting techniques
- Soil moisture relations
- Fertilizers
- Silviculture
- Wood properties

Pests and diseases

Watershed (catchment) and hydrological research

Tropical silviculture and management

Minor forest products

Agroforestry

Wood as an energy source

Institutional research

5. CHANGING EMPHASIS IN FORESTRY IN DEVELOPING COUNTRIES AND IDENTIFICATION OF RESEARCH NEEDS

Changing emphasis in forestry

Research needs for developing countries in the coming decade

Page No.

Role of forests and trees to contribute to agriculture and rural development
Forestry research related to energy production
Management and conservation of existing resources (mainly natural forests)
Forestry research related to industrial needs

6. PHYSICAL NEEDS FOR STRENGTHENING FORESTRY RESEARCH IN DEVELOPING COUNTRIES

Staff numbers

Professional research education and personal development

Career structure

Relevant facilities

Information and communication
Compilation and dissemination of information
Publications
Abstracts, data bases and retrieval systems
Microfilms, microfiches, photocopies
Translation
Project indices
Computing sub-committees

Extension and effective application of research results

7. POSSIBLE STRATEGIES FOR STRENGTHENING FORESTRY RESEARCH IN DEVELOPING COUNTRIES

Increased support for national forestry research institutions

Increased support for research organizations already working in areas of primary concern to developing countries

Page No.

Examples of possible twinning arrangements between forestry research institutions

(a) In relation to agriculture and rural development

(b) In relation to wood-based energy

(c) In relation to management and conservation of existing resources (mainly natural forests)

Is there a need for new institutions?

Quality of Research

8. STRATEGIES FOR INCREASING PROMOTION, SUPPORT AND COORDINATION OF FORESTRY RESEARCH IN DEVELOPING COUNTRIES

IUFRO

FAO

9. FINANCIAL IMPLICATIONS

REFERENCES

ANNEXES

1. Abbreviations
2. Products and benefits derived from forests
3. Mechanism for establishing priorities for forestry
4. Forestry research needs for developing countries
5. Forestry research needs in developing countries and number of existing countries with relevant activity
6. Examples of organizations with current programs relevant to the forestry research needs of developing countries
7. Acronyms and locations of the centers listed in Annex 6
8. Information centers

TEXT TABLES

1. Distribution of FAO questionnaire on forestry research institutes

EXECUTIVE SUMMARY

CONCLUSIONS AND MAIN RECOMMENDATIONS

1. During the 1970s, there has been increasing recognition in many developing countries of the important role that forests and trees can play in helping to increase agricultural productivity, to improve rural welfare, to alleviate the negative impacts of the energy crisis and to preserve the environment. There has been a major shift in forestry development towards these areas of concern but this change has not been paralleled by a similar shift in the emphasis of forestry research. The main objectives of this paper, outlined in Chapter 1, are therefore, to review the current status of forestry research in developing countries and to identify areas of research that need to be strengthened so that they can contribute more effectively to the new areas of developmental priority. Chapter 2 defines the types of research dealt with in this paper and briefly introduces the topic of economic rates of return which might be achieved through investment in soundly conceived forestry research programs.

2. Since no comprehensive review of the status of world forestry research has been carried out since 1963, and there was no readily available study to indicate who is doing what and where, Chapter 3 is devoted to such a review. A major conclusion is that there are far more agencies engaged in forestry research than is generally perceived. More than 600 research organizations have been identified on a global basis.

3. Chapter 4 briefly summarizes the major forestry achievements of the last decade to see to what extent these relate to the changing emphasis in forestry. The conclusion is reached that most research expenditure in the 1970s (probably more than 90 per cent) was related to utilization of natural forest resources and to creating new industrial plantations, improving knowledge of species in the remaining natural forests of the developing world and, in particular, examining the potential for better industrial utilization with emphasis on products such as sawn lumber, plywood, veneer or pulp. By contrast, research into fuelwood, charcoal and other wood-based energy products, which account for more than 80 per cent of total wood consumption in the developing world, has been minimal. Whilst industrial forestry research will remain important to those countries that do possess a major resource, it is clear that a fresh look is needed at research priorities. Only about 40 out of some 140 developing countries possess a significant natural forest resource and for the majority the main thrust of forestry during the 1980s will be on afforestation or reforestation with fast growing species with special emphasis on fuelwood and planting multi-purpose trees around homesteads, along farm boundaries, in village woodlots and in upland watersheds. Research needs in these countries should reflect this fact.

4. Chapter 5 of the paper identifies major needs for future research in developing countries and focusses on three main topics:

- Research related to the contributions of forestry to agriculture and rural welfare including productive and protective functions of trees and forests;

- Research related to energy production and use;

- Research related to more effective conservation and management of tropical forest ecosystems with special reference to protection of the environment.

Appropriate research topics covering these three main areas are discussed, including (a) greater emphasis on research into farming systems incorporating trees and on watershed protection, (b) research into ways and means of increasing the productivity of trees to produce the maximum biomass and energy yield per hectare in the shortest possible time, and (c) conservative oriented research to make more effective use of remaining wood resources and to protect plant and wildlife resources for the benefit of future generations. Because industrial research will remain important for some developing countries, an attempt is also made to identify special areas of industrial research concern for the 1980s.

5. Chapter 6 discusses physical needs to meet future research requirements. It deals with the important issues of physical means for more effective research in developing countries and briefly summarizes the range of modern technological systems available to developing countries that can help to speed up the process of data recording, classification and dissemination of research results. This chapter also mentions staff requirements for expanded research and focusses on the complementary need for strengthening of forestry education and extension mechanisms so as to ensure that research results are effectively made available to the farmer who could most benefit from their adoption.

6. Chapter 7 discusses alternative institutional strategies for ensuring a shift in emphasis of forestry research more towards the areas of concern identified above. The main conclusions are that the first priority should be given to strengthening of national research institutions in the developing countries themselves, the majority of which are weak and have been severely constrained by lack of staff and funding. Well conceived national research is likely to be more enduring than imported research.

7. Notwithstanding this conclusion, and recognizing that it will take a long time effectively to build up such national research capability, it is recommended that more effective use is made of the research capability that already exists in the many (at least 90) centers that are already carrying out research into the priority areas listed in para. 4 above of which 50 are located within developed and 40 in developing countries. Some of these could play a major role in assisting national research agencies, particularly in the areas of technical guidance on the design

of research projects, interchange of staff for training purposes, and dissemination of research results. The major bottlenecks in this area are lack of communication between these established organizations and those national agencies that could most benefit from such contact and, secondly, the financial resources to enable the existing centers to play a more positive effort in this area. It is recommended that as a follow-up to this report, a systematic review of the scope for more effective 'twinning' arrangements between existing institutions and those national agencies working in these priority fields be undertaken.

8. In reviewing alternative institutional strategies for strengthening forestry research, an attempt has also been made to identify gaps in the current institutional framework and to address the issue as to whether new research agencies are needed. The main gap identified lies in the area of research into sustainable farming systems for the wet tropical forest latosols of such regions as the Amazon and Indonesia which are under great pressure for agricultural settlement but for which at present no sustainable farming system based on annual food cropping has been developed apart from traditional shifting cultivation. Whether new institutions are required to focus on this topic, or whether they could be effectively dealt with by expanding the work of existing agencies already located in such regions, is an issue that merits further study. Of particular importance is the question of the institutional arrangement for conducting research on trees and agricultural crops when, traditionally, agriculture and forestry have been treated as distinct disciplines. Whereas evaluation of tree species and their yields as pure crop can be carried out by classical forestry research organizations, the inclusion of trees in a farming system requires an interactive approach.

9. Chapter 8 discusses the current status of coordination and backstopping of international forestry research and focusses on the roles of IUFRO and FAO in this area. IUFRO has provided an effective international forum for research scientists to meet periodically and to review topics of common interest. However, lack of funds and staff availability have precluded developing countries from effectively participating in such meetings and it is recommended that consideration be given to arranging more systematic funding mechanisms that would enable forestry research scientists from developing countries to participate in research meetings organized not only by IUFRO but also by other agencies. The current structure of IUFRO's technical divisions reflects the historical preoccupation of the developed countries with resource related forestry research, and it is recommended that consideration be given to restructuring IUFRO so as to give clearer identity to new areas of concern to developing countries such as agricultural and energy related forestry research.

10. It is also recommended that IUFRO working in conjunction with FAO and other lead agencies should give consideration to the creation of a strengthened Forestry Research Secretariat, the functions of which would include (a) monitoring the progress of developing countries' forestry research, (b) assisting these countries in shifting the emphasis of forestry research towards new priority areas of concern, (c) ensuring more effective participation by researchers from developing countries in inter-

national meetings concerned with these topics of interest, (d) ensuring that research results are effectively disseminated and (e) through complementary extension and training programs, encouraging the dispersion of research results among small farmers and other individuals and institutions that can most readily benefit from such research.

11. FAO, in the past, has played the leading role in the international community in disseminating forestry technical information including some research results and has been the executing agency for many UNDP and bilaterally funded technical assistance programs dealing with forestry, some of which have included forest research components. In the last decade, partly because of its increasing commitments in other areas, it has been constrained in its ability more effectively to backstop national forestry research and to provide technical guidance on such issues. FAO is currently carrying out an assessment of its future role in this area and including the possibility of strengthening its capability to backstop research and disseminate research results.

12. The contents of this report are primarily intended to provoke discussion of the topics summarized above at the IUFRO Kyoto Congress at which it is intended to form a special panel of forestry researchers predominantly from developing countries to discuss the implications of the report in relation to the extent to which the findings of this report accurately reflect the main areas of concern to developing countries. Subject to the outcome of this meeting and to availability of funding, FAO and IUFRO jointly plan to host a special meeting of representative scientists and relevant agencies in Rome in mid-1982 further to review the conclusions of this paper as modified by the deliberations of the IUFRO Congress and to focus on practical ways and means of implementing the above recommendations.

13. Finally, the report refers briefly to the financial implications of an expanded forestry research program aimed at new areas of concern discussed above. In the time available for preparation of this paper, it has not been possible to review individual research budgets and needs of the 600 or so agencies working in this field. However, it has been ascertained that the current level of multilateral and bilateral support for forestry research is minimal (probably less than US$10 million a year which amounts to less than 2 per cent of external aid flows to forestry). As a follow-up to the FAO/IUFRO meeting in 1982, the World Bank would be willing to consider hosting a meeting of donor countries to discuss the finacial implications of an expanded program of forestry research, at this stage without further financial commitment by the Bank. Within the Bank itself, the primary thrust of research effort would continue to be through the Bank's lending programs to national governments.

1. OBJECTIVES OF PAPER

The objectives of this paper are to review the achievements in forestry research during the past decade, to determine priorities for the next decade in developing countries, to examine the physical needs to meet these priorities, and to consider mechanisms to provide these needs.

During the latter half of the 1970s, the emphasis of forestry programs in developing countries responded to increasing public awareness of the negative consequences of continued deforestation. Population pressure, conversion of forest land to agriculture, ecological deterioration in watersheds and arid lands and, more recently, the renewable energy crisis led to re-appraisal of priorities for forestry development and a broadening of the scope of externally funded programs of technical assistance and forestry development. There has been increasing recognition of the role of forestry as an integral component of the rural development process to contribute to increased agricultural productivity and to improvement of rural incomes and quality of life. This shift in the emphasis of forestry development should influence forestry research priorities.

The focus of programs being implemented by the leading forestry research agencies in both developed as well as in most developing countries has a strong bias towards making more effective use of existing forestry resources and creating new industrial resources. The reality in the developing world is that approximately 100 out of 140 developing countries do not possess a significant natural forest resource and their main concern in the 1980s will be on afforestation with fast-growing, multipurpose species that can produce fuelwood, fodder, fruit, building poles and other essential materials and which can protect soil and water resources. Fuelwood, for example, which accounts for less than 10 per cent of total wood use in the developed world, accounts for more than 80 per cent of total wood consumption in the developing countries. Reforestation of marginal lands, particularly upland watersheds, and encouragement of tree planting by small farmers around homesteads and along farm boundaries in order to supply basic domestic needs for cooking and heating will be major areas or concern.

Current arrangements for coordination and backstopping of forestry research in developing countries depend to a high degree on voluntary participation of forestry research scientists in periodic meetings such as those sponsored by IUFRO devoted to particular subjects or species; these have worked admirably for the developed world but have not served developing countries' needs because constraints on staff and finances have precluded many developing countries from actively participating in such meetings.

This paper is concerned with redressing such imbalances and it is addressed both to research scientists as well as to the donor community. The choice of research topics for the coming decade which is a major concern of the paper (Chapter 5) should be of interest to individual research workers and directors. Physical needs for research programs which are discussed in Chapter 6 should be of concern to research administrators. Alternative strategies to meet research requirements in developing countries, discussed in Chapter 7, are intended as a basis for discussion by policy makers in national governments and in multi-lateral and bilateral development agencies. The paper is presented to solicit the views of persons from this range of interests and responsibilities. It was prepared by the World Bank and FAO[1/] with assistance and advice from a large number of organizations and individuals but it does not represent an official policy statement of either the World Bank or FAO. It is an attempt to review the needs of developing countries at a time when awareness of the benefits of trees and investment in forestry are increasing dramatically. It is planned that after the technical discussions at the IUFRO Congress, a revised document would form the basis of discussion among representatives of developing countries, donor agencies and support institutions. It is hoped that the paper would provide a starting point for the donor community in general to focus on the order of magnitude of resources needed to ensure more effective forestry research progress in the coming decade.

1/ Abbreviations are explained in Annex 1.

2. DEFINITIONS AND CLASSIFICATION OF RESEARCH AND ECONOMIC RETURNS

Definitions and classification of research

In its paper on agricultural research systems, the World Bank (1980a) defined research simply as a systematic effort to develop new methods (technology) and to increase productivity or technical efficiency. This same definition may be applied equally to forestry and it would include socioeconomic research as well as conventional field and laboratory work by forest scientists.

It is useful to differentiate research activity into two functional components - science and technology. Science is taken to be that research activity which results in the generation of knowledge with varying degrees of applicability to immediate problems. In contrast, technology development in agriculture and forestry is the research activity, based on scientific knowledge, that results in a mechanical, biological or institutional innovation. Competent research scientists move freely between science (knowledge generation) and technology (technology generation). Basic research is essentially the generation of knowledge while applied research is more akin to the generation of technology. Both basic and applied research represent extremes on a spectrum of research activities and, in practice, the resolution of a particular research problem may utilize all types.

The research that is needed in a particular country is determined in part by unique soils, climate, social and other conditions found there. The cost of research can sometimes be reduced by the transfer of technology from one country to another or from an international center to a national research system. For the developing countries, however, the vast majority of which have tropical or sub-tropical climates, effective transfer of technology from the developed countries, which by contrast have largely temperate climates, is frequently difficult. Sociocultural differences are also sometimes important. Accordingly, the developing countries have particular research needs that must be met largely through research carried out in the agroclimatic and socioeconomic circumstances where the resulting technology is to be employed.

There are many ways of classifying research in addition to these basic/applied or science/technology divisions. Research can be examined by comparing types of forest (natural/plantation/agroforest), types of benefit (production/protection/amenity), ecological types (humid tropics/dry tropics/arid zones/Mediterranean), organization and funding levels (national/regional/international), or orientations of research (species/problem); inevitably, some overlap occurs and arguments developed here are based mainly on types of benefit and ecological zones.

Economic returns from forestry research

Since forestry is a long term business it would be useful to emphasize at the outset of this paper that there is well quantified evidence to suggest that soundly conceived forestry research programs can lead to significant economic gains. A few examples to illustrate this point are given below.

The products and benefits obtainable from trees and forests are many, and are summarized in Annex 2. The impact of past research on the forestry and forest products sector is very evident. Advances in process technology have enabled a rapid broadening of the range of species, sizes and qualities of wood raw material that can be used by industry thus expanding the productivity of the existing resource. Technological advances, at the harvesting as well as the processing stages, have enabled forest-based industries to remain competitive in the face of rising input costs. Substantial improvements in forest productivity and quality through species and provenance selection, tree breeding and improved establishment and management techniques have also been achieved..

Systematic studies on the economic returns from such research are limited, and have been mainly confined to study of the efficiency of tree breeding, an area in which the physical results can be measured and valued with reasonable accuracy. Such studies indicate very substantial returns. In most tree species at least 10 per cent and, in some, 10 to 25 per cent gains in growth can be expected through selection and breeding. Trees can be selected for hardiness and resistance to insects or diseases. Stem and crown form, wood and chemical properties can also be selected and improved.

All of these contribute to crop value and security or to efficiency of harvesting and manufacture of forest products. It has been shown that in the case of the pulping industry, for example, even a small (5 per cent) increase in wood quality due to tree selection would raise mill profits by 15 per cent to 41 per cent by increasing yield of product per unit of wood processed and reducing mill processing time. Rates of return on investment in tree improvement have been computed, ranging from 13.2 per cent for poplar in the Netherlands, and 12 per cent to 20 per cent in some of the USA southern pine programs, to the more modest 4.0 - 6.8 per cent for red pine (Pinus resinosa) and jack pine (P. banksiana) in the USA, and 6.7 per cent for white spruce (Picea glauca) in Canada (see Carlisle and Teich, 1978).

Provenance research has also been shown to give spectacular returns. For example, although they may be extreme cases, the volume production from different provenances of Eucalyptus camaldulensis varied by a factor of 8 in Israel and by a factor of 3 in Nigeria. Virtually all other species tested (except Pinus resinosa in Canada) have shown that gains from provenance selection can be great.

