

Consultative Group on International Agricultural Research

Mailing Address: 1818 H Street, N.W., Washington, D.C. 20433, U.S.A.

Office Location: 801 19th Street, N.W.

Telephone (Area Code 202) 334-8021

Cable Address—INTBAFRAD

CGIAR LIBRARY

From: The Secretariat

March 31, 1989

Consultative Group Meeting

May 29 - June 2, 1989

Canberra, Australia

Proposal to Incorporate Forestry Research into the CG System

Agenda Item 12

Document number MT/89/16, Proposal to Incorporate Forestry Research into the CG System, is being issued shortly. The attached documents, Report of an International Task Force on Forestry Research, dated September 1988, and Statement of The Bellagio Strategy Meeting on Tropical Forests held on 1 and 2 July 1987, are cited in the that document for background reading. Copies are provided herewith for the convenience of members.

Attachment

Distribution

CGIAR Members
TAC chairman
TAC members
TAC secretariat

A GLOBAL RESEARCH STRATEGY FOR TROPICAL FORESTRY



REPORT OF AN INTERNATIONAL TASK FORCE ON FORESTRY RESEARCH

Sponsored by:
the Rockefeller Foundation
the United Nations Development Programme
the World Bank
the Food and Agriculture Organization of
the United Nations



SEPTEMBER 1988

CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	i
PREFACE	vi
I. <u>INTRODUCTION</u>	
A. Deforestation and Tropical Forest Problems	1
B. The Current Response -- the Tropical Forestry Action Plan	2
C. The Need for an Expanded Global Research Effort	3
D. Organization of the Report	5
II. <u>POTENTIAL GAINS FROM RESEARCH</u>	6
A. The Contribution of Forests and Trees to Sustainable Land Use and Food Security	7
B. The Contribution of Forests and Trees to Energy Security	19
C. Sustainable Forest Industry Development	21
D. Conservation and Management of Tropical Forest Ecosystems	27
E. Priorities by Research Fields	29
F. Potential Benefits from an Expanded Research Programme	36
III. <u>CAPACITY OF NATIONAL RESEARCH SYSTEMS</u>	39
A. Dimensions of the Global Forestry Research System ..	39
B. The Quantity and Quality of Resources Available	40
C. Research Organization and Management	44
IV. <u>AN INTERNATIONAL STRATEGY FOR STRENGTHENING RESEARCH</u>	
A. General Considerations	47
B. Institutional Requirements.....	49
C. A New Institution? The Options	50
D. Recommendations for an International Forestry Research Council	53

CONTENTS (Cont.)

Page

FIGURES

1.	Impacts of Watershed Management	9
2.	Some Causal Factors in Desert Encroachment in Northern Kenya	13
3.	On-Farm Benefits from Trees in the Farming System ...	14
4.	Factors Affecting Forestry Research Capacity	41
5.	The Framework for an International Tropical Forestry Research Council	55

TABLES

1.	Recommended Research Priorities	30
2.	Policy and Socio-Economic Research Needed to Implement the Recommendations of Bellagio I	35

ANNEXES

1.	Statement of the Bellagio Strategy Meeting on Tropical Forestry	63
2.	Membership of the Task Force	67
3.	List of Background Papers	72
4.	Preliminary Annual Cost Estimates for a Tropical Forestry Research Council for 1990-1995	74

REFERENCES	77
------------------	----

TERMINOLOGY NOTE

The Task Force reviewed forestry research needs in all developing regions and, for purposes of convenience in this report, this coverage is referred to as "tropical countries." The geographical boundaries of the developing countries lie mainly between the Tropics of Cancer and Capricorn, but they embrace a wide environmental spectrum. Included are areas of temperate and sub-tropical forests at higher altitudes within the tropics, or at mid-latitudes, especially within the Mediterranean winter rainfall climatic region.

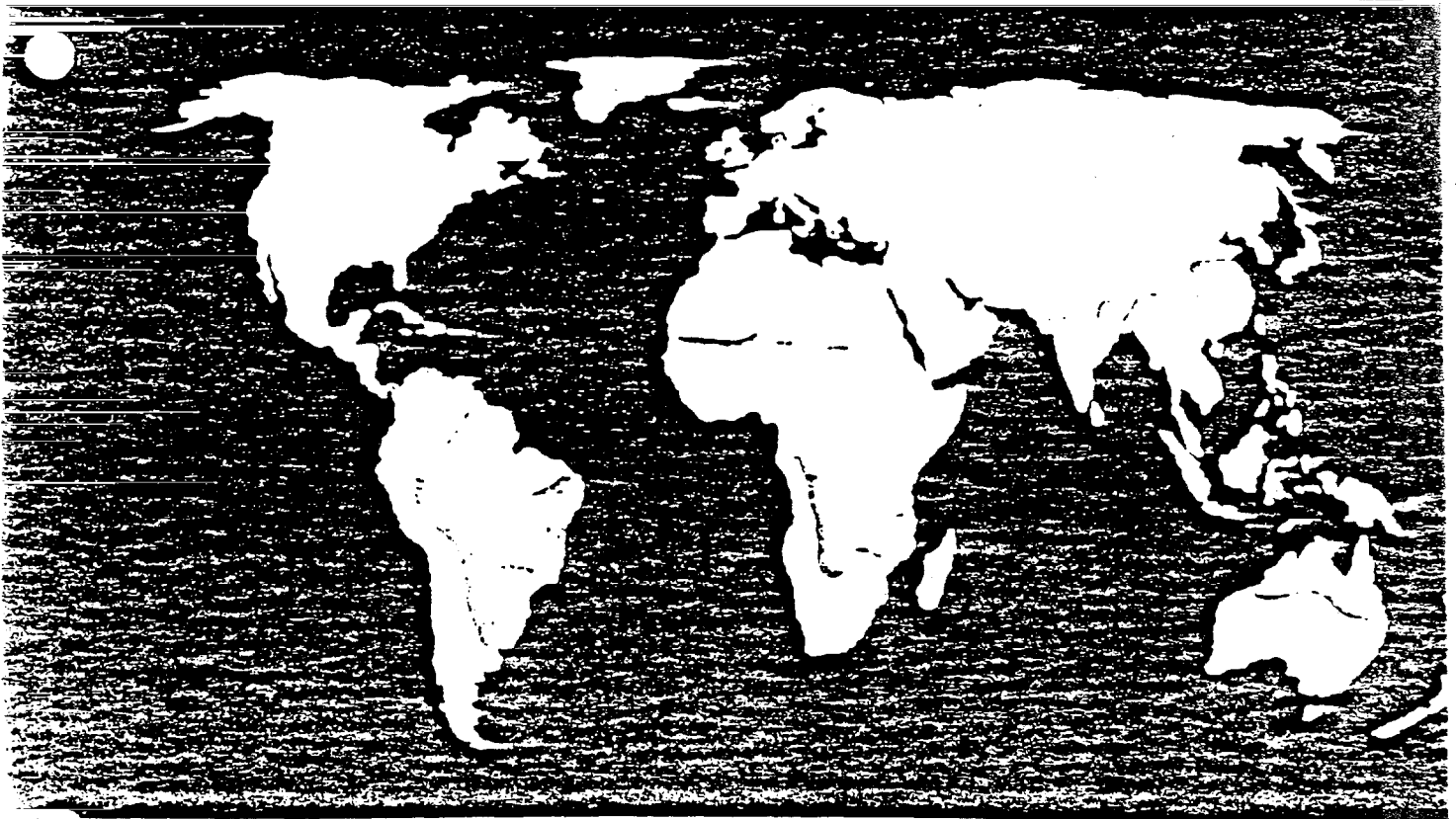
LIST OF ACRONYMS

AGRIS	International Information System for the Agricultural Sciences and Technology (of FAO)
CARIS	Current Agricultural Research Information System (of FAO)
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (in Turrialba, Costa Rica)
CFDT	Committee on Forestry Development in the Tropics (of FAO)
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
COFO	Committee on Forestry (of FAO)
CSIRO	Commonwealth Scientific Industrial Research Organization
CTFT	Centre Technique Forestier Tropical
DANIDA	Danish International Development Agency
FAO	Food and Agriculture Organization of the United Nations
FTAC	Forestry Technical Advisory Committee
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IARCs	International Agricultural Research Centres
ICRAF	International Council for Research in Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDB	Inter-American Development Bank
IDRC	International Development Research Centre
IIED	International Institute for Environment and Development
IITA	International Institute for Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILO	International Labour Organization
INCOFORE	International Council for Forestry Research and Extension
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research

ITFRC	International Tropical Forestry Research Council
ITTO	International Tropical Timber Organization
IUCN	International Union for the Conservation of Nature
IUFRO	International Union of Forest Research Organizations
NFTA	Nitrogen-Fixing Tree Association
NGO	Non-Governmental Organization
ODA	Overseas Development Administration (of the U.K.)
OFI	Oxford Forestry Institute
ORSTOM	Office de Recherche Scientifique et Technique d'Outre-Mer
SIDA	Swedish International Development Authority
SPAAR	Special Programme on African Agricultural Research
SPDC	Special Programme for Developing Countries (of IUFRO)
TAC	Technical Advisory Committee (of the CGIAR)
TFAP	Tropical Forestry Action Plan
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WRI	World Resources Institute
WWF	World Wildlife Fund

TROPICAL FORESTS

- Energy for cooking and heating for nearly 2.5 billion people.
- Source of more than half the world's bio-diversity.
- Food security and sustainable livelihood for 200 million forest dwellers.
- Export earnings for 33 developing countries.
- Essential for maintaining the quality of our earth's atmosphere.



EXECUTIVE SUMMARY



A. BACKGROUND

The Bellagio II Task Force on Tropical Forestry Research was convened in February 1988 by the Rockefeller Foundation, the United Nations Development Programme (UNDP), the World Bank and the Food and Agriculture Organization of the United Nations (FAO). The Task Force had been called for by an earlier Bellagio meeting of July 1987, which recognized that the state of forestry research and the level of support to provide solutions to problems of deforestation and associated environmental degradation fall far short of needs. The July meeting had, in turn, been convened to give further impetus to an international effort to reduce tropical deforestation known as the Tropical Forestry Action Plan (TFAP).

Even though total international expenditure in support of forestry development, broadly defined, has roughly doubled over the past five years to about US\$1,000 million, research expenditure is still only five per cent of the total. This compares to 10 per cent of the total in the case of agriculture.

The Task Force was asked to 1) assess the potential benefits from a significant expansion of investment in research, 2) identify priority research opportunities, and 3) define and recommend appropriate institutional mechanisms to guide and co-ordinate an expanded global research effort to meet the potentials and the opportunities.

B. POTENTIAL BENEFITS FROM AN EXPANDED RESEARCH PROGRAMME

The Task Force began with a comprehensive review of the gains from past research. The review covered the four areas of opportunity addressed by the TFAP:

- ★★ the contribution of forests and trees to sustainable land use and food security;
- ★★ the contribution of forests and trees to energy security;
- ★★ the expansion of sustainable forest industry development; and
- ★★ the conservation and management of tropical forest ecosystems.

It concluded that significant additional investment in priority research has the potential for making major contributions to human welfare and to sustaining development efforts in other fields such as agriculture, energy, and industrial development. The many gains within reach could include the following:

1. In addition to direct benefits of fuel and fodder, there can be major gains in food security as a result of research on improved land use that incorporates trees. For example, shelterbelts, alley cropping and other agro-forestry practices have been shown to contribute to raising crop yields and increasing the sustainability of agriculture.
2. Downstream benefits from application of watershed management research include reduced erosion and siltation of reservoirs needed for irrigation, hydropower production and flood control.
3. Research to improve the productivity of multi-purpose trees would significantly increase the supply of fuel, fodder and other goods for many of the 120 million people in the Sahelian and Himalayan regions who rely on trees for those products.
4. Many of the 300 million people living in dryland regions which are severely or moderately desertified could benefit from expanded research on management of natural savannah woodlands, as well as from research on tree species tolerant of aridity and salinity.

5. Research to select, improve and establish trees could more than double the average productivity of trees used in the tropics to produce fuel. Aggressive application of such research results could benefit 200 to 400 million people out of the 3,000 million people who will face acute scarcity or deficits of fuelwood by the turn of the century.

6. Research on small and large-scale industrial forestry and forest products can expand export revenues, decrease dependence on imports of essential forest products, and generate rural employment and income. For example, based to a great extent on a solid and intensive research effort, Chile has increased its forest products exports up to US\$500 million per year.

7. Tree selection and improvement research has already shown the potentials for reducing costs per cubic metre of wood in the tropics to levels that are competitive anywhere in the world. As a result, the costs of producing paper could be brought down, thus helping educational programmes that could, potentially, raise the literacy levels of hundreds of millions of people. This is an essential prerequisite for sustainable development.

8. Research on conservation and management of tropical forest ecosystems, particularly the knowledge and practices of indigenous forest-dwelling peoples, can contribute to safeguarding a major proportion of the world's biological diversity. This will help ensure that present and future generations will be able to tap the vast reservoir of plant and animal genetic resources in tropical forests to maintain and to broaden the genetic base for food crops, medicines, industrial products, and other useful goods. Based on past experience with the domestication of tropical plants, this is clearly a critical resource requiring protection.

From this review of past progress and promising future opportunities, five fields emerge as priorities for expanded investment in research:

- ** agro-forestry and watershed management;
- ** natural forest ecology and management;
- ** tree breeding and tree improvement;
- ** utilization and marketing; and
- ** policy and socio-economic issues.

Specific topics within each of these fields are identified in this report. It is fully recognized that priorities will differ among countries and circumstances within countries.

C. WEAKNESSES IN EXISTING RESEARCH CAPACITY

While the potential for substantial gains from research exists, it is recognized that an expanded research effort will not make progress unless there is the capacity to manage it and implement it, however

well-chosen the objectives and priorities. The Task Force concludes that the current state of national research systems in developing countries will be a major constraint unless significant effort is made to expand capacity. Of particular importance will be efforts to:

- ** generate internal political awareness of the importance of the issues being addressed and the potential contribution of research; and secure long-term financing;*
- ** re-orient research to better address the needs of the rural poor, and strengthen the education of researchers and technicians;*
- ** improve research organization and management, including incentives for retention of key staff; and*
- ** strengthen interactions among researchers, both nationally and internationally, and between researchers and users.*

The weaknesses of national research organizations are compounded by the lack of any international focal point for addressing the weaknesses through financial and technical assistance. Although tropical forest research is being supported by many bilateral and multilateral donors, there is no central body that can co-ordinate and offer well-informed help to donors, to national bodies, and to research establishments. In particular, they need help in evaluating needs and priorities, mobilizing support, developing capacity, focussing research, and sharing information with countries that need it most.

Thus, the Task Force recommends the establishment of an international mechanism to stimulate, plan, co-ordinate, and support a centrally or regionally-directed tropical forestry research strategy and programme, and to encourage relevant research work at the national or regional levels through a variety of funding arrangements. The potential exists to achieve rapid results in research findings and in strengthening national research capabilities.

D. RECOMMENDATIONS

Against this background, the Task Force recommends a three-pronged approach to overcoming the constraints and meeting the opportunities for expanded research. These are:

- ** creating an international framework to plan, co-ordinate and support a re-enforced and expanded research programme;*
- ** building national research capabilities, especially in the near term, in order to facilitate expanded research; and*

- ** providing a focal point for an enhanced, decentralized research effort in the five priority fields identified by the Task Force.**

To this end, the Task Force recommends the establishment of an International Tropical Forestry Research Council (ITFRC). It would provide a mechanism for channelling and co-ordinating international financial and technical support to forestry research in the developing countries. The Council would be supported by, and answer to, a group of interested donors. It would have a Technical Advisory Committee, an Executive Secretariat, and regional co-ordinators.

Its main tasks would be:

- ** to improve research capability and capacity in tropical countries through information systems development, technical and management training programmes, and other support activities; and**
- ** to accelerate progress in research by generating well-planned project proposals for donor funding.**

Approaches to these tasks might include networks, twinning arrangements, contract research, training activities and other special projects. Flexibility in funding research in the field would be emphasized, but a base of core funds would have to be secured for operational stability of the Council and its support staff.

Financial requirements for core support to the operations of the Council are seen as modest -- on the order of US\$3 million annually. In addition, the Task Force estimates that external support for research and improved research capability should progressively rise from a level of US\$46 million reported in 1986 to approximately US\$90-US\$100 million per annum by 1995.

Specific forestry research programmes related to increasing productivity of multi-purpose trees in Asia and Africa and improved forest products utilization in Latin America have already been formulated and are ready for prompt implementation.

E. SUGGESTED FOLLOW-UP ACTION

Should a decision be taken at the Bellagio II Conference to support this new initiative, there is enough information available to enable a more detailed programme within the framework proposed to be developed quite quickly. The next steps that might be taken to achieve this are indicated in the Task Force report.

PREFACE



In July 1987, an international strategy meeting on tropical forests was convened under the auspices of The Rockefeller Foundation, UNDP, the World Bank, FAO and the World Resources Institute (WRI). Twenty-five world political, financial and scientific leaders met at the Bellagio Study and Conference Centre in Italy to discuss global action to address tropical deforestation.

This meeting, known as Bellagio Forestry I, was organized in response to the TFAP, which was launched in October 1985. The TFAP represents a major international effort to provide a strategy for reducing deforestation and promoting sustainable use of tropical forest resources. The purpose of the meeting was to debate the constraints to effective implementation of the Plan at the national level, and to recommend steps to overcome them. A ten-point Statement emerged, which is presented in Annex 1. The meeting concluded with a call for the formation of a task force to prepare proposals on policy responses, financing strategies, and institutional mechanisms to implement the action agenda. The task force would report to a second Bellagio Forestry meeting in 1988.

At Bellagio Forestry I and in subsequent consultations, there was widespread agreement that the weakness of the existing tropical forest-related research system is a major constraint. The forestry advisers of bilateral and multilateral agencies, as well as non-governmental

organizations (NGOs), working to implement the TFAP, recommended that Bellagio Forestry II should focus on research strategies to support implementation of the TFAP. In response, the Rockefeller Foundation, UNDP, the World Bank and FAO formed an international Task Force on Forestry Research to report to the Bellagio Forestry II meeting.

The Task Force had the following terms of reference:

- to review the relevance, effectiveness, and capacity of tropical forest-related research and its relations with all aspects of development;
- to identify priority research needs over the short, medium and long term; and
- to recommend appropriate institutional frameworks and mechanisms, and estimate their cost.

The Task Force commenced work in February 1988, and its membership is given in Annex 2. The Task Force has taken a broad approach in its review of institutional options for strengthening the contributions of forestry-related research to implementing the TFAP. It has placed great emphasis on the need to strengthen policy research, as well as technical research on forest resource management within the general concept of sustainable development as outlined in the report of the World Commission on Environment and Development (the "Brundtland Report").

The conclusions and recommendations of the Task Force are based on:

- (i) a review of major studies and recent conference reports on tropical forest-related research (many of which are listed in the References section of this report);
- (ii) a series of background papers prepared by the Task Force members and others (see Annex 3);
- (iii) eighty-five responses to a questionnaire sent to research organizations working on tropical forestry issues in Africa, Asia and Latin America; and
- (iv) extensive consultations by Task Force members with a wide range of institutions in 40 countries. Members met with more than 350 forestry specialists, researchers, policy makers, staff of bilateral and multilateral development assistance agencies, members of NGOs and representatives of the private sector.

Through this process, the Task Force has attempted to specify an institutional framework which is practical, cost-effective, and capable of stimulating and co-ordinating areas of research that are critical to addressing forest land-use problems in developing countries, particularly the needs of the rural poor.

I. INTRODUCTION



A. DEFORESTATION AND TROPICAL FORESTRY PROBLEMS

Deforestation threatens the sustainability of development.

1. Hundreds of millions of people living in the tropics depend on forests for their survival. Forests and trees are their main source of food, fuel, fibre, fodder and other necessities.
2. For many additional hundreds of millions -- farmers in tropical agricultural environments, rural communities, and urban dwellers -- trees play an essential role. They improve the productivity of farming systems, thus contributing to food security. They stabilize watersheds and reduce erosion and flooding. They provide wood for energy, raw materials for construction, fibre products such as paper, and countless other goods and services needed to improve human welfare.
3. In more subtle ways, forests contribute to global welfare, for example, providing the genetic material which now underlies many of our basic foods and generating employment opportunities. Tropical forests will become increasingly important in meeting future needs of an expanding global population.

4. Despite the significant contributions made by forests and trees in the tropics, every year more than 11 million hectares are being destroyed. In addition, incalculable millions of trees are lost through forest degradation, over-exploitation for timber and fuelwood overgrazing by livestock, and other non-sustainable uses.

5. The negative impacts of deforestation, forest degradation and loss of farm trees in the tropics are growing. These impacts include:

- ** increasing soil degradation and desertification which lead to food insecurity;
- ** declining water quality, which affects human health;
- ** rising costs for hydropower and irrigation projects as dam reservoirs become filled with silt from erosion;
- ** hardship and misery for a huge and increasing population who cannot find fuelwood or afford alternative fuels;
- ** declines in productive employment, because wood, both as a raw material and a fuel for industry, is becoming scarce and expensive;
- ** declining foreign exchange earnings and increasing import bills for forest products as forests are depleted of commercial woods;
- ** loss of biological diversity and the gene pool which has been so important in supplying the basic genetic material underlying many of our important food products and medicines;
- ** the cutting and burning of tropical forests ** which is contributing to atmospheric emissions of "greenhouse gases," thereby amplifying the problem of global warming.

