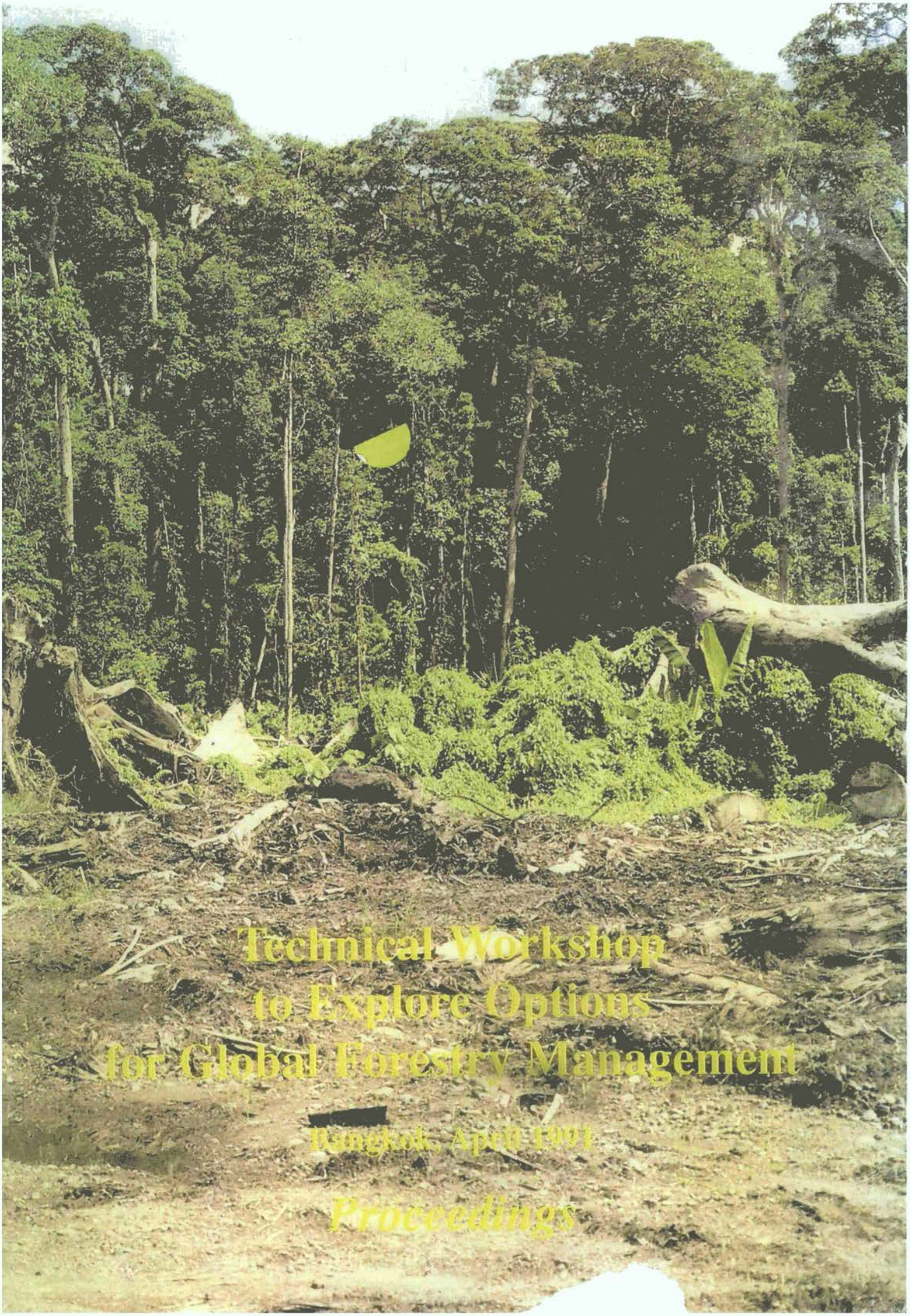

Technical Workshop to Explore Options for Global Forestry Management

Bangkok, April 1991

Proceedings

TECHNICAL WORKSHOP

TO

EXPLORE OPTIONS

FOR GLOBAL FORESTRY MANAGEMENT

PROCEEDINGS

TECHNICAL WORKSHOP

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EXPLORE OPTIONS

FOR GLOBAL FORESTRY MANAGEMENT

BANGKOK, THAILAND

24 to 30 April 1991

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Ministry of Science, Technology and Energy

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Editors Note

In editing these proceedings we followed closely the Summary prepared by the Chairman. In my opinion this reflected well the sense and ambience of the meeting, emphasising those ideas which were of paramount interest to the majority of participants, and around which most discussion evolved.

The Chairman's Summary thus serves as an introduction to the Proceedings, following which the keynote speeches will be found. The main body of the text (Part A) is concerned with the meeting sessions. For each session, the invited paper is given and is supported by abstracts of offered contributions and by rapporteur's notes, where these were made available to us. Offered papers are given in Part B for those who wish to pursue ideas in greater detail.

In some cases readers may wish to contact the authors for fuller versions of texts than we have considered appropriate. Although we have included all Tables, in order to publish the Proceedings prior to the UNCED Preparatory Committee, August 1991, we have been unable to reproduce Maps and Figures. We accept full responsibility for all editorial decisions, and hope very much that in our efforts to produce a cogent and readable text, we have not ommitted any important observation or distorted the point of view of any contributor.

David Howlett and I are particularly grateful for the constructive assistance given to us by the Office of the National Environment Board, Government of Thailand, and especially to the good humoured efforts of Ms. Monthip Tabucanon. At IIED a very great debt is owed to Ms. Elaine Morrison, who worked tirelessly and diligently, and to Christine Barton, Emma Dewhurst, Simon Rietbergen, Deviani Vyas, Karen Aylward and Rachel Howard.

Caroline Sargent.

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Purpose and Objectives of Workshop

1 Global interest in forest resources has broadened recently to include all forest biomass (tropical, temperate, boreal), and the need for sustainable provision of a wide range of forest services, including forest products, biofuels, carbon stock and sinks, biodiversity, and maintenance of hydrological cycles. While nations have sovereign control over their forests, the global resource aspects of forests are being increasingly recognized.