Applied research, such as pilot trials aimed at introduction of exotic species that can yield up to 20 times more biomass per ha than the natural forests they replace, can also yield very high rates of return. Thus, in Zambia, a five year program of research trials of exotic Pinus and Eucalyptus species carried out in the mid 1950s, costing something in order of US$3 million (1981 prices), made it possible to introduce fast growing species with mean annual increments of 15 to 20 m^3 per annum and rotations of between 10 and 25 years, compared with mean annual increments of less than 1 m^3 ha per annum, and rotations of between 80 and 100 years that are typical of the natural Brachystegia savannah woodlands that these plantations have replaced. Some 30,000 ha of plantations now exist, supplying sawmilling and various other wood based industries. Many similar examples could be quoted from other developing countries.

The performance of research in species and provenance selection and tree breeding is, of course, not necessarily representative of forestry research as a whole. However, the lack of information about returns in some areas of forest research is due not to poor economic performance but to difficulties in quantifying and valuing the outputs and their impact. This is the case, for example, with the environmental, protective, recreational and landscape impacts of forestry and with such subsistence outputs as fuelwood and forage. These problems are made greater by the fact that a given development may have multiple impacts - wood and energy production and soil protection, for example - all of which have to be assessed in order to arrive at an estimate of the aggregate returns.

3. CURRENT SOURCES OF FORESTRY RESEARCH

This topic is presented here because no recent comprehensive review has yet been completed of forestry research agencies implementing research programs of interest to the developing countries. Many of the smaller types of institution and smaller sub-divisional structures and activities of well known institutions are not widely known in relation to forestry research and development; yet a knowledge of their existence and interests is necessary to plan the optimum distribution of additional resources. They are considered on a geographic basis as agencies working with national, regional or international interests. However, no claim is made that this is a comprehensive survey of individual organizations but examples of each type are given.

National level

Governmental organizations

The bulk of applied forestry research is conducted by governmental forestry departments or forestry divisions of agriculture departments. Basic or supporting research is commonly conducted by research institutes often physically, administratively and conceptually distant from the forestry line department and commonly associated with universities. This is particularly the case for research on forest products including pulp and paper.

The Forestry Department of FAO is currently updating its World Directory of Forest and Forest Products Research Institutions (FAO, 1963); a summary of information provided in response to a questionnaire circulated in 1979-80 is given in Table 1.

The total number of research institutions reported was 635 with 427 in developed countries and 208 in developing countries. Seven countries accounted for a disproportionate number of research institutions (Argentina 63; Brazil 25; Korea 15; Japan 80; USA 58; Canada 27; Germany 29). Virtually all of these institutions are funded nationally and conduct research on local problems. It is difficult to suggest meaningful numbers for China since there are many small research institutes that are only now being reactivated and also since some experimental work is conducted by many local forestry and extension offices. However, forestry research is recorded as being one of the main scientific activities in China with a central research institute plus forestry research institutes, experimental stations and farms in the provinces, prefectures and communes respectively (FAO, 1978b; Huguet, 1980). The Botanical Research Institute in Guangzhou (Canton) also includes a wide range of forestry research activities. Throughout China emphasis is given to the involvement of the people at all levels of research.

Universities and polytechnics

The majority of nations now possess one or more universities and/or polytechnic institutes for undergraduate and, in many cases, postgraduate training in science and some 250 professional forestry schools are recorded

Table 1. Distribution of FAO questionnaire on forestry research institutions

Stage of development	Region	Number of countries: Questionnaire sent	Number of countries: Replies received
Less developed countries	Africa	43	24
	Asia/Pacific	22	14
	Middle East	19	5
	Latin America	29	22
	Sub-total	113	65
More developed countries	Asia/Pacific	3	3
	Europe	29	27
	North America	2	2
	Sub-total	34	32
Grand total		147	97

in the World List of Forestry Schools (FAO, 1977). The majority of these occur in Europe, North America and the China/Indonesia/Japan/Korea region; the standards of education obviously vary considerably and it is not easy to determine which universities are currently conducting applied or basic research but they clearly have the potential to play a significant role.

Some universities in developing countries have been established with international support and now have a good reputation as centers of forestry teaching and research, e.g. DFRM (Nigeria). Some universities in more developed countries have special interest and experience in teaching and research for application in tropical and developing countries, e.g. BFH (Germany) and DAFOX (UK). In some cases, teaching and research experience is pooled among several universities in one country, e.g. UNIFOR (USA) or in a group of countries, e.g. IUC (UK), OTS (Costa Rica and USA).

Non-governmental organizations (NGOs) and national societies

Many organizations with no formal governmental status conduct or contribute to forestry and forestry research programs, particularly in developing countries. These NGOs include religious organizations, women's groups, schools, youth movements; these are active in Kenya and Sri Lanka, for example. National societies include amateur and professional societies of individuals that have a complete or partial interest in forestry, e.g. national forestry societies, wildlife societies, bird-watching or other sporting associations.

Forest research sponsored by the private sector

Many larger companies and some private individuals with extensive tropical land holdings or concessions conduct forestry and forest products research. Such activities are commercially oriented applied research and the results are often confidential to the company but, when published, they are of great value for national and often regional or international use; e.g. ARACRUZ (Brazil), JARI (Brazil) and WEY (USA).

In some cases, groups of commercial companies, while not conducting research themselves, give financial support to technical institutions either as grants, levies or client payments. This is most common in forest products research including pulp and paper, e.g. PIRA and TRADA (UK) or WFPL (Canada). Alternatively, commercial companies may form trade associations that sponsor and coordinate research, publish results and develop standards for an industry, e.g. TAPPI (USA).

Regional level

The identification of regional research priorities is discussed in a later section including the possibility of creating regional institutions. It sufficies here to contrast two regional institutes that are currently conducting forestry research with three that were successful but ceased to operate because of political, technical or economic difficulties among the participating countries.

CATIE (Costa Rica) conducts research and offers graduate courses in a range of topics within the broad fields of forest management, including recent emphasis on agroforestry, for the countries of Central America. It is supported by a number of national, bilateral and multilateral organizations. BIOTROP (Indonesia) offers similar research and training facilities for South East Asia and concentrates on tropical forest biology and conservation of genetic resources; it is also supported by a range of national and international sources.

Contrasted with these, are three defunct regional organizations that provided a significant impetus to agricultural and forestry development in their member countries. Two were terminated for political rather than technical reasons, ARCCA (working in Malawi, Rhodesia - now Zimbabwe - and Zambia) and EAAFRO (Kenya, Tanzania and Uganda). Financial and technical reasons caused the cessation of IFLAIC (Venezuela).

Such practical institutions have received valuable support in planning, coordinating and conducting research from the regionally oriented working parties of IUFRO and the regional committees of FAO (both of which are described in more detail below). Forestry research coordination is also included in the programs of the CILSS (Upper Volta).

In addition, a recent regional cooperative for forest genetic resource conservation has been established by companies in North, Central and South America (CAMCORE, Guatamala and USA).

International level

International institutes funded through the CGIAR

The largest network of international institutes is that formed for agriculture by the multilaterally funded Consultative Group for International Agricultural Research (CGIAR). It was organized in 1971 to bring together countries, public and private institutions, international and regional organizations, and representatives from developing countries. The World Bank provides the Chairman and Executive Secretariat of the CGIAR and about 10 per cent of the CGIAR budget; the secretariat for the Technical Advisory Committee is provided by FAO.

The basic objective is to improve the quantity and quality of food production in developing countries and some 30 donors provide US$140 million per year to 13 international crop-oriented centers and programs. Some of these centers already carry out limited research on the role of trees in farming systems and fallow, for example, (CIAT, Colombia; IITA, Nigeria).

UN agencies and organizations

Several UN agencies are directly or indirectly concerned with forestry, some including forestry research. These range from the remote concern of WHO and WMO through the forest industry related activities of ILO and UNIDO to the largely funding roles of UNDP and UNEP. The two most directly associated with forest research are UNESCO with its MAB program and FAO which is the UN agency with responsibility for agricultural research (which includes research on fish and forestry problems).

In the UNESCO MAB program, launched in the early 1970s, scientists from many countries are participating in some 900 interdisciplinary research projects in 14 themes on representatives of all major ecological systems including tropical and temperate forests in 95 countries to determine how the systems function, how human activities affect them and how they affect people. The projects have strong training components in resource management as a whole and exchange of information occurs through publications and through small technical workshops. An international network of research and training has been developed and some 162 biosphere reserves have been established in 40 countries to provide conservation of genetic material as well as for applied research, education and training, and monitoring of long term change (see e.g. UNESCO, 1980a).

FAO, in representing its member countries, is advised by six Regional Forestry Commissions that meet every 2-4 years in Africa (AFC), Asia/Pacific (APFC), Europe (EFC), Latin America (LAFC), North America (NAFC), and Near East (NEFC). In addition, FAO is advised by a Committee on Forestry (COFO), a Committee on Forest Development in the Tropics, an Advisory Committee on Forestry Education, a Panel of Experts on Forest Gene Resources, an Advisory Committee on Pulp and Paper and various ad-hoc committees including the Committee on Forestry for Local Community Development. An international Poplar Commission is active but the AFC/EFC/NEFC Committee on Mediterranean Forestry Questions has been dormant since 1970 although recent Regional Commission meetings have recommended its revitalization.

At the fifth session of the Committee on Forestry (1980), reports from various Regional Commissions implied research is needed in a wide range of topics from soil erosion and salinity through conservation of forest genetic resources to appropriate technology and fuelwood issues.

FAO currently has approximately 20 operational and 40 technical professional staff in Rome backstopping 288 field staff in 150 forestry projects of which some 45 have a research component. Sources of funds for FAO include UNDP, FAO Regular Programme and TCP funds, UNEP (four projects), multilateral/bilateral funds including Funds-in-trust, and IBPGR (International Board for Plant Genetic Resources - US$250,000 for two years for conservation of arid zone species, see FAO, 1980c).

Two other UN agencies with interest in forestry research are UNU (Tokyo) and UNCTAD (Geneva). The UNU, established in 1975, is setting up, through its Natural Resources Programme, a network of cooperating institutes to conduct research and offer workshops and symposia in four subjects related to forestry, agroforestry, arid zone development, highland-lowland interactions and rural energy systems. Nine institutes have actual, and two projected, associate status and research and training units are to be based at seven (actual) and 12 (projected) institutes.

UNCTAD is currently negotiating a Tropical Timber Commodity Agreement and is proposing to include finance for forestry and forest products research and development. The Agreement was concluded at the Fifth Preparatory Meeting in 1980 and proposals for research projects have been received from several institutions; these will be evaluated by regional and global expert groups and considered at the Sixth Preparatory Meeting in October, 1981.

The UNCTAD common fund was established in 1980, but the secretariat may not be completed until 1982. "First window" funds are mainly for market stability measures. "Second window" funds are for commodity development including research. Exact details are not yet available, but it is possible that US$300 million may be shared between 5-10 commodities, including tropical timber.

Other agencies and commissions

In addition to the major UN agencies described above, the UN Regional Economic Commissions occasionally support forestry and forestry research. The European Economic Community is currently debating a major research and development program for wood as a renewable raw material within member countries of the Community (EEC, 1980).

The Community for Economic Assistance (COMECON) and the Association of South East Asian Nations (ASEAN) also review needs in general research and development, although forestry has received relatively little attention in comparison to industrial and agricultural subjects. The ASEAN countries are planning to establish an Institute of Forest Management to include training, research and development.

A world conservation strategy was published by IUCN (1980) with guidelines for the conservation of all natural resources including natural forests and their component plant and animal resources. Although IUCN does not conduct research other than preparing the Red Data Book of threatened species, it recognizes the need for research in determining conservation methodology and has supported projects in 20 countries.

ICRAF (Kenya) was established in 1977 largely as a result of the findings of IDRC (Bene, Beal and Coté, 1977). The Technical Advisory Committee (TAC) of the Consultative Group for International Agricultural Research (CGIAR) decided against including agroforestry in its programs and ICRAF is an autonomous unit. To date, its main activities have included the compilation of information on agroforestry systems, the organization of symposia/workshops on soil and plant aspects of agroforestry research, and the preparation of teaching packages for agroforestry within university courses in agriculture and forestry. From 1981, ICRAF will initiate a research program that will have two objectives; (i) to develop a diagnostic methodology to assess characteristics and requirements of agroforestry within a particular region or zone and (ii) to develop research methodology that can be used to generate new technology appropriate for a particular agroforestry situation.

National research institutes in developed countries with programs of relevance to developing countries

In several more developed countries, national institutes conduct research of international significance and offer support, services, information and expertise to programs in less developed countries. Often this forms part of a governmental overseas assistance program and, in some cases, additional financial or moral support is given by FAO.

Examples of the major institutes with international activity include: - BFH (Germany) - tropical forest management and inventory, wood properties; CTFT[2/] (France) - tropical forest botany and management, plantation silviculture and arid zone forestry in francophone countries, wood and pulp properties; and the CFI (UK) - tropical forest botany, management and plantation silviculture, exploration and conservation of tropical pines and plantation hardwoods, genetics, wood properties, inventory, research methods, data and literature storage, retrieval and dissemination, international networks of trials.

In support of developing countries CSIRO (Australia) carries out research *inter alia* into (a) exploration, collection and genetic conservation of eucalypts and other Australian trees, e.g. species of *Acacia*, *Araucaria*, *Callitris*, and *Casuarina*.

2/ CTFT also maintains 12 experimental stations in three continents although two of these are to be closed shortly.

UHH (USA) has specialized in promoting the widespread use of the genus Leucaena, GIT (USA) in vegetative propagation of pine species, IBA (Japan) in vegetative propagation and tissue culture of tree species and FPL (USA) in identification, wood and pulp properties of tropical hardwoods. IARC and APC (Holland) offer both short and long courses for tropical land use classification and inventory, workshops and symposia.

ITF (USA) has a program for strengthening the silviculture of Latin American tropical forests; PRL (UK) identifies and studies wood properties of tropical hardwoods; and TPI (UK) examines pulp properties and extractives of tropical plantation species, especially pines.

In addition, several institutes in COMECON countries conduct limited research in collaboration with Cuba and provide expertise.

The above summary of national institutes is not comprehensive but it is sufficient to illustrate that there are many forestry research programs on which it would be possible to build an expanded program of forestry research for the benefit of developing countries.

Foundations, trusts, religious and charitable organizations

Most trusts, religious and charitable organizations with forestry interest support rural development in individual countries but some contribute to international institutes. Larger foundations, such as the Ford and Rockefeller Foundations, make significant contributions to international agricultural research through the CGIAR and to forestry research through grants to individual scientists and national institutes. A recent promotion of research at the individual scientist level is the offer of US$200,000 by the Wahlenberg Foundation (Sweden) to an outstanding forest researcher.

International societies

Societies that have an impact on international forestry research include those that are organizations of individuals and publish news or research results, e.g. CFA (UK) or ISTF (USA), and those that are organizations of organizations and have an information and coordination value, e.g. ICSU, IUBS and IUFS.

Role of the donor community

UNDP has been the largest single source of technical assistance support for forestry projects in the developing world for the last 20 years and has funded a wide variety of research field projects, some of which include institutional support for agencies. FAO has acted as the executing agency for these UNDP and many other bilaterally funded field projects. The regional and international development banks (Asian, African, Inter-American and World Bank) have all supported forestry programs with strong emphasis on building up institutional and infrastructural capability for larger reforestation programs in the future including forestry research; of the approximately US$1,000 million invested in forestry by the World Bank, for example, since 1966 about US$ 10 million have been allocated to forestry research. IFAD has also funded small forestry components of rural development projects and WFP has strongly supported reforestation in many countries.

In support of national, regional or international activities, many bilateral donor countries have contributed to forestry research. Australia has focussed on programs that build on that country's extensive knowledge of the genus Eucalyptus. Belgium has supported the exploitation of tropical hardwoods and development of markets for secondary species, particularly in Africa. Canada (through CIDA and IDRC) has strongly supported forest inventories and aerial and land-use surveys in the tropics; IDRC has encouraged initiation of small pilot scale programs involving species trials and has also sponsored symposia dealing with selected species such as bamboo and rattan. Denmark has supported the exploration and testing of Gmelina, pines and teak in the South East Asian region. France (through CTFT) has supported institution building of forestry research agencies, particularly in West Africa, and has funded extensive research programs dealing with more effective utilization of mixed tropical hardwoods, as well as trials of fast growing exotic species. Finland has specialized in industrial feasibility studies and has funded individual experts particularly in developing research techniques for pulp and paper and other industrial products. German aid funded forestry research programs cover a wide range, with the emphasis on strengthening of local institutions, pilot research trials of new species, socioeconomic studies of farming systems combining trees and range management programs, and tropical forest management. Holland has supported research in land use capability surveys and, more recently, became involved in fuelwood energy related research particularly in the Sahelian zone. Japan is supporting research programs aimed at making more effective use of mixed tropical hardwoods and pilot reforestation programs in countries such as Indonesia and Philippines. Norway has considerable experience in the fields of logging research and reforestation program techniques and supports these in a number of countries: Sweden, through its associated program with FAO, has given strong support to socioeconomic research in the area of village and community forestry

development, has also supported logging training in a number of countries and is concerned with pulp mill construction. Switzerland has supported pilot reforestation trials as well as introduction of road and logging engineering research programs. The USA (through AID, Peace Corps and other programs) has supported a wide range of small scale research trials, testing arid and semi-arid zone species and sand dune stabilization techniques, introduction of fast growing species such as Leucaena, range management and watershed related research and, more recently, research aimed at conservation of tropical forest ecosystems. The UK has also specialized in field provenance trials and laboratory examination of wood properties (tropical pines, tropical hardwoods and species for arid zones), properties and data bases for secondary hardwood species, management of plantations and natural tropical forest, and mycological and entomological research aimed at combatting tropical forest pests and diseases.