B. CURRENT RESPONSE -- THE TROPICAL FORESTRY ACTION PLAN

6. Donors and development organizations, both governmental and nongovernmental, are well aware of these problems and increasingly are taking action to reverse the trends. Indeed, official development assistance for forestry has been increasing at an annual rate of some 15 percent since 1984, doubling to about US\$1 billion at present (FAO, 1987).

7. Recognition of the need to improve the effectiveness and efficiency of national and international efforts to address tropical forest problems led to the development of the TFAP under the overall coordination of FAO. Some 60 tropical and donor countries endorsed the TFAP as a global strategy following its release in 1985, and it has been adopted as a common framework for action by the development assistance

community. The basic objectives of the TFAP are to contain tropical deforestation, to ensure the basic needs of rural and urban poor for food, fuelwood, fodder and shelter, and to increase the contributions of forests as a sustainable source of employment, income and export earnings.

8. To achieve these objectives, the TFAP addresses opportunities to:

- ** enhance the role of forests and trees in promoting sustainable land-use patterns through introduction of watershed management and agro-forestry approaches;*
- ** increase the efficiency of fuelwood use and the supply of fuelwood and other resources through improved technology and improved policies and actions by governments and local citizens;*
- ** increase the sustainability of forest industry operations and forest management through introduction of incentives and technologies to encourage more widespread use of sustained yield forest management and improved efficiency in conversion of wood to products; and*
- ** reduce deforestation and expand and improve the conservation of tropical forest ecosystems to protect biological diversity and the genetic resources which may be required by future generations.*

9. National-level TFAP activities are now in various stages of implementation in 55 tropical countries. It is becoming increasingly clear, through these activities and through more detailed enquiries such as those of the present Task Force, that the information on which to base effective strategies, plans and actions is critically inadequate, as is the research capacity to generate the needed information.

C. THE NEED FOR EXPANDED GLOBAL RESEARCH

10. A significant expansion of investment in research, particularly the strengthening of forest research capabilities of developing countries, is needed to fill critical information gaps and to expand the information base. This need was emphasized in one of the 10 recommendations put forth at the first Bellagio forestry meeting, which

are summarized in Annex 1. Attempts to implement the other nine recommendations have encountered serious information bottlenecks, thus further justifying a significant expansion of research. Understanding what specifically needs to be done and how to do it effectively requires research.

11. Development assistance for the forestry sector has shifted in recent years. For example, in the case of the World Bank, over the 1977-1986 decade, some 60 percent of resources for the forestry sector were devoted to the areas of farm and community forestry and watershed management, as compared with only five per cent in the previous decade. Research to support this new area of emphasis is sorely lacking and critically needed. Of particular importance is the need to orient research to addressing the needs and problems of the rural poor. This requires research on low-input technologies which conform to local social and ecological conditions. However, it has become clear that technologies are available to help address many of the existing problems, but the policy reforms and other measures required to promote widespread use of such technologies are poorly understood. A significant expansion in policy research is urgently needed.

12. While development assistance in the forestry sector has expanded rapidly over the past few years, still only five per cent of the total or some US\$46 million per year, goes into research, according to FAO's most recent enquiries. By comparison, the percentage of total agricultural assistance (excluding technical assistance grants) that went to research and training increased from around four per cent in 1977-78 to nine percent in 1984 (FAO 1986). If the same percentage of forestry aid went into research and training as in the case of agriculture, the level of annual assistance would be on the order of US\$100-110 million. Such an expansion would be reasonable, given the size and critical nature of the problems and the poor state of knowledge on how to confront them.

13. Without added investment, the existing global tropical forestry research system will lack the capacity to generate the information needed to implement the TFAP. The poor state of the research system was recognized in 1981 when the World Congress of the International Union of Forestry Research Organizations (IUFRO) called for re-assessment of research priorities and strengthening of tropical forestry research. The urgency of the issue has grown since then. In 1987, this led donors and action organizations, both governmental and nongovernmental, to call for an assessment of the problems and opportunities, and for a high-level forum of donors, national leaders and scientists to consider the alternatives for action. The present report summarizes the called-for assessment; the second Bellagio forestry meeting in November 1988 provides an initial forum for discussion and decisions concerning appropriate strategy and action to expand tropical forestry research.

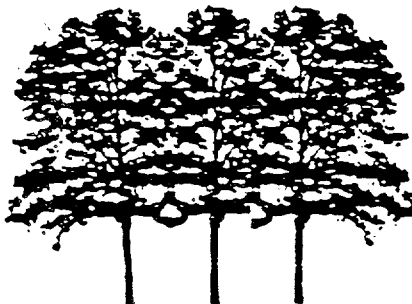
D. ORGANIZATION OF THE REPORT

14. In section II, priority research needs and opportunities are identified in light of the problems which need to be addressed and the promising areas of research as evidenced by current research activity. Continuity with past and current activity is emphasized, recognizing that future expansion and improvement of the global tropical forestry system should be evolutionary, rather than revolutionary, and should build on existing strengths in national and international research organizations. The emphasis should be on investment in actual research; investment in institutions would be justified only if required to develop, implement and co-ordinate research needed to underpin TFAP activities.

15. Section III provides an overview of the capacity and shortcomings of the existing global tropical forestry research system to meet the needs identified in section II. Emphasis is given to the adequacy of the human, physical and financial resources available and to the adequacy of the organization and management of such resources in meeting research objectives and needs.

16. Finally, section IV provides a recommended strategy and plan of action for addressing the problems identified in section III, and for expanding research in the key opportunity areas identified in section II.

II. POTENTIAL GAINS FROM RESEARCH



17. Tropical forest research needs have been assessed by FAO, the World Bank, IUFRO, the International Council for Research on Agro-Forestry (ICRAF), the Rockefeller Foundation, and regional and national organizations. These assessments, together with the results of the Task Force's questionnaire survey and its widespread consultations, have been used to develop the potentials and priorities for research presented in this section.

18. Reducing lengthy "shopping lists" of research topics down to a systematic, focused set of priorities for expanded investment is an arduous process, involving a great deal of consultation, discussion and evaluation. However, the Task Force considered it a necessary process in order to avoid a past tendency in forestry research to disperse limited resources over too many research areas. Agricultural research experience has demonstrated the benefits of concentrating resources in a limited number of areas with high potential payoff.

19. The present section reviews key areas of research which have contributed in the past, and could contribute in the future, to achieving objectives for each of the four TFAP areas of opportunity listed in section I. These areas are: forests and trees in land use and their role in achieving food security; trees and energy security;

industrial forestry; and ecosystem conservation and the maintenance of biological diversity. Research to address these opportunity areas has to be integrative, involving physical, biological and social science researchers working together.

20. The presentation for each area also includes capsule descriptions of research findings (in italics) which warrant further testing and should be pursued in additional cases.

A. THE CONTRIBUTION OF FORESTS AND TREES TO SUSTAINABLE LAND USE AND FOOD SECURITY

21. Within this area of opportunity, research needs to deal with four main types of situations: 1) integrated upland watershed management; 2) integrated arid zone land-use management; 3) farm-level agro-forestry; and 4) the role of natural forests in meeting food and other basic needs. There is overlap between the four, but from a research point of view they tend to be dealt with separately.

Upland watershed management

22. The TFAP identified some 32 developing countries with serious problems of upland watershed degradation. More than 150 million hectares are involved, and the area is growing daily. An estimated 400 million farmers downstream from the degraded lands are being affected adversely by soil erosion. In many areas, more than 70 per cent of food crops are produced on irrigated lands. Irrigation often depends directly on the capacity of dams receiving water from upland watersheds to deliver that water at the right time and in the right amounts. As erosion increases, so does the rate of siltation of the dam reservoirs. The costs involved -- both due to increased maintenance and crop losses -- are tremendous in many areas. Food security is compromised.

23. Research is needed to understand the interdependence of forestry, agriculture and energy-related interventions in upland watersheds. Some useful work has been done.

*** Singh, Panday and Tiwari (1984) documented these inter-relationships for two Himalayan villages. They found that animals accounted for more than 70 per cent of total energy input into the farming system. Beyond this, the animals themselves depended on the forest for 87 per cent of their fodder. To sustain the existing system, more than five hectares of forest were needed per family, while the actual forest available was slightly over one hectare. This situation is repeated in thousands of villages throughout the Himalayan region.*

**** Kumar and Hotchkiss (1988, in press) show how the progressive encroachment of cultivation into forested areas forces women and other members of farm families to walk increasing distances to gather fuelwood and fodder from trees. This reduces the time that they can work on their farms and reduces farm productivity. As a result, families are forced into a further extension of area under crops to produce enough food, perpetuating a downward spiral of decreasing output from both arable and forest areas.**

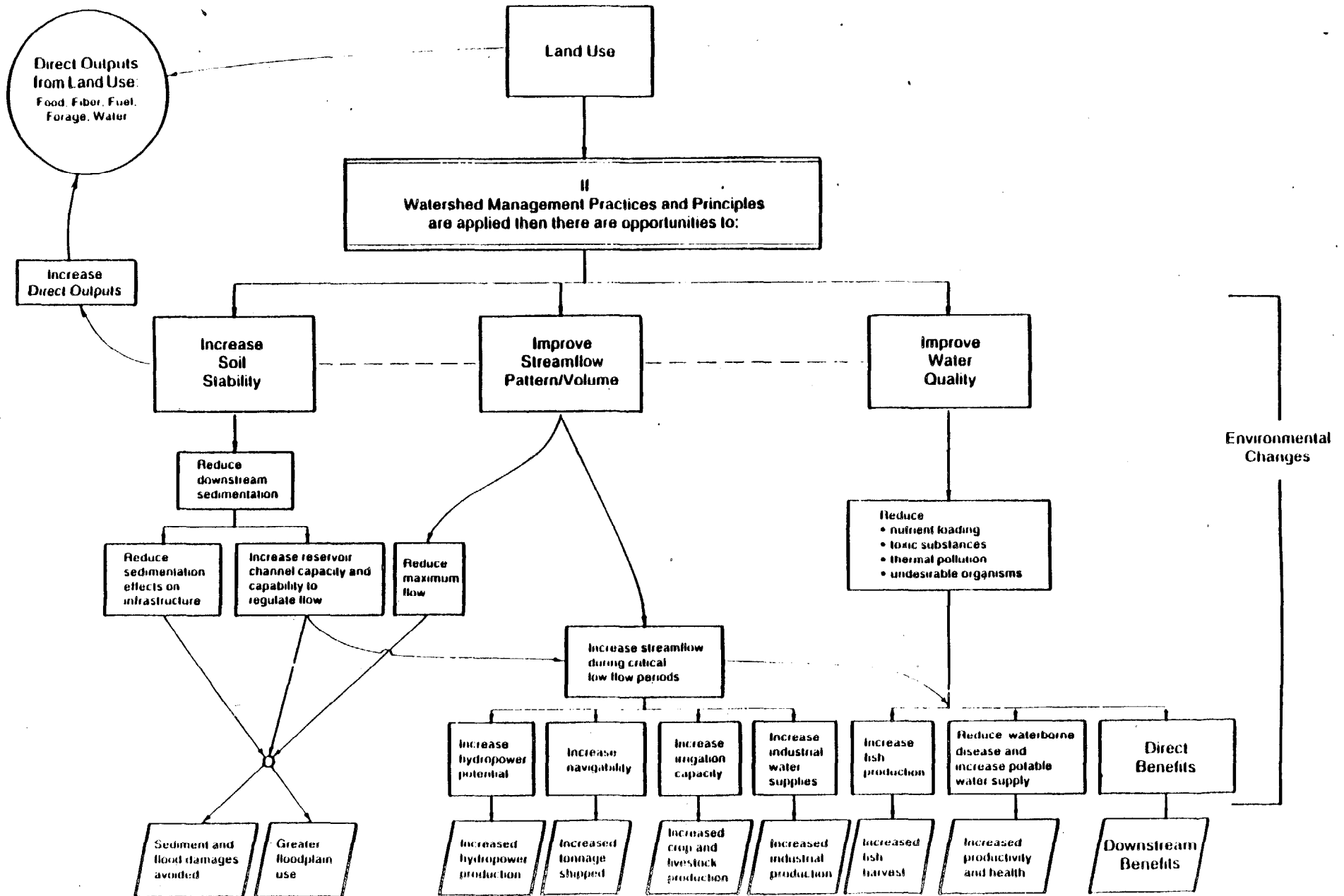
24. Much more of this type of work is needed in order to provide the information on which to base strategies and plans for policy and project level-interventions. Once basic causal relationships are better understood, then research is needed to design the most effective interventions to put upland dwellers on a more sustainable footing. Among the innovations to consider are the development of stall feeding of livestock with increased on-farm fodder production, intensification of range management, breeding programmes which increase tree fodder production, and improved harvesting approaches. The ultimate objective is to increase productivity and to reduce erosion and downstream damage.

**** Panday (1982) has shown the great variation in production of dry matter in different fodder species, which, in the Himalayan region varies from as low as five to seven kilogrammes to as high as 50-70 kilogrammes annually per tree. There are significant implications in terms of tree selection and selection of provenances for given species.**

**** Work by Flemming (1983) indicates that improved harvesting and management practices can increase significantly the yields from grass and forest grazing lands in Nepal. For example, the increase was from 1,200 to 6,000 kilogrammes per hectare per year for grasslands and from 3,000 to 6,000 kilogrammes per hectare per year for forest lands.**

25. Research also is documenting the linkages between upland watershed management activities and effects downstream. The types of inter-relationships involved are summarized in Figure 1 on the next page. As indicated, the effects of watershed management interventions can go far beyond linkages with agriculture and food security. They relate to health, transportation, energy production, and so forth. Implied is the need for a systems approach in researching watershed management inter-relationships. Some examples of useful past research indicate the type of information which is needed for decision making:

Figure 1: Impacts of Watershed Management



** Researchers have developed a method of predicting the influence of trees upon landslides (Hawley 1988). Reforestation can reduce shallow soil landsliding by at least 70 per cent. The occurrence of land-slides dramatically increased when forest areas were converted to pastures; over 60 per cent of the converted areas had landslides. Productivity on these landslide areas was reduced by 20 per cent to 30 per cent for over 80 years following the landslides. (Trustum *et al.*, 1984.) This research did not follow the effects downstream -- although research elsewhere suggests that landslides that occur into channels are major sources of sediment to downstream areas.

** Achlil (1984) reports 48 per cent, 20 per cent, and 17 per cent reductions in peak monthly runoff, annual sediment transport, and peak monthly sediment transport, respectively, caused by improved farming, terracing, and tree planting in the Solo watershed on Java, Indonesia.

** Wiersum (1984) studied surface erosion rates under different agro-forestry systems in Java, Indonesia. This led to better understanding of the role of trees, in combination with crops, in protecting the soil. Soil surface management was recommended -- trees without soil conservation measures beneath them will not adequately control erosion.

26. There is a critical need for more research on the economics of watershed management. A review of available approaches has been produced by FAO (Gregersen *et al.*, 1987). FAO also has produced an overview of incentive mechanisms for encouraging sustainable land uses by upland watershed dwellers (de Camino 1987). More research on incentives is needed.

Arid zone land-use management

27. Desertification is a growing problem which needs significant research, since it affects the lives of millions of people. In Africa alone, an estimated 60 million hectares of rangelands are desertified, and the lives of more than 80 million people are affected. The importance of trees and woody shrubs to the livelihood of dry zone dwellers has been documented through the work of many researchers. Vo

Maydell (1988) and Le Houerou (1988) have summarized the state of knowledge in this area. Trees have a significant role to play in the dry zones in terms of fuelwood, foods and medicines, and fodder supplies. For example, trees and wood shrubs account for about one third of the dry-weather feed of livestock in the Sahelian/Sudanian zone.

28. Knowledge about sustainable land-use options for the dry zones is limited. As in the case of upland watersheds, research is urgently needed to understand better the interrelationships between forestry, agriculture and energy in the dry zones. Such information is needed to design more effective strategies and actions to increase the productivity of the dry zones and to develop policies for their protection as population pressure increases.

29. Some promising research is in progress which needs to be expanded and replicated in different parts of the dry zones of Africa, Asia and Latin America.

**** Openshaw (World Bank 1986) summarizes the potential of improved management of natural savannah woodlands to contribute to tree fodder and fuelwood needs in the Sudan. Research has shown that, in many cases, application of simple management techniques, such as control of harvest and burning, can more than double sustainable outputs from less than one to two cubic metres per hectare per year (Winterbottom and Hazlewood, 1987). Costs can be very low, creating cost-effective management opportunities. Similar results have been demonstrated for Niger and other countries.**

**** FAO's project on genetic resources of the arid zones, focussing on woody species, is a worldwide effort. The initial eight countries involved collected seed, explored natural ranges of species (mainly Acacia and Prosopis species) conserved stands on site, evaluated materials, did field trials and made seed available to other countries. Over the years 1980-1987, a total of 281 well-documented seedlots (provenances) of 43 species were explored, and seed distributed for testing and conservation. Work was undertaken in at least one institution in some 17 countries. The potential yield gains from use of results of this work are significant.**

30. Technologies for improved productivity and sustained management of natural savannah woodlands and plantations in the dry zones are understood better than the policy reforms and socio-economic changes needed to get such technologies widely applied. There is an urgent need for more policy and social science research to understand both the requirements of local inhabitants and the types of policies and incentives to encourage improved land use.

31. Large-scale success in moving toward more sustainable land use in the dry zones will require systems approaches and widespread policy reforms in a number of sectors.

32. Lampry (1978), for example, has looked at the causal factors involved in desert encroachment in Northern Kenya; as indicated in Figure 2 on the next page, the causal linkages include a complex array of social, political, economic and technological factors. Research is needed to provide insight into the potential effectiveness of alternative strategies. Of particular importance is policy/socio-economics research on common property management issues. A summary of specific research problems is provided in a recent proceedings of a meeting on common property resource management (U.S. National Research Council 1985).

Trees in farming systems -- agro-forestry research

33. Agro-forestry is a collective name for all land-use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops and/or animals. This can be either in some form of spatial arrangement or in a time sequence (Lundgren 1987)

34. There is widespread understanding of the role of trees in farming systems, both from the results of research and from anecdotal experience expressed through indigenous knowledge systems. If trees always complemented agricultural crops, there would be less urgency for an expanded research programme. However, because trees also compete with agricultural crops and livestock production for space, water and nutrients, it is critical that research be expanded so that the complementarities and competitive relationships can be better known and taken into account in planning and management.

35. The variety of ways in which trees can contribute within a farming system is great, as indicated in Figure 3 on page 14. The benefits can come from improvements in crop productivity, in livestock production or control, and/or in income from sale of tree products or savings due to shift to consumption of home production.

36. While agro-forestry has been practised for centuries in the tropics, it is only recently that it has been subjected to major scientific investigation by organizations such as ICRAF, CATIE, FAO and various other regional and national research institutions. A more concentrated effort is needed to expand quantitative analytical research

13

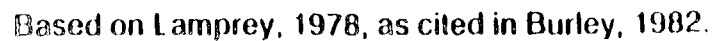
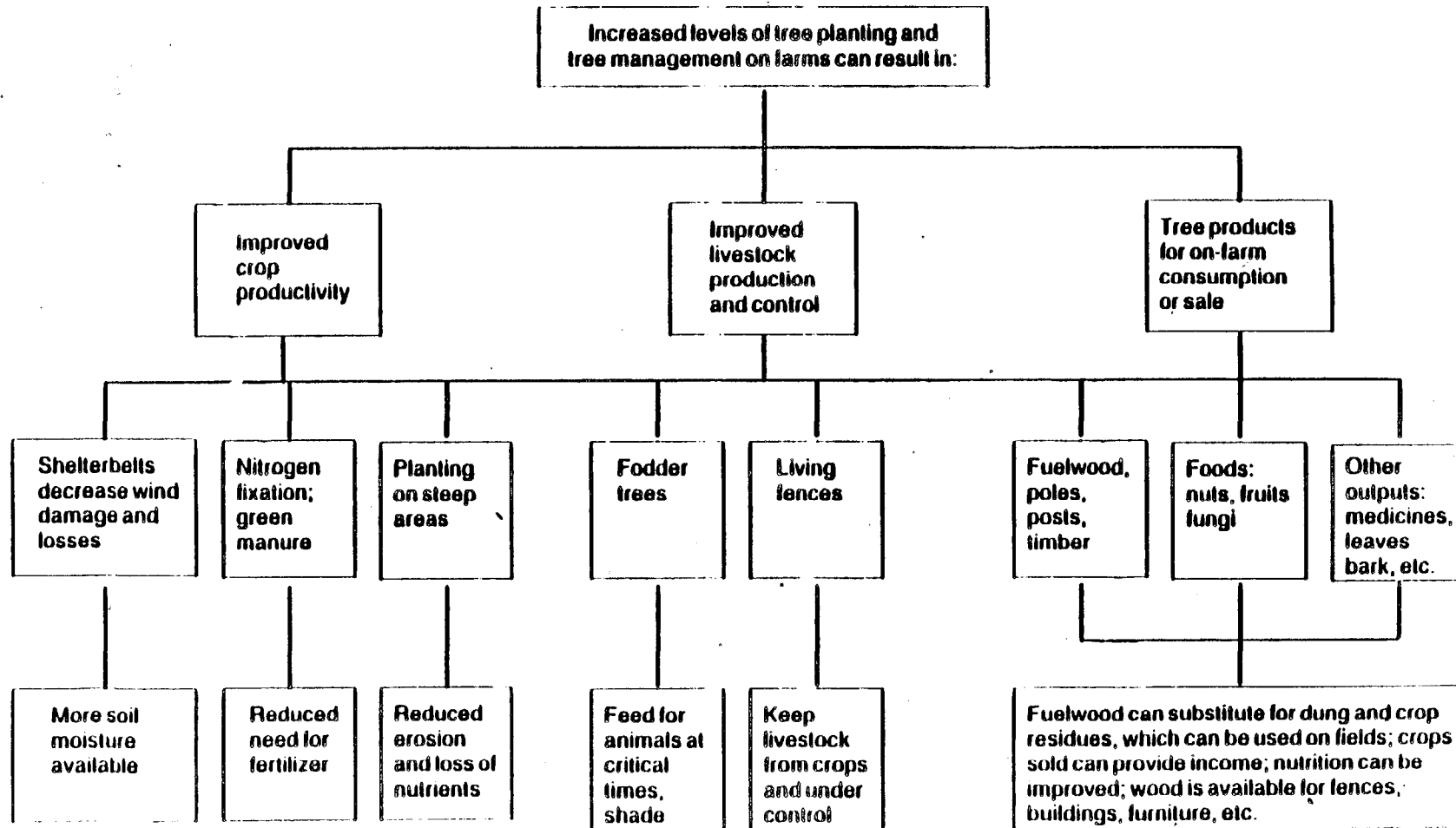


Figure 3: On-Farm Benefits from Trees in the Farming System



on agro-forestry, in contrast with the descriptive work which has dominated the field in the past. There is a need to focus on quantification of the physical-biological inter-relationships involved in different agro-forestry systems in different agro-climatic environments.