2 A number of major international initiatives to improve management of forest resources are underway, including the Tropical Forest Action Plan, Climate Convention, Biodiversity Convention, and Global Forest Instrument. In light of these efforts, policy-makers urgently need the best information and technical assessment of potential site-level, national, and international options to protect and better manage forests.

To contribute policy-relevant technical information to assist current international discussion of initiatives, by:

1 Summarizing **current status** of linkages among various international initiatives relating to forest resources.

2 Evaluating **land availability** in different regions to meet Noordwijk Targets and other forestry options.

3 Evaluating **technologies and practices** that could be utilized at different sites and regions to manage forest area while meeting other environmental, social, and economic objectives.

4 Assessing **costs** of various policy options for sustainable forest development and their implications for agriculture, forest products trade, and economic development.

5 Assessing **options** for the coordination of national, regional, and international activities pertinent to these goals.

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Chairman's Summary

H.E. Professor Sanga Sabhasri[1]

1 INTRODUCTION

The conservation and sustainable management of forest resources is attracting increasing attention world wide. Forests serve a wide variety of functions at local, national and global levels. The forest issue is high on the agenda of the UN Conference on Environment and Development which takes place in Brazil in June 1992. At the invitation of the Royal Thai Government, over 80 experts from more than 20 developed and developing countries, and 11 international organisations and non governmental organisations gathered in Bangkok for 5 days of intensive discussions on a wide range of issues related to global forest management.

The following comments represent a summary of many different papers, presentations and discussions. Participants felt that the approach adopted in the workshop was important in a number of respects. First, the fact that it was proposed and hosted by a tropical country brought a welcome new balance into the discussion of international forest issues. Second, the workshop was important in bringing together technical and policy specialists for substantive discussions. Third, it broke new ground by considering the similarities and divergent experiences of forest management in temperate, boreal and tropical forests together.

The topics discussed included national issues related to the management of temperate, boreal and tropical forests; the need to develop a global consensus for collaborative technical assessments and action to safeguard local, national and international benefits from the services of forests; preliminary discussions of methods to estimate the costs of achieving goals at the national and international level and associated economic issues; and further action needed to promote a constructive and action oriented approach to tackling global forest problems.

Participants emphasised that forests are dynamic and long lived ecosystems which provide multiple goods and services. Action should start from the need to meet the economic, social and environmental needs of the world. At the same time, it was stressed that sustainable development of forests implies meeting the needs of the present generation while securing the ability of future generations to meet their needs. It was vital to keep in mind the variety of functions that forests fulfil when designing policy interventions. In particular, carbon fixing and biodiversity conservation objectives need to be balanced with objectives related to, inter alia, forest products, watershed management and meeting basic local needs for fuelwood and land for agriculture.

Participants noted that the threats to forest land come primarily from outside the forestry sector, including those from population growth, air pollution and, in some parts of the world, the pressures to convert forested land to agriculture. Measures to safeguard forests therefore need to address such cross sectoral issues.

2 NATIONAL FOREST OPTIONS

2.1 Temperate and Boreal Forests

Among the main conclusions were:

- the management and maintenance of existing temperate and boreal forests is the most effective approach in terms of maintaining carbon reservoirs, costs and ecological services. Strategies to manage and maintain existing forests have the advantage of immediate beneficial impacts as against the longer term benefits from new forestation;

- in addition, there is generally significant potential for increasing biomass in existing forests, especially

1 Minister for Science, Technology and Energy, Thailand.

in young, understocked, overlogged and/or misused forests;

- for the boreal zones, the scope for increasing overall forest areas is limited. In the temperate zones, substantial areas might theoretically be available for afforestation during the next several decades;

- the use of wood from sustainably managed sources in long lived products has benefits both in terms of the forest ecosystem and in terms of fixing carbon. The development and application of technologies for more efficient use of wood residues and lower grades of timber should be encouraged;

- wood from sustainably managed sources is an environmentally friendly raw material and fuel. The forecast increase in world demand may best be met through increased wood production where that is feasible, in combination with a more effective use of wood, rather than substitution by non renewable materials such as concrete, plastics, steel and aluminium. The most promising approaches are:

  - more efficient use of wood (eg reducing waste and using wood in more long lived products);

  - the use of wood as an energy source to replace fossil fuels;

  - recycling of wood products including paper and paper board;

  - the use of wood to replace more energy intensive raw materials.

2.2 Dry Tropical Forests

Among the main conclusions were:

- that the main forest management constraints were social, economic and institutional rather than technical or physical. There is a need to reduce uncertainty of land tenure so as to improve incentives for good community forest management. Experience in some (though not all) countries shows that when tenure rights are vested in individual farmers, this results in limiting the access of landless people to common property resources. This needs to be taken into account in the design of interventions. There is also a need for donor assistance to strengthen and refocus Forest Departments in some countries, particularly with respect to training, extension and research.

- farm forestry (especially tree planting by small scale land holders), agroforestry and the conservation by local people of existing woodlands were priorities for action, rather than the creation of new plantations;

- the need to provide fuelwood for large and rapidly growing urban populations is a major cause of forest loss in dry tropical regions. There is an urgent need to identify workable ways to promote switching to alternative fuels for urban communities.

2.3 Tropical Moist Forests

Among the main conclusions were:

- the definition of terms (such as tropical moist forest, deforestation and forest cover) used in international forest discussions needs clarification;

- land tenure and tree tenure problems are often central to land degradation problems. More should be done at the national level to clarify, establish and guarantee what people's rights are and to ensure that they are fully respected;

- multiple use management of the productive tropical moist forest (which provides biodiversity, carbon storage and other services) should be fully integrated in stand and national level forest policies and working plans;

- research should be given high financial priority in order to understand the structure, functions and dynamics of tropical moist forest ecosystems and to bring the forest under sustainable management. This will require long term support;

- transfer of information and technology relating to forest management, timber processing, etc. should be encouraged both from South to South and from North to South;

- institutional, financial and legislative measures should be developed in order to enhance social and economic incentives to maintain, restore and manage the tropical moist forest.