4. RESEARCH ACHIEVEMENTS OF THE LAST DECADE

The objective of this section is not to provide a detailed review of all national research conducted in the 1970s but to present an admittedly arbitrary selection of topics in which significant research achievements have been made that are of international importance, particularly to developing countries. The most notable achievements have been in the areas of natural forest resource assessment, parasite control, management and utilization. In the latter area, most of the research has been in industrial forest products such as pulp and paper, sawn lumber, plywood and veneer. Many of the resource-oriented results have not had a major impact on developing countries because they catered to the needs of the developed world. Nevertheless, some community-oriented and agroforestry research has been initiated (e.g. CATIE, ICRAF) and some major development and acceptance of techniques has occurred (e.g. China, see FAO, 1978b).

Monitoring and inventory of natural forest

During the decade there have developed international awareness and concern for the rate of loss of natural ecosystems, particularly tropical high forests (see Spears, 1978; Lanly, 1981; Lanly and Clement, 1979; IUCN 1980). Estimates of the rates vary but it is clear that all countries need to monitor the boundaries and composition of their forest lands. Remote sensing techniques, especially satellite imagery, have been researched and developed to a level suitable for this purpose and FAO undertook a pilot tropical forest monitoring project financed by UNEP in five West African countries (FAO/UNEP, 1981).

Research into the applications of satellite and airborne imagery to forest inventory has been productive throughout the decade such that provided adequately trained staff are available, most major forest types can now be assessed. Very significant cost savings in land and forest type assessment have been achieved and satellite-based inventory has potential although not yet refined in practice for developed or developing countries as a basis for planning of forest management and for monitoring area changes. Probably more important progress has been made in the application of statistical techniques, forest mensuration and automated data processing to forest surveys.

Utilization of secondary species

Extraction in the tropical forests of South East Asia, South/Central America and West Africa has, in most countries, been a 'mining' operation, extracting the high value species for export. Less than 20 species out of more than 400 occurring in harvestable amounts in the natural forest account for 80 per cent of all logs extracted in the 1970s decade. There has been much emphasis on research programs into the possibility of utilizing more fully all the species in the natural mixture. "Secondary"

here implies currently economically less desirable species, not ecologically secondary species that follow the clear cutting of climax forests. A large amount of research has been done in forest products laboratories, particularly in Australia, Brazil, Chile, Europe, Holland, Ghana, India, Indonesia, Japan, Malaysia, Mexico, New Zealand, North America, Philippines, Venezuela and six countries of the Andean Pact on the anatomical, physical and mechanical properties of many species that are not yet widely traded.

This research has allowed the description of properties required for particular purposes, the prediction of end use properties of a species and the grouping of species for use. In many cases, the information was yielded by research before the need to increase the utilization of a particular species was apparent. (This implies that sometimes new research is not needed as much as a compilation of existing data.) In other cases, of course, where population demands rose and supplies of desirable species declined significantly, or where political problems limited import of alternatives, economic research was initiated to encourage the acceptance and wider use of unfamiliar species and this was often more effective than technological research.

Industrial utilization

Four research achievements have significance for both developed and developing countries:

Reduced industrial scale

Considerable attention has been given to reducing the economic size of industrial facilities; a major breakthrough has been the development of thermo-mechanical pulp (TMP) in which outputs as low as 10,000 tons per year may be viable compared with the 200,000 tpy mills that are believed necessary for other pulp processes, and TMP may have potential in developing countries.

Mixed tropical hardwood pulp

Forest product research centers such as CSIRO (Australia), CTFT (France), FPL (USA), FRIM (Malaysia and PPRII (India) and several commercial companies and Government laboratories undertook studies that facilitated the development of techniques to pulp mixtures of tropical hardwood species and these are now used commercially (e.g. in Colombia, India, Japan, Philippines and Taiwan).

Reconstituted wood

Research has yielded a wide range of methods for bonding wood particles of many species in the manufacture of chip board, fiber board, flake board, wood-wool cement and similar composites.

Laminated wood structures

The development of suitable adhesives and jointing machinery has also permitted the manufacture of laminated beams of large dimensions from small dimension stock with poor properties.

The general impact of these research results has been to make it possible to use a higher proportion of the wood resource. This has been of particular significance in tropical forests in which past extraction has concentrated on very few high value species.

Logging methods

Mechanized logging

For both natural forests and plantations there have been considerable advances in high lead and wheeled or tracked machinery. Improved feller-bunchers, timber jacks, forwarders and rubber-tyred skidders have been developed by research in developed countries, particularly in North America and Scandinavia; however, the technology has been transferred with success to many developing countries and is particularly relevant to extraction of large diameter logs in tropical high forests where the size of the logs and extraction distances may preclude dependence on manual or animal logging systems. Attention must be given, however, to possible damage to the site and reduction in employment. Research into appropriate techniques for logging and all other aspects of forest work was undertaken in the Philippines by a joint Philippines/FINNIDA/ILO project (ILO, 1977).

Harvesting

Two concepts have beome widely accepted - whole tree harvesting and on-site tree chipping. These techniques, developed in North America, could be of considerable relevance to tropical countries for total biomass harvesting in production of wood-based fuels but again attention must be paid to possible environmental consequences.

Plantation forestry

Although only two per cent of the world's forests are planted, plantation research is justified for at least two reasons: firstly, the extent of the total area of industrial plantations to 1980 (6.5 million ha, Lanly and Clement, 1979; Lanly, 1981), and the likelihood that this will at least double by the year 2000; secondly, the fact that production from plantations is substantially greater per hectare than that of natural forests and thus plantations will help relieve pressure on the rapidly dwindling natural forests. In Europe, plantation research has continued throughout the present century but in tropical and sub-tropical areas it has only achieved a significant level in the last two decades. In the 1970s, global achievements have been observed in the recognition of the importance of species and population differences, practical genetic conservation, tree breeding,

vegetative propagation, nursery and plantation techniques, and evaluation of wood properties.

Species/population variation and genetic conservation

The bulk of plantations in developing countries is composed of exotic, pioneer species that can tolerate planting in open areas and competition with members of the same species; they yield a relatively uniform product that is desirably long-fibered in the case of conifers.

Through the stimulus and assistance, for example, of CFI, CSIRO, CTFT, DTSC, FAO, INIF and IUFRO, many developing countries have established comparative trials of species and provenances within species (since natural populations vary genetically in respouse to differential natural selection). The species include tropical species of Cedrela, Cordia, Eucalyptus, Gmelina, Pinus and Tectona. With tropical pines alone, some 500 replicated experiments with up to 20 provenances in each have been established in over 80 countries. Results are accumulating rapidly on population mean performance and on population-site interactions so that for many sites the best species and provenance may be chosen.

More recent subjects of research interest have been the choice of species for fuelwood plantations (see Burley, 1980a; NAS, 1980b; FAO, 1980c), particularly in arid zones and for agroforestry (e.g. Burley, 1980b).

Since many of the chosen populations are threatened with extinction or genetic impoverishment in their native habitats, great efforts have been made to explore, evaluate and conserve the range of avilable genetic variability. Sociopolitical problems in some countries preclude in situ conservation and increase the need for ex situ methods.

Tree breeding

The principles of genetic improvement that have been used in animal and plant breeding all this century have been applied to forest trees since the 1950s; many national programs were established in the 1970s (see e.g. the reports of IUFRO Working Party meetings and the FAO/IUFRO World Consultation of Forest Tree Breeding, Canberra, Australia, from which the position papers were reproduced in Unasylva, 1978).

Advances include (i) the determination of genetic parameters for many characters of tree volume, stem form, pest resistance and wood properties, (ii) actual gains in yield of 10-30 per cent in the first generation, (iii) creation of seed orchards for local self-sufficiency in improved seed supply and (iv) second generation selections for continued breeding.

Vegetative propagation including tissue culture

Excluding individual woody plants such as rubber, clonal propagation by grafting was commonly used only in breeding for the formation of

seed orchards, wherein the genotype of a given selection is propagated many times on seedling stocks which have no effect on the genetic quality of the seed produced. However, the cost of grafting and the occurrence of graft incompatibility in some species have made it desirable to establish propagules on their own root system and research on rooting cuttings and pine needle fasicles has been undertaken with success.

Recently attention has been given to the possible development of tissue culture for genetic conservation and possibly for commercial afforestation. CTFT (France and Congo), AFOCEL and the University of Fontainebleau (France), WEY (USA), GIT (USA), IBA (Japan) and UNILEV (UK) have been active in this field. Commercial application has been only with oil palm and the currently high cost of this technique could be a limitation for commercial forestry.

The ability to root cuttings of some species, possibly after rejuvenation of a selected mature tree by repeated coppicing, has enabled commercial plantations to be established of Pinus radiata (FRINZ, New Zealand), Douglas fir and Norway spruce (ESCH, Germany), poplars in some 30 countries based mainly on the work of poplar research institutes in Belgium, France, Italy, Spain and Turkey. Plantations of willows (Argentina) and of eucalypts (Congo, CTFT) have also been established this way. This technique allows maximum genetic gain from the selected trees because no sexual recombination occurs and it results in straighter, more uniform crops than plantations derived from seedlings. The problem of increased genetic uniformity and hence risk of disease or market changes is minimized by clonal mixtures (see Libby, 1980). Also for tissue cultures and cuttings, some genotypes propagate more easily than others and consequently an additional selection criterion is involuntarily introduced.

Nursery techniques

Nursery research has concentrated on achieving, for a wide range of species and environments, uniform planting stock with good field survival at low cost. Depending on the climatic conditions, success has been achieved with bare-rooted or tubed planting stock, with containers of small size to minimize the cost of soil transport, packing, fertilizer and watering. Considerable operational savings have been achieved as a result of this research (e.g. Australia, Brazil, Cameroun, Gabon, Ivory Coast, Kenya, South Africa, Swaziland, Venezuela, Zambia and Zimbabwe).

Land preparation and planting techniques

Research on these topics has resulted in techniques that are suitable for a wide range of site types. They are mainly based on machinery and often include pairs of bulldozers pulling chains to remove existing forest, followed by wheeled tractors to plough and weed. Developed largely in the USA and Canada, the techniques have been transferred to some developing countries, e.g. Brazil, Zambia and some States of India. Substantial

improvements in survival and savings in replacement, weeding and fire protection costs have been achieved. Machine planting of tubed stock has been developed in grasslands of Venezuela.

Encouraging progress has been made with direct planting in difficult site conditions, e.g. Bangladesh (mangroves) and Sahel zone countries with various Acacia and Eucalyptus species (Delwaulle, 1980).

Soil moisture relations

For many tropical areas, particularly savannahs and arid zones, the availability of soil moisture is critical to the survival of planted stock and careful research in Zambia demonstrated the need for clean weeding. This experience is being transferred to other dry countries. Where grass competition is intense, fire risk is also reduced by using these high yielding methods. Large amounts of data on soil moisture relations in arid and semi-arid lands are held by CSIRO (Australia).

Fertilizers

Many countries have conducted research on nutrient requirements in the nursery and at planting time in the field; for some conifers, fertilizer application later in the rotation has been studied in some countries including Australia, Canada, Germany, Madagascar, New Zealand, Scandinavia, UK and USA. Although the results are mainly specific to location, a conclusion of widespread implication for many tropical soils is the need for boron for successful tree growth, particularly of pines and eucalypts.

Silviculture

Research on spacing, thinning and pruning of plantation crops has continued throughout this century but recent work has shown the value of special experimental methods and designs - the Correlated Curve Trend (used in South Africa and Zimbabwe, e.g. O'Connor, 1960; Wright, 1976); and the Nelder systematic design (see e.g. Smith, 1978). Whereas close initial spacing, subsequent thinning and some pruning are commonly recommended for timber crops, the trend in pulpwood crops has been towards wider spacing with no thinning or pruning. Associated with these silvicultural experiments has been the development of yield models and variable density yield tables in many countries (see e.g. Alder, 1977). As interest in total biomass/energy production began in the late 1970s, some experiments have begun to examine the effect of extremely close spacing (e.g. Brazil).

Wood properties

As the area and age of plantations increased, research on the anatomical and physical properties of the wood produced has expanded. Efforts have concentrated on the feasibility of small scale sampling (e.g. increment cores) and rapid, automated laboratory processing including

densitometry by X-rays (CFI, UK: ENGR, France; WFPL, Canada) and β-rays (PRL, UK, and FRINZ, New Zealand). Techniques were established for many species and sites together with the links between anatomical features and wood or pulp properties. Reference to these topics in the literature are numerous.

Pests and diseases

While populations of pests and diseases exist in a mildly fluctuating balance in natural forests, in plantations extreme fluctuations occur and local epidemics have occurred in several countries. Research in the decade on pest biology, population dynamics and the relationships of organism numbers to environmental factors has accumulated a large store of information before the outbreak of epidemics (see IUFRO/NATO, 1981). Some research on pesticide chemistry, effectiveness and breakdown and in addition considerable work on biological control including virus control of insect pests has been done and there is now wide acceptance of the concept of integrated pest management.

Watershed (catchment) and hydrological research

Throughout the present century, there has been controversy over the effect of trees on water yields and the pioneering work in Coweeta, San Dimas and Wagon Wheel, in USA, and EAAFRO in East Africa, with many other catchment studies in Austria, France, Germany, Romania, Switzerland, UK and Yugoslavia, led the way for more refined technical reconnaissance of watersheds in the last decade (see Pereira, 1973; Pereira and Wang'ati, 1981). Although more research is needed (in Asia, for example), the physical and biological processes that govern the hydrological behaviour of streamsource areas are now understood reasonably well and computer simulations have extended the range of experimental data, particularly comparing the effectiveness of natural forest or plantation trees with other forms of vegetative cover and land use, grazing land under livestock, arable cultivation and so on in relation to climate, substrate, etc.

Tropical silviculture and management

This is a subject in which considerable research efforts have been expended but in which few positive achievements can be claimed. This is perhaps not surprising in view of the variation of tropical forests between regions and within individual forests, the complexity of biological processes and ecological interactions, the time span required to detect the results of experimental treatments, and the political, institutional and legislative aspects.

Efforts have concentrated on natural regeneration of commercial species and group or line enrichment planting to increase artificially the number of individuals of desirable species. These were reviewed at a meeting of the FAO Committee on Forest Development in the Tropics (see Unasylva, 1976). Because of the variation in the composition and behaviour of tropical

forests, results from one region do not apply necessarily elsewhere. Leslie (1977) concluded that, in general, the economic viability of tropical forest management is not yet proven but he pointed out that some of the most important costs and benefits are not yet quantifiable. Compensatory plantations of other species outside the natural forest may be more economically productive than attempts to manipulate the high forest itself in many situations; nevertheless, some successful management is claimed for the forests of Malaysia (West Malaysia and Sarawak), Cameroun, Madagascar, Gabon and Ivory Coast. Attention is being given more to favoring the tree population that remains after exploitation than in stimulating greater regeneration of particular species. Some work on tropical silviculture and its relation to agroforestry has been included in the UNESCO MAB program. The needs to study the management of high forest for scientific conservation purposes are great and are discussed elsewhere.

Minor forest products

Traditionally any produce derived from the forest, other than timber and poles, was considered a minor forest product. However, since fuelwood accounts for over half the wood used in the world each year, it can hardly be considered minor. Nevertheless, there are many other forest products that may be minor in terms of proportional value but that are of great significance to the economies of some countries or communities.

For some of these research has been conducted during the 1970s either to discover new products such as drugs (Amazon area, India, Pakistan) or to improve the quantity and quality of well known products such as pine resin (e.g. France, India, Portugal, Russia, USA) or eucalypt essential oils (e.g. Australia, Brazil, India).

Agroforestry

During the past few years, management systems that combine aspects of forestry, crop production and/or livestock production have emerged as a significant topic. The volume of research has been limited and, reflecting the newness of the subject, has concentrated on survey and study of the existing situation. Attention has focussed on situations where joint systems contribute to improving productivity of land (shifting cultivation), to stabilizing land use in environmentally fragile areas (upland and arid areas), to providing local needs for forest products (fuelwood, forage, etc.) and to broadening the range of benefits obtainable from forests and forest lands.

Most work has been directed to identifying the characteristics of species suitable for intercropping and for introduction into farming systems. This has focussed on both technical characteristics such as optimal aggregate use of sunlight and soil, and on compatibility with farmers' needs and constraints. Relevant work has been done in agricultural as well as forestry research (e.g. CATIE, CIAT, ICRAF, IITA and UNU) and the emphasis has been on fast growing, multiple purpose, leguminous species (see e.g.

NAS, 1979). Increasing attention is being paid to the socioeconomic context of agroforestry production systems. Shifting cultivation has received particular attention notably in South East Asia (e.g. EWC and UNU).

Wood as an energy source

Wood has always been a major source of energy for domestic uses accounting for over 50 per cent of the annual use of wood in the world and over 80 per cent in developing countries. Recent industrial use has increased particularly with charcoal (e.g. Brazil, India). Charcoal may account for 15 per cent of the global total and in some countries it may account for 50 per cent of domestic use, e.g. Senegal, Thailand (Arnold, 1978; Arnold and Jongma, 1978; Earl, 1974, 1975).

In the wake of the 'energy crisis' attention has been paid to the improved use of wood as an energy source including choice of species and silvicultural systems for fuelwood (e.g. NAS, 1980b), determination of calorific yields (e.g. Doat, 1973), improved design of charcoal kilns (e.g. TPI, UK) and stoves (ITDG, UK, and EIN, Holland), the initial development of methods for briquetting and pelletization (Czechoslovakia and Romania), and the determination of the technical and economic feasibility of using wood (and other biomass components) as a liquid fuel or chemical feedstock (Australia, Brazil, Canada, New Zealand, Scandinavia, South Africa and USA). The production and use of fuelwood has also come under increasing study. This has focussed on interactions at the household and rural community level that constrain interventions (e.g. Wood and Brokensha, 1980), interactions between rural use and commercial wood fuel systems (e.g. UNU and IFE) and the place of fuelwood in overall rural and natural energy systems (e.g. FAO, WB). In general, current expenditure on wood based energy research in most developing countries bears no relationship to the importance which this topic has assumed since the advent of the energy crisis.