37. Agro-forestry research on this topic has, in some cases, produced extremely useful information:

** CATIE (Enriquez 1983) researched combinations of pasture and various tree species, such as Cordia alliodora and nitrogen-fixing Erythrina poeppigiana. The presence of Erythrina resulted in a 70 per cent increase in total grass and protein production. Other similar studies exist.

** Kang and Wilson (1984) have researched alley cropping in Nigeria, involving production of maize inter-cropped with rows of Leucaena leucocephala. Maize yields were consistently higher when Leucaena prunings were maintained on the fields. When nitrogen was added in addition to the prunings, yields increased even further.

38. Additional research is needed before moving into major programmes of extension and diffusion of technologies. One practice which is a clear candidate for further research, both because of the positive results documented by past research and because of the tremendous potential, is the establishment of shelterbelts:

** A well-documented case is the shelterbelt programme in the Maijja valley of Niger. Use of windbreaks resulted in an average 17 per cent increase in total crop yield, despite the fact that land was taken out of crop production for growing the shelterbelts. In addition to the protection benefits, the shelterbelts provide fuelwood estimated at 52 cubic metres every four years per linear kilometre of windbreak, and fodder estimated at four tons every four years per linear kilometre of windbreak (Rorison and Dennison 1986, and Long and Dennison 1986).

** Research by El-Lakany (1986) and others in Egypt has demonstrated yield increases as high as 47 per cent for maize grown with windbreak protection. Protection benefits vary widely by crops.

**** Farnsworth (1976) has researched the effects of shade or shelter trees and found that cattle with access to shelter gained 676 grammes per day, while the control group (without shade) only gained 472 grammes per day. Similarly, research has found that, under high temperatures, milk yields increase when cattle have access to shade.**

39. There also is a need for more research on the economics of agro-forestry systems so the benefits and costs to farmers can be better understood and taken into account in designing programmes. Some recent findings:

- ** Arnold (1988) reviewed selected research on agro-forestry from an economic point of view. He considered the influence of relative scarcity of factors of production on farmers' decisions and found that they often maximize returns to labour input rather than capital. Often this is because the opportunity cost of labour is high, and tree growing takes less labour and involves more flexible timing.**
- ** Dewees (World Bank 1986) researched how farmers in parts of Kenya are conditioned by availability of capital and labour. In areas where labour is scarce, tree growing may take place where the returns per hectare are lower than from other crops, but the returns to labour are some 50 per cent greater than from maize production. Reduced risk also entered the picture.**
- ** Research at CATIE shows that returns to farmers can be more than twice as high when pure pasture management using post fences is changed to pasture management using living fences with clumps of trees scattered throughout the pasture (personal communication from R. de Camino).**
- ** Anderson (1987) carried out detailed research on the economics of multi-purpose tree species in Nigeria. The results indicate that rates of return can increase from 7.4 to 16.9 per cent when soil**

conservation benefits are included in addition to wood and fruit benefits in agro-forestry components, and from 4.7 to 21.8 per cent when shelterbelt soil conservation benefits are added to wood benefits (poles and fuelwood) alone.

40. Anderson suggests three key areas for future research:
1) measurement of crop yield in sheltered vs. unsheltered areas;
2) measurement over time of the influence of shelterbelts on soil nutrients and soil erosion; and 3) more intensive analysis of economic returns to investment in shelterbelts.

41. Basic to all of this agro-forestry management research is the underlying need for a strong programme of research on tree selection, seed supply, and tree improvement and establishment techniques. Although useful work has been done in these areas, much more is needed. Some results so far:

** Research has shown that great gains in productivity can be made simply by identifying and selecting the seed source most adapted to a planting locality. In provenance trials in Nigeria with Eucalyptus camaldulensis, the best provenance had a mean annual increment of 17.3 cubic metres per hectare, while the poorest only had 5.1 cubic metres (FAO 1979). In the Congo and Brazil, the yield of eucalyptus plantations has been increased by up to 80 per cent by selection of the best seed sources (Chaperon 1978; Brune and Zobel 1981). FAO, CTFT, DANIDA and other groups have established seed procurement systems around the world which aim at improved seed selection, exchange and distribution.

** Research in India by Pathak and Patil (1982) found that the difference in forage production between the best and worst provenances of Leucaena leucocephala over a three-year period was around 70 per cent.

** Much useful work on nitrogen-fixing trees has been done by various countries (Senegal, Egypt, China) and various groups including CTFT/ORSTOM, NFTA, IITA, FAO and others. Dommergues (1987) indicates the importance of

research in this area. Certain trees can fix significant amounts of nitrogen in the humid tropics, substituting at least partially for purchased nitrogen fertilizers or providing a source where access to fertilizers is limited.

- ** In the Tree Seed Centre programme for developing countries of Australia's CSIRO, estimates were made of the value of timber and areas likely to be planted with improved seed in nine developing countries. Financial internal rates of return on incremental investment in the most productive seeds were calculated (Development Digest 1988). They ranged from 22 per cent in Lesotho to over 80 per cent at Dongmen, China. In addition to financial benefits from timber, other benefits included improved tree form, earlier harvest possibilities, reduced maintenance, and improvements in agro-forestry and soil conservation results.**

Direct contributions of forests to food supplies and food security

42. In some parts of the world, people rely entirely on the forest for food. Many forest dwellers obtain nearly all their protein from wild animal and fish meat; fruits, nuts, roots and other edible products make up the rest of their diets. Many forest food products, such as fruits, mushrooms, nuts and honey are harvested and commercially marketed, providing sources of employment and income for rural people.

- ** Research by Dourojeanni (1978 as cited in Falconer 1987) showed that in the Ucayali region of the Peruvian Amazon, some 85 per cent of animal protein consumed came from wild game and fish. Similar results were obtained in a study of the forest from Botswana (Butynski 1974).**

43. Papers from a recent FAO meeting on forestry for food production and security provide background on the subject and emphasize the urgent need for additional research in this area (cf. Falconer 1987; Arnold and Falconer 1987). Wildlife management research and species identification and utilization research are needed to improve the contributions of forests to food security.

+

B. THE CONTRIBUTION OF TREES TO ENERGY SECURITY

44. Worldwide concern about the fuelwood crisis affecting millions of the world's poorest people arose in the 1970s. The situation has since become far worse. At present, well over 100 million persons live in situations of acute fuelwood scarcity. Some 1.3 billion experience hardship because of lack of readily available fuelwood and the high cost of switching to more commercial fuels such as kerosene.

45. Experience from the 1970s and early 1980s suggests that an appropriate strategy to attack the fuelwood problem in developing countries should involve:

- i) selective encouragement of use of substitute fuels, particularly in urban areas;
- ii) conservation of fuelwood through improvements in wood-burning stoves, cooking habits and so forth; and
- iii) increased development of new fuelwood resources.

Expanded research is needed to support selection of appropriate actions in each of these areas. Past experience indicates that the needed research -- particularly on policy and economics issues -- must be co-ordinated and integrated with research on non-wood energy in the context of national energy policies and strategies.

Use of substitute fuels

46. In many parts of the world, crop residues and animal dung are burned for fuel instead of being put back into the soil to enhance productivity, or being used for animal feed, contour bunding, roof thatching and so forth. Enough research has been done on this subject (cf. Foley 1987, Lal 1988) to indicate that burning dung sometimes makes no difference and in other cases a critical difference in terms of crop productivity losses. Similarly, the opportunity cost of using crop residues for fuel rather than other uses varies widely with the situation.

47. Thus, sound general prescriptions are not possible without more research to document the costs and benefits associated with dung and crop residue burning.

48. Policy research is needed to document effects of existing energy substitution policies and to help design more effective policies. Past research has indicated how variable the impacts of a given type of policy can be:

- ** An ILO study in 1987 showed that subsidy policies to encourage substitution of kerosene for wood-based fuels were very effective in Addis Ababa, Ethiopia; some 60*

per cent of the population shifted to kerosene within four years. On the other hand, a World Bank household energy study in 1947 showed that in Senegal it was the more affluent urban households who benefitted from the campaign initiated in 1974 to encourage substitution of butane for wood-based charcoal. At the national level, introduction of liquid propane gas led to savings of only about 16-17,000 tons of charcoal annually, after 13 years of promotion and subsidization. The impact on forest conservation has been minimal.

**** Economics research by Raiche and Campos (1986) shows that drying coffee in Costa Rica with electricity is about six times - and using diesel fuel is three to four times - more expensive than using wood. This type of research has significant direct implications for fuelwood and other energy markets and indirect implications for policies on forest protection and energy in Costa Rica.**

Fuelwood conservation -- stove research

49. Use of improved wood and charcoal-burning stoves with existing technology could quite easily result in savings in wood fuel consumption of some 20 to 30 per cent. However, experience over the past decade or so indicates that technical possibilities are not enough to stimulate adoption of new stove technologies. People have a preference for their traditional cooking methods; designs are not appropriate for local environments and economies; or costs may be too high. Whatever the reasons, adoption rates for improved wood stoves have been disappointingly low. Sociological and economic research are needed to better understand the barriers and to provide information on which to base strategies and programmes for improved stove production and adoption.

Increased fuelwood supply

50. The third element in a co-ordinated wood-energy strategy is increased production of fuelwood. Experience has shown that problems of fuelwood scarcity cannot be addressed as an isolated problem. Rather they must be tackled primarily within the broader context of the role of forests and trees in rural production systems. Among other things, this can help take pressures off fragile natural forests and woodlands and maintain their important conservation and watershed management functions.

51. Many of the key problems associated with rural fuelwood production on farms and common property lands in developing countries relate to economic incentives and land and tree tenure. There is a need for more research on these issues. Fortmann and Riddell (1985) have reviewed studies dealing with tenure issues, and Dewees (1987) and Foley (1987) have reviewed the economics issues. A key issue relates to appropriate government pricing policies and how they affect tree growing and harvesting behavior.

52. Further investigation is needed of the number of options for increasing sustainable production of fuelwood from natural forests and woodlands, in agro-forestry systems, and in plantations and farm woodlots.

*** Winterbottom and Hazlewood (1987) have summarized research being undertaken in the Gusselbodi forest in Niger. This research has shown that simple, low-cost management techniques in the natural forest, such as early burning and careful timing of lopping and felling, can produce three cubic metres of fuelwood per hectare per year, or roughly six times the yield that is generally assumed for unmanaged forests. At the same time, a number of other products result (gums, fodder, medicines).*

C. EXPANSION OF SUSTAINABLE FOREST INDUSTRY DEVELOPMENT

53. Forest-based industries -- both small and large-scale -- can benefit local and national economies by generating employment and income, by providing inputs to other sectors of the economy, and by generating foreign exchange. However, forest depletion in many countries seriously threatens the supply of both wood and non-wood resources. This is due to destruction and over-exploitation of natural forests, inefficient use and wasteful harvesting practices, and inadequate investment in forest management and reforestation.

54. As a result, several countries that were major exporters of industrial wood (such as Nigeria and Thailand), are now faced with increasing import bills for manufactured forest products. In 1985, developing-country imports of industrial forest products exceeded US\$10 billion. This figure will more than double by the end of the century unless steps are taken to reverse current trends.

55. Many developing countries have sufficient land and suitable ecological conditions to meet their domestic industrial wood needs at a significantly lower cost than the alternative of increasing imports. Major research needs relate to improving natural forest management and use, establishing plantation forests, and promoting appropriate and sustainable small and large-scale forest-based industries.

Natural forest management and concession policies

56. Less than five percent of productive closed forests in the tropics is managed. Although better use needs to be made of past research to improve and expand natural forest management, both technical and policy research in this area have been seriously neglected.

57. Much remains to be learned about the technical and economic viability of natural forest management systems in the tropics. Forest management research should focus more directly on natural regeneration and perpetuation of high-value species, and on improved harvesting systems to increase efficiency and reduce logging damage. A major need is for research on appropriate concession and pricing policies for tropical forestry.

**** A recent study by WRI (Repetto 1988) reveals that, in Indonesia, Sabah/Malaysia, Ghana and the Philippines, government policies on forest revenue systems and wood-processing industries provided strong economic incentives, which led to accelerated rates of forest depletion and substantial losses of government revenue, due to lack of adequate rent capture from concessionaires. The economic losses due to these policies, in addition to other social and environmental impacts, are enormous.**

58. Priority areas for policy research include site-specific assessments of the need and scope for policy reform to promote sound management of forest resources, including: (1) the level and structure of timber royalties and other charges; (2) other forest concession policies, such as the duration of concessions, area licence fees, and harvesting prescriptions; and (3) the trade-offs between policies to promote log exports or domestic processing.

59. Past emphasis on timber production from natural forests often has obscured the fact that there are hundreds of other products which can sustainably be harvested from tropical forests. Additional research is needed to study the opportunities for management of natural forests for non-timber products such as foods, medicines, gums, other extracts such as chicle, barks, vines and so forth.

**** Research by Anderson et al (1987) documented the significant economic and ecological roles that the naturally occurring babassu palm (*Orbignya spp.*) plays in the Maranhao state of Brazil. Some 64 per cent of total cash and non-cash income in three municipalities of Maranhao came from**

babassu products during the peak harvest period of October to December. This has policy implications in terms of protection and management. Findings also led to management guidelines for the palm areas.

- ** Repetto (1988) notes that non-wood forest products brought in US\$120 million in 1982 in Indonesia. Most of the associated harvesting and production activity involved employment in local economies, whereas much of the wood export value was retained by timber companies as profits.

Industrial plantations

60. Achieving the dual objectives of reducing pressures for natural forest exploitation while meeting industrial wood needs will require accelerated establishment of industrial forest plantations. A concentrated research effort is needed in two major areas: (1) tree selection and breeding to improve growth and yield, disease resistance, and other characteristics; and (2) management strategies to improve the sustainability of large-scale plantations of fast-growing species in the humid tropics, particularly in terms of ecological impacts on soil and water resources.

61. Some major successes already have been achieved in terms of selection and breeding of fast-growing species.

- ** Research in Nigeria, already mentioned in paragraph 41, studied different provenances of Eucalyptus camaldulensis. This has shown mean annual increments varying from 5.1 cubic metres per hectare for the worst provenance to 17.3 for the best provenance (FAO 1979).
- ** Genetic improvement research over the past 15 years in Brazil has resulted in doubling eucalyptus yields from 33 to 70 cubic metres per hectare per year (Aracruz Florestal).
- ** Research has contributed in a major way to the five-fold increase in rubber yields achieved in Malaysia since 1920. The estimated rate of return on investment in rubber tree research in Malaysia is 22 per cent (Pee 1977).
- ** A programme of eucalyptus selection and breeding initiated in the early 1950s by CTFT in the Congo has led to improved commercial plantations that are planned to

produce several million cubic metres of wood per year, mainly for pulp and paper. Mean annual growth per hectare is in the 25-40 cubic metre range (L. Huguet, personal communication).

- ** OFI has promoted worldwide distribution and use of Central American tropical pines through its research network. Through the network, OFI has helped collect, distribute, test, and evaluate various genetic stocks of these pines. By exchanging seed, standardizing experimental design, and developing information systems, the network has enabled countries to match the genetic material to a site, thereby increasing plantation yields.

62. Policy studies also are needed in the area of plantation forestry particularly regarding incentive policies and financing mechanisms used in different countries. Some work already has been carried out in this area, but more is needed. IDB has recently completed a review of research in this area (McGaughey and Gregersen 1988).

- ** Santa Cruz (1988) researched the Chilean forestry incentives programme (Law 701) and concluded that the financial rates of return on *Pinus radiata* growing are, on average, high enough without incentives to attract investment. However, when Law 701 was passed, there were high risks and uncertainties surrounding investment in pine growing, and particularly a lack of secure markets and liquidity of such investment over the first years. The development of the major Chilean pine export business would likely have been delayed a number of years without the incentives to ease the burden of risk and uncertainty.

63. A critical area requiring further research is that of the sustainability of intensive plantation forestry in the tropics. Very little sound information on the subject is available (Chijioka, 1980, reviews available information). The studies available do not provide conclusive evidence for more general prescriptions. Research is needed on the ecological impacts of intensive plantation forestry in order to assess and improve its sustainability.

Forest industries and improved wood utilization

64. Expansion of employment in rural areas is a key concern of most developing countries. Recent FAO studies of forest-based small-scale enterprises (SSE), such as sawmilling, furniture-making, wood carving and other activities, indicate their significant contributions to rural employment and income (Fisseha 1987; FAO 1987).

**** Research in six countries reported by Fisseha (1987) indicates that the contribution of forest-based SSEs to total SSE employment varies between 13 and 34 per cent. Their contribution to total value added varies between 16 and 47 per cent, and to total value of production from 14 to 49 per cent. In all cases forest-based SSEs were one of the more important sectors.**

65. The paucity of past research in this area is emphasized in the FAO studies. Research is needed to improve understanding of the nature and extent of the potential contributions of small-scale forest-based enterprises to off-farm employment and income, and of ways to improve their efficiency and productivity.

66. Significant gains can come from wood utilization research on making more efficient use of already existing wood supplies. Many countries have considerable scope to improve the use of lesser-known species, particularly hardwood species, and to make greater use of small-sized trees. The more sophisticated wood technologies, such as softwood plywood research and other wood products research, are well advanced in industrial countries; they represent areas where temperate zone experience can often be adapted readily and quickly to local situations and species in the tropics. Available studies indicate that rates of return on investment in utilization research can be quite high.

**** Bengston (1984, 1985) found average economic rates of return of 19-22 per cent for structural particle board research and 34-40 per cent for lumber and wood products research in the United States. Haygreen *et al.* (1986) calculated that public investment in all timber utilization research in the United States had economic rates of return between 14 and 36 per cent, depending on assumptions used concerning costs to be included. (In the lowest rate, 14 per cent, all costs of research on timber management, forest products utilization, and forest products marketing were included).**

**** Research has permitted Malaysia to increase the number of species it uses commercially from 100 to more than 654 in 100 timber groups (Salleh Mohd. Nor, personal communication). Similar progress in species utilization has been made in Costa Rica and other countries. Research in the Philippines, Colombia and several developed countries has vastly increased the range of species from the natural tropical forest which can be utilized in paper production, thus opening up opportunities for productive, sustainable use of previously unused resources.**

**** Ten years ago, rubberwood was unknown as a commercial species in Malaysia. Research on species properties, processing, protection and utilization led the way to markets for rubberwood. As a result, Malaysia exported over 258,000 cubic metres of rubberwood in 1987 with a value over M\$37 million (Salleh Mohd. Nor, personal communication).**

67. Some of the developed country technologies which might have rapid payoffs in tropical countries through adaptive research include:

- ** power backup rolls for veneer production, which permit higher veneer recovery and peeling of difficult species;**
- ** press drying in paper making, which uses short fibre hardwoods and consumes less energy;**
- ** wood preservation to overcome decay and termite problems;**
- ** improved wood engineering for cost savings and other benefits in housing production;**
- ** developing uses for lesser-known species;**
- ** waferboard and other reconstituted wood products technologies permit use of many different species and treatment for fire, decay, and insect resistance; and**
- ** improved harvesting and transport technologies, which can lower costs and reduce environmental damage from logging.**

D. CONSERVATION AND MANAGEMENT OF TROPICAL FOREST ECOSYSTEMS

68. Tropical forest ecosystems, particularly tropical rain forests, are the world's richest source of plant and animal life and thus a critical reservoir of genetic resources. Tropical forests are home to millions of indigenous peoples and forest settlers, and provide a vast array of wood and non-wood products for subsistence and commercial uses. Further, there is growing scientific evidence that tropical forests are critical to maintaining the earth's biosphere, including global temperature and climate regimes.