3 INTERNATIONAL AND GLOBAL ISSUES

While the future of forests will be largely determined by the policies and programmes of people and their governments, external international factors may be influential. These are receiving increasing attention with the recognition that local and national environmental problems are closely related to global concerns such as loss of biodiversity and climate change.

3.1 International Cooperation

International cooperation complementing national action can contribute substantially towards the wise use of forests and forest lands.

Areas where particular contributions can be made are in the relationship between international trade and sustainable forest management, forest management guidelines, technologies for the use and protection of forests and forest products, and in providing assistance as necessary to enable less developed countries to prepare and implement appropriate forest and development policies and action oriented programmes.

The participants particularly recommend strengthened research, monitoring and evaluation, and improved information and technology transfer. Greater attention should be paid to education, the role of women, NGOs and community participation, and to extension activities which focus on the sustainable management of forests and on the establishment of forest and tree cover.

3.2 Trade

Participants noted that there were a number of proposals for restricting the trade in forest products. The majority stressed that punitive trade restrictions were likely to be counter-productive to the good management of forests. They proposed that a number of positive steps could be taken, aimed at making the trade sustainable:

- joint recommendations from consumers and producers to ensure that traded forest products come from sustainably managed sources;

- measures to help developing countries export products with a higher degree of value added, including through the transfer of technologies;

- periodic monitoring of international trade, addressing the current and future demand and supply of timber and non timber forests products.

3.3 Targets for Global Forest Areas

Participants discussed the feasibility of achieving the target established at the Noordwijk Conference on Atmospheric Pollution in December 1989 for a net global increase in forest area of 12 million hectares a year by the year 2000. They concluded that:

- given estimated current rates of loss of forests globally, and rapidly growing populations in many areas of the world which would add to the pressures on forest land, the prospects for halting the net rate of loss of forest areas within the next decade and longer were very limited;

- on the basis of work already carried out to assess the scope for national action in 50 countries, it seems possible that over the longer term to 2050, the net rate of forest loss could be slowed and reversed. The main constraints were likely to be financial, economic, social and institutional rather than the availability of land;

- an analysis for Africa and Asia indicated that some 200 million hectares of land currently without significant tree cover could be forested through regeneration, farm forestry and, to a lesser extent, plantations, by the year 2050. In addition one scenario suggests that almost 100 million hectares of forest that would otherwise be lost in Africa and Asia by 2050 could be maintained under forest cover through broad ranging policy initiatives. However, the overall analysis concluded that even with successful implementation of both these measures, Africa and Asia are likely to see a significant net reduction in forest cover between 1990 and 2050. For the reasons given above, participants urged great caution in the use of these figures;

- it was important to assess the feasibility of increasing forest areas in temperate and boreal areas. Industrial plantations may be the best approach in such regions, whilst in the tropics a more appropriate way to increase forest and tree cover may be through social and community efforts.

4 ECONOMIC AND COST ISSUES

Since many of the benefits from forests are difficult to quantify in financial terms, they tend to be underestimated by markets and policy makers. Participants stressed that generating better information on the costs, benefits and opportunity costs of forest actions in temperate, boreal and tropical areas was an urgent priority. Most existing economic analyses only take account of 1 or 2 out of the range of benefits, typically timber production, and do not take into account maintenance, management or opportunity costs.

Participants discussed a number of estimates for the costs of reforestation and afforestation in different parts of the world:

- in many areas, the most cost effective option is likely to be the maintenance and better management of existing forest areas;

- harvesting non timber forest products and extending agricultural systems which include trees may complement existing forest management in some areas. This is a priority area for further work;

- preliminary assessments of forest investments in representative countries suggest that the financial, environmental and social benefits taken together generally outweigh establishment and maintenance costs. There will, however, in many cases, be significant opportunity costs of forest investments.

Participants stressed that it was vital that further work be done on a collaborative international basis on the cost effectiveness of different options, the valuation of benefits, and the institutional feasibility of options in different circumstances.

5 CONCLUSIONS

The main conclusions from the workshop are as follows:

- the wide variety of valuable papers presented and discussed should be transmitted urgently to the Secretariat of the UN Conference on Environment and Development (UNCED) to contribute towards deliberations on a global consensus on forests for the 1992 Rio Conference; to the Intergovernmental Negotiating Committee (INC) to support its work to prepare a framework convention on climate change and to the Intergovernmental Panel on Climate Change (IPCC) which is providing objective scientific and technical advice for these negotiations; to the UNEP Ad Hoc Working Group of Legal and Technical Experts on Biological Diversity to support their work towards a global biological diversity convention; and to other international fora including, inter alia, the ITTO, FAO and IUCN;

- the prospect of further such technical workshops should be welcomed as a useful way of assembling information and technical data to facilitate the work of the UNCED and other fora, especially where such workshops were hosted by important forest countries;

- there was a need for better information on the extent of forests, including further effort to ensure that appropriate definitions were used for each forest type and objective. Nomenclature for tropical rain forest is extremely variable; this leads to considerable confusion over their extent, biomass and diversity. In considering carbon fixation objectives, for example, it was noted that agroforestry and agricultural tree crops may need to be taken into account. It was also noted that on-farm trees, which are generally not included in figures on forest cover are in many countries at least as important in carbon terms as formal forest areas;

- a collaborative global and regional effort was urgently required, building on existing remote sensing and ground truthing capacity, to reinforce work on monitoring the status of and changes in forests in boreal, temperate and tropical regions. Current data on open forests and scattered farmland trees - which are very important to the total figure - are weak because these formations are poorly identified by remote sensing;

- it was essential in all discussions to acknowledge that trees and forests provided a wide variety of social, economic and environmental functions, both for present generations and for those to come. A comprehensive approach was therefore essential in addressing forest issues.

- better information on the cost effectiveness of and the social and economic basis for different options for global forest management, and on quantifying the multiple roles of forests, was an urgent research priority;

- policies and programmes need to be tailored closely to local conditions and circumstances, in particular the socio-economic and institutional setting and constraints;

- there is a continuing need for substantial and high quality technical and financial cooperation in the management of the world's trees and forests.