Institutional research

Another emerging area of research is the expanding participation of rural people in forestry activities (FAO, 1978c). Areas of focus have been artisanal and household level activities - minor forest products, charcoal, etc. (e.g. XAV, IIMA), tree growing to produce cash crops (Gupta, 1979), forms of producer organization (e.g. Digby and Edwardson, 1976), appropriate technology in forest and forest product processing (e.g. ILO), and institutional support (e.g. FAO, 1980d). Again, most of the work, to date, has been study and analysis of existing situations.

There have been a number of recent studies or recommendations of forestry research priorities in developing countries by, for example, the Commonwealth Forestry Conference (1980), FAO (1980), IFIAS (1981), IDRC (Bene, Beall and Coté, 1977), UNCTAD (Menon, 1980; Tamolang, 1980), US Department of State (1980), USAID (1980) and Wadsworth (1968, 1969), in addition, the US National Academy of Sciences' review of priorities in

tropical biology (NAS, 1980c) and the Bonn Conference on agricultural production (Wolff, 1979) make recommendations on forestry research. With the exception of the IDRC report, most of these tend towards consolidation of past research trends.

5. CHANGING EMPHASIS IN FORESTRY IN DEVELOPING COUNTRIES AND IDENTIFICATION OF RESEARCH NEEDS

Changing emphasis in forestry

A fresh look at research needs in developing countries is needed because within the last decade there has been a significant shift in forestry programs in developing countries towards activities designed to meet basic needs of rural people, to improve rural incomes and to combat ecological decline (e.g. watershed damage). These shifts are directed towards avoiding or reducing costs, e.g. direct costs due to shortage of essential forest products such as fuelwood, fodder or poles for indigenous consumption, timber or fiber for industry, and indirect costs such as those due to deforestation (soil degradation, soil loss, flooding, siltation, consequent crop losses, etc.).

It is necessary to re-emphasize that the primary purpose of this paper is to provide a basis for discussion of this topic and not to lay down definitive prescriptions for individual country research programs. Guidelines for determining national agricultural research priorities have been prepared by CGIAR/TAC (1979) which are equally relevant to forestry research. Clearly research priorities can only be established at the national level[3/] and to attempt a detailed analysis of this subject on a global scale would be beyond the scope and purpose of the paper. Nevertheless, it has been possible to identify certain obvious issues and research needs that have widespread application in view of the changing emphasis in forestry development yet which at the present time are inadequately supported in relation to their important role to contribute to meeting basic needs and improving rural welfare.

In 1980, about 1,000 million people in developing countries were obtaining fuelwood supplies only by overcutting the accessible woody vegetation. Under present trends, FAO studies suggest that this number is likely to double by the year 2000. As fuelwood supplies decline, crop and animal residues are diverted from agricultural to fuel use, to the detriment of crop and livestock production; people have to expend more time, effort and income on acquiring fuel and, in some countries, the situation has already been reached where the lack of cooked food is adversely affecting nutrition.

About 1,000 million people burn agricultural residues or animal dung instead of wood or charcoal. In India, Pant (1978) has suggested that about 460 million metric tons of wet dung are burned annually which, at 5 tons per hectare, would fertilize some 90 million hectares, yielding an additional 45 million tons of food at a value of US$4,500 million.

3/ The need for objective methods of allocating priorities in forestry research is discussed in Annex 3.

Additional fuelwood supplies equivalent to at least 50 million ha of new fuelwood planting would be needed between now and the turn of the century to ensure a reasonable degree of domestic self-sufficiency (World Bank, 1980). The practical possibilities for doing this in the short term are severely constrained by institutional, sociological and other problems. To overcome these, research is needed in a wide variety of areas - alternative fuels, better systems of production and distribution of energy from existing forest resources, more efficient use of wood fuels, the development of high yielding, short rotation, new production systems compatible with the situations within which fuelwood is needed. If such research led to only a 10 per cent increase in yields between now and the turn of the century, it could reduce by up to US$5,000 million the investment needed to establish additional fuelwood resources.

The extent of damage due to excessive deforestation in upland areas in developing countries has been well documented. The incidence of flooding in the Indus River system in Pakistan, for example, has been far higher in the past 25 years than during the previous 60. Increased flooding, partly attributable to denudation of catchment areas, has led to silting of dams and canals of Pakistan's irrigation system. Flood damage below the deforested Himalayan catchment areas in Northern India has affected an area averaging 6 million ha a year for the last 10 years and the cost of crop losses and repairs to flood damage has averaged about US$250 million a year.

Despite these well documented examples of environmental degradation, research to date into sustainable farming patterns for these upland regions and development of farming systems that are less ecologically disruptive has been minimal. Most ongoing watershed research in developing countries is partially or completely copied from research projects in temperate countries, particularly USA; countries in tropical and sub-tropical regions have different ecological and socioeconomic problems and water has a determining role in both on-site and off-site development. The development of sustainable farming systems is urgently required for the tropical acid latosols that are widely distributed in areas subject to human migration, e.g., Amazon and Indonesia.

Although farming systems, watershed forestry and energy production may be considered new directions for forestry in many developing countries, traditional forest products are becoming subjects of changing emphasis in some countries. Because of rapidly rising domestic demand for industrial products, such as lumber and paper, most developing countries will be hard pressed to ensure future domestic supplies by the turn of the century. Nigeria, for example, which was a major net exporter of forest products in the early 1970s, has now been forced to ban log exports. Current imports of manufactured forest products cost something in the order of US$150 million a year and are expected to increase to more than US$500 million by the year 1990. The Government's current reforestation program of 100,000 ha of plantations over the next decade will cost an estimated US$200 million and high priority is being given to research into fast growing industrial species which could lead to significant saving in investment costs and early reduction of the size of the import bill for forest products.

With increasing international awareness of the issues discussed above, national and development aid funds for rurally and environmentally oriented activities are now beginning to account for a higher proportion of total expenditure on forestry development than in the past. During the last decade, the proportions changed dramatically in many countries from virtually zero to 12 per cent (Kenya), 20 per cent (five central and southern States of Nigeria, 40 per cent (India) and over 80 per cent (Korea). Of the US$500 million which the World Bank has loaned for forestry since 1978, 60 per cent has been for rural and environmental forestry. The forestry activities of FAO directed towards rural development changed from less than 5 per cent in 1978-79 to 25 per cent in 1982-3.

By contrast to these shifts in the emphasis of forest development, past and current research as illustrated in the previous chapter has tended to emphasize improving knowledge of the land and forest resource and utilization of industrial products such as lumber, wood-based panels and paper products. While no systematic study has been undertaken, probably over 90 per cent of global forestry research expenditure in the 1970s was directed to these activities.

For countries that possess indigenous forest and in which land hunger is not severe, this resource orientation will continue to predominate. However, in practice, less than 40 out of approximately 140 developing countries are fortunate enough to possess a significant, indigenous, forest resource and for the majority of developing countries the main preoccupation is afforestation in agricultural and denuded marginal lands. Similarly, past forestry research programs have not adequately reflected the growing international concern over the possible environmental consequences of continued destruction of tropical forest ecosystems. Comparatively little research expenditure has gone into the identification of unique faunal and floral associations and recognition of potential future biotic reserves.

Research needs for developing countries in the coming decade.

Analysis of the research priorities listed by the many developing country research agencies contacted during the course of preparing this paper suggest that the following are areas of particular concern: (i) research into the role of forests and trees to contribute to agriculture and rural development; (ii) energy related forestry research; (iii) research aimed at more effective conservation of existing forest resources, particularly of the wet tropical forest ecosystem. These topics are discussed below and more details of their component problems are given in Annex 4. Whilst the three priority areas defined above are those which will call for special emphasis in the coming decade, industrial forestry research particularly into the role of fast growing plantations will also remain of paramount importance in many countries. In this section, a broad review is also included of the likely research topics in this area with special reference to increasing productivity and reducing costs.

Role of forests and trees to contribute to agriculture and rural development

This broad topic includes subjects that have received relatively little research attention to date yet reflect most significantly the changing emphasis in forestry development. They all recognize that trees can play an important role in improving agricultural productivity, supplying basic products needed for economic development and in providing other benefits (e.g. amenity, shade, reduced expenditure of time and labor in collecting fuel, etc.); This implies the incorporation of trees into farming systems and the application on forest lands of agricultural and related activities (e.g. production of honey, mushrooms, silk). Many of the topics have been studied for agricultural and horticultural crops but the concepts, methods and results are not well known to foresters. The topics include socioeconomic and institutional problems and technical research into land management and protection measures.

One of the most important tasks confronting forestry research at the present time is to improve understanding of the local social, institutional and economic framework within which a forestry activity has to function. This includes understanding the constraints and possibilities for positive change created by people's habits, aspirations, needs, possibilities and social and cultural practices as they pertain to trees and their products and benefits.

This subject includes the determination of the role of trees as perceived by rural communities and families living in or near forests and the potential for increasing their participation in, and benefits from, forestry activities. The acceptability of interventions in the existing pattern of land use and responses to innovations need to be evaluated, including pilot projects that test methods and incentives for establishing community, family and individual woodlots. Guidelines are required for the sociological aspects of project preparation, appraisal and monitoring. (World Bank, 1980d). Institutional frameworks need evaluation together with the development of training and extension systems.

Research is required to develop farming systems that incorporate trees. The various subjects here might be loosely described as 'agroforestry. Research in this topic is central to the provision of fuelwood, fodder, poles and other products in rural areas and to the maintenance of ecological stability in areas subject to decline, whether or not the decline is caused by shifting cultivation.

Little systematic research has been carried out in developing countries, for example, on the impact of intercropping of trees and agricultural crops on yields of both crops. The work initiated by CATIE (Costa Rica), ICRAF (Kenya) and IITA (Nigeria) should be extended to cover a wide range of tropical environments. Research into the economic feasibility of combined agricultural crop/tree cropping systems is an area of particular importance. Ecological damage that was caused by large scale spontaneous settlement in humid tropical forest lands such as those of Brazil and Indonesia has been widely publicized; yet little is known about sustainable farming systems for application on the acid tropical latosols underlying such forest lands.

There is a need to widen the range of species producing fuel and fodder that are suitable for use in agricultural systems (e.g. NAS, 1980b; FAO, 1980c); also an urgent need to discover the quantitative effects of leguminous trees (e.g. NAS, 1979) on the soil and agricultural crop and to compare economically the use of trees with organic and inorganic fertilizers and to examine phosphorous cycling. Quantitative information is lacking on the effects of shelterbelts on soil loss and crop yields. Most of the research on this subject has been carried out in USA, USSR, Denmark and other developed countries but little systematic information exists on the positive (and also negative) impact of shelterbelts on crop and livestock yields in tropical environments. The important role of soil microbiology to the functioning and reestablishment of trees and forests should be recognized. Similarly, there has been little study of the effect on soil fertility and crop yields of burning crop residues and animal dung. For a wide range of sites agricultural methods, including tree fallows, need to be developed that are acceptable to local farmers and that do not cause site deterioration with repeated cropping.

The damage due to deforestation in upland areas was discussed earlier in this chapter and previous research was described in Chapter 4. The physical and biological processes of catchment decline are known and their effects can be seen or predicted in many developing countries. More research is needed in some areas (e.g. Asia) and topics (e.g. effect of fast growing trees such as eucalypts or water supplies).

As experience has evolved in this area, it has become more widely recognized by foresters that effective watershed rehabilitation can only be achieved by offering the small farmers living in tropical watersheds an alternative to their ecologically destructive way of life. In essence, this implies a holistic approach to development including provision of improved seeds, upgrading of rangelands, strengthened extension services, provision of credit, investment in schools, health clinics and so on, in addition to soil conservation, reforestation and improved forest management. Forestry plays a supporting but rarely a dominant role in heavily populated upland watersheds and watershed research priorities need to reflect this fact. The major needs are to develop acceptable techniques for improving range uplands and for establishing ground cover and tree crops as an integral component of soil conservation works (e.g. gully plugging) or planting of fodder tree species along contour boundaries. In some areas where natural forests or plantations exist appropriate logging systems are required.

Rangelands in many developing countries fall under the control of Forestry Departments, yet past investment in forest research related to rangeland improvement has been minimal. The priority areas for further work include improving knowledge of livestock carrying capacity of rangelands, particularly in arid zones, and technical options for improving fodder supplies (upland reseeding, growing of farm fodder crops, planting of fodder trees in rangelands), alternative approaches to grazing, management and so on.

Another indirectly related area of weaknesses lies in that of wildlife research. Many species of wildlife, if managed on a sustained yield basis can contribute significantly to provision of food, skins and other items of human consumption, yet little research has been carried out in this area. Wildlife research is commonly assigned to universities and then to Departments of Zoology, although an active wildlife program exists at DFRM (Nigeria). Research to date has concentrated on behavioural studies of individual animals and ecological monitoring of wildlife habitats. While these should continue, particularly the latter, the emphasis of behavioural studies should shift to populations of outstanding importance as well as to preservation of threatened species.

Forestry research specifically related to energy production

The energy crisis has sharply focussed attention on the need for increasing total biomass production and the research into silvicultural and genetic methods such as choice of species and provenance, tree breeding, seed problems, silvicultural systems including ground preparation methods and pest management are important areas for the future.

Of outstanding interest and potential is the development of economic techniques for vegetative propagation including rooted cuttings and tissue culture. Further evaluation is needed of the potential application and economics of genetic manipulation including cellular engineering (for e.g. nitrogen fixation) and somatic hybridization (protoplast fusion for hybrids that are difficult to produce by conventional means such as controlled pollination); linking techniques of inoculation of Rhizobium and mycorrhizae with tissue culture technology could be a powerful tool for increasing yields.

"Energy forestry" requires re-examination of non-traditional silvicultural systems to maximize volume production; work in progress in Brazil, Scandinavia, USA and elsewhere has indicated the great potential for increasing total volume by using close espacements and early harvesting.

Traditional methods of measuring tree volume, which were developed for determination of pulpwood and sawlog yields, will need considerable modification. The present trend is towards whole tree harvesting using small branches, twigs, and even leaves for energy production and new methods of accurately measuring total biomass yields are actively being researched by many agencies.

Biomass harvesting and transportation methods are another area in which research can be expected to lead to substantial cost savings. Whole tree harvesting and chip transport technologies developed for the pulp industry in North America may have application in larger developing countries such as Brazil whereas in many other situations more labor intensive methods would be more appropriate.

Determination of wood densities, calorific values, cellulose and lignin content can all be expected to influence the energy yield and economic viability of growing wood based energy crops. CFI (UK), CTFT (France) and TPI (UK) have initiated work on these subjects. A particularly critical topic is the impact on soil structure and chemistry of repeated short rotations of species such as Eucalyptus and Gmelina that currently account for a high proportion of the total area of fuelwood being planted.

Together with the above research into agricultural and industrial tree planting, it would be desirable to research the efficiency and applicability of systems to use wood and other biomass as an energy source; particularly introduction of more efficient wood stoves, pyrolysis, gasification, pelletization and liquid fuel technology will assume greater importance.

Industrial research is already active on a large scale but attention is needed to the development of technology appropriate to the village and farm level; this includes improved preparation of fuelwood and charcoal and improved designs for stoves, steam generators and machinery for processing rural products.

Management and conservation of existing resources (mainly natural forests)

Despite the emphasis in this chapter on planting trees for agricultural benefits, industrial wood and energy production, there is still urgent need for research on the remaining natural resources.

The rate, total and implications of losses of the tropical forest have been extensively documented in the last decade and considerable lip-service has been paid to the concepts of conservation. Less attention has been given to the decline of forest resources in other ecological zones although the UNESCO MAB program attempts to secure representatives of all major ecosystems and a strategy for conserving the world's threatened natural resources was published by IUCN (1980).

Research is needed on the terrestrial and satellite survey and monitoring of natural forests to determine the ecosystems and genetic resources they contain; representatives must be identified and both technical and political solutions must be found to the problems of conserving them.

Research directed towards understanding the ecological processes that affect forest vegetation and studies of silvicultural systems for natural forests, research into the effects of whole tree harvesting, the use of lesser known species and the development of local methods for wood preservation are priority areas. Of particular significance is the recognition of the importance of incorporating energy production in management systems for natural forests. There is also need to examine the institutional framework for management of natural forests and its appropriateness to rural development.

Forestry research related to industrial needs

It is important to emphasize that this fresh look at priority areas of developing countries is not intended to imply that traditional forestry research programs should be discontinued. For those countries that do possess an abundant forestry resource (either natural or planted) and that possess an already well established forest industrial base (e.g. Brazil, Chile, Guyana, Indonesia, Kenya, Malaysia, etc.), the past emphasis in research on making better use of the existing resource, on introducing exotics such as Pinus and Eucalyptus species, and on development of markets for secondary hardwoods will remain important.