69. Widespread forest clearance is disrupting these ecosystems, contributing to the global loss of biological diversity and possibly to the process of global warming. Major research needs relate to more effective conservation of tropical forest ecosystems through the establishment and improved management of conservation areas, together with promotion of sustainable land-use systems in and around critically threatened forests to reduce pressures for further encroachment.

70. As stressed in the TFAP, many of the solutions for forest conservation will have to come from outside the forestry sector. Thus, there is an urgent need to strengthen policy research on the linkages between forestry and other development sectors. This includes improved economic analysis to better quantify the social costs of deforestation and land misuse in terms of major development objectives of concern to decision makers, such as food security, employment creation, and balance of payments improvements.

Understanding, conserving and managing the tropical forest

71. A first priority is more research to understand the tropical forest and its actual and potential contributions to human welfare. It is estimated that only about one fifth of the plant and animal species in the tropical forests of the world have been identified, and less than one per cent have been chemically screened for potential medicinal properties. Only about 10 per cent of the plant species found on earth have been investigated even in a cursory fashion to assess utilization potentials (Miller et al 1984).

** Many otherwise obscure insect species in the tropics have major economic importance. For example, the oil palm (Elaeis guineensis) is pollinated in the wild in Africa by a weevil (Elaeidobius kamerunicus). The oil palm was introduced in what is now Malaysia in 1917 without the weevil and thus required costly, inefficient hand pollination. In 1980-81, the pollinator was collected from its native habitat in the forests of the Cameroon and brought to Malaysia after a six-month quarantine; significant improvement in pollination resulted, with the percentage of

fruit set increasing by eight to 28 per cent. After considering other factors of production, it is estimated that the increase in national oil palm production could reach 12.3 per cent (Salleh Mohd. Nor personal communication). The improvement was worth some US\$50 to US\$60 million in foreign exchange in the first year alone (Goodland 1985).

72. On site protection of tropical forests is a prerequisite for conserving biological diversity and the germ-plasm base for many of our important foods and medicines. More than 50 per cent of modern medicines come from the natural world, many of them from tropical plants.

****** Two major anti-cancer compounds derive from the periwinkle plant, which only occurs naturally in Madagascar. With these drugs, there is now a 99 per cent chance of remission in children suffering from lymphocytic leukaemia and a 58 per cent chance of remission from Hodgkin's disease.

73. Domesticated tropical forest plants (cacao, rubber, oil palm, etc.) are important sources of income and employment in many parts of the world. Throughout the developing world, national networks of protected areas and the capacity to manage them are generally inadequate to fulfil this task. A major constraint is the poor state of knowledge of tropical forest ecosystems.

74. A greatly expanded research effort is needed to improve understanding of the structure and functioning of tropical forest ecosystems, and of the value and role of wood and non-wood forest products in local and national economies. Related to this is the need for improved monitoring of tropical forest resources. Greater support should be given to the emerging research field of conservation biology in order to strengthen its contributions to identifying, designing and managing conservation areas. Of primary importance is economic research to understand the value of non-timber outputs from tropical forests, a research to understand the long-term opportunity costs of clearing forests for quick returns from agriculture or livestock projects.

****** Research by Hecht and Schwartzman (1988) indicate that the costs of recuperation of three million hectares of degraded forest land in Acre, Brazil, would be some US\$781 million in direct recuperation costs and some US\$150 million in extractive benefits foregone.

A systems approach to reducing deforestation

75. No single measure will change the momentum of population encroachment on tropical forests and the senseless destruction of forests for quick, non-sustainable profits. Rather, a systems approach is needed which combines both technical and policy research. Many of the types of research discussed in earlier paragraphs will have a direct impact on the success of programmes to reduce deforestation.

76. Among the research topics which merit investment, research on intensified agro-forestry and forest management to develop sustainable farming systems and other appropriate uses of the forest, could help to provide the 200 million people living in forest areas with alternatives to further forest clearance. In addition, to help relieve outside pressures for forest encroachment, policy and technical research is needed to develop strategies for establishing buffer zones around threatened forests, including: intensifying agriculture on non-forest lands; incorporating trees into farming and pastoral systems; developing small-scale forest-based industries; and establishing plantations on degraded, already cleared land.

77. Inappropriate policies that provide strong incentives for forest depletion can overwhelm these efforts to protect tropical forests. Research is needed to improve the understanding of policies for forestry and other sectors that currently encourage accelerated forest depletion -- such as policies related to timber pricing, land tenure, agricultural settlement, and industrial development.

E. PRIORITIES BY RESEARCH FIELDS

78. In the first part of this chapter, research opportunities and needs are discussed in some detail in terms of helping to resolve major issues and to meet opportunities addressed by the TFAP. Concrete examples of past research contributions are cited, and promising fields for future research are discussed. A great number of promising research topics are mentioned.

79. However, when one organizes all these topics by research fields, five priority fields emerge: 1) agro-forestry and watershed management; 2) natural forest ecology and management; 3) tree breeding and tree improvement; 4) utilization and marketing; and 5) policy and socio-economics. The Task Force recommends these five as priority areas for investment. Specific research needs within each of the five fields, cross-classified by the four TFAP opportunity areas discussed in previous sections, are indicated in Table 1 on the next page and summarized on pages 31-34.

Table 1. Recommended Research Priorities
(Classified by research fields and TFAP opportunity areas)

		TFAP OPPORTUNITY AREAS			
		1. <u>Forestry and Sustainable Agriculture</u>	2. <u>Energy Issues</u>	3. <u>Forest Ecosystems</u>	4. <u>Forest Industries</u>
R E S E A R C H F I E L D S	A. <u>Agro-forestry and Watershed Management</u>	Forest/agriculture/energy interactions Agro-forestry systems, e.g., - alley cropping - shelterbelts - fodder productivity Watershed management and land reclamation Arid zone management	Close spacing biomass farming many of the (same as in 1.A, since fuel is a major component for agro-forestry)	Buffer zones - sustainable agriculture systems Germ-plasm and agricultural crops, e.g., oil palm Shifting cultivation	(Sale of products from activities in 1.A and 2.A)
	B. <u>Natural Forest Ecology and Management</u>	Game, fish and other food products from the forest Natural savannah woodlands management	Pollarding and coppicing yields Forest area and biomass inventories and access studies Natural woodland studies (see 1.B)	Ethno-botanical research Ecosystem research Pest and disease research	Alternative silvicultural techniques
	C. <u>Tree Breeding and Tree Improvement</u>	Rapid propagation of MPTS in arid zones Nitrogen-fixing species Seed collection and storage and direct seeding Breeding for salt and stress tolerance Cash crop and local use	See 1.C	Germ-plasm collection and storage (oil palm, rubber, coffee) Studies of genetic variability	Tree selection, improvement and establishment (e.g., eucalypts, pines and other species)
	D. <u>Utilization and Marketing</u>	Markets for farm tree crops and products	Local market studies Stove studies Fuel efficiency	Medicinal plants and other useful outputs from the natural forest	Increased use of lesser-known species Conversion technologies Small-scale industry development

80. While the research needs listed within each field should be given high priority, other types of research should not be ignored. Each specific situation will dictate a unique set of specific programme priorities. Thus, what follows is not put forth as a research programme, but rather as a list of widespread needs which merit immediate, expanded investment, based on the past record of research in each area and on the Task Force's assessment of their potential and relative importance.

PRIORITIES BY RESEARCH
FIELDS

MAIN EMPHASIS

1. AGRO-FORESTRY AND WATERSHED MANAGEMENT RESEARCH

- | | |
|--|--|
| 1.1 <u>Agro-forestry
research</u> | <ul style="list-style-type: none"> - tree/food crop interactions (e.g., alley cropping) - tree/pasture interactions (e.g., effects of shade, nitrogen-fixation and fodder relationships) - shelterbelts (effects on long-term productivity of sheltered crops and animals) - fuelwood production on farms using multi-purpose tree species. |
| 1.2 <u>Watershed
management
research</u> | <ul style="list-style-type: none"> - identification and quantification of upstream/downstream inter-relationships - effects of alteration of land-use practices - use of agro-forestry practices to reduce erosion - options for fuelwood and fodder production and improved livestock management practices, such as stall feeding to take pressure off fragile natural forests. |
| 1.3 <u>Dry zone woodland
management
research</u> | <ul style="list-style-type: none"> - low-cost technologies for improving sustainable productivity of fuelwood, fodder and other needed outputs. |

2. NATURAL FOREST ECOLOGY AND MANAGEMENT RESEARCH

- | | |
|---|---|
| 2.1 <u>Species
identification and
classification,
and ethno-
botanical research</u> | <ul style="list-style-type: none"> - human uses of the various species from the tropical forest. |
|---|---|

PRIORITIES BY RESEARCH
FIELDS

MAIN EMPHASIS

- | | |
|---|---|
| 2.2 <u>Ecosystem
conservation and
maintenance of
biological
diversity</u> | <ul style="list-style-type: none">- structure and functioning of tropical forest ecosystemsidentification, collection, and storage of germ-plasm. |
| 2.3 <u>Management for
non-wood products</u> | <ul style="list-style-type: none">- integration of sustained yield management for non-wood products with ecosystem conservation and maintenance of biological diversity. |
| 2.4 <u>Management for
sustained yield
wood production</u> | <ul style="list-style-type: none">- maintenance of forest quality and biological diversity within the natural, managed forest- forest inventory with remote sensing and monitoring- ecological foundations for sound sustainable management practices- research on tree pests and diseases |

3. TREE SELECTION, IMPROVEMENT AND ESTABLISHMENT RESEARCH

- | | |
|--|---|
| 3.1 <u>Selection and
improvement of
multi-purpose tree
species</u> | <ul style="list-style-type: none">- seed collection and storage, species and provenance trials on both native and exotic species which can be used within agro-forestry systems and by rural communities in meeting their basic needs, including fuel, fodder, food and construction materials- nitrogen-fixing species- salt and stress tolerance in dry zones |
| 3.2 <u>Selection and
improvement of
fast-growing
industrial tree
species</u> | <ul style="list-style-type: none">- species adapted to particular agro-climatic conditions and product needs- continued work on eucalypts, pines, rubber and other well-known producers |

PRIORITIES BY RESEARCH
FIELDS

MAIN EMPHASIS

3.3 Tree and stand
establishment

- establishing trees on adverse sites
- improving nursery practices
- afforestation and reforestation technologies

4. UTILIZATION AND MARKET RESEARCH

4.1 Utilization of
lesser-known
species and non-
wood products from
the tropical
forest

- utilization technologies that can be widely disseminated and adopted by local communities, given their skills, the availability of labour and other relevant factors

4.2 Research to adapt
already-existing
technologies to
local conditions

- to be locally determined

4.3 Local market
studies and
research on market
structures and
functioning

- to be locally determined

5. POLICY AND SOCIO-ECONOMICS RESEARCH

5.1 Policy reforms in
forestry and other
sectors to promote
reductions in
deforestation

- to be locally determined

5.2 Potentials for
increased
government rent
capture for
utilization of
natural tropical
forests

- how to link increased rent capture with improved management to increase sustainability of natural tropical forest management

PRIORITIES BY RESEARCH
FIELDS

MAIN EMPHASIS

- | | |
|--|--|
| 5.3 <u>Understanding
better the
incentives which
motivate
smallholders to
grow trees</u> | - effectiveness and efficiency of
alternative incentive mechanisms
designed to stimulate local
participation in tree-growing and
conservation activities |
| 5.4 <u>Integrated
watershed
management
research</u> | - systems studies of integrated
watershed management options to
reduce on-site and downstream
damages from erosion, stream flow
alterations and water pollution
- policy options and incentive
mechanisms to encourage sound land
use |
| 5.5 <u>Promotion of
small-scale
sustainable
industry</u> | - relation between raw material
supplies and employment creation |

81. The selective nature of the priorities discussed here can be illustrated using policy and socio-economics research as an example. The Task Force's list of priorities indicated above includes five policy/socio-economic topics. However, in total, the Task Force considered the 68 topics shown in Table 2, which cross-classifies policy/socio-economic research needs by the TFAP issue areas and the recommendations of Bellagio Forestry I. The point to stress here is that the Task Force considers each of the 68 listed topics to be important within its own context; and each probably could be considered a top priority in at least one part of the world.

82. The policy/socio-economic topics chosen in this section are considered to have particularly widespread and immediate relevance to the issues addressed by the TFAP. They are considered to be prime candidates for immediate investment. These topics are spelled out in greater detail in Table 2 on the next page.

83. The same logic applies to the choice of topics within the other four research fields. Regional variations in priorities are indicated in the Task Force Background Papers (see Annex 3).

Table 2. Policy and Socio-Economic Research Needed
to Implement the Recommendations of Bellagio I
(Classified by research fields and TFAP opportunity areas)

		TFAP OPPORTUNITY AREAS			
		1. <u>Forestry and Sustainable Agriculture</u>	2. <u>Energy Issues</u>	3. <u>Forest Ecosystems</u>	4. <u>Forest Industries</u>
M E L L A G I O	A. <u>Quantifying the Costs of Inaction</u>	Economic inter-relationships between trees and sustainable agriculture Benefits and costs foregone Watershed management benefits	Potentials for substitute fuels Effects of over-exploitation for fuelwood	Losses being incurred due to deforestation and degradation Appropriate distribution of costs	Opportunity costs, e.g., imports vs. domestic production
	B. <u>Incorporating Recommendations for Action into National Development Plans</u>	Relating TFAP activities to national development goals Institutional mechanisms for incorporation	Relate fuelwood to national energy plans, needs, sources	Agricultural and other policies in relation to forest protection goals Quantifying the benefits of protection to the nation	Understanding the role of industry in national development Role of small-scale labour-intensive tree-based industry
	C. <u>Promoting Community Participation</u>	Alternative incentive policies and mechanisms (market and non-market) Role of different groups	Energy pricing policies Alternative incentives Fuel conservation policies and programmes	Role of conservation NGOs	Role of co-operatives and local community business Employment policies
	D. <u>Encouraging Private Sector Participation</u>	Appropriate market policies and regulatory mechanisms Developing extension capability	Energy pricing policy Fuelwood market rationalization Loans and subsidies to encourage action	Agricultural reform policies (subsidies for land settlement, etc.)	Incentives for sustained yield management Market research Pricing policies Small-scale industry development
	E. <u>Introducing Policy Reforms</u>	Land use regulations Land and tree tenure policies Pricing policies Administrative reforms	Energy pricing policies Tenure reform Role of government regulation and subsidization	Alternative agricultural taxation policies Land tenure reforms Buffer zone policies World community role	Stumpage pricing policies Concession policies Timber trade policies (logs vs. processing; export, pricing, taxes, etc.)
	F. <u>Protecting Tropical Forests</u>	Land settlement policies Role of agricultural or land-use intensification	Alternative fuel potentials Policies regarding harvest, e.g., savannah woodlands	Policies regarding reserves, parks, etc. Determining critical minimum size reserves	Concession policies Economics of non-destructive, sustained yield management
	G. <u>Integrating Forestry into Broader Land-Use Concerns</u>	Policies and administrative reform for closer integration of forestry and agriculture	Energy conservation policies Administrative co-ordination of energy policies and programmes	Alternatives for developing buffers around reserves Expanding non-destructive uses of forests	Harmonizing industrial use of forests with other uses Sustained yield forestry areas as buffer zones
	H. <u>Monitoring Tropical</u>	Monitoring role of on-farm vegetative barriers in	Role of fuelwood in deforestation	How to use monitoring results more effectively	Impact of industrial development on
R E C O M M E N D A T I O N S					

TABLE 2

F. POTENTIAL BENEFITS FROM AN EXPANDED RESEARCH PROGRAMME

84. Significant additional investment in priority research such as discussed in the previous sections has the potential for making major contributions to human welfare and to sustaining development efforts in other fields such as agriculture, energy and industrial development. It is impossible to estimate in quantitative, monetary terms what those global benefits might amount to over time; however, as indicated earlier, for specific research programmes the economic and financial rates of return can be substantial. It is possible to provide a qualitative picture of the nature and rough order of magnitude of the benefits in terms of numbers of people potentially benefitting from an expanded research programme.

85. Extrapolating from the results of past research on tree selection improvement and establishment, it is clear that the potential exists to more than double over the next 15 to 20 years the average productivity of trees used in the tropics to produce fuel. Aggressive application of such research results could benefit at least 200 to 400 million people out of the 3,000 million people who will face acute scarcity or deficit of fuelwood past the turn of the century (FAO 1983).

86. If research efforts focus on multi-purpose rather than single-purpose fuelwood species, then the gains could be much greater. For example, in the Sahelian and Himalayan regions, people rely on trees as a significant source of fodder. In these areas, the potential exists for some 120 million people to benefit from improved fodder production in addition to benefitting from fuelwood gains. Examples cited earlier also indicate the potential for shelterbelt research to contribute significantly to increasing food security for people living in some of the most fragile and hostile agricultural environments. As noted, net crop increases due to windbreak effects would be in addition to the fuelwood, shade and fodder benefits associated with use of multi-purpose shelterbelt trees.

87. In addition to fodder, fuel and shelter benefits, the potential also exists to reduce erosion and downstream losses in irrigated agriculture, power production, fish production, etc. (Figure 1), by combining results from tree improvement research with the results of more policy-oriented research on integrated watershed management. The combination would provide the technologies and policy rationale for introduction of sustainable land-use systems that not only would benefit upstream land users, but also downstream land users and others affected by erosion, flooding and polluted water.

88. As developing countries expand their reliance on irrigation water to increase agricultural productivity and food security, the need to improve upland watershed management also increases. Often, the prevention of future losses due to watershed deterioration does not receive the same attention as expansion of such present benefits as crop increases, even though loss prevention is fully as important from a human welfare point of view.

89. Many of the 300 million people who live in moderately or severely-desertified arid regions could benefit from an expansion of the types of arid-zone management research illustrated earlier. Low-cost management of natural savannah woodlands could provide fuel, fodder and many other locally important products in greater abundance, and, most importantly, do so on an ecologically sound and sustainable basis.

90. Much of the research suggested by the Task Force does in fact relate to the objective of changing land uses. This change has to be toward more sustainable approaches that can raise people out of the frightening state of subsistence living associated with pushing the land beyond its ecologically sustainable potential. Although the benefits are not immediate, such changes could have far-reaching social and economic effects on future generations.

91. For the above types and magnitudes of benefits to be achieved, the results of research on agro-forestry systems and policy research on tenure issues and pricing policies also would have to be applied. The close relationships between the issues addressed and the results sought by the proposed research priorities cannot be over-stressed. For example, significant expansion of welfare, particularly of the rural poor, cannot be expected from application of the results of tree breeding research alone. Policy reforms based on sound information also are needed to ensure that the poorer segments of the population gain. Consideration of inter-dependencies is the rule rather than the exception in research success stories when they are looked at in terms of human welfare rather than technical progress alone.

92. Although the benefits are very difficult to quantify, research on conservation and management of tropical forest ecosystems will make a major contribution to safeguarding a large proportion of the world's biological diversity. This will help ensure that present and future generations will have the opportunity to retain and broaden the genetic base for food crops, medicines, industrial products, and other useful goods yet to be discovered among the millions of unknown plant and animal species in tropical forests. Based on past experience with the domestication of tropical plants, it seems evident that this is a critical resource which merits protection.

93. Natural forest management research can point the way to opportunities for increased sustained yield management of tropical forests. Economic arguments must be developed and refined in order to stimulate and facilitate the necessary policy reforms which can reduce tropical deforestation. The benefits from such reductions have already been enumerated.

94. Research related to industrial development has the potential of reducing import bills for forest products in developing countries and, in some cases, of increasing export revenues. Chile and Brazil are two excellent examples of countries which have systematically researched

market opportunities, wood utilization potentials, and quality controls and have developed major export sectors for forest products. The value of exports of forest products in 1987 from Chile and Brazil was US\$1,60 million (FAO unpublished).

95. Tree selection and improvement research has already shown the potential for reducing costs per cubic metre of wood in the tropics to levels that are competitive anywhere in the world. At the same time, lower costs, if passed on to consumers in the form of lower paper prices, would benefit educational programmes that could potentially raise the literacy levels of hundreds of millions of people.

96. The above discussion of gains from research merely touches on some of the benefits which could flow from an expanded and intensified programme of research dealing with tropical forests. In refining plans for concrete actions to expand research, it will be desirable to quantify more accurately the relative levels and types of costs and benefits involved in different types of research. For example, one widely-held concern is that benefits may not reach the poor. Deliberate actions will be needed to ensure a desirable distribution of the benefits flowing from improved technologies. The relative effectiveness of different actions and policies in achieving this goal will have to be researched.