Opening Session

Opening Address

H.E. Professor Sanga Sabhasri[1]

It is my privilege to address this distinguished gathering of scholars, experts and policymakers on the problems related to forest resources, particularly in the tropical world. I am overwhelmed to find that this particular technical workshop receives very high honour from great personalities such as the Former Prime Minister of Sweden, His Excellency Ola Ullsten and the Former Minister of Foreign Affairs of Japan, H.E. Saburo Okita, who so kindly accepted our invitation to give the Keynote Address this morning. Also the workshop is honoured to have high ranking diplomats and government officials from overseas participate in this workshop, not only as representatives of their countries, but also as knowledgeable figures with personal experience to share on this issue. On behalf of the Royal Thai Government, may I take this opportunity to extend a warm welcome and best wishes to all distinguished participants. I sincerely hope you all will have a joyous stay in Thailand. I speak today not as an authority on forest policy for Thailand, but as a forest scientist who would like to share views on options for global forest management. Discussions on forestry issues have received special attention during the past few decades. As the years have passed, most problems related to forest destruction still remain. Policy and planning have been formulated, upgraded, and revised to try to control the situation. The problems are no longer technical problems. The socio-economic constraints of mankind have forced the migration of people into the forest. Encroachment and resettlement in the forest area always involves increasing the farm area to produce sufficient food to feed society and provide exports. Today, the problems related to tropical forests are being discussed in most donor countries, international societies, international financial organisations, non-governmental agencies, as well as the local agencies responsible directly or indirectly for addressing forestry issues. Policy issues have been updated to meet the needs of the people and to manage forest resources on a sustainable basis.

Thai society is regarded as an agricultural-based society, with more than 70% of the population being farmers. With increasing population, the forest area was depleted and farmland was increased. The introduction of each new cash crop always resulted in forest destruction. Farmers continuously tried to increase planting of cassava, maize, rubber, oil palm, fruit orchard, coffee, etc. The close relationship between human society and forest resources still remains. Farmers still need wood as well as other minor forest products for construction, utensils, and fuel.

In the logging concession areas, management plans were not systematically applied to obtain sustainable production. Forest inventories were carried out but the allowable cut was not enforced. Overcutting was reported in some concession areas and illegal cutting disturbed the natural regeneration. In many cases, the concession area was revoked because little growing stock remained. The selection system has been used for years. Often trees with good morphology were removed leaving the poor ones to regenerate thereafter. Land was encroached in the concession areas both before and after logging operations. Today, 10 million people live in the forest in Thailand and this pressure on land use has almost overwhelmed forestry problems.

The disturbance of the forest ecosystem has caused erosion, long and severe periods of drought and devastating floods. Following serious floods in late November 1988, the government declared a logging ban, with much support from the mass media and the public sector.

After the logging ban, concessions were officially closed. The basic aim was to protect the forest ecosystem and allow natural regeneration. Sawmills were partially closed, so the technical skills in sawmilling accumulated over 100 years were blocked. As the demand for timber has not declined and imported wood supplies have been insufficient to satisfy that demand, illegal cutting in concession areas has continued. Chainsaws are used to make sawnwood, and simple wooden houses are constructed and sold to enable buyers to obtain timber legally. The blame still lies with businessmen, not rural people. The logging ban would be most effective in a society where people understand the necessity of conserving the forest ecosystem.

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1 Minister for Science, Technology and Energy, Thailand.

Laws, rules, and regulations on forest protection have been promulgated. In 1985, the Council of Ministers declared a national forest policy to manage and develop forest resources, to achieve long term and coordinated national forest administration and development, and for better understanding between the state and the people.

The policy promotes the sharing of roles and responsibilities among various government agencies and the private sector. Science and technology for increasing the efficiency of agricultural production are to be enhanced to reduce the risk for deforestation caused by increasing demand of agricultural land. Forestry extension to create more public awareness on forestry issues has been promoted. Tree planting has been encouraged and forest productivity is to be increased to meet the actual needs of the country; the protected forest is to be kept to about 15% to ensure nature conservation, biodiversity and environmental quality protection, and to provide recreation areas. Forest research is promoted in forestry related agencies.

The national forest policy has been implemented for too short a period to make a clear assessment of its effects. At present, valuable suggestions are made by both the public and private sector, including the active participation of NGOs and several interested groups.

Ladies and Gentlemen, I strongly believe that most problems can be solved if society agrees to do so. Here are some practical considerations that I would like to present to you.

1 The state must place high priority on conserving forest resources and biological diversity. This critical task cannot be left to private companies and citizen organisations alone. Research and development in this field must be supported. The Office of the National Environment Board this year will complete the classification of all watershed areas, using five categories of potential land use protection, based on the ecological significance and forest health of each watershed. The improvement of the degraded watershed areas will be one of the major objectives.

2 Tree planting in different forms, including enrichment planting in conserved forest, tree farming, agroforestry, and planting trees in homesteads, should be promoted. Large scale industrial plantations will not be easily established due to the lack of land available and the continued expansion of agriculture. The controversial issue of large scale planting of some exotic species and their impacts on local water supply, forest health and village economies still remains unsolved. However, I would like to propose growing economic native species and promising multipurpose trees capable of fixing nitrogen. These species provide a wide variety of products for both local and market needs - for example, timber, medicines, fruit, dyes, fuelwood. There are also 38 million rai of land that are unsuitable for agriculture and there are many mountains without trees now. These have the potential to be converted to forest areas by restoring degraded lands to productivity. Similarly, many mangrove forests on our southern coast have been damaged but could be restored to provide nurseries for the seafood upon which Thai cuisine is based. Many different types of reforestation for a variety of uses and products need to be considered besides industrial plantation forestry, if we are to successfully restore and regrow our forests.

3 The Thai community is now familiar with the concept of community forestry, which has become popular in forestry over the past decade. The traditional Thai temple forests which have flourished around monasteries are protected by monks as sacred groves. If we can build on this tradition today throughout Thailand, it will enable socially-minded foresters or forestry-minded social scientists to carry out their enormous task. I strongly believe that the state authorities will take the community forestry concept into practical consideration.