During the coming decade, major emphasis in industrially oriented research should, as in the past, be directed towards increasing the productivity of forest trees particularly in plantations. About 6.5 million ha of industrial plantations have already been established in developing countries (excluding China, Middle East, Mongolia, North Africa and North Korea) and the current rate is 700,000 ha per year (Lanly and Clement, 1980; Lanly, 1981). Recent World Bank information suggests that in 1980 the forest cover of China was 120 million ha, accounting for 12.5 per cent of the total land area. Some 28 million ha of plantations were reported established during 1949-1979. Little is yet known of the survival and yield of these plantations, but it is planned to increase the extent of plantations to 20 per cent of the land area by the year 2000. This implies another 44 million ha or an annual planting rate of 2.3 million ha (three times that of the rest of the developing world together). The critical point already highlighted in this area is that exotic species, which account for a high proportion of the total area planted, often yield 10 to 20 times the volume of the natural forests that they are replacing. A major thrust of future research should, therefore, continue to be directed towards introduction of exotics wherever this is compatible with local ecological circumstances. The second major area of potential gain lies, as described in the case of energy related forestry research above, in identifying best provenances, practicing tree breeding, adopting seed handling, certification and zonation practices, developing methods for vegetative propagation and so on, which, in many species, can lead to a further 20 - 30 per cent improvement in total economic yield and to a significant shortening of rotation cycles needed to achieve industrial logs of appropriate diameter for processing.

The past emphasis on research aimed at widening the range of secondary hardwoods that can be used from natural forests should be consolidated during the 1980s. Countries such as Colombia, Nigeria and Taiwan have clearly demonstrated the potential for wider use of secondary species particularly in those situations where domestic market demand has outstripped availability of higher value species and compelled sawmillers, pulp manufacturers and other industrial processing enterprises to accept a wider range of species than in the past.

Continued emphasis can be expected also in the coming decade on the search for smaller scale processing options (particularly in the area of pulp and paper manufacture), into more effective use of waste residues

(e.g. through the manufacture of wood-based panels of various types) into the scope for laminated timber beams and so on.

Further elaboration of industrial forestry research needs is not warranted in this paper mainly because this is the area in which much traditional research has already been carried out and in which there is already a high degree of awareness of needs and appropriate topics for research.

6. PHYSICAL NEEDS FOR STRENGTHENING FORESTRY RESEARCH IN DEVELOPING COUNTRIES

Regardless of which research topics are taken up, or whatever strategies are adopted for strengthening research, there are several constraints to the initiation and continuation of relevant research programs in developing countries and to the effective appreciation of research results including lack of staff, poor career structure for research personnel, inadequate facilities, lack of information and communication and the weakness of forestry extension services.

Staff numbers

The majority of developing countries have inadequate numbers of professionally trained staff in all fields and the 'brain drain' between ministries, between government and private industry, and between countries and/or international agencies is rapid and inhibits the sensible, continuous management of operational and research departments. This situation is worse for post-graduate staff with research training and the main solution is to train enough so that some individuals stay in place; increased local training is probably the way to attain the large numbers required.

The number or proportions of forestry researchers in forestry departments varies considerably and it is difficult to obtain exact numbers. Richardson (1969), in his study of manpower and training requirements in forestry development planning, estimated that 5 per cent of total forestry manpower should be devoted to research and another 5 per cent to training. At present FAO is conducting a survey of manpower needs with 14 consultants' reports to be compiled.

As an example, for West Africa, Kulkarni (1979) recommended that the needs for professional staff by the year 2000 will be: 7 (Gambia), 251 (Ghana), 141 (Liberia), 879 (Nigeria) and 31 (Sierra Leone); assuming Richardson's 5 per cent figure, 65 of these 1,309 professionals should be in research. Similarly, for East Africa, Roche (1980) recognized professional needs by the year 2000 as: 156 (Ethiopia), 137 (Kenya), 64 (Malawi), 53 (Somalia), 149 (Sudan), 113 (Tanzania) and 97 (Zambia); i.e. 38 out of a total of 769 would be needed in research.

Although the present figures for research staff were not analyzed in detail, the numbers are clearly much lower, probably less than one third of the desirable figure. Even if they are higher than this, however, the continuous and early loss of appropriately trained staff implies that continuous replacement is needed.

Professional research education and personal development

The sources of graduate training are located principally in developed countries and more support should be considered for upgrading or creating new academic institutions in developing countries; in francophone Africa, for example, graduate teaching of forestry occurs only at Yaounde (Cameroun) and is planned at Abidjan (Ivory Coast).

Appropriateness of training is another issue. Double standards in academic institutions in developed countries are clearly undesirable from the point of view of both the academic establishment itself and the developing country and its students. In many cases, an advanced degree, especially a doctorate, is recognized as an essential element in personal progression along administrative and political pathways but a short specialized course in appropriate research methods might be more beneficial to the country and the staff member himself in the conduct of his research.

University graduate education is not the only source of appropriate research training. Short intensive courses in research are offered regularly by CFI (UK) and CTFT (France) and irregularly by FAO, IDRC, SIDA, DANIDA and other agencies. These are valuable and much in demand. Typical costs for a three month course, excluding travel and subsistence, range from US$1,000 to US$3,000 per head. Short courses are particularly attractive to organizations with few staff that could ill afford to lose the services of a professional for one to three years for graduate work.

One key element of research training is learning how to determine what problems need to be solved and how to set up research programs to solve them. The bulk of research training is in the scientific background and in biological, chemical and physical techniques. Good research that is either not solving a problem or solving the wrong problem is not useful and is not likely to generate much support. The importance of team work and the inclusion of different scientific disciplines in problem solving can not be over-emphasized in research training. Formal systems for monitoring (supervising) research programs and for discontinuing unproductive research are also needed.

Mechanisms to provide increased research training are essentially concerned with allocation of new funds. In addition to building new institutions, funds can be provided direct to existing academic institutions, to centers of excellence for short courses, to international agencies for field courses, and to national units for funding individual students. Many bilateral assistance programs and some agencies and foundations already assist university students from developing countries to enroll at academic institutions in developed countries and some of these coordinate their programs through such schemes as the Colombo Plan.

Participation in conferences and workshops holds an important place in personal development and mechanisms for this are described in Chapter 8 under the subject of IUFRO as a backstopping system.

Career structure

There is considerable reluctance on the part of foresters to enter or continue in research in many national forestry departments. Research officers commonly fail to receive certain peripheral benefits that accrue to field managers and they may feel they lose seniority or promotion prospects. Also, many non-research foresters feel that the researcher is divorced from real problems while the researcher feels that operational staff do not take sufficient notice of research findings. Consequently, there is considerable value in exchanging field and research posts for limited periods (3-5 years), particularly in small forestry departments, but the disadvantages of such short research assignments are lack of continuity, lower average understanding of problems and research methods, and difficulty in obtaining staff with a talent for research.

Relevant facilities

There is a limit to the value of research that even appropriately trained staff can undertake without adequate equipment, vehicles and buildings, all of which imply a need for funds for purchase, operation and maintenance, including associated technical and administrative staff.

The relevance of topics selected for post-graduate training in advanced centers of learning was mentioned above; is it appropriate for a student to base a doctoral thesis on a subject that requires the use of scanning electron microscopy or gas chromatography when, in his own country, insufficient information is available on such basic matters as the choice of species or silvicultural methods? One possible method to ameliorate this situation is to provide the student with funds to purchase small and relevant equipment to use in the overseas university and then to take home for use in his own employer's research program. More effective screening of post graduate research topics would be one way of tackling this issue.

Information and communication

Throughout the world, but particularly in developed countries, there is a tendency to rediscover the wheel in every country and with every new generation of research staff. While this may be due partly to the lack of continuity discussed above, it is mainly due to a lack of awareness of the current state of knowledge. In many countries, vast quantities of unpublished forestry research information are held in filing cabinets, the contents of which are not known to or not made available to new and junior staff with the consequence that many experiments are established to obtain information that already exists; a review of past research should be mandatory before new projects are approved.

Sometimes the information exists in a rough field form that is unintelligible or uninterpretable by new staff; hence there is a need for standard methods, forms and reporting systems. In many countries, data

may be analyzed and reports written but not circulated because of shortage of paper and reprographic facilities.

Even when material is published, it is commonly not circulated widely either within or outside the country of origin; yet to be of value, the information should reach a number of identifiable, but quite separate, audiences: forest managers, other researchers (including those in foreign countries), administrators/politicians and the public. This implies that the same information has to be presented in several different forms in order to encourage understanding and implementation of results and continued investment in research.

Compilation and dissemination of information

Compilation of existing national research information

When national staff are limited, new or not specially trained, technical assistance from an international agency or center of excellence may be the best method of compiling, interpreting and reporting on a mass of field data. A good example of this approach was the work of an FAO expert in publishing a report on all data on growth and form data of introduced species in Uganda (Kriek, 1970). This type of exercise can avoid repetition of earlier research.

Publication

The dissemination of research results through local bulletins and technical notes as well as international journals is a standard practice. A bottleneck is the lack of reprographic facilities within forestry departments.

Quicker, cheaper publication could be achieved by adopting standard formats for some types of report, and this is becoming more widely adopted in planning conferences and publication of their proceedings, but it is inappropriate for many journals that have their own style.

Synoptic publication is being actively pursued in some countries and, if methods of optical character recognition improve, whole synopses could be automatically stored in computers for use in retrieval systems.

Abstracts, data bases and retrieval systems

As publications appear in print, wider dissemination of their information is obtained if they are noted by the various abstracting institutes. The main agencies working in this field are Commonwealth Forestry Bureau (CFB, UK) and Rheferati Zhurnal (USSR). The CFB produces Forestry Abstracts (FA) and Forest Products Abstracts (FPA) which, together with many other CAB services, enter the Lockheed DIALOG computer retrieval system available on-line by standard telephone system from California, USA. Coordination of an international network of information

services is one object of FAO's AGRIS Forestry (see FAO, 1980a) and a similar network of energy-related subjects is planned by UNESCO (1980b).

More funds are needed for institutions in developing countries to purchase hard copies of FA and FPA, including back numbers, and for the provision of terminal links to the DIALOG system for countries where the international telephone is reliable. These could be located at national information/documentation centres and FAO is already helping many countries to develop such centres and national data bases. Brazil now has an extensive agricultural literature data base and many terminals. The major international information centres are listed in Appendix 6 and FAO has prepared a World Catalogue of Information and Documentation Services for Forestry which lists 430 entries from 90 countries.

Microfilms, microfiches, photocopies

Where computer-based systems are not appropriate, microfilm copies of original literature are valuable. For a new institution, it is probably the only way to build up a comprehensive library of relevant past literature, abstracts or titles. A microfilm service was funded by the Ford Foundation (USA) to make available copies of the entire card catalogue of the library at CFI (UK) and of literature on request. Although microfilms are still available, a sum of US$100,000 would be needed to continue a service of the scale reached in the first phase and envisaged as desirable to support the expansion of research described in this paper. In addition, possibly US$2000 per institute would be required to provide a multi-size film reader.

Photocopy/microfiche services of the type offered in the 1960s under a Rockefeller Foundation (USA) grant and based at EAAFRO (Kenya) could be more widely used. This provided agricultural and forestry stations in East and Central Africa with a photocopy of the contents page of each new issue of a wide range of journals. Individual researchers could request photocopies of entire articles.

Translation

Clearly wider dissemination of information occurs when the material is available in one or more major languages and some translation services exist, e.g. in Israel for Russian to English; TNO (Holland), translates on demand and also maintains a data bank on translations. Some organizations make available their translations of selected literature, e.g. PRI (USA) and the New Zealand Forest Service. Additional support is needed to cover the exponentially increasing literature particularly from Russia, Japan and China and also from countries speaking so-called minor languages.

The process would be enhanced if mechanical translation were further advanced and available. Computer-based systems do exist, e.g. SYSTRAN in the EEC (Luxembourg) and terminologies are being developed;

the AGROVOC vocabulary was compiled by FAO with EEC and a word list is in preparation by CAB (UK). At the national level, a system is operational in the Hanover Technical Information Library, Germany.

Project indices

FAO has compiled CARIS, a list of research institutes, staff and projects (FAO, 1978a). Many forestry research organizations are not represented and need assistance in the preparation of national and regional project indices.

Computing sub-committees

As the information pool increases dramatically, so more attention is being given to computer-based information storage and retrieval systems. It is highly desirable to establish and support sub-committees within each of the major disciplines (say the various divisions of IUFRO) to monitor progress and contribute to the development of appropriate computer systems so that information may be freely accessed and disseminated, including the use of microprocessors.

Extension and effective applicaton of research results

This is one of the most critical elements of the research chain yet currently one of the weakest. The main reason is that forestry up to the 1970s was concerned mainly with improving the management and utilization of existing forest resources or industrial plantations. With the notable exceptions of China, India (Gujarat) and Korea, there has been very little experience of extension techniques aimed at dissemination of information on trees among small farmers. It would be beyond the scope of this paper to attempt a review of alternative approaches or physical needs in the area of forestry extension. (FAO is studying this subject). However, it has to be clearly stated that any strengthening of research in areas such as re-ordering of priorities, developing forestry techniques for increased agricultural productivity, attaining self-sufficiency in seed (especially of exotic species), or identifying new fuelwood species, would be a wasted effort unless national forestry institutions are provided with the resources to replicate such techniques on a field scale and unless there is a firmly established link between such national research institutions and the extension services on whom the dissemination of this research to the individual farmer or village community will ultimately depend.

7. INSTITUTIONAL STRATEGIES FOR STRENGTHENING FORESTRY RESEARCH IN DEVELOPING COUNTRIES

To meet the physical and subject needs discussed above there are three main strategies that have been examined: (i) to strengthen national capability, (ii) to support existing organizations already undertaking research in the priority areas discussed in Chapter 5, and (iii) to create new organizations. These are not mutually exclusive, and all three approaches could be considered for a given research topic.

Increased support for national forestry research institutions

Several strengths and weaknesses common to national forestry research institutions were discussed by FAO (1980b). Among these the strengths include the ability to relate research to development needs and the close involvement of local staff in planning and implementing research. The weaknesses include the lack of trained staff, funds and facilities, a vulnerability to arbitrary changes and a tendency to duplicate research completed or in progress elsewhere.

Despite these and other weaknesses, almost all the organizations and individuals contacted during the course of this study have emphasized that the first priority should be to strengthen national forestry research institutions or create them where none exist. The various reasons cited can be briefly summarized. Firstly, because of the wide diversity of climatic and ecological conditions and the large numbers of tree species used in developing countries, it is necessary that research be specific to site, particularly for species and provenance trials. Secondly, research capability built on a firm foundation at the country level is likely to be more enduring than imported research. Thirdly, biomass based energy research is likely to be of far greater economic significance in many developing countries than for most developed countries. Fourthly, the alternative, (i.e. too great a degree of dependence on overseas resources) fails to recognize that, for some of the newer research topics of interest to developing countries, appropriate techniques and experience are not available in the developed world. The general thrust of the comments on institutional strategies made on the first draft of this paper by many agencies to whom it was circulated advocated a massive shift in the physical location of research to the developing countries themselves with emphasis on the technology of equilibrium and on appropriate operational scale accompanied by closer direction, stricter monitoring and a firmer commitment to forestry research for people.

Ways and means of bringing about a significant improvement in national forestry research capability are easy to identify but not so easy to sustain in practice. They include, firstly, securing a strong central government commitment to forestry programs. Without a clear central government perception of the role of forestry in economic development and a commitment to increased budgetary support for forestry, the chances of securing increased support for forestry research will remain poor. A second priority is to improve the perception of the value of research by decision

makers while a third is to shift the emphasis in future national forestry research towards current development needs in the agricultural and forestry sectors.

A first step would be to ensure that government Planning and Finance Ministries clearly appreciate the role of forestry in economic development. Here forestry sector reviews are needed that identify and illuminate such issues as: the negative effects of continued deforestation on agricultural productivity; the potential contribution of forestry to rural incomes, to combatting the negative effects of the energy crisis, and in relation to industrial products, the role of reforestation in helping to contain the rising import bill for manufactured forest products which can be anticipated in many countries if nothing is done to initiate reforestation on a larger scale. Good examples are forest economy profiles prepared by ADB for some Pacific islands and those prepared for countries such as Nepal (World Bank, (1978). Examination of forestry sector reviews carried out in the past suggests that inadequate attention has been given to the role of forestry research, that forestry research should be integrated with other land use sectors and that more careful planning is needed for national action plans. The allocation of relevant priorities is itself a priority.

Sector analysis is basic to policy formulation, and is consequently an area in which countries will wish to develop their own capability. External aid agencies can assist in this process through the provision of advice or methodology and through training. Similarly, external agencies can play a positive role in helping to redefine forestry research needs as integral components of broadly based forestry programs. For example, many FAO and bilateral projects already provide such assistance and the World Bank has provided funding and expertise for studies of forestry research priorities in some countries, notably Brazil, India (UP and Gujarat States), Indonesia and Spain. The response in most cases has been positive but far more would be achieved by a conscious policy decision to focus on research in a more systematic way.

Physical needs for strengthening national forestry research programs, e.g. staff, laboratory facilities, methods of obtaining appropriate research training and increased support services were discussed in Chapter 6 and a long but not exhaustive list of other steps necessary to strengthen national capability was given by FAO (1980b). A key issue is that national institutes must have adequate resources for implementation and sustained future monitoring of field research programs in such key areas as farming systems research, species and provenance trials and testing of new energy-related industrial technology.

In some developing countries research projects are still operated by expatriates and here attempts must be made to minimize the physical, mental and cultural separation of the expatriate and the local counterpart; good human relations are prerequisites for useful science and technology transfer (Kauman, 1965).

For national research to be effective, strong governmental support and public awareness are invaluable; however, while governments face critical, immediate problems, it is hard for them to comprehend or support research that may not provide answers for many years. High priority should thus be given in developing countries to learning and interpreting the relevance of what has already been discovered in research institutions and through industrial and agricultural practice in more developed countries.

In many countries it will take a considerable time to strengthen national forestry research institutions, particularly the training and career aspects; while national expertise is being built up, increased technical assistance may be sought from foreign bilateral and multilateral aid agencies, from centers of excellence or major activity (including CGIAR centers that include some forestry research in their program). The program of Technical Cooperation among Developing Countries (TCDC) has a role to play in this area. TCDC was defined at the UN Conference in Buenos Aires in 1978 and emphasizes the strengthening and accelerated use of national institutions and developing country inputs. It provides for study tours and the exchange of consultants between developing countries; FAO has been active in promoting such activities in forestry (see FAO, 1979a, b) and IUFRO could act as a clearing house.