III. CAPACITY OF NATIONAL RESEARCH SYSTEMS



97. The purpose of assessing research capacity is to identify the weaknesses and gaps in the global tropical forestry research system that must be filled in order to properly address the research needs identified in Chapter II. The assessment was based on a review of recent reports on forestry research capacity in developing countries (see References), responses to a task force questionnaire, and extensive consultations with individuals and institutions around the world involved in tropical forest research. More detailed discussion is provided in Background Papers 2, 3, 4, 5, 7 and 9.

A. DIMENSIONS OF THE GLOBAL FORESTRY RESEARCH SYSTEM

98. Many different institutions are involved in research on issues related to the objectives of the TFAP. These include national forest services and research institutes, universities, regional research groups, international research organizations, NGOs, private industry, and various organizations which carry on informal research as part of the implementation of their programmes. It is impossible to give a precise number and, in any case, such a number would be meaningless because many of those which list forestry research as a field only devote one half or one quarter of a scientist year to the subject.

99. Most of the organizations in developing countries which undertake forestry and forest products research are small in size. There is wide variation among them in the number of scientists and other trained staff, the support for individual scientists, infrastructure, and funding.

100. Much of the research dealing with the priority areas of the TFAP is done by organizations outside the traditional forestry research system. This is true, for example, in research areas such as agro-forestry and nitrogen-fixing tree species. Somehow these organizations have to be considered and included in a programme to strengthen research related to implementation of the TFAP.

101. A great many factors influence national research capacity, which in turn is defined by 1) the quantity and quality of resources available, and 2) the ways in which those resources are organized and managed. The relative importance of various factors within these two categories is indicated in Figure 4 (see next page), based on the views of administrators of forestry research organizations in 46 developing countries (Bengston and Gregersen 1988).

102. The Task Force concurs in general with the relative importance attributed to the various factors indicated in Figure 4. However, two related points should be noted in considering them and their influence on capacity:

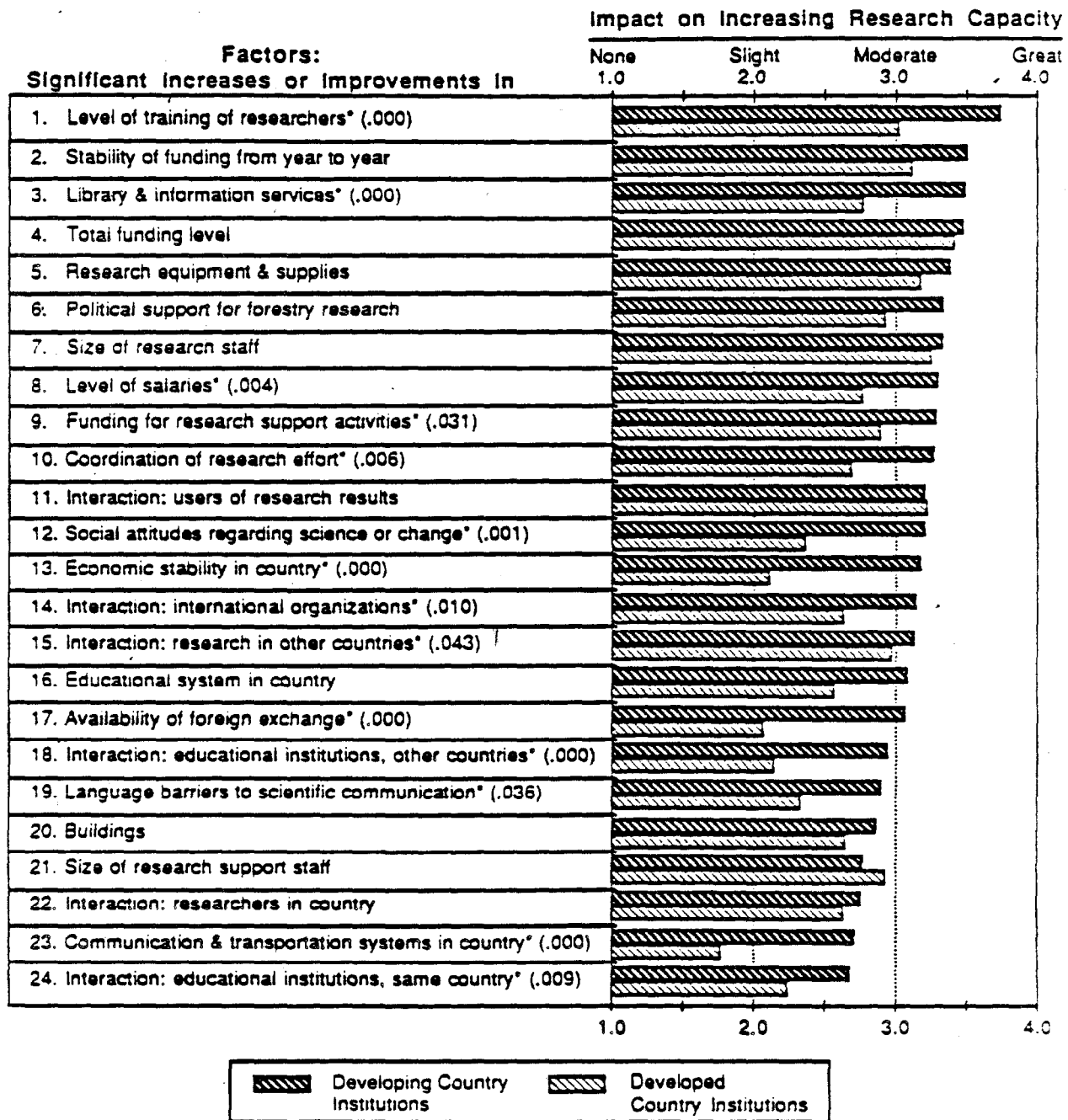
- i) the diversity of research organizations involved in TFAP-related research means that the relative importance of different factors will vary widely between organizations and countries; these differences must be borne in mind in any planning effort and action programme adopted; and
- ii) the fact that many non-forestry organizations do research related to TFAP objectives provides some flexibility in terms of expansion of research.

B. THE QUANTITY AND QUALITY OF RESOURCES AVAILABLE

Human resources

103. Lack of trained personnel is identified by respondents to the Task Force questionnaire and in other studies as the most critical problem facing developing-country forestry research organizations. A study of 39 developing-country forestry research institutions revealed a median number of scientists per organization of only 16 (Bengston, Xu and Gregersen 1988). About two thirds of the sampled organizations had between 0 and 5 Ph.D. and between 0 and 10 Masters-level scientists. Almost half the sampled organizations had only between 0 and 10 technicians. It is obvious that investment in the education and training of researchers and technicians is a critical need which must be addressed.

Figure 4: Factors Affecting Forestry Research Capacity



Note: Chart uses average rating of factors affecting research capacity in 46 forestry research institutions in developing countries institutions, and 45 in developed countries. Standard errors range from 0.079 to 0.136 for developing countries, and from 0.093 to 0.164 for developed countries.

* Indicates significantly different ratings by developed and less-developed country respondents. Numbers in parentheses indicate levels of statistical significance as calculated for the chi-square statistic.

Source: Bengtson and Gregersen 1987

104. However, many countries do not have adequate capacity to educate and train forestry researchers. In the Bengston et al sample, more than one quarter of the researchers and administrators have degrees from universities outside their home countries, often in an environment where many things learned were irrelevant to home-country problems. A concerted effort is needed to strengthen training systems which prepare researchers to work on tropical forestry problems of relevance in the home countries. In some cases, countries must work together on educational programmes.

Physical resources

105. The situations in different countries are highly variable. In some there are facilities that go unused, while in others scientists work out of makeshift labs and offices with inadequate equipment and infrastructural support. The key to strengthening research institutions dealing with TFAP-related issues is to balance the support for training, institutional reform, and investment in physical infrastructure.

106. Lack of adequate library and other information sources is a major problem in many research organizations. There is considerable potential for expansion of computerized database systems which can improve access to data and information. FAO surveys of developing-country forestry research institutions indicate widespread inadequacies in equipment and facilities. Only a few organizations in Africa were found to have adequate equipment and laboratory facilities, and only about 25 per cent in Asia and the Pacific and about 50 per cent in Latin America have adequately-equipped laboratories. Specialized research equipment is lacking in most organizations. Lack of equipment was cited as a critical problem in the response to the Task Force questionnaire. Funding and trained staff to maintain equipment is also an important constraint.

Financial resources

107. Expenditure on forestry research in the developing regions was only about US\$180 million in 1981 (Mergen, Evenson and Judd 1988). This accounted for only 12 per cent of the total expenditure on forestry research worldwide in 1981. Based on past expenditure trends, total expenditure on TFAP-related research in developing countries was probably somewhere between US\$220 and 250 million by 1987.

108. Two points of comparison are worth noting to put these figures in context: 1) the U.S. Forest Service alone spent US\$128 million on research in 1981; and 2) total expenditure on agricultural research in developing countries was around US\$2.2 billion in 1981 (P. Oram, personal communication).

109. A better perspective can be gained by looking at research intensities. This measures forestry research expenditure as a percentage of the value of production of forest products. These percentages for forestry research in developing countries are in the 0.05 to 0.12 per cent range. They are considerably below the percentages for

agriculture, which now average about 0.5 per cent of agricultural gross domestic product. Also, the percentages in developing countries for forestry research are about five times lower than the comparable percentages for developed countries.

110. Clearly, investment in forestry research is very low in developing countries in comparison with the value of goods and services flowing from the forestry sector. The ratio would be even lower if non-marketed outputs were included in the value of production figures used. There is a critical need to find ways of expanding such investment in a productive, effective way.

111. Few forestry research institutions in developing countries have the security of funding needed to establish efficient and effective long-term programmes. Long time-lags in forestry research make long-term funding particularly important. Mechanisms need to be found so that organizations can count on stable core funding. If such mechanisms are not developed, then it will be very difficult, even for the best existing research institutions, to expand research programmes significantly.

International support

112. In 1986, international donors provided some US\$46 million of assistance for forestry research. This means that about 20-25 per cent of the total expenditure on forestry research in developing countries was funded by international donors as compared to about 35-40 per cent in agriculture. Whereas nearly 10 per cent of aid (including technical assistance) for agriculture is spent on research, less than five percent of total bilateral and multilateral assistance for forestry is used for research.

113. The level of research effort and funding from bilateral and multilateral programmes was critical to successes achieved in forestry in the past. Such successes are associated with programmes supported by, among others, Australia, CIDA, DANIDA, France, GTZ, the Netherlands, ODA, SIDA, Switzerland and USAID. Multilateral examples include FAO, IADB, ITTO, UNDP, UNEP, UNESCO and the World Bank. A number of other organizations, including NGOs, have also made significant contributions, among them ICRAF, ICRISAT, IDRC, IIED, IITA, ILCA, IUCN, NFTA, WRI and WWF.

114. Also, co-ordination of the international inputs is improving, due in large part to twice-yearly meetings of the TFAP Forestry Advisers Group, which bring together almost all the technical advisers to donors to review progress of the TFAP, including research.

115. The extent to which international leadership and co-ordination can improve matters is illustrated by IUFRO's Special Programme for Developing Countries (SPDC). This was launched by IUFRO in response to a challenge from the World Bank and FAO in 1981 to bring forestry research to bear on the problems of the developing world.

116. Within two years, IUFRO/SPDC had initiated a series of regional workshops around the world on a selection of research topics of special interest to groups of countries. These events generated a series of fundable projects for training in research, for information systems improvement, and for research projects run by networking and other collaborative systems. IUFRO's regional research planning workshops have been primarily concerned with problem analysis of selected broad topics, notably multi-purpose tree species and improved wood use.

C. RESEARCH ORGANIZATION AND MANAGEMENT

117. The impacts of inadequate resources on research capacity and effectiveness are compounded by problems associated with the way in which resources are organized, managed, and used over time.

Political awareness

118. A fundamental barrier to strengthening forestry-related research in developing countries is the general lack of political awareness of the critical nature of the policy and other issues involved in tropical forestry and deforestation, and the role of research in helping to resolve them. This has led to under-funding of forestry-related research programmes. A substantial expansion of policy research is needed to establish clearly the links between forestry and the broader issues of development and welfare that are of concern to political leaders.

Interaction among researchers

119. Interaction among researchers is generally poor in developing countries, largely because of lack of opportunity. There are increasing indications that this can result in inefficiencies, unneeded duplication of effort, and waste of resources. Experience indicates that having a "critical mass" of researchers in an area -- which is lacking in most developing countries in the case of forestry research -- is an important stimulus and can help to achieve significant progress in a reasonable time. Mechanisms need to be developed for expanding information exchange and research interaction within countries, with particular emphasis on developing mechanisms to foster linkages between researchers, including information systems such as AGRIS and CARIS.

Interaction with agricultural researchers and others

120. A major area of weakness in most countries is the lack of interaction between forestry and agricultural researchers. This stems from the historical separation of forestry and agriculture. It is reflected in the institutional separation of forestry and agricultural research, and of statistical data collection and publication activities

and services. Specialist missions to review national "agricultural" research systems, which deal with crops and livestock, rarely encompass any aspects of forestry and conservation. Mechanisms for improving the interaction of forestry and agricultural research need to be developed.

Interaction between researchers and research users

121. Another major area of weakness in most countries is the lack of interaction between researchers and the "users" of research. This includes the failure of outreach or extension services adequately to disseminate and help implement research results in the field, particularly in farm and community forestry. Forestry research in developing countries must become more relevant to local conditions and needs. This requires mechanisms for integrating rural people's perspectives into the research planning process. NGOs can play an important role here.

122. The extension of research results to potential users is a critical area which must be addressed in parallel with research improvement. This can be accomplished in part by building on existing agricultural extension programmes and by working more closely with NGOs. Incentive mechanisms are needed to encourage closer co-operation.

Interaction among countries

123. Formal interaction among countries is improving, and progress is being made in the area of information exchange. Research networks are being formed, and promising results are being achieved with database management systems to collate, process, and analyse data from sites around the world on species trials and the results of other biological research.

124. An encouraging example is the establishment of research networks through IUFRO's SPDC, and through, for example, IDRC (Asia) and USAID (Central America and Asia). Others have been established with the support of various bilateral and multilateral organizations (e.g., NFTA and FAO's networks).

125. However, substantial expansion of funding is needed to meet the major opportunities which exist right now for information exchange and research interaction. In addition, support is needed for other mechanisms to expand and improve international interaction among researchers, such as exchanges of scientists and attendance at scientific meetings.

126. In addition to networks, a number of developed-country research institutions co-operate with developing-country institutions in forestry research on a one-to-one basis. These types of twinning arrangements need to be encouraged and expanded in a productive and effective manner.

Incentives for researchers

127. The lack in many countries of adequate incentives (both monetary and non-monetary) for attracting and retaining skilled researchers poses a major constraint to improving forestry-related research in developing countries. Salary levels for forestry researchers are considerably below those for comparable professionals in the same country (Bengston, Xu and Gregersen 1988).

128. A related problem is the lack of opportunity for professional advancement. Greater support is needed to help national research organizations build improved incentives into their systems, in some cases through drastic re-organization and in other cases through greater inputs of financial and other resources into existing, relatively effective organizations.

IV. AN INTERNATIONAL STRATEGY FOR STRENGTHENING RESEARCH



A. GENERAL CONSIDERATIONS

129. Any future framework for supporting expanded research on tropical forests needs to be built around a clearly-defined set of research priorities. In this regard, the Task Force recommends expanded investment in five fields of research over the next decade to help meet opportunities considered within the TFAP (see Chapter II). These fields are:

- 1) agro-forestry and watershed management research;
- 2) natural forest ecology and management research;
- 3) tree breeding and tree improvement research;
- 4) utilization and market research; and
- 5) policy and socio-economic research.

130. The effectiveness of expanded research will depend on an expansion of national capacity to do productive research in these fields. Capacity at the present time is already being strained in many countries. Based on the assessment of weaknesses in existing capacity presented in chapter III, the Task Force identified five major areas of institutional strengthening which require immediate attention. These are:

1. Strengthen the mechanisms by which public officials and political leaders become aware of the critical problems which tropical deforestation and degradation create in a broader development context and the important contributions which research can make to solving these problems.
2. Strengthen education and training systems which prepare researchers to work on tropical forestry problems.
3. Develop mechanisms to secure needed core funding for national and international tropical forestry research organizations. Success in addressing this issue will depend on the effectiveness of efforts to change the understanding and attitudes of political decision makers and efforts to improve the effectiveness of research so real benefits to society can be demonstrated.
4. Strengthen the efforts of national research organizations to build more effective incentives and management systems into their programmes, in some cases through assistance in re-organization and in other cases through greater inputs of financial and other resources (including equipment).
5. Strengthen mechanisms for improving interaction between:
 - a) forestry researchers and their peers at home and abroad. This would encourage scientific soundness and relevance of research work and stimulate research ideas. It will involve intensified efforts to support networks, scientific meetings, travel to visit with fellow researchers, exchanges, better access to scientific literature, and so forth;
 - b) forestry researchers and other non-forestry researchers and research organizations working on problems of relevance to the TFAP, e.g., agricultural research groups, and basic research organizations working on biodiversity, genetics, soils, energy, etc. This will help encourage inter-disciplinary research needed to

solve complex problems, such as those associated with integrated watershed management. Incentives for such interaction will have to be created along with establishment of lines of communication and concrete means to make inter-disciplinary linkages relevant and attractive to researchers; and

- c) forestry researchers and the clients of research, or those who will be disseminating or applying the results in the field. This will help to ensure the relevance of research to solving critical current and emerging problems. It involves intensification of field travel and contacts, attendance at non-scientific meetings, closer collaboration with NGOs, and other interaction mechanisms.

131. In putting forth the above priorities for research and for institutional strengthening, the Task Force is mindful of the fact that the relative importance of each field will vary between countries and regions, as will the needs for institution building.

B. INSTITUTIONAL REQUIREMENTS

132. To carry out the basic strategy described above requires a mechanism to ensure effective and efficient use of expanded funding and technical support. Any new mechanism to assist the process must provide international leadership, co-operation and a measure of co-ordination. Although tropical forest research is being supported by many bilateral and multilateral donors, there is at present no central body that can co-ordinate and offer well-informed help to donors, national bodies, and research establishments. They could benefit from such help in evaluating needs and priorities, mobilizing support, developing capacity, focussing research, and sharing information with the countries that need it most.

133. Thus, the need at present is for an international mechanism to stimulate, plan, co-ordinate and support a centrally or regionally-directed tropical forestry research strategy and programme, and to encourage relevant research work at the national or regional levels through a variety of funding arrangements. The potential exists to achieve rapid results in research findings and in strengthening national research capabilities.

134. Any new organization must be small and efficient, yet flexible in its approaches to supporting research and the building up of national and regional research capacity in the five priority research fields. It will need to:

- 1) Create a high standard of awareness and debate to permit periodical critical review and assessment of research priorities and progress in the strengthening of institutions.

- ii) Inspire support and mobilize increased funding for international and national research programmes.
- iii) Build on success by developing selected existing institutions as centres of expertise, and secure more effective deployment of the best existing international, regional, and national research institutions (including IARCs), to address the problems of tropical countries.
- iv) Increase national research capabilities by educating and motivating of research workers, by facilitating twinning and networking arrangements, and by selective strengthening of some research centres of high potential.
- v) Increase the interactions among forestry and non-forestry research institutions, including IARCs, universities, NGOs and private industry.
- vi) Develop improved information systems which give greater access to existing knowledge and the results of research.
- vii) Improve use of research results through collaboration with extension services and NGOs.

135. The question then arises, what is the most appropriate institutional mechanism or option for achieving the above in the most effective and efficient manner, given the needs of the global tropical forestry research system as assessed by the Task Force and discussed in the previous chapters?

C. A NEW INSTITUTION? THE OPTIONS

136. Several institutional options for strengthening forestry research in the tropics are discussed in Background Paper No. 13. These and some other options were considered by the Task Force, as follows:

- 1. Continue the present, essentially informal arrangements comprising a variety of networks, each self-governing and relatively independent, together with increased support for existing national and regional forest research and training institutes, at the discretion of individual donors.
- 2. Establish a major central international research institution, similar in concept to IRRI, to serve as a world centre for the direction, execution and co-ordination of tropical forestry research.
- 3. Establish a number (about five) of international research centres, appropriately located, staffed and equipped to undertake needed research on a regional basis.

4. Expand the existing CGIAR and TAC to include forestry research. This would require new members in the TAC and an increase in the total budget.
5. Expand the CGIAR's responsibilities but with a new and separate TAC for forestry research. This group would be small but have similar responsibilities to CGIAR's TAC.
6. Establish a new Consultative Group for forestry, i.e., the "CGIFR" with a forestry TAC, which would be similar in mode of action and overall composition to the CGIAR.
7. Create a new modality, not dissimilar to 6 above, but comprising a small international research council of Trustees, instead of a larger Consultative Group of donors.

137. The Task Force has considered each of these options and has analysed each, as follows:

Option 1

This is, to all intents and purposes, the status quo and would achieve little other than encouraging more of what is already in progress. It does not meet the clear need for an international structure to help define, guide and support a major expansion of tropical forestry research.

Option 2

One of the most outstanding and consistent features of forestry in the tropics is the wide diversity of the problems demanding research in the foreseeable future. This wide variety of topics and the skills and resources required, together with the fact that much of the work needing to be done is highly location-specific, makes it quite impractical to think in terms of a single, international research centre.