4 Adapted technology should be developed even for use by the rural poor. Thailand has promoted research in biotechnology, particularly on rhizobium and tissue culture, to improve growth rates and reforestation success. Research on technology to improve seeds, nursery techniques and planting systems is being conducted. There is a need to develop technology for utilisation of small size trees and lesser known species, in order to more fully utilise any area of forest that is harvested and thereby reduce the need to log larger areas.

5 The Forestry Sector Master Plan which is now being drafted will provide the opportunity for Thailand to develop the conservation of forest ecosystems, production and processing of wood and minor forest products, and institutions. This will be another attempt to solve existing problems. The action plan will

be drafted later. This process offers Thailand on opportunity to plan for conservation in a way that promotes sustainable development of her resources over the next planning cycle.

6 The national forest planning process in Thailand continues to evolve, as our needs and our forests change over time. Each country has a different experience and history in managing its forests, and in planning for the development and conservation of forests I would like to recommend that countries within a particular region have much to gain by comparing and contrasting their forest planning processes, data, and plans. Any solution to global forest issues, a major cause to global climate change, will require increased attention to and evolution of such plans. Regional workshops to study country forest plans could be held soon to speed this evolution through a cooperative regional and international process.

To steer a middle way between science and policy, I would like to suggest an approach to this meeting. Many new ideas are under active discussion now, for example a global forest charter or instrument, and are still very new and very complex. Thus, we should start today to create a process that focuses on the successes and failures of our forest management practices and policies thus far - that will provide us with the best tools with which to evaluate whatever set of guiding principles or agreements emerge from the multi-faceted policy processes underway in several international arenas.

Let us ask the questions now for which we will need answers in the months and years to come. In this way, our efforts may bring together the separate winding channels of science and policy into a middle path between those who would push hard for a quick policy decision on global forest matters, and those who would only ask questions and sift the data over and over. This middle path may allow a strong current to flow through many fora, processes and nations, and through many villages and fields, with both true force and direction, and may serve us best.

Our goal, then, is to identify technical data, both that currently available and that still needed, that can be used to provide a set of options for government policymakers to consider in addressing global forest issues in the UNCED process and other fora. Our goal is not to choose or make policy here, but instead to sift and sort data, and to assemble the choices available for other processes.

Gracious support and assistance is acknowledged from the International Tropical Timber Organisation, (ITTO), UNEP, FAO, the Forest and Agriculture Subgroup of the Intergovernmental Panel on Climate Change, Forestry Canada, the Ministry of Agriculture, Nature Management and Fisheries of the Netherlands, Environment Protection Agency of USA, and the Overseas Development Administration of the UK. I would also like to introduce the Steering Committee chosen at the preparatory meeting held here in January that will help guide the workshops: myself as Chairman, Cornellia Quennet of IPCC and Germany as co-chair, and members Jimmy Aggrey Orleans of ITTO, Mark Lowcock of ODA-UK, J.S. Maini of Forestry Canada, Dr Yow Pong Tho of Malaysia, Dr Y.S. Rao, FAO, Bangkok and Kenneth Andrasko of USEPA.

I am extremely confident that this meeting will make significant progress towards the exchange of views and experiences among the representatives from developing and industrialised countries as well as relevant international agencies; and will generate important ideas and recommendations towards the development of different reforestation technologies and practices, and other forestry options.

Since the auspicious moment has arrived, may I now have the honour to declare open the Technical Workshop to Explore Feasibility of Forest Options, and to wish you all every success in your deliberations.

Keynote Speech

H.E. Ola Ullsten[1]

We cannot escape it any longer. Planet Earth is in danger. The threat doesn't come from invaders arriving from another planet as in the fantasy of science fiction writers and movie makers. To our knowledge, our planet is the only one that is inhabited by humans or by any other living organism. The threat comes from man himself. Not too many years ago any suggestion of this kind would have been considered an overreaction by misled doomsday sayers or as a militarian's prophecy. Today it is a warning spelled out in earnest by scientific communities in most disciplines. Slowly, politicians are also starting to take these warnings seriously.

One of them, the Italian Minister of Environment, was both very eloquent and scientifically on target when he recently responded to the question of why we should take seriously today warnings that have been ignored for so long. Said the minister; "..it is only as this century comes to a close that man has realised that he is the first inhabitant of the biosphere more powerful than the biosphere itself, and that indeed he is unable to control his power." His observation seems accurate. If it was man's ambition to "tame nature", he has been very successful indeed, although at a very high price. It is a victory that has also overtaken the assailants.

If we add up the different elements of the environmental crisis, what emerges is a complex challenge to the entire ecological equilibrium on which life on Earth depends.

- We have learned how to exploit the world's coal reserves, but we are rather helpless in trying to arrest the greenhouse effect that is an uncontrollable by-product of all burning of fossil fuel.

- We have understood how to use CFC gases in 'fridges and air conditioners, but only very late did we come to realise that those gases also destroy the life-protecting ozone layer.

- We have long since known that huge areas of economically and ecologically invaluable tropical forests are destroyed every day, but the countries involved are caught in a vicious circle of underdevelopment and are unable to do very much about it.

- We have long been aware that symbols of our successful economies, like crowded highways, power plants and super efficient farm practices are engaged in an acid saturated assault against trees, soil and lakes, a problem that we still lack the power to handle.

- We have all the knowledge needed to realise that we have to stop using the oceans as if they were a garbage dump with unlimited capacity, but we don't; we are stuck with an economic philosophy that doesn't allow us to do so.

- We have statistics that tell us that the world's population grows by 1,500 people every minute and that every minute the earth's stock of arable land falls by five hectares; it scares us, but we don't seem able to do anything about that either.

Man didn't put himself in this situation intentionally. At least not at the start of those processes, of which we can now see the destructive result. Europe's industrial pioneers back at the end of the 18th century were not told by any scientific community that the technological revolution they had set in motion was potentially dangerous. All natural resources were up for grabs and seemed to provide an unlimited source of wealth and better life for many. The notion that resources, like the forest, the ore, the coal, the soil and the water, could ever be exhausted most likely never occurred to them. Even less so the idea that the very use of some of those wealth producing commodities, the burning of coal for instance, would rock Earth's life-supporting chemical balance.