One of the most promising arrangements for this transfer of experience and the strengthening of national research capability is twinning or multiple twinning with existing research organizations already working on topics of primary interest, e.g. as defined in Chapter 5. The staff of twinned institutions get to know each other and can establish good human relations, while short and long assignments can be planned well in advance and supported by both institutions. Fellowships with job security for the student are also easier to arrange. This option is further examined below.

Increased support for research organizations already working in areas of primary concern to developing countries

It is not possible, in a paper devoted to principles and strategies to identify all individual organizations. However, in preparing this paper, a wide ranging survey was undertaken of institutions that conduct apparently reliable research on one or more of the main topics identified in Chapter 5. These are summarized in Annexes 5, 6 and 7. More than 90 examples of such agencies have been identified[6/] of which approximately 40 are located in developing countries and 50 in developed countries. It is recommended as a follow up to the paper that a systematic review

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6/ There is an obvious risk that in citing these organizations by name that some important agencies will have been omitted. After careful consideration it has been decided to include the list of organizations cited in Annex 6 because of the urgent need to disseminate information on the range of research agencies already working in the priority areas defined in Chapter 5. Annex 6 includes examples of organizations which might help to accelerate the research effort on these topics. It does not claim to be a comprehensive listing and other agencies will no doubt be added as the dialogue on this subject proceeds.

be initiated of the scope for more effective twinning arrangements between these existing agencies and national forestry research institutions. Specific examples of the scope for such twinning in relation to the priority topics already discussed are given below:

Examples of possible twinning arrangements between forestry research institutions

(a) In relation to agriculture and rural development

For agriculture related forestry research in the humid tropics CATIE (Costa Rica) and CIAT (Colombia) are active in Latin America and IITA (Nigeria) in West Africa. Multiple twinning of these institutions with national forestry research agencies in countries such as Nicaragua, El Salvador, Brazil, Ghana, Cameroun and replicated trials of agroforestry demonstrations in such countries would be an obvious route to follow. Similarly, in the dry tropics and arid/semi-arid lands. ICRAF (Kenya) would be well sited to carry out basic research into agroforestry sytems in the East Africa region working in close conjunction with existing national institutions in countries such as Uganda, Tanzania, Rwanda, Burundi, Malawi, Zimbabwe, and so on. ICRISAT (India), a CGIAR center, has a research program for farming systems in the arid zone that has potential to include more emphasis on tree crops and CAZRI (India) has had a long history of successful forestry research in arid zones that is relevant to the South Asia Region. The programs of these institutes might be linked to similar agroforestry research trials by national research agencies in countries such as Burma, Bangladesh and Pakistan.

Whilst agroforestry research and closer involvement with farming systems are comparatively new areas of interest to forestry research workers, it cannot be overstressed that the main thrust of this new area of forest research is to examine the complementary role which forest trees can play in helping to improve agricultural productivity and to increase rural incomes. At the national level in the developing countries themselves, there are already in existence more than 1,000 agricultural research institutes or agencies many of whom are working on farming systems research, and it is likely that these existing agricultural research agencies could play a major role in transferring agroforestry research technology into the rural areas. To ensure this, there will need to be much more effective collaboration between agriculture and forestry reseach institutes than has been the case in the past. A good example is the recent decision by ICRAF to undertake part of its field research programs in the Katumani Agricultural Forestry Research Station located near Machakos in Kenya. This is an agricultural research institute which, for many years, has been studying appropriate farming systems for the semi-arid zones. By grafting agroforestry research onto an existing well-established agricultural research program which already has contacts with extension staff in the field, there will be the optimal chance of rapid transfer of agroforestry research related experience to the small farmer level.

(b) In relation to wood-based energy research

First and foremost in this area is the important question of the potential of vegetative propagation, tissue culture and genetic manipulation to contribute to increased biomass yield and to shortening of forest rotations. The main agencies already working in this field include CSIRO (Australia), AFOCEL AND CTFT (France), IBA (Japan), FRINZ (New Zealand), UNILEV (UK), (in India) and GIT, PRI, PRIU and WEY (USA). In addition to these well-established centralized agencies, a large number of individual university institutions and national forestry research institutes are experimenting with vegetative propagation on a small scale and closer association between those national agencies and organizations such as those cited above could be an effective way of accelerating the impact of such technologies in reforestation programs. An excellent example of this is the cooperative work undertaken on Leucaena by UHH (Hawii, USA) and ULB (Philippines).

In view of the basic and expensive nature of research on tissue culture and genetic manipulation (genetic engineering, somatic cell hybridization), it may be more appropriate to identify existing institutions that would be prepared to undertake additional work rather than to create new institutes dealing specifically with this subject. Vegetative propagation by cuttings, effectively pioneered by ARACRUZ and Florestal Acesita (Brazil), CTFT (Congo), and ESCH (Germany), also requires a sustained technical input from research personnel of high calibre over considerable periods of time, and more systematic 'twinning' arrangements between developing country national research agencies and institutions such as those cited above would be a cost effective way of rapidly transferring this technology to developing countries. A good illustration is the recent development of oil palm tissue culture technology by UNILEVER in UK which is now being transferred to Malaysi and other South East Asia Region countries.

In industrial technology, particularly relating to such matters as pyrolosis, gasification and production of liquid fuels, most research is implemented by industrial agencies with a strong chemical or industrial engineering background. They are not forestry research agencies in the classic sense.

A preliminary review suggests that there is a substantial amount of technological research and development by existing organizations located, for example, in Brazil, France, New Zealand, United Kingdom, USA and many other countries. A SERI report by Barnard and Hall (1981) listed 180 organizations in 72 countries that are undertaking research on alternative energy sources and processes. Some of the agencies working on this topic are already actively engaged in assisting developing countries to develop technology appropriate for use in the developing countries themselves; good examples are the research program on biomass yields and calorific values of tropical trees being sponsored by CTFT with West African tropical hardwoods. At first sight, it seems doubtful whether there is a need for new organizations in this area. What is needed is a more thorough agency by agency review of the scope of present programs and identification of those

specific developing countries and national forest research institutions that could most benefit from closer association with already established, overseas industrial agencies. It is recommended that this should be carried out as a follow-up to this report.

Pilot scale testing programs for new technologies are needed in the developing countries such as the alternative charcoal manufacturing techniques being developed by Florestal Acesita (Brazil) or the pilot program of wood-based ethanol production that is shortly to be initiated by EMBRAPA (Brazil); other examples are the JYOTI (India) and NEC (Philippines), both of which are funding pilot programs for installation of small (3 MW or less) thermal power electricity generating plants to be fueled by fast-growing forest tree species and which could be of special interest to national research agencies in many other developing countries. A more systematic effort is needed to publicize the work of these agencies and to enable the results of their programs to be rapidly disseminated.

Since much of the technology for small scale industrial manufacture of liquid fuels or thermal power generation emanates from private companies, a major effort should also be made to determine the extent of the research programs already being initiated by private sector groups and an evaluation of their own long range plans for marketing such technology overseas. Active encouragement of joint ventures between developing and developed country engineering and industrial companie, aimed at the local manufacture of equipment and plant would be another priority area for further study.

(c) <u>In relation to management and conservation of existing resources (mainly natural forests)</u>

In the field of conservation-oriented research, especially that aimed at preservation of the tropical forest ecosystem, broadly speaking there are two main areas of emphasis: (i) monitoring programs, remote sensing and other inventory techniques for keeping track of vegetation change; (ii) identification through field surveys of flora and fauna that should be preserved as a source of future genetic material or for other purposes.

In the former area, the technology is so sophisticated (e.g. satellite imagery) and so well advanced, that this appears to be a clear case where the appropriate solution is to build on what already exists in the developed world and to make this technology available for developing country use through externally assisted programs mainly at the governmental level. Agencies such as NASA (USA) can play a key role in this area.

In the area of resource surveys, particularly of floral and faunal resources, much of the basic work is carried out by existing institutes in the developed world such as CTFT (France), NYB (USA), RBG (UK) and RTI (Holland) and/ also by national forestry and other research institutions. There is an urgent need to transfer this experience to existing institutions in developing countries. such as INPA in Brazil and BOGOR (Indonesia)

In the light of the wide range of existing institutions already identified in which to launch an experimental program of research, it seems doubtful at this stage whether there is really a need for new regional institutions supported by governments of countries in a particular ecological or geographic zone. Generally, regional research institutions face obstacles that impede their efficiency, particularly the need for political compatibility among participating countries, the security of long term finance, the difficulties of agreeing research priorities and staffing policies. As stressed by FAO (1980b), it is unlikely that there will be significant opportunity to meet the needs of developing countries through regional or global organizations with the exceptions of forest products research in which the finalcial and skill requirements are great.

Quality of Research

Recommending a policy of more systematic twinning of national research agencies with overseas established research institutes already working in priority areas of interest is a step in the right direction for institutional strengthening and rapid transfer of research results to the developing countries, but for this policy to be effective, the issue of the quality of research being carried out in such overseas agencies needs further to be reviewed.

In the course of drafting this paper, it has not been possible to review the quality of research and capacity for backstopping national research agencies by the 90 or so institutions listed in Annex 7. While some of them are already acknowledged as 'centers of excellence' and are actively engaged in supporting work in overseas countries, others may not be in a position to offer such services, and it is far from certain that the quality of their research work is of such a high standard that it could be transferred with confidence elsewhere. Accordingly, it is recommended that as an integral part of any program aimed at more systematic twinning arrangements, a first step should be a systematic review of the 90 institutes identified in Annex 6 (together with any other subsequently identified which are working in the priority areas identifed in Chapter 5) which would focus on the quality of their research work and on their capability and willingness to backstop national research institutions.

The task of carrying out this review might appropriately be one of the first assignments for the Forestry Research Secretariat proposed in Chapter 8.

Is there a need for new institutions?

A major conclusion of this paper is that there is far more going on in international forestry research than is generally recognized. As noted earlier, more than 600 forestry research agencies have been identified on a global basis of which about 90 are already carrying on research programs into topics of priority interest to developing countries. Nevertheless, some gaps and imbalances in the institutional support network of forestry research have been identified.

In the area of agriculture related research, for example, whilst agencies such as CATIE, CIAT and IITA are active in the humid tropical zones of Central America and West Africa and ICRAF, ICRISAT, CASRI, and so on are carrying out research which is relevant to the arid and semi-arid zones of Africa and South Asia, there is no major comparable activity ongoing in the South East Asia or Pacific region which is concerned with identification of sustainable farming systems for wet tropical forest lands such as those now being settled under the Indonesian Transmigration Scheme. Similarly, there is a need to strengthen agroforestry research in the Amazon forested regions of Brazil and Colombia, which are being encroached on for agricultural settlement. It is recommended that further study of alternative institutional approaches to filling this gap be undertaken.

If a gap is perceived in this area, a decision is needed as to whether development of sustainable farming systems to incorporate trees for use in countries such as Indonesia, Malaysia, Papua New Guinea or Sri Lanka should be undertaken at existing agricultural institutions e.g. MARDI (Malaysia) or in forestry institutions such as FRIM (Malaysia) or in universities, (e.g. CMU, Thailand, and the University of Papua New Guinea). In Brazil, for example, more support of INPA in Manaus would be one possible option for strengthening agroforestry research in the Amazon Region.

With regard to increasing the productivity of forest tree species for use in energy production as well as for industrial reforestation programs, an immediate gap can be identified with relation to suitable species and provenances, particularly for fuelwood. Current forestry research is heavily oriented towards tropical Pinus, Eucalyptus, Leucaena, Tectona and high value tropical hardwoods for industrial and export use. About 700 fuelwood species have been identified as potentially valuable fuel crops and 35 that deserve immediate recognition and research (NAS, 1980b) with the exception of Acacia and Prosopis (FAO, 1980c) and Casuarina (joint Australian/Egyptian project) there are no specialized research programs in progress for most of these.

Although it would be possible to fill such gaps by following the same route already taken by agriculture in setting up specialized agencies to deal with individual crops (e.g. CIMMYT for maize and wheat or IRRI for rice), on balance this may be judged impracticable. More support in the phases of exploration and evaluation, however, could be given to national research institutions located in countries where those species are of priority as well as to existing agencies with well established research programs dealing with some of these species, e.g. CFI (UK), CSIRO (Australia), CTFT (France) and INIF (Mexico).

of their staff), its output of published proceedings of meetings, books, manuals, training workshops and similar activities is highly cost effective. This is because the costs of publication, postage and organizing or participating in meetings are borne by the individual scientist's financial resources, usually his home organization.

Through the network of its Working Parties and the publication of IUFRO News, IUFRO facilitates the personal and official exchange of information on current problems and progress in all aspects of research in forestry and forest products although at present not strongly related to agricultural needs and energy production. For many years, IUFRO activity was mainly in Europe and North America; now many Working Parties have expanded their interest to tropical and sub-tropical problems and a central committee has been formed to intensify tropical activity. In addition to its own quinquennial Congress, IUFRO has collaborated in the arrangements for international meetings with other agencies including FAO (pests and diseases, genetics, fast growing species and forest fertilization), ECE (air pollution), ISSS (land evaluation for forestry), IDRC (bamboo) and UNESCO/MAB (several).

At the level of practical research organizations and individual scientists, IUFRO provides the greatest level of awareness and collaboration. Its finances are very limited and funds for participating in meetings have to be found by the member scientist and his institute. This clearly limits participation from developing countries both in the leadership of working parties and in participation in meetings. Significant improvements in the operation and effectiveness of IUFRO could be made by providing funds at two levels.

Firstly, to encourage individual participation, one possible option would be to allocate funding either to the President and Executive Board of IUFRO, or to individual working party leaders, or to member organizations to finance attendance of researchers from developing countries at IUFRO meetings. The disbursement of such funds would have to be on a case by case basis. It is recommended that this possibility be further explored.

Secondly, IUFRO could support developing countries more effectively if its structure included provision for an enlarged permanent Forestry Research Secretariat the main function of which might include, for example, keeping scientists in developing countries in touch with what is happening elsewhere in their own field, promoting new research concepts and following up on what is being done to realign national research programs closer to perceived needs, anticipating useful discussion panels, and helping to organize conferences on selected topics, ensuring that research agencies in developing countries are aware of appropriate publications and information of relevance to their programs. The staff of the Secretariat could also play a role in selecting and screening applicants seeking financial assistance for attendance at overseas meetings. In addition, the Secretariat or each Division of IUFRO could bank information on personal exchanges between institutes. Additional funds could be used with significant

8. STRATEGIES FOR PROMOTION, SUPPORT AND COORDINATION OF FORESTRY RESEARCH IN DEVELOPING COUNTRIES

Whatever strategies are adopted for changing the emphasis in forestry research priorities, there is an obvious need to provide supporting services. Also, for the most efficient use of global resources devoted to research, the programs of different nations and organizations should be coordinated[5/] or 'harmonized' to obtain maximum relevance and minimum duplication of effort. This may be achieved both by undertaking planned, cooperative and complementary research programs and by greater awareness of other organizations' activities.

There are three major sources of this support and coordination - IUFRO, FAO and centers of excellence or major activity in specialized topics that were analyzed in the previous chapter. In relation to coordination at the international level, IUFRO and FAO have played the main role in the past with staff of centers of excellence contributing significantly and voluntarily to the leadership and activities of IUFRO.

IUFRO

Membership of IUFRO comprises some 600 forestry research organizations with 10,000 individual scientists; these are grouped in six Divisions, covering the fields of Forest Environment and Silviculture; Forest Plants and Forest Protection; Forest Operations and Techniques; Planning, Economics, Growth and Yield, Management and Policy; Forest Products; and General Subjects; these have varying numbers of Subject Groups and inter-divisional Project Groups, each with varying numbers of Working Parties. These Working Parties comprise 10 to 300 individuals working on a particular problem in their own institutes and they operate through correspondence, workshops/symposia and associated field or laboratory tours.

In relation to its secretariat expenses (US$ 112,000 per year, contributed by member organizations in proportion to the number

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5/ The term 'coordination' has connotations that are not acceptable to all developing countries, donors or institutions, implying that some 'Supra-Agency' would impose its own philosophies on what are essentially national programs. Nevertheless, there are obvious advantages to be gained by harmonization of research programs aimed at avoidance of duplication and waste of resources.

effects in providing facilities for translation and interpretation within IUFRO; English, French and German are the official languages but even among these interchange occurs only in the Statutes and News. Spanish and Chinese could be considered in view of the large numbers of people, countries and forestry research programs covered by these languages.

If IUFRO is to support the new research needs of the developing world, some restructuring may be needed, possibly by creation of new subdivisions dealing specifically with forestry research related to trees in farming systems, wood-based energy and conservation-oriented research. It is recommended that the administrative and financial implications of restructuring IUFROs Secretariat along the above lines should be further reviewed; it is recommended that following the Kyoto Congress IUFRO and FAO, working together with the other lead agencies should jointly explore ways and means of implementing the tentative recommendations outlined above.

FAO

For the last 35 years FAO has played a dominant role in international, technical forestry and it is the logical forum for the interchange of views on the status, current issues and future priorities in forestry. It has played an active role in helping investment agencies such as the World Bank to expand their own forestry investment. It has also assisted developing countries in improving national research institutional capability (FAO, 1979c) and provides followships for advanced study. All of these activities are still needed.

While IUFRO coordinates at the institutional and individual level, FAO acts mainly at the governmental level and represents the interests of member countries as transmsitted through its various committees and commissions. FAO, in fact, does not coordinate but disseminates information in support of national research efforts. Nevertheless, a measure of coordination, in the sense of rationalizing research expenditure and minimizing duplication, occurs not only through the publication of the large number of committee reports and technical papers but also through the stimulus of major international conferences organized by FAO often in association with IUFRO.