Option 3

This option was discussed at some length, as it is not inconceivable that a number of well-endowed and well-located international forestry research centres could have an early and effective impact on the research requirements identified. A parallel can be drawn between this prospect and the success of the IARC stations of the CGIAR in the field of agricultural research. Once again, it is considered that the range and diversity of research problems in forestry worldwide cannot be adequately covered in this way alone. It will be

necessary to draw upon and develop research skills and capabilities across a much wider spectrum of institutions, both national and international. Nevertheless, the development of major international research centres in due course remains a viable option, providing it is properly and fully evaluated and integrated within the wider approach advocated. This requirement can only be met by means of an international co-ordinating agency and it therefore becomes part of Options 4-7 inclusive.

Option 4

In theory, this offers the advantage of integrating forestry and agriculture research under one umbrella in the CGIAR system. In practice, there are serious reservations about the interests of forestry being lost within the larger system, and it is submitted that, without substantial further enlargement, the system would not be capable of addressing the diversity of tropical forestry research needs.

Option 5

This is more practical, as the separate and diverse needs of the forestry-related programme could be catered for by a separate forestry TAC. However, the extra burden on the CGIAR and the Secretariat would be considerable and, unless there was a distinct and separate budget provision, it is hard to see forestry requirements competing with agriculture.

Option 6

This has many attractions as a free-standing institution made up of individuals fully aware of the special needs of forestry and its links with other fields. However, it is questionable whether a large CGIAR-scale donor group would be prepared to meet separately for this purpose. Nevertheless, the option has to be kept in mind along with Option 7, which is the one favoured by the Task Force.

Option 7

This option has emerged as the one favoured by the Task Force. It is considered the simplest, most practical and cost-effective mechanism for international co-ordination of the research and capacity-building activities needed to address the opportunities and priorities described in Chapter II, and to overcome the constraints described in Chapter III. As envisaged, the priority tasks of this International Tropical Forestry Research Council (ITFRC) will be:

- to assess research needs and focus on selected priorities;
- to mobilize additional financing and co-ordinate donor support;

- to share information;
- to raise and maintain scientific standards of work; and
- to the maximum possible extent, work through, and build on, existing national and regional institutions, thereby strengthening their capacity.

D. RECOMMENDATIONS FOR AN INTERNATIONAL TROPICAL FORESTRY RESEARCH COUNCIL (ITFRQ)

138. The recommendations which follow are only an outline of a structure and organization which is considered to offer a sound beginning and one which can evolve in the light of experience. As there is an urgent need to address the principal research problems, it is also recommended that steps to set up such a council be taken with the minimum of delay.

The Structure of the Research Council

139. The organization recommended for a Research Council is similar to that of the CGIAR system in that it has no legal constitution and would operate entirely on the goodwill and voluntary support of its participants. It is also similar to the concept of INCOFORE developed by IUFRO, based on experience with their SPDC and described in detail in Background Paper No. 16. The Task Force sees great merit in setting up the Council so that it has a high degree of independence from existing institutions and governments and is free to consider issues on scientific merit with the minimum of political and bureaucratic diversion. It must, of course, be accountable to its sponsors, to the developing countries, and to an appropriate form of periodic external scientific audit to ensure that the international community is getting good value for money. Otherwise, the institution should be as free-standing as it can be made, while also ensuring that its vital communication links with other international bodies are strong and clear. In particular, it needs to link with:

- CGIAR - This includes participation in its Centres Week and close liaison with TAC and the CGIAR Secretariat.
- FAO - Its involvement is essential given its mandate in forestry and forestry research; the importance and relevance of its forestry programmes and bodies (Committee on Forestry (COFO), Committee on Forestry Development in the Tropics (CFDT), Regional Forestry Commissions and technical forestry bodies); and because of its co-ordinating role in the implementation of the TFAP.

IUFRO - Its participation is essential with its worldwide membership of scientists and its invaluable experience in the SPDC. The work of the new Council should evolve and flow from that initiative which is already under way.

140. In the view of the Task Force, none of these three bodies should control the Council, but the linkages are, nonetheless, so important that it is recommended that each should nominate a member for the Council of Trustees (see below).

141. An international programme of the diversity and scope envisaged for tropical forestry research requires the co-ordination and co-operation of those who:

- determine research priorities and resource needs;
- carry out research;
- finance the research;
- disseminate the results of research;
- use or adapt the results of the research; and
- benefit from the consequences of the research.

142. The recommended structure of the Research Council is based on the belief that good communications between all these interests is essential at all stages of planning and work throughout the life of the programme. A corporate memory must be established from the beginning.

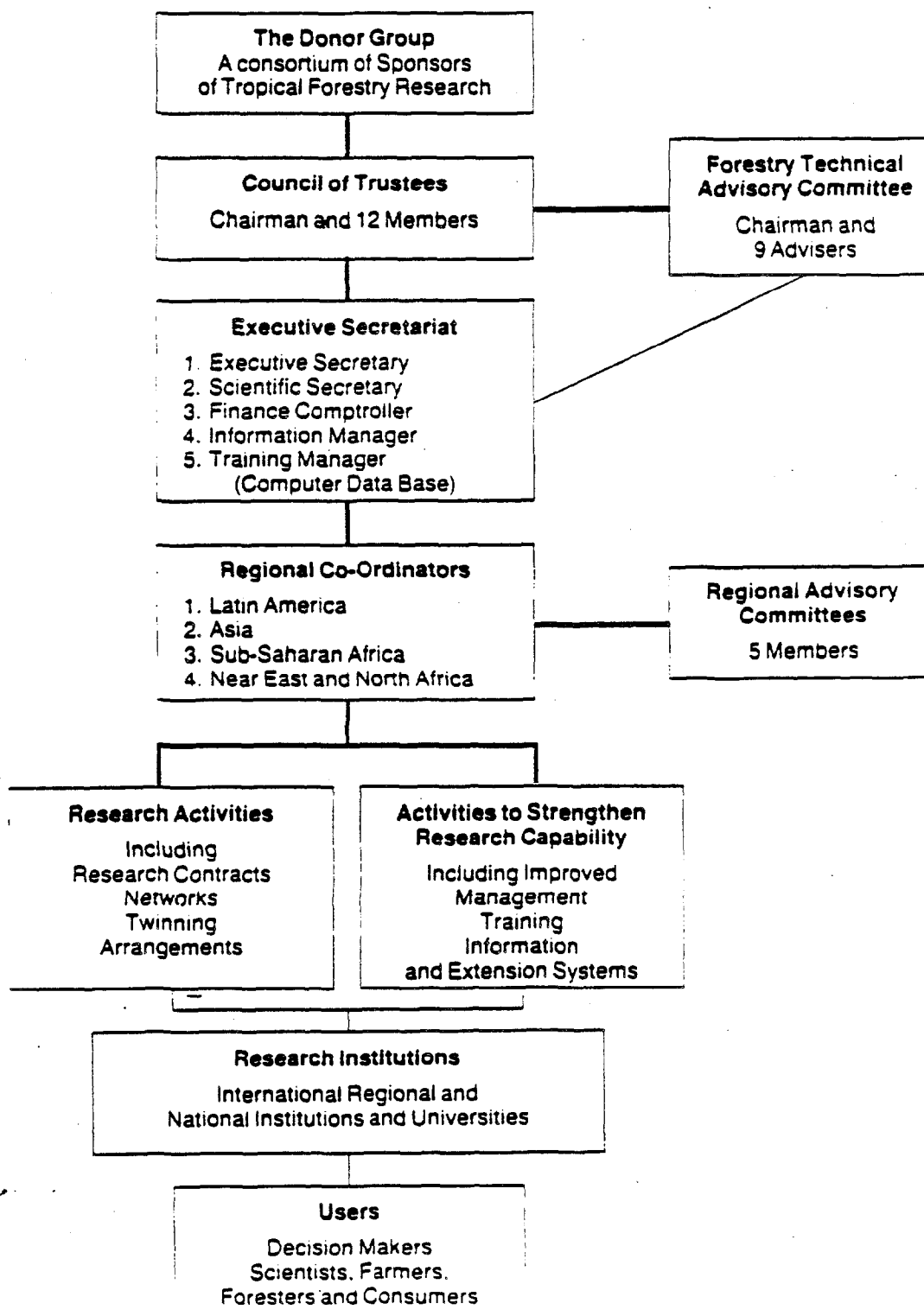
143. The Task Force considered a number of institutional options for managing an international research programme, and proposes the following management structure:

- a Council of Trustees;
- an Executive Secretariat; and
- a Forestry Technical and Advisory Committee (FTAC).

144. Figure 5 on the next page illustrates the component parts essential to a co-ordinated international research programme, and suggests the relations between those who prescribe policy and priorities, those who do research, those who finance, and those who use and adapt the information.

145. The Task Force is convinced that the proposed Council and the Tropical Forestry Research Programme must function as a complete entity, whether it stands alone or is eventually absorbed into the CGIAR system.

Figure 3: The Framework for an International Tropical Forestry Research Council:



Council of Trustees

146. The Council of Trustees will govern the entire system. Figure 5 shows the Council of Trustees answering to a Donor Group comprising a consortium of sponsors of tropical forestry research. The size, composition and frequency of meeting of this group depend entirely on the wishes of the donors concerned. It seems possible that one meeting of such a group each year could be closely associated with the CGIAR itself and its Centres Week.

147. The Council of Trustees will be responsible for:

- i) formulating policy and decisions on finance and procedures;
- ii) assessing research priorities and resource needs;
- iii) attracting donor support and recommending resource allocations; and
- iv) prescribing the responsibilities and activities of the Executive Secretariat.

148. In formulating its policies, the Council will be assisted by a Forestry Technical Advisory Committee (FTAC) and will also consult with the Directors of its various research components, with countries which the programme is designed to benefit, and with donors.

149. The Council should be composed of people with broad experience in the management of science and technology for development, and include competence in institutional, financial and human resource management. The Trustees would meet twice per year, and would comprise not less than 13 members including a Chairman of broad experience in international development. Other members should be nominated from contributing donors, by developing countries, by NGOs, by scientific bodies including IUFRO, by international agencies including FAO and by the CGIAR.

Forestry Technical Advisory Committee (FTAC)

150. The FTAC will have responsibilities similar to those of the CGIAR TAC. It will advise the Council on strategic, scientific, and organizational issues related to research priorities, programmes and procedures. The FTAC will formulate and implement procedures for monitoring progress and for periodic review and evaluation of the results of the overall programme and its components.

151. The FTAC will have a heavy workload, and it is recommended that it consists of a Chairman and nine members who are active research scientists drawn from a broad spectrum of the natural, physical and social sciences.

The Executive Secretariat

152. The Executive Secretariat will provide services to the Council of Trustees and to the FTAC, and the various programme components. In turn, it will receive policy instructions and technical guidance from the Council and the FTAC, respectively. It is envisaged that the Secretariat should consist of a core group of permanent staff with resources to employ consultants and to contract other contract services if needed. The core should comprise:

- an Executive Secretary;
- a Scientific Secretary (Secretary of FTAC);
- a Financial Comptroller;
- an Information Manager; and
- a Training Manager.

153. An important responsibility of the Secretariat will be the systematic collection, analysis, storage and dissemination of the relevant data and information on tropical forestry research. The Secretariat will maintain a computerized data and information base and have on-line access to other data and information bases. The information will be derived primarily from its own programmes. Any additional material should fill identified gaps in existing databases to which the Research Council can gain direct access. The Task Force regards the information system as a vital component, and recommends that the Information Manager be appointed as soon as possible after the Council has selected its Executive Secretary.

154. The question of location of the Central Secretariat is of supreme importance. The criteria of good communications, ease of travel, access to information, stimulating environment and contacts with professional peers, and good quality office accommodation and services are all crucial aspects. This question needs to be discussed and resolved without delay by the appropriate donor group and executing agent (see below).

155. The Secretariat will also include an out-stationed group of Regional Co-ordinators based in:

- Latin America;
- Asia;
- Sub-Saharan Africa; and
- the Near East and North Africa.

156. The regional co-ordinators should be located in or near an appropriate existing Research Institute in the region concerned. Each would be supported by at least one permanent Scientific Assistant, an Information/Training Officer, and a part-time Advisory Committee of not more than five members from a range of disciplines, and including an NGO representative.

157. The Task Force attaches great importance to the regional strength of the Research Council and therefore has proposed regional units which will serve as the field focus for much of its work. The Regional Co-ordinators will be responsible, working through the Secretariat, for:

- advising the Technical Advisory Committee;
- identifying regional needs;
- generating and formulating projects and networks;
- liaison with donors on implementation of approved projects and networks, and overall co-ordination of these networks;
- training and human resources development; and
- developing and putting to use a regional database and information system.

158. The possibility of upgrading the regional units into Regional Research Centres must not be excluded if this is necessary in order to strengthen research capacity in a region, or in order to develop a defined field of research, e.g., genetic improvement of selected tree species. The Task Force feels that the starting base for the Research Council should be the organization here outlined, with options open for more direct involvement in research if the need arises at a future date.

The Activities of the Research Council

159. The activities recommended for the Research Council are wide-ranging and diverse. In essence, they come down to the provision of a central service to donors and research agencies which offers a sound overview of the needs and resources for research in tropical forestry, a source of information and ideas, and a means of well-informed evaluation of strategic options. Given high-calibre staff, the Research Council system can stimulate and serve as a catalyst for donors and research agencies by generating relevant and well-thought-out project proposals, which will attract funds and raise the quality of work.

160. As well as promoting and supporting research by various means, a vitally important part of the work of the Council will be to raise the standards of work and raise the level of research capability in tropical countries. The correct balance will have to be struck in order to make certain that research investment is preceded by steps to ensure a high standard of research performance.

161. The Council's activities can be broadly grouped under two headings:

A - Improving Research Capability in Tropical Countries by:

- i) improvement of information systems for the capture, storage, retrieval, and dissemination of scientific and technical data through project definition and support, training and advice;
- ii) improvement of extension systems;

- iii) training of research personnel in the management and conduct of research through courses, manuals, handbooks, etc.;
- iv) reform and improvement of research organization and management at national level by giving advice and by commissioning studies through ISNAR and other agencies; and
- v) institution-building in the form of facilities and equipment on a selective basis. This includes, where appropriate, upgrading of Research Centres with the potential to meet closely-defined needs or gaps.

B - Research Activities by:

- i) "facilitating" research through analysis, advocacy and debate in order to generate ideas and well-planned "fundable" project proposals which attract donors and also help research agencies. These ideas and insights on research projects and priorities will be the product of analysis and debate by the Research Council and its consultants, as well as co-ordinated regional (or subject-aligned) research workshops;
- ii) building up a tropical forestry research programme will be built up under a Strategic Plan to be reviewed annually. It will be executed by a variety of methods, but mainly by:
 - establishment of regional research project networks with clearly-defined objectives, and under strong leadership;
 - encouragement of "twinning" as a means of effective collaborative research where appropriate;
 - contracting of research projects with individual institutions, agencies and groups; and
 - undertaking special projects at research centres or by research groups which are funded by donors through the Research Council.

162. It is anticipated that much of the research funding will come via bilateral support for clearly-defined projects which may or may not involve the Council controlling and dispensing the funds. The theme has to be flexibility and funding to encourage all kinds of initiatives -- existing and new -- providing there is secure long-term core funding to support the "institution" of the Research Council and a number of key research activities.

Financial Requirements

163. The preliminary cost estimates for the Research Council system and its operation are presented below. These show the breakdown between the components of start-up expenses, the central and regional structure, and the cost of research and research improvement activities. Apart from start-up costs, the estimates are for recurrent annual costs commencing in 1990 for the Research Council, and developing over the period 1990-1995 for research activities. A breakdown of these estimates is shown in tabular form in Annex 4.

US\$ Millions

- | | | |
|----|--|------|
| 1. | Start-up costs for the Research Council organizations: | 0.5 |
| 2. | The Research Council system -- annual costs for its Central and regional organization, i.e., the Council of Trustees, the FTAC, and the Central Secretariat: | 3.0 |
| 3. | The Council's research activities -- annual external support for research and improved research capability, rising progressively over the 1990-1995 period to: | 50.0 |

164. The budget lacks precision at this stage of planning. However, the estimates can be relied upon for purposes of taking decisions on follow-up action.

165. Concerning the research activities, the Task Force has made its case for a substantial increase and re-orientation of current inputs. Also, IUFRO, through its SPDC regional workshops, has prepared well-documented recommendations for research in improvement of multi-purpose tree species in Asia, Africa and Latin America, totalling US\$20 million per annum, and for forest utilization and forest products research at some US\$10 million per annum. Taken together with estimates for new work required in the fields of conservation and policy research, this adds up to the broad estimate of US\$50 million per annum by 1995 in addition to the estimated current support level of US\$46 million per annum.

166. With this projected increase, total expenditure in external assistance would amount to some US\$90-US\$100 million per annum. It is not considered that this is in any way out of scale with the magnitude of the problems that exist or with the prospects and benefits of success from well-planned research. The actual development of research investment up to 1995 and later would, of course, depend on much more detailed evaluation by the Research Council in consultation with all the interests concerned.

Post-Conference Action

167. If the Conference accepts the Task Force's recommendations, a follow-up meeting of potentially interested donors should be convened as soon as possible. This meeting could:

- consider the proposed plan for a Research Council;
- appoint an executing agency;
- agree on a programme of work and procedure; and
- indicate probable patterns and levels of support.

168. Thereafter, the first step should be to appoint the Council of Trustees, which in turn will be responsible for the appointment of the members of FIAC and the senior staff of the Secretariat. It is anticipated that the Council and the FIAC would meet twice every year, including once per year at the same time and place.

169. The executing agency will need to perform several tasks in the interim period:

- formulating a constitution;
- selecting the headquarters location;
- negotiating conditions of residence, privileges and immunities with the government of the country in which the headquarters is to be located (the advice of the CGIAR should be sought in formulating the constitution and in defining the Council's legal personality); and
- arranging the selection and election of the Council members, whose first responsibility would be to draw up a detailed work programme.

170. Concerning sources of finance, the Council needs to identify those donors who are willing to contribute to unrestricted core budgets and those who insist upon bilateral external funding. It seems likely that the Council will need to impress upon donors the necessity for a global perspective. While the needs of Africa may appear to be the most urgent, the absorptive capacity of African research institutions is lower than in Asia, Latin America and some Middle Eastern countries. It will be necessary to convince donors to contribute in a rational and logical fashion with due regard to the institutional capabilities of the different regions and nations.

171. The inventory of forestry research projects and programmes being assembled by the World Bank's SPAAR Secretariat should provide useful information both to the Council and to donors who support research in Africa. It would clearly be valuable if similar sets of information could be assembled relative to donor support for forestry research in Asia, the Middle East and Latin America.

STATEMENT
OF
THE BELLAGIO STRATEGY MEETING ON TROPICAL FORESTS

1 and 2 July 1987

A conference at Bellagio, Italy, on the state of the world's tropical forests called upon world leaders to join in a "Tropical Forestry Action Plan" aimed at conservation and sustainable use of remaining natural tropical forests for the benefit of developing-country populations and the world at large.

THE TROPICAL FOREST CRISIS

Tropical forests are being rapidly destroyed. Their loss is one of the most serious environmental threats of our time.

Tropical deforestation in developing countries is having a devastating effect on food production, fuelwood and fodder supplies, soil fertility, and water resources. It is undermining agriculture in these countries and exacerbating rural poverty. Specifically:

- more than half of the world's tropical forests have disappeared since the turn of the century;
- the current rate of deforestation exceeds 11 million hectares a year;
- the livelihood of 200 million forest dwellers is threatened;
- more than one billion people are suffering from shortages of fuelwood and fodder;
- developing-country imports of forest products already exceed US\$10 billion;
- the destruction of tropical forests is resulting in widespread loss of unique ecosystems, directly contributing to the extinction of plant and animal genetic resources; and
- more than half of the developing world's population live in the 56 most critically-affected countries.

The causes of deforestation are well known. They include population pressure for agricultural land, the demand for fuelwood and fodder, the unsustainable exploitation of forests for industrial timber production and export, and inappropriate government policies regarding land tenure, economic incentives, forest settlement, and other population issues. Development assistance agencies contribute to the problem when they finance environmentally unsound large-scale development projects.

The Tropical Forestry Action Plan has focussed world attention on this crisis. The plan has been endorsed by forestry leaders of more than 60 developing countries and has been accepted as a basis for action by a score of bilateral and multilateral development assistance agencies. A doubling of annual forestry assistance in support of the plan has been pledged, from US\$500 million in 1984 to US\$1 billion in 1988.

THE CONFERENCE RECOMMENDATIONS

The Bellagio conference shares the sense of urgency for global action called for in the Tropical Forestry Action Plan. It concentrated on 10 major recommendations for addressing the crisis of deforestation.

1. Quantifying the Costs of Inaction

Tropical deforestation has been ignored or inadequately reflected in most government development plans. Action is needed on a country-by-country basis to specify the consequences for human welfare and the environment of the failure to contain deforestation. This is a necessary first step to generating political awareness and commitment.

2. Incorporating Recommendations for Action into National Development Plans

The urgency of the forestry crisis must be communicated to national economic planners and to financial and political leaders. Within five years, all of the critically-affected countries should have incorporated into their national development plans a long-range strategy for conservation and sustainable use of their tropical forests.