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1 Swedish Ambassador to Italy.

Today we do know. We do know that even the most well intended practices, processes and policies to further social and economic progress for the benefit of mankind, at least for those who can afford to pursue them, are also the main causes of the environmental degradation that is now recognised by most people. Those of us who are not experts have come to understand that air pollution, land degradation, unmanageable quantities of waste, diminishing water supplies, oil spills, congested cities and the like are not due to isolated mistakes, but are instead a consequence of the way we live.

To put things right would be a relatively easy task, were it only a matter of finding and financing technical solutions. But it is not. What it takes is a new approach to development. We need to give full recognition to the fact that all economic activities, regardless of where they take place and for which purpose, are dependent on natural resources and inherently limited biological and chemical processes. In particular for us in the so-called developed world this means that we have to revise, step by step, our definition of what is social and economic progress or a good standard of living. We will have to look upon ecological considerations, not as a subordinate, but as an integral part of economic policies and planning.

In concrete terms this means that even if a particular project - be it in agriculture or forestry, transport or city planning, energy production or manufacturing industry - proves to be technologically possible, economically feasible, job creating and what have you - still it wouldn't necessarily be desirable. It would also have to be examined from the point of view of how it affects the environment. This doesn't mean that we in the rich countries should start dressing ourselves in sackcloth and ashes and try to reverse our technological and economic development. Neither does it contradict the need and desire of the developing countries for a rapid increase in their standard of living. Nor do I believe that changing the current models of development will be an easy task. But I do think it is worthwhile trying, and I think that the way we see the role of the forest sector - the theme of this conference - could serve as a test case.

Why is it that many of us are so deeply concerned about the fact that millions of hectares of tropical forests are disappearing every year? Deforestation's contribution to the greenhouse effect is one reason. The loss of biodiversity that follows in the wake of lost forest is another. Both these aspects are on the agenda of next year's UN conference on environment and development. The global aspect of deforestation concerns all of us regardless of where we live and what we do. It is important that these issues are being addressed and I hope that the efforts underway to negotiate legal instruments to be signed in Brazil in 1992, will prove to be successful.

Yet, the world's forests are so much more than a carbon sink and a reservoir for an unusual richness of plant and animal species. In countries in the temperate zone of the northern hemisphere forest products are a mainstay in rich economies. In my own country, Sweden, half of our net export earnings comes from the forest sector. In the tropical belt of the globe forests are also a natural resource of immense importance. 70% of the people in the developing countries depend mainly on wood to meet their household energy needs. Trees provide wood for housing construction, furniture, fencing, household implements and a variety of other uses. Export of hardwood timber still plays a role in the economy of some tropical countries.

Trees are also an essential source of fodder for livestock and provide man with fruits and nuts, honey, rubber, oils, resins, medicines, fibres, and lots of other products that are of vital importance for people's income, health and welfare. More than 500 million people live in tropical forests, and many more depend on wood and non-wood products from those forests. The importance of trees and forests also extends beyond their value as a source of wood and non-wood products. Trees help maintain the soil and water base for agricultural production by reducing erosion and moderating stream flows, particularly in upland watersheds. They slow wind and increase soil moisture, to mention only a few of the many important tasks that nature has given to that part of the ecological system that we call forest. None of the services provided by the tropical forest are easily replaced.

- Who is bold enough to suggest that, within the foreseeable future, a majority of the fast-growing populations in the developing countries will have physical access to or be able to afford any other major energy source than firewood?

- Which is the suitable building material in developing countries that would replace wood?

- Which is the commodity by which countries in the tropical belt can replace their export earnings on timber?

- How do rubber tappers, peasants and other forest dwellers make a decent living except in even more ecologically fragile lands, when their forest is being cleared for mining, cattle ranging or for other purposes in which they themselves usually don't have any part?

- How do we prevent soil erosion due to flooding and strong winds when the forest is gone?

- How do we cope with the spreading of the desert, siltation of hydro power dams and the general worsening of the food supply situation which follows as a direct or indirect consequence of tropical deforestation?

The fact that huge areas of tropical forest disappear every year may well prove to have an impact on global warming. It certainly does have a very destructive impact on the economies of the developing countries and thus on the living conditions for already poverty-stricken people. Efforts to combat this evil may be referred to as part of policies to save the environment or as part of a strategy for fighting underdevelopment. It doesn't really matter except that it proves that there are no contradictions between the two aims.

The tropical forest is by nature and definition a renewable natural resource which has the capacity to generate wealth for generations to come. Instead it is being used rather as a non-renewable resource. Some 17 million hectares of tropical forest disappear every year according to the latest assessment made by FAO in Rome. Some is due to mining, some is due to forest land being turned into grazing land for cattle, but most of it is being slashed and burned by poor people in search for land on which to survive.

Although many tropical countries do have both large areas of natural forests and ecological conditions for industrial plantation, only a small percentage of forest land in those countries is managed in a sustainable way. Thus, while the developing countries possess almost half of the world's forest cover, they produce less than one fifth of its industrial timber. The demand for forest products is increasing dramatically. But the developing countries are not able to take advantage of the situation. Poor and indebted, they are forced by a greedy market to sell out their stock of unique hardwood timber. But they lack money, technical know-how and other conditions needed for sustainable forestry. Forestry is a sector in decline in most of the third world countries. Even some previous net exporters of timber now have to use their scarce financial resources for import. Deforestation in the tropics is indeed a sad example of the vicious circle of underdevelopment.

Europe and North America have also gone through periods of forest decline, resulting in environmental problems and harsh living conditions. Along with other ideas on how to build strong economies for countries and earn money for business, political and industrial leaders started to introduce principles of sustainable yield forestry as early as the turn of this century. In Sweden the first piece of forest legislation dates back to 1902. Today the temperate and boreal forests are under a new kind of threat. Smog, acid rain and similar airborne pollution add to other factors of stress that confront forests in the northern hemisphere. Huge areas of forests in Europe - more than half of the forest land of Germany for instance - are affected. In the eastern part of Europe the situation is even worse.