Most important of these that have had an impact on forestry research, either by reporting results of current programs or by identifying new subjects requiring research, included the following: (i) nine World Forestry Congresses (held at 6-year intervals since the 1920s); (ii) Symposium on Man-made Forests (1967); (iv) three World Consultations on Forest Tree Breeding (the most recent in 1977). In addition, the UN Conferences on Desertification (1977) and New and Renewable Sources of Energy (1981) can be expected to stimulate research in arid zone and fuelwood forestry; FAO provided the Secretariat for the latter's technical panel on fuelwood and charcoal. This list is incomplete and is confined to large, conventional meetings. On a smaller scale, but of obvious relevance to the present paper, are the Third FAO SIDA Expert Consultation on Forestry for Local Community Development (1977) and the several meetings of the FAO Panel of Experts on Forest Gene Resources.

FAO's main constraint to ensuring more effective technical backstopping for forestry research is its lack of budgetary support for core staff working in this field. Given additional resources, it could, undoubtedly, play a more effective role. One possible step would be to resurrect FAO Regional Forestry Research Committees which were disbanded during the 1970s mainly due to lack of funds and resources. It is recommended that the scope for strengthening FAO activies in these areas be reviewed.

Following the Kyoto Congress, FAO plans in conjunction with IUFRO, the World Bank and other lead agencies and subject to availability of financing, to host a meeting in Rome in mid-1982 which will examine options for strengthening this capability for backstopping research for introducing greater emphasis on research into the field projects and improving the capability of disseminating research information.

9. FINANCIAL IMPLICATIONS

To attempt a detailed survey of the financial requirements for expanded forestry research programs along the lines outlined in this paper would be premature and would, more logically, follow on a discussion of the alternative strategies previously discussed. However, some general points of relevance could be made.

Firstly, in view of the very low level of aid funding currently allocated to forestry research in the developing world (which probably amounts to less than US$10 million per annum on a global basis), a doubling or even tripling of research expenditure would, in the immediate future, constitute an extremely small proportion of total external aid in agriculture as a whole (which, for the World Bank alone, is currently running at US$3,000 million a year).

Even though this paper has not attempted a detailed review of future financial needs, a number of broad priority areas likely to need additional financial support have been identified and it would be useful to summarize them. They include strengthening of national forestry research institutions and funding of specific projects or programs covering the priority areas defined in Chapter 5 of this paper, namely agriculture, energy and conservation oriented forestry research. Secondly, support for existing well-established research organizations that are already carrying out research programs related to these topics with special reference to strengthening of twinning arrangements between these organizations and national research agencies located in developing countries.

Thirdly, a major gap has been identified in the area of research into sustainable cropping systems for the acid latosols underlying tropical forests of regions such as the Amazon Basin and Indonesian archipelago. Fourthly, increased funding is recommended of staff training and extension services needed to ensure effective dissemination of research results. Fifthly, financing of improved data collection, computerization and documentation of research results.

As discussed in Chapter 8, to ensure more effective support and coordination of research, there is a possible need for creation of a Forestry Research Secretariat to focus specifically on developing countries' research needs and for further strengthening of FAO's research related field programs and technical core staff capability so that they will be able to support more effectively national research institutions and centers of excellence as well as continuing to play a key role in disseminating literature.

As a follow-up to the FAO/IUFRO Research meeting planned in mid-1982, which will review the topics discussed in this paper and examine practical ways and means of achieving these objectives, the World Bank would be willing to consider hosting a meeting of donor agencies to discuss the financial implications of an expanded program of forestry research - at this

stage without financial commitment to the Bank. Within the Bank's own lending program, the primary thrust of forestry research effort will continue to be channelled through its forestry lending programs to individual Governments.

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ANNEX 1

ABBREVIATIONS

All organizations mentioned in this paper were given an acronym for brevity in the text and to facilitate the computation of the numbers of centers of major activity shown in Annex 4; these acronyms are not necessarily used by the organizations themselves. Locations are given for the headquarters, secretariat or main center of activity of each organization.

Those marked with asterisks (*) indicate forestry research in progress of direct relevance to developing countries other than the one in which the organization is located -

* located in developed country;

** located in developing country;

1/ indicated organization no longer exists.

	ADB	Asian Development Bank, Manila, Philippines
	AFC	FAO Forestry Commission for Africa
	AFDB	African Development Bank, Abidjan, Ivory Coast
*	AFOCEL	Assocation Forestière de Cellulose, Nangis, France
*	APC	International Institute for Aerial Survey and Land Sciences, Enschede, Holland
	APFC	FAO Forestry Commission for Asia and the Pacific
**	ARACRUZ	Aracruz Florestal S.A., Vitoria, Espiritu Santo, Brazil
**	ARCCA 1/	Agricultural Research Council of Central Africa, Salisbury, Rhodesia (now Zimbabwe)
**	ARIANE	Institut National de Recherche Forestier, Ariane, Tunisia
	ASEAN	Association of South East Asian Nations, Manila, Philippines
**	BANG	Dryland Research Center, Baugalore, India
**	BEI	Central Forest Research Institute, Beijung, China
*	BFH	Bundesforschungsanstalt für Forst - und Holzwirtschaft, Hamburg, Germany
**	BIOTROP	Organization for Tropical Biology, Bogor, Indonesia
**	BOGOR	Forest and Forest Products Research Institutes, Bogor, Indonesia
	CAB	Commonwealth Agricultural Bureau, Farnham Royal, U.K.
	CASAFA	Committee for the Application fo Science to Agriculture, Forestry and Aquaculture, ICSU, Paris, France

**	CATIE	Centro Agronomico Tropical de Investigacion y Ensenanza, Turrialba, Costa Rica
**	CAZRI	Central Arid Zone Research Institute, Jodhpur, India
	CFA	Commonwealth Forestry Association, Oxford, U.K.
	CFB	Commonwealth Forestry Bureau, Oxford, U.K.
*	CFI	Commonwealth Forestry Institute, Oxford, U.K.
	CGIAR	Consultative Group for International Agricultural Research, Washington, D.C., USA
**	CIAT	Centro International de Agricultura Tropical, Cali, Colombia
**	CIDIAT	Venezuela
	CILSS	Comite International contre la Lutte et la Sécheresse au Sahel, Ouagadougou, Upper Volta
	CIMMYT	Centro Internacional de Mejoramiento de Mais y Trigo, Londres 40, Mexico 6, DF, Mexico
**	CMU	University of Chiang Mai, Thailand
*	CNEEMA	Centre National d'Etudes et d'Experimentation du Machinisme Agricole, Creusot, Loire, France
	CNRS	Centre National de la Recherche Scientifique, Nancy, France
*	COLF	College of Forestry and Natural Resources, Fort Collins, Colorado, USA
*	COLW	Department of Forest and Wood Sciences, Fort Collins, Colorado, USA
	COMECON	Community for Economic Assistance, Moscow, USSR
	COW	Coweeta Hydrological Research Station, Coweeta, North Carolina, USA
*	CSIRO	Commonwealth Scientific and Industrial Research Organization, Canberra and Melbourne, Australia
**	CSWCRTI	Central Soil and Water Conservation Research and Training Institute, Dehra Dun, India
*	CTB	Centre Technique du Bois, Paris, France
*	CTFT	Centre Technique Forestier Tropical, Paris, France
	CTGR	Centre Technique du Genie Rural des Eaux et des Forêts, San Martin, France
*	DAFOX	Department of Agricultural and Forest Sciences, Oxford University, U.K.
	DANIDA	Danish International Development Agency, Copenhagen, Denmark
**	DFRM	Department of Forest Resources Management, Ibadan University, Nigeria
	DSE	Deutsche Stiftung für Internationale Entwicklung, Berlin, Germany

*	DTSC	Danish Tree Seed Centre, Humlebaek, Denmark
**	EAAFRO[1/]	East African Agriculture & Forestry Research Organization, Muguga, Kenya
	EEC	European Economic Community, Brussels, Belgium
	EFC	FAO Forestry Commission for Europe
*	EIN	Eindhoven University of Technology, Eindhoven, Holland
**	EMBRAPA	Empresa Brasileira de Pesquisas Agropecuatia Brasilia, Brazil
*	ENCC	Societa Agricole Forestale, Casale Monteferrato, Italy
*	ENGR	Ecole Nationale du Genie Rural des Eaux et des Forêts, Nancy, France
*	ERIM	Environmental Research Institute of Michigan, Ann Arbor, Michigan, USA
*	ESCH	Niedersachsiche Forschungsanstalt, Escherode, Germany
*	EWC	East-West Centre, Honolulu, Hawaii, USA
	FA	Forestry Abstracts
	FAO	Food and Agricultural Organization of the United Nations, Rome, Italy
	FINNIDA	Finnish International Development Authority, Helsinki, Finland
	FPA	Forest Products Abstracts
*	FPL	Forest Products Laboratory, Madison, Wisconsin, USA
**	FPLP	Forest Products Laboratory, Los Baños, Philippines
**	FRI	Forest Research Institute, Dehra Dun, India
**	FRIA	Forest Research Institute, Ankara, Turkey
**	FRIM	Forest Research Institute, Kepong, Malaysia
**	FRIN	Forest Research Institute, Ibadan, Nigeria
*	FRINZ	Forest Research Institute, Rotorua, New Zealand
**	FRIP	Forest Research Institute, Peshawar, Pakistan
*	GIT	Institute of Technology, Atlanta, Georgia, USA
*	GSFC	Goddard Space Flight Center, Greenbelt, Maryland, USA
	GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit, Frankfurt, Germany
*	HAN	Institute for Forest Hydrology, Hanover, Germany
	IARC	International Agriculture Research Center, Wageningen, Holland
*	IBA	Government Forest Experiment Station, Ibaraki, Japan
	IBDF	Instituto Brasileiro de Desenvolvimento Florestal, Brasilia, Brazil

	IBPGR	International Board for Plant Genetic Resources, Washington, D.C. USA
*	ICONA	Instituto por la Conservacion Naturaleza, Madrid, Spain
**	ICRAF	International Council for Research in Agro-forestry, Nairobi, Kenya
**	ICRISAT	International Crop Research Institute for the Semi-Arid Tropics, Hyderabad, India
	ICSU	International Council of Scientific Unions, Paris, France
	IDB	Inter-American Development Bank, Washington, D.C. USA
	IDRC	International Development Research Centre, Ottawa, Canada
	IFAD	International Fund for Agricultural Development, Rome, Italy
	IFE	University of Ife, Ife, Nigeria
	IFIAS	International Federation of Institutes of Advanced Studies, Stockhom, Sweden
	IFLAIC[1/]	Instituto Forestal Latino-Americano de Investigaciones y Capacitacion, Merida, Venezuela
*	IHW	Institute of Hydrology, Wallingford, U.K.
**	IIMA	Indian Institute for Management, Allahabad, U.P. India
**	IITA	International Institute for Tropical Agriculture, Ibadan, Nigeria
	ILO	International Labour Organization of the United Nations, Geneva, Switzerland
**	INIF	Instituto Nacional de Investigaciones Forestales, Mexico City, Mexico
**	INPA	Instituto Nacional de Pesquisas da Amazonia, Manaus, Brazil
*	INRA	Institut National de Recherche Agronomique, Paris, France
**	IRRI	International Rice Research Institute, Los Baños, Philippines
	ISNAR	International Service for National Agricultural Research, The Hague, Holland
	ISSS	International Soil Science Society, IARC, Wageningen, Holland
	ISTF	International Society of Tropical Foresters, Washington, D.C., USA.
*	ITDG	Intermmediate Technology Development Group, London and Reading, UK
*	ITE	Institute of Terrestrial Ecology, Cambridge, Edinburgh and Grange-over-Sands, UK
**	ITF	Institute of Tropical Forestry, Rio Piedras, Puerto Rico, USA
	IUBS	International Union of Biological Sciences, Paris, France
	IUC	Inter-Universities Council, London, UK
	IUCN	International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland

68

	IUFRO	International Union of Forestry Research Organizations, Vienna, Austria
	IUFS	International Union of Forestry Societies, Bangor, Wales
**	IVIC	Instituto Venezolano de Investigaciones Cientificas, Caracas, Venezuela
**	JARI	Jari Forestal, Amazon, Brazil
	JICA	Japanese International Cooperation Agency, Tokyo, Japan
**	JYOTI	Jyoti Solar Energy Institute, Kaira, Gujarat, India
**	KARADJ	Forestry Faculty, University of Teheran, Karadj, Iran
**	KARI	Kenya Agricultural Research Institute, Muguga, Kenya
**	KUM	Forest Products Research Institute, Kumasi, Ghana
*	KYO	College of Forestry, Kyoto University, Kyoto, Japan
	LAFC	FAO Forestry Commission for Latin America
*	LRDC	Land Resources Development Centre, Tolworth, UK
	MAB	Man and the Biosphere Program, UNESCO, Paris, France
**	MARDI	Malaysia Agricultural Research and Development Institute, Serdang, Kuala Lumpur, W. Malaysia
**	MOSUL	Forest Research Centre, Mosul, Iraq
	NAFC	FAO Forestry Commission for North America
	NAS	National Academy of Sciences, Washington, D.C., USA
	NATO	North Atlantic Treaty Organization, Brussels, Belgium
**	NEC	National Electricity Corporation, Manila, Philippines
	NEFC	FAO Forestry Commission, Near East
	NTI	Neem Tree Institute, Paris, France
**	NUK	University of Nairobi, Nairobi, Kenya
*	NYB	New York Botanical Gardens, Bronx, New York, New York, USA
	NZERDC	New Zealand Energy Research and Development Committee, Auckland, New Zealand
	ODA	Overseas Development Administration, London, England
	ODC	Oxford Decimal Classification for Forestry, CFB, UK
**	OTS	Organization for Tropical Studies, Turrialba, Costa Rica
	OJI	Forest Tree Breeding Institute, Oji Paper Company, West Malaysia (headquarters in Japan)
**	PIC	Pine Improvement Centre, Chiang Mai, Thailand
**	PICOP	Paper Industries Corporation of the Philippines, Makati, Philippines
	PIRA	Paper Industries Research Association, Leatherhead, UK

**	PLATA	Instituto de Ordenacion, Universidade Nacional de la Plata, Argentina
**	PNG	University of Papua New Guinea, Lae, Papua-New Guinea
**	POONA	National Chemical Laboratory, Poona, India
**	PP.	Perum Perhutani, Jakarta, Indonesia
**	PPRII	Pulp and Paper Research Institute of India, Saranpur, India
*	PRI	Paper Research Institute, Appleton, Wisconsin, USA
*	PRIU	Plant Research Institute, Salt Lake City, Utah, USA
*	PRL	Princes Risborough Laboratory, Princes Risborough, UK
*	QLD	Department of Froestry, Brisbane, Queensland, Australia
*	RBG	Royal Botanical Gardens, Kew, London, UK
**	RIFR	Research Institute of Forests and Rangelands, Teheran, Iran
	RSL	Royal Society, London, UK
*	RTI	Royal Tropical Institute, Amsterdam, Holland
	SAN	San Dimas Experimental Watershed, San Dimas, California, USA
*	SERI	Solar Energy Research Institute, Colorado, USA
**	SFRS	Savannah Forest Research Station, Samaru, Nigeria
	SIDA	Swedish International Development Association, Stockholm, Sweden
*	SSM	Station de Sylviculture Mediterranéen, Avignon, France
	TAC	Technical Advisory Committee (CGIAR), Rome, Italy
	TAPPI	Technical Association of Pulp and Paper Industries, New York, N.Y., USA
	TCDC	Technical Cooperation among Developing Countries
	TCP	Technical Cooperation Program
**	TIC	Teak Improvement Centre, Chiang Rai, Thailand
*	TNO	Forest Products Research Institute T.N.O., Delft, Holland
*	TOK	College of Forestry, Tokyo University, Tokyo, Japan
*	TPI	Tropical Products Institute, London and Culham, UK
*	TRADA	Timber Research and Development Association, High Wycombe, UK
**	TURK	Fast Growing Trees Research Institute, Izmir, Turkey
*	TUT	Twente University of Technology, Enschede, Holland
	TVA	Tennessee Valley Authority, Tennessee, USA
*	UA	University of Arizona, Tuscon, Arizona, USA
*	UHH	University of Hawaii, Honolulu, USA

10

	UK	United Kingdom
**	UL3	University of Los Baños, Philippines
	UNCTAD	United Nations Conference on Trade and Development, Geneva, Switzerland
	UNDP	United Nations Development Program, New York, N.Y., USA
	UNEP	United Nations Environmental Program, Nairobi, Kenya
	UNESCO	United Nations Educational, Scientific and Cultural Organization, Paris, France
	UNIDO	United Nations Industrial Development Organization, Vienna, Austria
	UNIFOR	Universities for International Forestry, Idaho, USA
*	UNILEV	Unilever Company, Bedford, UK
	UNU	United Nations University, Tokyo, Japan
	US, USA	United States of America
	USAID	United States Aid for International Development, Washington, D.C. USA
	USDS	United States Department of State, Washington, D.C., USA
	WB	World Bank, Washington, D.C., USA
*	WEY	Weyerhaeuser Company, Tacoma, Washington, D.C., USA
	WFP	World Food Program
*	WFPL	Western Forest Products Laboratory, Vancouver, B.C., Canada
	WHO	World Health Organization of the United Nations, Geneva, Switzerland
	WMO	World Meteorological Organization of the United Nations, Geneva, Switzerland
*	WWG	US Forest Service Experiments at Wagon Wheel Gap, Colorado, USA
**	XAV	Xavier Institute, Bihar, India

ANNEX 3

Mechanism for establishing priorities for forestry research

Whatever the population's needs, one weakness in past forestry research, at both the level of individual research programs and the national and international allocation of resources to such research, is failure to relate research sufficiently closely to those needs. A mechanism is needed for establishing priorities. This should start with the identification of appropriate criteria and parameters.