3. Promoting Community Participation

Developing countries should be assisted to implement a major programme for involving men and women of local communities in forest conservation and tree planting. Non-governmental organizations have a critical role to play in promoting action to save tropical forests and in assuring grassroots participation. Special attention should be given to reclamation of agricultural wasteland and degraded watersheds.

4. Encouraging Participation of the Private Sectors

Government forest administrations on their own cannot cope with this crisis. Policy incentives should be introduced that would provide the necessary stimulus for private sector participation in reforestation and sustainable forest management, particularly by small farmers and local communities. Women, who are the main harvesters and users of wood, should be more directly involved in formulating rural forest policies. Private industry should be encouraged through fiscal incentives and similar programmes to undertake large-scale industrial forest management and reforestation projects within a suitable legal framework which ensures net replenishment of forest resources.

5. Policy Reforms

Policy reform is needed from both national governments and development assistance agencies. National governments should, for example, act to remove subsidies and other inappropriate policies that encourage economic inefficiency and over-harvesting of forest resources. Development assistance agencies should, for example, revise policies that are contributing to the destruction of natural ecosystems, and design project strategies that favour protection of these valuable resources.

6. Protecting Tropical Forest Ecosystems

Concerted international support should be given to a campaign for protecting the 700 million hectares of remaining tropical rain forest, the planet's greatest source of plant and animal diversity. This can be achieved by major expansions of protected areas and biosphere reserves. By encouraging more intensive and profitable use of degraded forest land, pressure on protected areas can be relieved.

7. Integration of Forestry into Broader Land-Use Concerns

Important solutions to deforestation will come from outside the forestry sector. Increasing farmers' agricultural productivity provides an alternative to forest encroachment. Energy conservation programmes can be a cost-effective strategy for saving forests. Such solutions to deforestation will be discovered and implemented only if forestry planning is integrated with planning in other sectors.

8. Strengthening Research

Technical, biological, socio-economic, and policy research must be intensified. As an example, there is significant potential to raise the productivity of multi-purpose trees through breeding and biotechnology, thereby helping to meet rural basic needs. Substantially-increased

funding for such research will be necessary, and opportunities should be examined for establishing a consultative group for international forestry research and policy development, with a vision and determination comparable to the one organized for agriculture on this same conference site almost 20 years ago.

9. Monitoring of Tropical Deforestation

An annual review of the status of world forest resources and of progress being made in halting forest destruction is urged. In addition to government and aid agency assessments, citizen reports should be encouraged on grassroots evaluation of whether national progress is being made in arresting deforestation.

10. Co-ordinating International Action

The Tropical Forestry Action Plan provides an effective framework for co-ordinating international action. To help governments of developing countries to implement the plan, the Food and Agriculture Organization is supporting efforts to co-ordinate bilateral and multilateral agency assistance for strengthening forestry sector planning.

FOLLOW-UP ACTION

An international task force will immediately begin to prepare specific recommendations for policy responses, funding strategies, and institutional mechanisms necessary to implement these and related recommendations. A second Bellagio forestry conference, to be held next year, will review the task force recommendations and make proposals for their adoption.

Agreed at Bellagio, Italy

2 July 1987

The Bellagio Strategy Meeting on Tropical Forests was convened under the auspices of:

Food and Agriculture Organization of the United Nations
The World Bank
United Nations Development Programme
World Resources Institute
The Rockefeller Foundation

ANNEX 2

The Bellagio II Task Force on Tropical Forestry Research

GEORGE D. HOLMES (Chairman)

- 1984-86 Chairman of the Committee on Forestry, Food and Agricultural Organization of the United Nations
- 1977-87 Director-General of the British Forestry Commission
- 1977-87 Chairman, Standing Committee on Commonwealth Forestry
- 1970-78 Member of IUFRO's Executive Board, and member of its International Council for five years
- 1948-75 Research Silviculturist of Alice Holt and Director of Research, Forestry Commission

ACHOKA AWORI

- 1982-88 Executive Co-ordinator, Kenya Energy and Environment Organization Association (KENGO)
- 1986-88 Member, National Energy Research Committee
Member, Board of Africa Development Informatics
- 1985-88 Member, Board of the Foundation for Woodfuel Development
Member, National Agroforestry Research Committee
Member, National Committee on Genetic Resources Conservation
- 1984-88 Member, Board of the Environment Liaison Centre International (ECC)
- 1983-88 Member, National Committee on Woodfuel Conservation

RONNIE DE CAMINO

- 1985 Head of the Forestry and Agroforestry Production Area; Regional Co-ordinator, Tree Crops Production Project, Agronomical Tropical Center for Research, and Training (CATIE), Costa Rica.
- 1977-84 Planning and Research Manager, National Reforestation Company (CONARE), Venezuela.
- 1975-76 Guest Researcher, University of Goettingen, Federal Republic of Germany.
- 1967-74 Director, Forestry School, Austral University, Chile. Head, Forest Management and Economics Institute.
- 1964-67 Land Reform Corporation, Forestry, VIII Region.

MOHAMED HOSNY EL-LAKANY

- 1985- Associate Director, Desert Development Center, American University in Cairo
- 1983- Professor of Forestry, Alexandria University
- 1981/82 Visiting Fellow, Australian National University/CSIRO, Australia
- 1969 Ph.D., Tree Improvement, University of British Columbia, Canada
- Consultant: IDRC, FAO, Georgia Tech., AID, ALECSO, AAAI
Member: NFTA; CASAFA; IUFRO (Leader Working Group on Casuarina); Canadian Institute of Forestry; Egyptian Society of Genetics

HANS GREGERSEN

- 1970- Professor, University of Minnesota. Joint appointment in Forest Resources and Agricultural and Applied Economics
- 1968-70 Research Associate, School of Natural Resources, University of Michigan
- 1965-68 Forestry Officer, Food and Agriculture Organization of the United Nations

Since 1970, Professor Gregersen has served as a consultant to many international organizations, including the World Bank; Inter-American Development Bank; FAO; OECD and USAID

ANNEX 2

PETER T. HAZLEWOOD

- 1983 - Associate, Forests and Biodiversity Program, World Resources Institute, Washington, D.C.
- 1982 Research Associate, Yale School of Forestry and Environmental Studies, New Haven, Connecticut
- 1981 Intern, Bureau of Oceans and International Environmental and Scientific Affairs, Office of Environment and Natural Resources, U.S. Department of State, Washington, D.C.
- 1979-80 Consultant, Bureau for Science and Technology, Office of Forestry, Environment, and Natural Resources, Agency for International Development, Washington, D.C.

LOUIS E. HUGUET

- 1985- Independent consultant (IBRD, UNDP, FAO and others)
- 1980-85 Director-General, Centre Technique Forestier Tropical, France
- 1968-80 Director, Forest Resources Division, FAO, and Chairman, FAO Group on Environment
- 1964-68 Regional Director, Forest Service, South of France

JOSEPH H. HULSE

- 1984-88 Vice-President, Research Programmes, International Development Research Centre (IDRC), Canada
- 1978-88 Chairman, ICSU International, Commission on the Application of Science to Agriculture, Forestry and Aquaculture
- 1970-84 Director, Agriculture, Food and Nutrition, IDRC
- 1966-70 Head, Food and Agricultural Industries, FAO

Has undertaken numerous international consultancies for different organizations and been associated with the CGIAR system since its inception.

DOMINIC E. IYAMABO

- 1987- IUFRO Research Co-ordinator for Africa.
- 1984-87 Co-ordinating Director of Science & Technology, Federal Ministry of Science and Technology, Lagos, Nigeria.
- 1977-84 Director of Agricultural Sciences, Federal Ministry Science and Technology, Lagos.
- 1975-77 Executive Secretary, Agricultural Research Council of Nigeria (ARCN), Ibadan, Nigeria.
- 1971-75 Director, Forestry Research Institute of Nigeria (FRIN), Ibadan.

Has served as Nigerian representative in the CGIAR; member, CGIAR Review Committee; member, IITA Board of Trustees; member, IUFRO International Council

ARVIND K. KHARE

- 1983- Programme Officer, Society for Promotion of Wastelands Development, New Delhi.
- 1982-83 Consultant to National Council of Applied Economic Research.
- 1975-82 Worked in rural areas of Rajasthan and Madhya Pradesh.
- 1973-75: Gujarat State Financial Corporation, Ahmedabad, initially evaluating term-lending proposals and subsequently heading Foreign Exchange Loans Department under IDA line of credit.

PETER A. ORAM

- 1986- Research Fellow Emeritus, International Food Policy Research Institute
- 1982-84 On secondment to ISNAR, responsible for developing research programme
- 1976-86 Deputy Director, IFPRI
- 1971-76 Head, Research Development, FAO
First Executive Secretary to Technical Advisory, CGIAR
- 1969-71 Assistant Director, Policy Advisory Bureau, FAO

ANNEX 2

SALLEH MOHD. NOR

- 1985- First Director-General, Forest Research Institute of Malaysia
- 1977-85 Director, Forest Research Institute, Kepong, under Forestry Department, Peninsula of Malaysia
- 1974-77 Graduate Research Assistant in remote sensing, Remote Sensing Project, Michigan State University, East Lansing
- 1970-73 Counterpart to FAO expert in forestry inventory on UNDP project

Positions include Honorary Vice-President, International Society for Tropical Forests; Vice-President, IUFRO 1986-90; President, Malayan Nature Society, 1978-present; has served as consultant to various international organizations, including UNDP, IDRC and Asian Development Bank

M.S. SWAMINATHAN

- 1982-88 Director-General of International Rice Research Institute, Philippines
- 1980-82 Member, Planning Commission, Department of Agriculture, Government of India
- 1980 Acting Deputy Chairman, Planning Commission
- 1979-80 Secretary to Government of India
- 1972-79 Director-General of Indian Council of Agricultural Research and Secretary to Government of India

Holds many international positions, including Honorary President of IUCN since 1984; Vice-President, World Wildlife Fund; also recipient of many international awards and honorary degrees.

LIST OF BACKGROUND PAPERSBackground Papers Commissioned
by the Task Force

- | | | |
|-----|--|---------------------------------------|
| 1. | Forestry Research Priorities for Underpinning the Tropical Forestry Action Plan | J. Spears |
| 2. | The Global Tropical Forestry Research System: Present Situation, Needed Improvements | H.M. Gregersen |
| 3. | Forestry Research in Africa: Problems, Priorities and Needs | D.E. Iyamabo
M.H. El Lakany |
| 4. | Opportunities for Forestry Research in North Africa and the Near East | M.H. El Lakany |
| 5. | Forestry Research in French-Speaking Tropical Africa: Ongoing Activities, Needs and Prospects | L. Huguet |
| 6. | Priority Issues on Forestry Research: An African NGO Perspective | A. Awori |
| 7. | Forestry Research Needs and Opportunities in Tropical Asia | Salleh Mohd. Nor
Abdul Manap Ahmad |
| 8. | Forestry Research: An Asian NGO Perspective | A. Khare |
| 9. | Some Considerations about Tropical Forestry Research in Latin America | R. de Camino |
| 10. | Perspectives of NGO Organizations on Natural Resource Research in Latin America | R. Solorzano |
| 11. | A Summary of the Three (NGO) Background Papers (Africa: Awori; Latin America: Solorzano; Asia: Khare;) Submitted to the Task Force | A. Khare |
| 12. | Information Management for Expanded Tropical Forestry Research | D.W. Rose |
| 13. | Tropical Forestry Research Programme: Institutional Alternatives | J.H. Hulse |
| 14. | Networks as a Research Modality | P.A. Oram |
| 15. | The Technical Advisory Committee (TAC) to the CGIAR | P.A. Oram |

ANNEX 3

Other Background Papers

- | | | |
|-----|---|-------|
| 16. | An Expanded Proposal for an INCOFORE System | IUFRO |
| 17. | Review of International Co-operation in
Tropical Forestry - Secretariat Note | FAO |

PRELIMINARY ANNUAL COST ESTIMATES
FOR AN INTERNATIONAL TROPICAL FORESTRY RESEARCH COUNCIL
FOR 1990-1995

A. THE COUNCIL OF
TRUSTEES AND THE
FORESTRY TECHNICAL
ADVISORY COMMITTEE
(FTAC)

(1) <u>THE COUNCIL OF TRUSTEES</u>	US\$
13 Trustees @ an average of \$3,000 flat honorarium per annum.	39,000
An average of \$3,000 per Trustee for travel and per diem for each of two meetings per annum.	78,000
Council meeting costs (including facilities, guests, support).	25,000
TOTAL (1)	142,000
(2) <u>THE FORESTRY TECHNICAL ADVISORY COMMITTEE (FTAC)</u>	
10 Members @ an average honorarium of \$1,500 per meeting for three meetings per annum.	45,000
An average of \$3,000 per Member for travel and per diem for each of three meetings per annum.	90,000
Consultants: Fees, travel and per diem.	100,000
TOTAL (2)	235,000
TOTAL (A)	377,000

B. CENTRAL
ADMINISTRATION

(3) <u>STAFF COSTS</u>	
Executive Secretary:	130,000
Scientific Secretary:	75,000
Financial Comptroller:	65,000
Information Manager:	60,000

ANNEX 4

Training Manager:	60.
4 Support Staff:	110.
TOTAL (3)	500.

(4) OFFICE COSTS

Space Rental:	300.
Communications/Supplies/ Reproduction.	25.
Legal and Audit fees.	10.
TOTAL (4)	335.

(5) COMPUTER SERVICES

40.

(6) PUBLICATIONS

(Annual Report,
General Brochures,
Newsletter,
Research Reports,
Mailing Costs, and
Database)

TOTAL (6) 145.**(7) STAFF TRAVEL****TOTAL (7)** 100.**TOTAL (B)** 1,120.**C. REGIONAL
ADMINISTRATION****(8) STAFF COSTS**

4 Co-ordinators	300.
4 Scientific Associates	240.
4 Information Officers	200.
Post allowances: @ 30% of salaries.	222.
Staff travel and per diem.	200.
TOTAL (8)	1,162.

<u>TOTAL ADMINISTRATION COSTS</u>	(9) Administrative Support for National Institutions (space, support staff, and office operations)	
	TOTAL (9)	300,000
	TOTAL (C)	1,462,000
	TOTAL A.B.C.	2,959,000
<u>D. START-UP COSTS</u>	Equipment/furniture	200,000
	Staff relocation	250,000
	Legal fees	30,000
	TOTAL (D)	480,000
<u>E. SUPPORT FOR RESEARCH AND STRENGTHENING RESEARCH CAPABILITY</u>	This is an estimate of the annual level of additional external support that would be needed by 1995 for research and related strengthening of research capability. The estimate includes direct bilateral and multilateral support that may not pass through the Council.	
	TOTAL (E)	50,000,000

- * FOOTNOTE: (i) Items A, B, and C are estimated current annual costs
for the period 1990-95.
(ii) Item D refers to start-up costs in 1990.

References

- Achlil, K. 1984. A Decrease of Runoff and Sediment Transport in the Kali Dumpul Subwatershed. Pp. 93-107 in Proceedings of a Seminar on Researches for Productive and Protective Watershed Resources in the ASEAN Region, 27-31 August, 1984, Forestry Training Centre, Bogor, Indonesia. College, Laguna, Philippines: ASEAN-US Watershed Project.
- Anderson, A., E. Susly Anderson, and J. Ewel. 1987. People and the Palm Forest: Biology and Utilization Babassu Forests in Maranhao, Brazil. In Lugo *et al* (eds.) People and the Tropical Forest: A Research Report from the United States Man and the Biosphere Programme. Washington, D.C.: U.S. Department of State. 75pp.
- Anderson, D. 1987. The Economics of Afforestation: A Case Study in Africa. Occasional Paper Number 1/New Series. Baltimore: Johns Hopkins Press.
- Araji, A. A. 1981. The Economic Impact of Investment in Integrated Pest Management. Research Bulletin 115, Agricultural Experiment Station, University of Idaho. 27 p.
- Arnold, J. E. M. n.d. Research Needs and Opportunities in Tropical Forestry: Policy Research. Prepared for the Rockefeller Foundation. 10 pp.
- Arnold, J.E.M. 1987. Economic Considerations in Agroforestry. pp. 173-190 in Steppler and Nair (eds.) 1987. Nairobi, Kenya: ICRAF.
- Arnold, J.E.M. and J. Falconer. 1987. The Socio-Economic Dimensions of Forestry and Food Security. Background Paper for the Expert Consultation on Forestry and Food Production/Security, Bangalore, India, 14-20 February, 1988. Rome: FAO of the United Nations.
- Bengston, D. N. 1984. Economic Impacts of Structural Particleboard Research. Forest Science 30(3):685-697.
- Bengston, D. N. 1985. Aggregate Returns to Lumber and Wood Products Research: An Index Number Approach. pp. 62-68 in: Forestry Research Evaluation: Current Progress, Future Directions, C. D. Risbrudt and P. J. Jakes (eds.). General Technical Report NC-104. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station. 140 p.
- Bengston, D. N. 1986. Research Capacity in Developing Countries: An Evaluation of Public Forestry Research Institutions. Ph.D. diss., University of Minnesota, St. Paul. 205pp.

- Bengston, D. N. 1988a. Researcher Incentives in Developing Countries: An Evaluation Approach and Application in Forestry. Presented at the International Conference on Technology Management, Feb. 17-19, 1988, Miami, FL. 12 pp.
- Bengston, D. N. and H. M. Gregersen. 1985. Forestry Research and Income Redistribution. In: IUFRO Proceedings, Evaluation and Planning of Forestry Research S6.06 and S6.06.01, Denver P. Burns (compiler), Colorado State University, Fort Collins, CO. July 25-26, 1985. pp. 117-122.
- Bengston, D. N. and H. M. Gregersen. 1988a. What Influences Forestry Research Capacity in Developed and Less-Developed Countries? *Journal of Forestry* 86(2):41-43.
- Bengston, D. N. and H. M. Gregersen. 1988b. Forestry Research Capacity in Developing Countries: A Review of Issues and Findings. University of Minnesota, Center for Natural Resource Policy and Management Studies, Working Paper no. 4. 38 pp.
- Bengston, D. N. and H. M. Gregersen. 1988c. Income Redistribution Impacts of Technical Change: A Framework for Assessment and Empirical Evidence. In: Proceedings of the First International Conference on Technology Management, Geneva, Switzerland. Interscience Press.
- Bengston, D. N., H. M. Gregersen, A. L. Lundgren, and L. S. Hamilton. 1987. Forestry Research Capacity in the Asia-Pacific Region: An Evaluation Model and Preliminary Assessment. East-West Environment and Policy Institute, Occasional Paper no. 6. 96 pp.
- Bengston, D. N., Zhi Xu, and H. Gregersen. 1988. Key Factors in Strengthening Forestry Research Capacity in Developing Countries. Forthcoming as a Working Paper from the Centre for Natural Resources Policy and Management Studies, University of Minnesota, St. Paul, MN 55108. 27 pp.
- Brune, A. and B. Zobel. 1981. Genetic Base Populations, Gene Pools, and Breeding Populations for Eucalyptus in Brazil. *Silvae Genetica* 30: 146-149.
- Brunner, A. D. and J. K. Strauss. 1987. The Social Returns to Public R & D in the U.S. Wood Preserving Industry: 1950-1980. SCFER Working Paper No. 35. Research Triangle Park, NC: Southeastern Center for Forest Economics Research. 36 p.
- Buckman, Robert E. 1986. Bringing Forest Sciences to Bear on Socio-Economic Problems of the Developing World. Congress Report: 18th IUFRO Congress, Ljubljana, Yugoslavia. pp 433-451.

- Buckman, Robert E. 1988. The Role of Science in Tropical Forestry -- Toward an International System for Forestry Research. The H.R. Macmillan Lectureship in Forestry, University of British Columbia, January 21, 1988. 15 pp.
- Burley, J. 1982. Obstacles to Tree Planting in Arid and Semi-Arid Lands: Comparative Case Studies from India and Kenya. Paper NRTS-18/UNUP-391. Tokyo: The United Nations University.
- Butynski, T. and W. Von Richter. 1974. In Botswana Most of the Meat is Wild. *Unasylva* 26(106): 24-29.
- Callahan, Robert Z. 1981. Criteria for Deciding About Forestry Research Programs. Gen. Tech. Report WO-29. Washington, D.C.: USDA Forest Service. 29 pp.
- Callahan, Robert Z. 1988. An Expanded Proposal for the INCOFORE System (International Consultative Organization for Forestry Research). Austria. Various pagings.
- Carlson, L and K. Shea (compilers). 1986. Increasing Productivity of Multi-Purpose Lands. Proceedings of a IUFRO Research Planning Workshop for Africa Sahelian and North Sudanian Zones, Nairobi, Kenya, 9-15 January 1986. Hull, Canada: Canadian Forestry Service. 333 pp.
- Chaperon, H. 1978. Particularites de l'Amelioration Genetique de Eucalyptus au Congo Brazzaville. Proceedings of the Third-World Consultation Forest Tree Breeding, 21-26 March, 1977, Canberra, Australia, pp. 579-591.
- Chijicke, E. 1980. Impact on Soils of Fast-Growing Species in Lowland Humid Tropics. FAO Forestry Paper 21. Rome: FAO of the United Nations. 111 pp.
- De Camino, R. 1987. Incentives for Community Involvement in Conservation Programmes. FAO Conservation Guide 12. Rome: FAO.
- Deweese, P. 1988. The Woodfuel Crisis Reconsidered: Observations on the Dynamics of Abundance and Scarcity. (Forthcoming in World Development)
- Dommergues, Y. 1987. The Role of Biological Nitrogen Fixation in Agroforestry. pp. 245-272 in Steppeler and Nair (eds.). Nairobi, Kenya: ICRAF
- Dourojeanni, M. 1978. The Integrated Management of Forest Wildlife as a Source of Protein for Rural Populations. Eighth World Forest Congress, Agenda Item No. B.FFF/8-0.