In a report that was introduced at the first meeting of "The European Forum for Forest Protection", held in Stockholm last year, an effort was made to measure the estimated cost of damage to European forests, both that had already occurred and that was foreseen. The result was staggering. Only the impact from one substance, sulphur dioxide, was taken into account. Furthermore, an assumption was made that an existing agreement among some of the European countries to cut sulphur dioxide emissions by 30% would in fact be implemented. It was also assumed that all forests in Europe would be managed in an sustainable way.

Despite those rather optimistic assumptions, it was still estimated that about 120 million cubic metres of wood production per year, or 20 per cent of current production, would be lost annually over the next 100 years. This represents a tremendous economic value, other related values not counted. There are, of course, those who want to question these kind of calculations, even when they are scientifically well founded. They want the full and complete proof before they feel ready to take action. It goes without saying that we need to know what we are doing - particularly since corrective measures in this field are usually costly. But it is likewise true that we sometimes have to take decisions although the scientific basis for them may not be complete.

The forest sector, both in the temperate and in the tropical areas, is indeed a case where we would rather do less than we know we should, than overreact on loose scientific grounds. Besides, a measure for which we may not have the full scientific proof as to the particular purpose for which it is suggested, may be unquestionably needed for other reasons. The report I just mentioned concluded, for instance, that the emission of sulphur dioxide not only affects the trees, but "has substantial degenerative effects on the overall environment." And that is true. Those who don't believe acid rain kills trees should find little comfort in their position because the suggested actions have to be taken in any case; in order to stop the monuments and historical buildings from being ruined; in order to stop bridges and other metal structures from falling apart; in order to stop children in the so-called "triangle of death" in central Europe from being born with brain damage, and for a great many other good reasons.

Despite difficult times that don't usually inspire far-sighted policies, some tropical countries have shown a great interest in sustainable forestry and environmental concerns. The donor community has shown an unusual willingness to invest money in forest protective measures. Money seems to be less of a problem than the lack of purposeful projects to be financed. Industrialised countries have also begun to take their own forest problems seriously.

We are in this together - in many ways. There is no time to lose though, so let's get started. And let's do it together.

Keynote Speech

Dr Saburo Okita[1]

At the outset I would like to stress that this technical workshop plays an extremely important role in the management of the world's forests and vegetation which are indispensable and irreplaceable treasures for humankind. Since last year, the Thai Government has expressed willingness to host this Workshop at various international forums, such as the Second World Climate Conference, and thanks to the close cooperation extended by interested governments and international organisations, we have gathered here today to attend this meeting.

The best way to formulate an international consensus on forestry issues would be to build a supportive international cooperation framework upon active initiatives which could be expected from developing countries. Therefore, I would like to express my most sincere and profound gratitude to Thailand which has lent every effort towards the realisation of this Workshop, and to the other governments and international organisations which have extended their cooperation.

Forests are, if managed appropriately, resources which can perform important functions not only for the people who live there but also for the whole of humankind over many generations. Forests play particularly important roles in preventing global warming and conserving valuable genetic resources. Furthermore, we must not forget that forests, through the production of timber and other forest goods, serve as economic resources from which economic and social benefits can be derived. The utilisation of forests must be carried out in a sustainable and effective manner based on the correct understanding of these various roles that forests play at the national, regional and global level; and only then, would it be possible to pursue the sustainable development of the developing countries' economies and the conservation of forests, simultaneously.

In recent years, we have seen the diminishing of the Earth's forest cover, particularly in the case of tropical forests, and the consequences of acid rain on temperate and boreal forests. The accelerated speed and magnitude of deforestation and degradation of forests has brought about deep concern over this problem, and it is now regarded as a global problem which needs immediate counteraction.

I believe that any approach to this problem requires the recognition that forests which are indispensable for ound global environment are at the same time renewable economic resources closely related to development. Furthermore, the approach must be based upon scientific and comprehensive deliberation and formulated by consensus. In this context there is no room for doubt regarding the importance of this current meeting in formulating such valid approaches to forestry issues.

An eminent person's group of the United Nations "World Commission on Environment and Development (WCED)", of which I was a member, introduced the concept of "sustainable development" in its report "Our Common Future", in 1987. This concept is now widely recognised as an important directive in order to meet the basic needs of the present generation while securing positive perspectives for the humankind's future. This concept of "sustainable development" must also serve as the basis for actions which will be taken in order to tackle forestry issues which are confronting us now.

The achievement of "sustainable development" in the forestry field requires a global approach, and as for concrete actions three elements are indispensable; firstly, we must establish policy objectives for up to the year 2000 from a long-term standpoint; secondly, concrete ways and means to achieve these objectives must be formulated; and lastly, financial and technical input must be ensured so that the policies are carried out effectively. Furthermore, it is most important that these policies should be built upon consensus which would be formulated through constant dialogue within the global community.

1 Former Minister for Foreign Affairs, Tokyo, Japan.

I expect that there would be no objection to confirmation that the policy objective should be that total exports of timber products should come from sustainably managed resources. Particularly in the case of tropical forests we already have before us the "ITTO Year 2000 Target". Therefore, what we have to do now is to formulate an international consensus to gradually phase down the volume of tropical timber harvests and trade to a sufficiently sustainable level.

Regarding the concrete ways and means, we must recall that the establishment of an international framework on forestry issues was taken up at the Second Preparatory Committee of the United Nations Conference on Environment and Development. As a result it was decided to examine all steps towards a global consensus on the management, conservation and development of forests, including at minimum a non-legally binding statement of principles. If we take into account that forests are multi-faceted resources, it is most important that the global framework on forest management be a comprehensive and independent one which focuses not only on the global warming problem and the conservation of biological diversity but also on the socio-economic and cultural development aspect. Vigorous effort must be made towards the formulation of the global consensus, thus actively contributing to the success of the United Nations Conference on Environment and Development which will be held in approximately one years' time.

In the case of forests, it is particularly important to carry out the following policies. Firstly, the value-added to wood products must be improved. This will contribute to the development of the local economies and at the same time will help to restrain excessive harvesting. Concrete actions to be taken would include transfer of technology to producer countries on more efficient processing and use of tropical timber and the development of high value-added products, or promotion of lesser known species and new wood products in the consumer countries' markets.