The following set of criteria are derived from those developed for application to agricultural research by the CGIAR:

(i) The activity should be of present or potential importance to the contribution of forestry to national or local development.

(ii) There should be clear evidence that there is potential for substantial progress or improvement in the activity.

(iii) There should be clear evidence that such improvement is now limited by deficiencies in presently available scientific technology and lack of the required information.

(iv) There should be a good prospect that new scientific information and technology on the subject can be developed and could be brought into use.

Such generalized criteria need to be broken down as far as possible into their component criteria, so that these can be examined and assessed. Thus, the parameters of the first criteria, on importance, could include the following:

(i) The activity contributes to governmental policy objectives of high priority (or has strong policy support).

(ii) The size of the activity (e.g. the proportion of forest output that is affected by the activity).

(iii) The numbers of people affected by the changes in the activity.

(iv) The contribution to meeting developmental objectives (growth, basic needs, equity, etc.).

Similarly, the fourth criterion, on prospective effectiveness of the research could be broken down as follows:

(i) The availability of the inputs needed for the research, e.g. status of the underlying scientific knowledge, relative complexity of the research needed, availability of researchers, adequacy of budget allocations.

(ii) The expected time lag before the research results would have an impact.

(iii) The conditions for transferring the results to the users, e.g. extension or other form of outreach service, the absorptive capacity of the users (knowledge, cost organizational, etc.), support facilities.

A further step towards a systematic and efficient system of establishing priorities could be the structuring of research options so as to ensure that all levels and dimensions of the sector are covered. Thus, it is possible to distinguish research that would affect three broad levels of decision making:

(i) Research at the operational level that would affect the use of the forest resources and other physical inputs (e.g. tree breeding research),

(ii) Research at the institutional level focussing on the impact of institutional forces (taxes, prices, land tenure, etc.).

(iii) Research at the policy level at which the institutional forces originate (e.g. forest policy, energy policy).

A structured categorization of research topics will help ensure that, for example, both the demand and the supply aspects of forestry are taken into account.

Even with a well defined set of criteria, and an orderly characterization of the sectoral issues, the process of setting priorities is likely to be largely by personal judgement in practice. In order to provide as much guidance as possible, the tools of economic analysis need to be brought into play to provide both an assessment of the costs and benefits of individual options and an objective basis for comparing options. As has been noted earlier, this can pose problems because many forest outputs are difficult to measure and quantify; also, a given activity may contribute to meeting a number of objectives, some of which may be mutually conflicting (e.g. protection versus production).

However, it is important that efforts be made to overcome these assessment problems. Forestry lags badly behind agriculture and other

sectors in its ability to evaluate and present its research needs and proposals in terms of their economic efficiency. It will become increasingly difficult to secure funding for forestry research until this can be done. An important research subject for forestry is consequently research on research itself and attention is drawn to the activities of IUFRO Working Party S.4.05-01 and to earlier Canadian work (Marshall, 1972; Babcock, 1975).

Finally, an effective research planning capability requires a mechanism for coordinating and harmonizing the views of the different parties involved. Within the sector, the planners, managers, researchers and users are likely to have different perceptions of what research is needed. There needs to be some process of consultation, review and feedback to accommodate and reconcile these different interests. A recent review of US experience with forestry research planning shows the improvements in research productivity that this can bring about and how the process can be achieved (Fedkiw, 1981).

FORESTRY RESEARCH NEEDS FOR DEVELOPING COUNTRIES

(i) Forestry in relation to agriculture and rural development

(A) Sociological and institutional research

1. Determination of perceived role of trees and forests in rural welfare
2. Origin and solution of conflicts for land
3. Determination of acceptability and response to innovative systems
4. Definition and testing of incentives to incorporate trees
5. Guidelines for project preparation
6. Extension methods
7. Institutional aspects
8. Economic returns from alternative farming systems incorporating trees

(B) Farming systems using trees

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

(C) Watersheds (catchments) and range management

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

(D) Wildlife in relation to rural welfare

1. Ecological monitoring of animal habitats
2. Population behaviour of animals
3. Socioeconomic aspects of the place of animal products in rural life

(ii) Forestry in relation to energy production and use

(A) Silviculture of biomass/fuelwood species and systems

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

(B) Yield, harvesting and properties

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

(C) Industrial research related to village technology

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

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

(E) Wood-based derivatives

1. Pyrolysis
2. Gasification
3. Pelletization
4. Methanol
5. Ethanol and liquid fuel technology

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

(A) Resource survey

1. Land use planning methods
2. Soil and land use survey and evaluation
3. Monitoring changes of forest area
4. Inventories of accessible natural forest

(B) Conservation

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

(C) Silvicultural systems for natural forests

1. Natural regeneration
2. Artificial enrichment

(D) Whole tree use

1. Harvesting
2. Utilization
3. Effects on site

(E) Use and marketing of secondary species

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

(F) Wood preservation

(iv) Industrial forestry

(A) Silviculture and management

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

(B) Wood properties

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

Forestry research needs in developing countries* and number of existing centers already carrying out research activities in these areas

(*As defined in Chapter 5.)

Research needs	Numbers of centers 1/ of major activity with international relevance: Humid tropics	Dry tropics	Arid/ Semi-arid lands	Mediterranean areas	Global totals 2/
(i) Forestry in relation to agriculture and rural development					
A. Sociological and institutional research	4	4	4	1	7
B. Farming systems using trees	12	7	2	2	15
C. Watersheds (catchments) and range management	10	14	11	15	26
D. Wildlife in relation to rural welfare	1	2	2	1	3
(ii) Forestry in relation to energy production and use					
A. Silviculture of biomass/fuelwood species and systems	20	18	10	6	37
B. Yield, harvesting and properties	8	8	8	8	8
C. Research related to stoves and other industrial technology.	11	11	11	11	11
D. Comparison with alternative fuels					
E. Wood-based derivatives	(Many companies and government laboratories)				
(iii) Management and conservation of existing resources					
A. Resource survey	14	9	1	2	20
B. Conservation	9	6	5	1	15
C. Silvicultural systems for natural forests	14	3	2	4	20
D. Whole tree use	Awaiting FAO				7
E. Use and marketing of secondary species	13	13	13	13	13
F. Wood preservation	9	9	9	9	9
(iv) Industrial forestry					
A. Silviculture and management	20	20	10	6	39
B. Wood properties	24	16	2	2	28

1/ The acronyms of these centers are listed in Annex 6 and their locations in Annex 7.

2/ The global total is not necessarily the sum of the zonal values because the activities of some centers are applicable to more than one ecological zone.

ANNEX 5

Best Available Document

EXAMPLES OF ORGANIZATIONS WITH CURRENT PROGRAMS RELEVANT TO THE FORESTRY RESEARCH NEEDS OF DEVELOPING COUNTRIES

It is emphasized that the organizations listed here are taken as examples to initiate this review and are not an exhaustive listing. At the risk of offending some institutions by omitting them, the list is provided now in response to frequent demands for information on current activities.

Note: All abbreviations are explained in Annex 1.

(** = Actually located in the zone.)

					Number
(i) Forestry in relation to agriculture and rural development					
A. Sociological and institutional research					
1. Humid tropics	CATIE**	CMU**	EWC**	ICRAF	4
2. Dry tropics	ICRAF**	IFE**	IIMA	XAV	4
3. Arid/Semi-arid lands	CAZRI**	ICRAF	IIMA**	XAV	4
4. Mediterranean areas	ICRAF				1
B. Farming systems using trees					
1. Humid tropics	CATIE** DFRM** MARDI**	CIAT** FRIM** PNG**	CMU** ICRAF PP*	CTFT IITA**	11
2. Dry tropics	BEI** ICRAF** SFRS**	CTFT KARI**	EMBRAPA** MARDI**		6
3. Arid/Semi-arid lands	BEI	CAZRI**	CTFT	ICRAF	2
4. Mwditerranean areas	ICRAF	SSM**			2
C. Watersheds (catchments) and range management					
1. Humid tropics	BOGOR** HAN TVA	CIDIAT** IBA WWG	COLF IHW	COW SAN	10
2. Dry tropics	FRI** BANG** FRIP** KARI** WWG	COLF HAN PLATA**	COW IBA SAN	CSWCRTI** IHW TVA	14

3. Arid/Semi-arid lands

BANG	CAZRI**	COLF	COW	
CSWCRTI**	HAN	IBA	IHW	
SAN	TVA	WWG		11

4. Mediterranean areas

ARIANE**	COLF	CTGR	COW	
FRIAA**	HAN	IBA	ICONA	
IHW	KARADJ**	MOSUL**	RIFR**	
SAN	TVA	WWG		15

D. Wildlife

1. Humid tropics — DFRM** — Awaiting from FAO (Childs)
2. Dry tropics — DFRM — NUK** — "
3. Arid/Semi-arid lands — DFRM — NUK — "
4. Mediterranean areas — ICONA** — "

(ii) Research in relation to energy production and use

A. Silviculture and genetics of biomass/fuelwood species and systems

1. Humid tropics

AFOCEL	BIOTROP**		BOGOR**	
CATIE**	CFI	CIAT**	CTFT	
EMBRAPA**		FRIM**	IITA**	ITE
ITF**	KUM**	PICOP	PNG**	
PP**	PRIU	UHH	UNILEV	
WEY				20

2. Dry tropics

AFOCEL	CFI	CSIRO	CTFT	
DTSC	EMBRAPA**		IBA	
IFE**	INIF**	IVIC**	KARI**	
NUK**	PICOP**	POONA**	PRIU	
QLD**	SFRS**	ULB**		18

3. Arid/Semi-arid lands

AFOCEL	CAZRI**	CFI	CSIRO	
CTFT	KARI	NUK	POONA	
PRIU	UA			10

4. Mediterraneas areas

AFOCEL	FRIA**	FRINZ	PRIU	
TURK**	UA			6

B. Yield, harvesting and properties

Common to all zones

CATIE	CFI	CIAT	CTFT	
IITA	INIF	KARI	SFRS	8

C. Industrial research related to village technology

Common to all zones

BOGOR	CNEEMA	EIN	GIT	
ITDG	JYOTI	NEC	PP	
SERI	TPI	TUT		11

D. Comparison with alternative fuels

Common to all zones	Many companies and Government. chemical laboratories	

E. Wood-based deravitives

Common to all zones	Many companies and Government chemical laboratories	

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

A. Resource survey

1. Humid tropics	BFH FRIM** IVIC RBG	CFI FRIN** LRDC TOK	COLW GSFC NYB	CTFT INPA** PP**	14
2. Dry tropics	CFI FRI** LRDC	COLW GSFC	CTFT INIF**	ERIM IVIC**	9
3. Arid/Semi-arid lands	CAZRI**				1
4. Mediterranean areas	FRIA**	SSM**			2

B. Conservation

1. Humid tropics	BFH CFI ITF**	BIOTROP** CTFT UHH**	DFRM**	CATIE** INPA**	9
2. Dry tropics	CFI FRIN	CSIRO INIF**	CTFT	FRI	6
3. Arid/Semi-arid lands	CAZRI** INIF	CFI	CSIRO	CTFT	5
4. Mediterranean areas	ICONA				1

C. Silvicultural systems for natural forest

1. Humid tropics	BFH EMBRAPA** INPA** PNG**	CFI ITF** QLD**	CTFT FRI** KUM** TOK	DFRM** FRIM** KYO	14
2. Dry tropics	EMBRAPA**		FRI**	INIF**	3

3. Arid/Semi-arid lands	CAZRI** FRI	2
4. Mediterranean areas	FRIA** KARADJ** MOSUL** SSM**	4

D. Whole tree use

1. Humid tropics	(ask FAO)	
2. Dry tropics	"	
3. Arid/Semi-arid lands	"	
4. Mediterranean areas	"	

2

E. Use and marketing of secondary species

No zonal distinctions are made	BFH BOGOR CFI CSIRO CTFT FPL FPLP FRIM KUM PP PPRII PRL TRADA	13

F. Wood preservation

No zonal distinctions are made	BFH CSIRO CTB CTFT FPL FRI FRIM INIF KUM	9

(iv) Industrial forestry

A. Silviculture and management

1. Humid tropics	AFOCEL BIOTROP** BOGOR** CATIE** CFI CIAT** CTFT EMBRAPA** FRIM** IITA** IFT** KUM** PICOP PNG** PP** PRIU UHH** UNILEV WEY	20
2. Dry tropics	AFOCEL CFI CSIRO CTFT DTSC EMBRAPA** IBA IFE** INIF** IVIC** KARI** NUK** PICOP** POONA** PRIU QLD** SFRS** ULB** PIC** TIC**	20
3. Arid/Semi-arid lands	AFOCEL CAZRI** CFI CSIRO CTFT KARI NUK POONA PRIU UA	10

4. A. Mediterranean areas	AFOCEL	FRIA**	FRINZ	PRIU	
	TURK**	UA			6

B. Wood properties and use characteristics

1. Humid tropics	BFH	BOGOR**	CFI	CSIRO	
	CTB	CTFT	DAFOX	DFRM**	
	EMBRAPA**		FPL	FPLP	
	FRIM**	FRIN**	IBAR	INPA**	
	ITF**	KUM**	OJI	PICOT	
	PPRII**	PRL	TPI	TRADA	
	ULB**				24
2. Dry tropics	BFH	CFI	CSIRO	CTB	
	CTFT	DAFOX	FPL	FRIP**	
	IBA	INIF**	IVIC**	PICOP**	
	PPRII**	PRL	TPI	TRADA	16
3. Arid/Semi arid lands	CFI	DAFOX			2
4. Mediterranean areas	FRIA**	KARADJ**			2

ACRONYMS AND LOCATIONS OF THE CENTERS LISTED IN ANNEX 6

* Located in developed country (52)

** Located in developing country (44)

Acronym	Location	Acronym	Location	Acronym	Location
* AFOCEL	France	* ENCC	Italy	* ITF	USA
* APC	Holland	* ENGR	France	** IVIC	Venezuela
** ARIANE	Tunisia	* ERIM	USA	** KARADJ	Iran
** BANG	India	* EWC	USA	** KARI	Kenya
** BEI	China	* FPL	USA	** KUM	Ghana
* BFH	Germany	** FPLP	Philippines	* KYO	Japan
** BIOTROP	Indonesia	** FRI	India	* LRDC	UK
** BOGOR	Indonesia	** FRIA	Turkey	** MARDI	Malaysia
** CATIE	Costa Rica	** FRIM	Malaysia	** MOSUL	Iraq
** CAZRI	India	** FRIN	Nigeria	** NUK	Kenya
* CFI	UK	* FRINZ	New Zealand	* NYB	USA
** CIAT	Colombia	** FRIP	Pakistan	* OJI	Malaysia/Japan
** CIDIAT	Venezuela	* GIT	USA	** PIC	Thailand
** CMU	Thailand	* GSFC	USA	** PICOP	Philippines
* CNEEMA	France	* HAN	Germany	** PLATA	Argentina
* COLF	USA	* IBAR	Japan	** PNG	Papua New Guinea
* COLW	USA	* ICONA	Spain	** POCHA	India
* CSIRO	Australia	** ICRAF	Kenya	** PP	Indonesia
** CSWCRTI	India	* IFE	Nigeria	** PPRII	India
* CTB	France	* IHW	UK	* PRI	USA
* CTFT	France	** IIMA	India	* PRIU	USA
* CTGR	France	** IITA	Nigeria	* PRL	UK
* DAF	UK	** INIF	Mexico	* QLD	Australia
** DFRM	Nigeria	** INPA	Brazil	* RBG	UK
* DTSC	Denmark	* INRA	France	** RIFR	Iran
* EIN	Holland	* ITDG	UK	* RTI	Holland
** EMBRAPA	Brazil	* ITE	UK	* SERI	USA

	Acronym	Location
**	SFRS	Nigeria
*	SSM	France
**	TIC	Thailand
*	TOK	Japan
*	TPI	UK
*	TRADA	UK
**	TURK	Turkey
*	TUT	Holland
*	UA	USA
*	UHH	USA
**	ULB	Philippines
*	UNILEV	UK
*	WEY	USA
*	WFPL	Canada
**	XAV	India

MAJOR INTERNATIONAL INFORMATION CENTERS

1. AGRIS
   FAO
   Via delle Terme di Caracalla
   Rome, Italy

2. Agricultural Information Bank for Asia (AIBA)
   SEARCA
   College, Laguna 3720
   Philippines

3. Interamerican Centre for Agricultural Documentation and Information (CIDIA)

4. IICA
   Apartado 10281
   San Jose, Costa Rica

5. Centre de Documentation de L'OMVS,
   Saint-Louis, Senegal

6. CARIS
   FAO
   via delle Terme di Caracalla
   Rome, Italy

7. INFOTERRA
   P.O. Box 30552
   Nairobi, Kenya

8. ISSS

9. MARDI

10. National Agricultural Library
United States Department of Agriculture
Beltsville, Maryland 20705
USA

11. Commonwealth Agricultural Bureaux
Farnham House, Farnham Royal
Slough SL2 3 BN
England

and

Commonwealth Forestry Bureau
Commonwealth Forestry Institute
South Parks Road
Oxford, England

12. Agricultural Information and Documentation Section
Royal Tropical Institute
63 Mauritskade
1092 Amsterdam, The Netherlands

13. CSIRO
Central Information, Library and Editorial Section
P.O. Box 89, East Melbourne
Victoria, Australia 3002

14. GERDAT
42 rue Scheffer
75016, Paris
France