- El-Lakany, M. H. 1987. The Importance of Shelterbelts in Egyptian Agriculture. Paper presented at the International Symposium on Windbreak Technology, Lincoln, Nebraska.
- Ellefson, Paul V. 1986a. Forest Sector Planning: Linking Forestry Interests with National Goals for Economic and Social Development. In: Forestry Legislation, Schmithüsen, Franz (ed.), Report of the IUFRO Working Party S4.06-04, Forstwissenschaftliche Beiträge 4. pp. 49-61.
- Ellefson, Paul V. 1986b. Decisions About Public Forestry Programs: The Role of Policy Analysts and Analytical Tools. Resource Management and Optimization 4(1):65-77.
- Enriquez, G. 1983. Breve Resumen de los Resultados del Experimento Central de Plantas Perennes de La Montaña. In L. Babbar (ed), Curso Corto Intensivo: Prácticas Agroforestales con Énfasis en la Medición y Evaluación de Parámetros Biológicos y Socioeconómicos. Turrialba, Costa Rica, 1983. Contribuciones de los Participantes. Turrialba: CATIE.
- Falconer, J. 1987. Forestry and diets. Paper prepared for the Expert Consultation on Forestry and Food Production/Security, Bangalore, India, 14-20 February 1988. Rome: FAO of the United Nations.
- FAO of the United Nations. 1984a. Survey of Wood Energy Research and Development Capabilities in Africa. Secretariat Note FO:WERD/A/84/9 for Technical Consultation on Wood Energy Research and Development in Africa. Addis Ababa, Ethiopia, 27-30 November, 1984. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1984b. Co-operation in Wood Energy Research and Development. Secretariat Note FO:WERD/A/84/10 for Technical Consultation on Wood Energy Research and Development in Africa. Addis Ababa, Ethiopia, 27-30 November, 1984. Rome: Food and Agriculture Organization of the United Nations (FAO). 22 pp.
- FAO of the United Nations. 1984c. Forestry Research in Asia and the Pacific Region - a Review. Report of Ad Hoc Study Group on Forestry Research FO:APFC/84/4 for Asia-Pacific Forestry Commission, Twelfth Session. Bangkok, Thailand, 19-23 March, 1984. Rome: Food and Agriculture Organization of the United Nations (FAO). 6 pp.
- FAO of the United Nations. 1984d. Preliminary Results of a Survey of Forestry Research Capabilities in the Asia/Pacific Region with Particular Emphasis on Fuelwood and Wood Energy. Rome: Food and Agriculture Organization of the United Nations (FAO). 15 pp.

- FAO of the United Nations. 1984e. Preliminary Results of a Survey of Forestry Research Capabilities in the Latin America Region with Particular Emphasis on Fuelwood and Wood Energy. Rome: Food and Agriculture Organization of the United Nations (FAO). 12 pp.
- FAO of the United Nations. 1985b. Tropical Forestry Action Plan. Committee on Forest Development in the Tropics. Rome: Food and Agriculture Organization of the United Nations (FAO). 159 pp.
- FAO of the United Nations. 1986. The State of Food and Agriculture 1985. Rome: FAO of the United Nations.
- FAO of the United Nations. 1986. World Compendium of Forestry and Forest Products Research Institutions. FAO Forestry Paper 71. Rome: Food and Agriculture Organization of the United Nations (FAO). 613 pp.
- FAO of the United Nations. 1987. Small-Scale Forest-Based Processing Enterprises. FAO Forestry Paper 79. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1987a. Overview of Current Forestry research situation and future trends in Africa South of the Sahara. Paper FAO/FORM - Sept. 1987, for the Special Programme for African Agricultural Research (SPAAR) Meeting, Paris, France, 9-10 September, 1987. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1987b. Forestry Research in Developing Countries. Secretariat Note FO: FDT/87/4 for the Eighth Session of the FAO Committee on Forest Development in the Tropics, Rome, 14-18 September, 1987. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1987c. Forestry Research in Developing Countries: Status and Trends. Supplement to Secretariat Note FO: FDT/87/4 for the Eighth Session of the FAO Committee on Forest Development in the Tropics, Rome, 14-18 September, 1987. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1987d. Review of International Co-operation in Tropical Forestry. Secretariat Note FO: FDT/87/3 for the Eighth Session of the FAO Committee on Forest Development in the Tropics, Rome, 14-18 September, 1987. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1987e. International Co-Operation in Tropical Forestry. Supplement to Secretariat Note FO: FDT/87/3 for the Eighth Session of the FAO Committee on Forest Development in the Tropics, Rome, 14-18 September, 1987. Rome: Food and Agriculture Organization of the United Nations (FAO).

- FAO of the United Nations. 1987f. Implementation of the Tropical Forestry Action Plan. Secretariat Note FO:FDT/87/5 for the Eighth Session of the FAO Committee on Forest Development in the Tropics, Rome, 14-18 September, 1987. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1979. Eucalyptus for Planting. FAO Forestry Series, No. 11. Rome: Food and Agriculture Organization of the United Nations (FAO).
- Farnsworth, M. 1976. The Farmer and Shelter. Farm Forestry 18(1):1-6.
- Fisseha, Y. 1987. Basic Features of Rural Small-Scale Forest-Based Processing Enterprises in Developing Countries. pp.31-60 in FAO, 1987.
- Flemming, W. 1983. Phewa Tal Catchment Management Programme: Benefits and Costs of Forestry and Soil Conservation in Nepal. pp. 217-288 in L. Hamilton (ed.) Forest and Watershed Development and Conservation Asia and the Pacific. Boulder: Westview Press.
- Foley, G. 1987. Discussion Paper on Demand Management. Paper prepared for the World Bank Eastern and Southern Africa Regional Seminar on Household Energy Planning, Harare, Zimbabwe, 1-5 February, 1988. (mimeo)
- Fortmann, L. and J. Riddell. 1985. Trees and Tenure: An Annotated Bibliography for Agroforesters and Others. Madison, Wisconsin/Nairobi, Kenya: Land Tenure Centre/ICRAF. 135pp.
- Fox, Glenn. 1986. A Framework for Identifying Public Research Priorities: An Application in Forestry Research. Gen. Tech. Report NC-109. USDA Forest Service, North Central Forest Experiment Station. 21 pp.
- Fox, Glenn. 1987. Models of Resource Allocation in Public Agricultural Research: A Survey. Journal of Agricultural Economics 38(3):449-462.
- Fox, Glenn, Robert E. Evenson and Vernon W. Ruttan. 1987. Balancing Basic and Applied Science: The Case of Agricultural Research. BioScience 37(7):507-509.
- Goodland, R. 1985. Wildland Management Policy. (Background paper for the World Bank's Wildland Management Policy Paper). Washington, D.C.: World Bank (unpublished draft).
- Grayson, A. J. 1987. Evaluation of Forestry Research. Forestry Commission, Occasional Paper 15. Surrey, Great Britain: Forestry Commission, Forest Research Station. 28 pp.

- Gregersen, H. M. 1981. Nonindustrial Private Forests and Forestry for Community Development: Economics and Policy Research Needs. In: Proceedings, XVII IUFRO World Congress, Division 4. Japan. pp. 31-39.
- Gregersen, H. M. 1984. Forestry Research Planning and Evaluation: An International Comparison. In Policy Analysis for Forestry Development, Proceedings of the International Conference, Thessaloniki, Greece, 27-31 August, 1984, Vol. 1, pp. 157-171. Thessaloniki, Greece: Forest Research Institute of Thessaloniki.
- Gregersen, H. M. 1987. Social Science Research Needs for Tropical Forest Management. Prepared for the Rockefeller Foundation. 12 pp.
- Gregersen, H. M. and D. N. Bengston. 1986. Comparison of Forestry Research Planning and Management in IUFRO Member Countries. In paper NE GTR-111, Proceedings, IUFRO Conference on Evaluation and Planning of Forestry Research, Fort Collins, Colorado, 25-26 July, 1985. Upper Darby, PA.: U.S. Department of Agriculture, Forest Service. pp 35-43.
- Gregersen, Hans and Jan Laarman. 1988. Forestry in the Developing World: Economics and Policy Research Needs. University of Minnesota/North Carolina State University. 32 pp.
- Gregersen, H., S. Draper and D. Elz (eds.). 1988. People and Trees: The Role of Social Forestry in Sustainable Development. Forthcoming as a publication of the Economic Development Institute of the World Bank. 369pp.
- Gregersen, H., K. Brooks, J. Dixon, and L. Hamilton. 1987. Guidelines for Economic Appraisal of Watershed Management Projects. FAO Conservation Guide 16. Rome: FAO.
- Hawley, J. G. 1988. Trees and Shallow Landslides. Report on Research in The Asia Pacific Forest Watershed Newsletter, No. 13. (January). Honolulu: East-West Centre, Environment and Policy Institute.
- Haygreen, J., H. Gregersen, I. Holland, and R. Stone. 1986. The Economic Impact of Timber Utilization Research. Forest Products Journal 36(2):12-20.
- Hazlewood, Peter. 1988. Expanding the Role of Non-Governmental Organizations (NGOs) in National Forestry Programs. Washington, D.C.: World Resources Institute, Environment Liaison Centre.
- Hecht, S. and S. Schwartzman. 1988. The Good, the Bad and the Ugly: Extraction, Colonist Agriculture and Livestock in Comparative Economic Perspective. Unpublished draft manuscript, June 22, 1988.

- Hecht, S. and S. Schwartzman. 1988. The Good, the Bad and the Ugly: Extraction, Colonist Agriculture and Livestock in Comparative Economic Impact of Timber Utilization Research. *Forest Products Journal* 36(2):12-20.
- Hulse, Joseph H. 1987. Fueling the Forest. Paper prepared for the 10th Anniversary of the International Council for Research in Agroforestry, 7-11 Sept. 1987. International Development Research Centre. 31 pp.
- Iyamabo, D. E. (editor). 1988. Tree Improvement and Silvo-Pastoral Management in Sahelian and North Sudanian Africa; Problems, Needs and Research Proposals. International Union of Forestry Research Organizations. 196 pp.
- Jackson, J. and G. Ojo. 1973. Provenance Trials of Eucalyptus Camaldulensis in the Savanna Region of Nigeria. Research Paper No. 14. Samaru, Zaria: Savanna Forestry Research Station.
- Jakes, P. J. and E. C. Leatherberry (compilers). 1986. Alternative Approaches to Forestry Research Evaluation: An Assessment. USDA Forest Service Gen. Tech. Report NC-110, North Central Forest Experiment Station. 32 pp.
- Kang, B. T. and G. F. Wilson. 1987. The Development of Alley Cropping as a Promising Technology. pp. 227-244 in Steppler and Nair (eds.) 1987. Nairobi, Kenya: ICRAF.
- Lal, 1988. Agroforestry as a Possible Sustainable Farming System in the Humid Tropics. Washington, D.C.: World Bank (unpublished draft).
- Lamprey, H. 1978. The Integrated Project on Arid Lands (IPAL). Nature and Resources 14(4):2-11. Paris: UNESCO.
- Le Houerou, H. 1987. Indigenous Shrubs and Trees in the Silvopastoral Systems of Africa. Ep. 141-156 in Steppler and Nair (eds.) 1987. Nairobi, Kenya: ICRAF
- Levenson, Burton E. 1984. Economic Analysis of Tree Improvement Research in Michigan. Ph.D. thesis, Michigan State University. 176 p.
- Long, S. and S. Dennison. 1986. Maijja Valley Inventory and Volume Estimation. Paper in the Maijja Valley Windbreaks Evaluation Study, CARE-Niger. (Unpublished draft manuscript)
- Lundgren, Allen L. 1986. A Resum. of Forestry Research Priorities in the Asia/Pacific Region. Working Paper, East-West Center, Honolulu, Hawaii. 33 pp.

- Lundgren, Allen L., Lawrence S. Hamilton, and Napoleon T. Vergara. 1986. Strategies for Improving the Effectiveness of Asia-Pacific Forestry Research for Sustainable Development. Workshop Report. East-West Environment and Policy Institute, Honolulu, Hawaii. 56 pp.
- Lundgren, B. 1987. Institutional Aspects of Agroforestry Development. Pp. 43-52 in Steppeler and Nair (eds.) 1987. Nairobi, Kenya: ICRAF
- McGaughey, S. and H. Gregersen. 1988. Investment Policies and Financing Mechanisms for Sustainable Forestry Development. Washington, D.C.: the Inter-American Development Bank.
- Mergen, F., R. E. Evenson, M. A. Judd, and J. Putnam. (Forthcoming). Forestry Research: A Provisional Global Inventory. In: Economic Development and Cultural Change. Previous version available as Discussion Paper No. 503, Economic Growth Center, Yale University. New Haven, Connecticut: Yale University. 42pp.
- Ministry of Environment and Natural Resources. 1983. Proceedings of the National Workshop on Strengthening Forestry Research in Kenya. November 1-4, 1983, Eldoret, Kenya. Nairobi: Ministry of Environment and Natural Resources. 291 pp.
- Oxford Forestry Institute. 1986. Report to the World Bank on Forestry Research in Eastern and Southern Africa. Oxford Forestry Institute, Oxford University, Oxford, England. Various pagings.
- Panday, K. 1982. Fodder Trees and Tree Fodder in Nepal. Berne, Switzerland: Swiss Development Co-operation. 107pp.
- Pathak, P. and B. Patil. 1982. Leucaena Research at the Indian Grassland and Fodder Research Institute. Pp. 83-88 in Proceedings of a Workshop on Leucaena Research in the Asia-Pacific Region, Singapore, November, 1982. 192pp.
- Pee, T.Y. 1977. Social Returns from Rubber Research on Peninsular Malaysia. Ph.D. dissertation, Michigan State University, East Lansing, Michigan.
- Polson, Skip and A. Lundgren. 1985. Non-Forestry Institutions, Agencies and Firms with Agroforestry Research in the Asia-Pacific Region. Environment and Policy Institute, East-West Center. Honolulu, Hawaii. (mimeo) 17pp.
- Poore, D. 1974. The Value of Tropical Moist Forest Ecosystems and the Environmental Consequences of Their Removal. In Unasylva 28(112-113):127-143.

- Raintree, J. B. and M. W. Hoskins. 1988. Appropriate R&D Support for Forestry Extension. Prepared for the FAO Expert Consultation on Organization of Forestry Extension, March 7-11, 1988. Bangkok. 26 pp.
- Ramos de Freitas, A., W. Kauman and R. Youngs (compilers). 1986. Improved Utilization of Timber Resources in South America: A Program for Action. IUFRO, Project Group P5.01: Properties and Utilization of Tropical Woods. 161 pp. (unpublished manuscript).
- Reiche C, C. and J. Campos A. 1986. El Consumo de Leña en los Beneficios de Café en Costa Rica: Problemas y Alternativas Forestales. Serie Técnica, Informe Técnico No. 68, Proyecto Leña y Fuentes Alternas de Energía. Turrialba, Costa Rica: CATIE.
- Repetto, R. 1988. The Forest for the Trees? Government Policies and the Misuse of Forest Resources. Washington, D.C.: World Resources Institute. 105pp.
- Rockefeller Foundation. 1987. Research: Needs and Opportunities for Improved Management of Tropical Forests. Background paper for the Strategy Meeting on Tropical Forests, Bellagio, Italy, July 1-2, 1987. 35 pp.
- Romm, Jeff. 1982. A Research Agenda for Social Forestry. The International Tree Crops Journal 2:25-59.
- Rorison, K. and S. Dennison. 1986. Harvesting and Harvesting Influences on Crop Production. Paper in the Maijja Valley Windbreaks Evaluation Study, CARE-Niger. (Unpublished manuscript)
- Ruttan, Vernon W. 1982. Agricultural Research Policy. Minneapolis, MN: University of Minnesota Press. 369 pp.
- Schnepf, Max, ed. 1983. Natural Resources Policy: Research Strategies for the Future. Ankeny, Iowa: Soil Conservation Society of America. 36 pp.
- Seldon, Barry J. 1987. A Nonresidual Estimation of Welfare Gains from Research: The Case of Public R&D in a Forest Product Industry. Southern Economic Journal 54(1):64-80.
- Shafer, Elwood L. and George H. Moeller. n.d. Some Benefits from Forestry Research -- or, What has Forestry Research Done for You Lately? Washington, D.C.: USDA Forest Service. 22 pp.
- Shea, Keith R. and Les W. Carlson (compilers). 1984. Increasing Productivity of Multipurpose Tree Species: A Blueprint for Action. IUFRO Planning Workshop for Asia, Kandy, Sri Lanka, July 16-28, 1984. USDA Forest Service and Canadian Forestry Service. 100 pp.

- Singh, J. S., U. Panday and A. K. Tiwari. 1984. Men and forests: A Central Himalayan Case Study. *Ambia* 13(2):80-87.
- Society of American Foresters Assessment Team. 1984. Assessment of USAID's Forestry Activities in Institutional Mechanisms, Private Enterprise, and Training, Education and Research. No. 40-319R-4-01017. USDA Forest Service and USAID. Sept. pp. 35-46.
- Spears, J. 1987. Tropical Deforestation. A Suggested Policy Research and Development Agenda for the Bank in the 1990s. 54 pp.
- Spears, J. 1988. Forestry Research Priorities in the 1990's. Background Discussion Paper for Proposed Rockefeller Foundation Meeting on Forestry Research, Bellagio, November 1988. 26 pp.
- Steppler, H. and P.K.R. Nair. 1987. Agroforestry: A Decade of Development. Nairobi, Kenya: ICRAF. 335 pp.
- Trustrum, N., V. Thomas and M. Lambert. 1984. Soil Erosion as a Constraint to Hill Country Pasture Production. *Proceedings, New Zealand Grassland Assoc.* 45:66-76.
- UNESCO. 1978. Method for Priority Determination in Science and Technology. *Science Policy Studies and Documents*, no. 40. 79 pp.
- United Nations Food and Agriculture Organization, World Resources Institute, World Bank, United Nations Development Programme, and Rockefeller Foundation. 1987. Strategy Meeting on Tropical Forests. Bellagio Study and Conference Center. Bellagio, Italy. July 1-2. Various pagings.
- U.S. Agency for International Development. 1987. Conserving Tropical Forests in Developing Countries. A Report to Congress on Implementation of Section 118 of the Foreign Assistance Act (as Amended). Washington, D.C.: U.S. Agency for International Development. 30 pp.
- U.S. Congress, Office of Technology Assessment. 1984. Technologies to Sustain Tropical Forest Resources. OTA-F-214, March. Washington, D.C. pp. 257-274.
- U.S. National Research Council, Panel on Common Property Resource Management. 1986. *Proceedings of the Conference on Common Property Resource Management*, April 21-26, Washington, D.C. Washington, D.C.: National Academy Press.
- Von Maydell, H-J. 1987. Agroforestry in the Dry Zones of Africa: Past, Present and Future. Pp. 89-116 in Steppler and Nair (eds.) 1987. Nairobi, Kenya: ICRAF.

- Westgate, Robert A. 1986. The Economics of Containerized Forest Tree Seedling Research in the United States. Canadian Journal of Forestry Research 16:1007-1012.
- Wiersum, F. 1984. Surface Erosion Under Various Tropical Agroforestry Systems. Pp. 231-239 in C. O'Loughlin and A. Pearce (eds.) . Proceedings of a Symposium on Effects of Forest Land Use on Erosion and Slope Stability, Honolulu: East-West Centre.
- Winterbottom, R. and P. Hazlewood. 1987. Agroforestry and Sustainable Development: Making the Connection: Ambio 16(2-3):100-110.
- World Bank. 1982. Natural Rubber: Sector Policy Paper. Washington, D.C.: The World Bank.
- World Bank. 1986. Annex IX, Sudan Forestry Sector Review. April 16, 1986. Washington, D.C.: The World Bank.
- World Bank. 1986. Economic Issues and Farm Forestry. Working paper prepared for the Kenya Forestry Sector Study. Washington, D.C.: the World Bank (mimeo).
- World Bank. 1987. Guidelines for Strengthening National Agricultural Research Systems in Sub-Saharan Africa. Special Program for African Agricultural Research (SPAAR) and International Service for National Agricultural Research (INSAR). Washington, D.C.: The World Bank. 28 pp.
- World Bank/Food and Agriculture Organization of the United Nations. 1981. Forestry Research Needs in Developing Countries -- Time for a Reappraisal? Paper for 17th IUFRO Congress, Kyoto, Japan, 6-7 September, 1981. Washington, D.C./Rome: The World Bank/FAO. 56 pp.
- World Resources Institute. 1985. A Call for Action. Washington, D.C. World Resources Institute