Secondly, the more efficient and rational use of precious timber resources must be pursued. The conservation of forests is not a burden which should be born only by the producer countries. Efficient and rational utilisation of timber must be promoted to the consumers too, thereby suppressing its wasteful use. Concrete actions, including the promotion of special anti-putrefaction treatment at the processing level in order to improve the resistance of timber, or the introduction of a special labelling system for environmentally sound products, such as those which are recycled, should be considered.

Thirdly and lastly, various policies must be implemented to achieve the ultimate goal that "total exports of tropical timber products should come from sustainably managed resources". It may be necessary to take actions such as monthly monitoring of the import volume on country and regional bases, taking into account the import volume perspectives for up to the year 2000. It could also be useful to hold periodic meetings among parties concerned with a view to ensuring stable trade.

At all events, close dialogue between interested parties is indispensable for the global management of forests. Furthermore, additional financial flows to developing countries through bilateral cooperation and multilateral cooperation through the International Tropical Timber Organisation (ITTO), Food and Agriculture Organisation (FAO) and the Global Environmental Facility (GEF) should be promoted in order to give impetus to this initiative.

The world's forests and vegetation can be conserved only if a shared and strong conviction to achieve the "sustainable development" of forests is held by the governments, the private sector and the NGOs, and if effective joint action is taken by them. It is our common mission and responsibility to hand down the rich nature and resources of Earth to future generations, and therefore we must all step forward together towards this goal.

I sincerely hope that through the dialogue between the policymakers and the specialists in the forestry and environment fields at this meeting, an international framework for cooperation could be formulated, and thereby substantial contribution to the solution of the forestry issue made.

1 Introduction

Overview of Status and Trends of World's Forests[1]

T. Allan and J.P. Lanly[2]

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EXECUTIVE SUMMARY

This paper gives a brief review of the status of the world's forests as a base for the Forestry Options Workshop (Bangkok, April 1991). From the established FAO 1980 data base, the current state and broad trends, particularly any changes in closed forest cover are considered, together with trends in forest removals. The forests are presented under the three major climatic divisions of the boreal, the temperate and the tropical zones.

The boreal forests of the colder northern hemisphere cover some 920 million hectares of which 72% is productive. These forests are subject to periodic damage from fire, snow, storm, insects and more recently air pollution, but the forest area is relatively stable.

The temperate and sub-temperate forests have been subject to extensive past clearing for agriculture. The total area of temperate forest is 767 million hectares of which 104 million are in the southern hemisphere. The general trend is a small increase in the exploitable closed forest area due to plantation development, but with the extension of improved management increasing growing stock and incremental rates.

The tropical forests cover some 1937 million hectares or some 53% of the global forest area. The main concern in tropical countries is the accelerating rate of deforestation and forest degradation, with the deforestation alone estimated to be more than 17 million hectares per annum in 1990. The harmful effects of certain forms of shifting cultivation, uncontrolled forest exploitation, and in the drier zones, indiscriminate bush fires are highlighted. The main global issues and options are briefly touched on including:

- the need for addressing the main factors of deforestation and forest degradation;
- the need for improved forest management;
- the opportunity for plantations to compensate for deforestation losses;
- the Tropical Forestry Action Programme as part of a global approach improving the forestry situation;

1 Presented by F Ng.

2 Forest Resources Division, FAO, Rome, Italy.

- a rational forestry approach to mitigating climate change.

1 INTRODUCTION

Reviewing the status of the world's forests in a short presentation is a difficult task, as is typical for the review of any subject at a global level. It is particularly so for forests since the concept embodies a very large number of forest types whose definition and range differ according to the authors, and where the subject of tropical deforestation has become sensational and politically sensitive.

The human population at the start of the 20th century was some 1.6 billion (thousand million), by mid century this had increased to 2.5 billion and by 1990 world population reached 5.2 billion. In tandem with this population increase, industrial growth has multiplied per capita consumption of natural resources and has led to increasing pollution of air and water. This has created concern about environmental degradation. The cumulative impact of toxic waste material is extinguishing species, reducing the carrying capacity of soils, forests and water resources, and gradually altering the atmosphere.

The status and development of forests has been influenced by this continuous demographic and environmental pressure. For forests, a major renewable resource covering some 28% of the global land area, the future challenge lies in meeting the potentially conflicting demands for economic growth, for improving living standards of rural communities and for global environmental stability.

Forests and farm trees are the sources of wood for fuel and raw material for production. Forests provide environmental protection, conservation of soil, water, biodiversity and genetic heritage, as well as yielding products other than wood and offering grazing, hunting and recreation. The growth of populations and economies puts the forests under pressure to provide more products and services from finite resources. At the same time there is pressure to direct forest land to other uses. Just to meet the needs of increased agricultural production in the foreseeable future, it is estimated that the gross transfer of land to agriculture may be of the order of 10 million hectares per year. Other sources of pressure including fuelwood gathering and burning to facilitate pasture growth or hunting add to the loss and degradation of forests.

The 1980 FAO Forest Assessment estimated the rate of deforestation in tropical countries as 11.4 millionper year, or 0.6% of the tropical forest area. Preliminary findings from the current 1990 revised assessment indicate a rate of more than 17 millionper year for the tropics, or more than 1% of the forest area. Such high rates of forest loss, most often associated with regions near to areas of high population density, have naturally created concern for the ability of the forest to fulfil its primary functions.

Whilst the Intergovernmental Panel on Climate Change (IPCC) is gathering data that should improve scientific understanding of global climate change, there is now widespread agreement that significant global warming results from the anthropogenic emission of greenhouse gases (GHG's). These gases derive from such activities as energy production and use, use of chlorofluor carbons (CFC's), some forms of forest clearance and certain agricultural and industrial practices. The primary GHG, CO_2, is mainly derived from the production and use of fossil fuels. Despite the uncertainties still outstanding, particularly those related to magnitude and timing of the change processes, it is necessary to take early action to identify the best available response alternatives and their likely cost effectiveness.

The Noordwijk Conference (1989) recognized the need for international action to combat the greenhouse effect. The general approach aims at maximum flexibility whilst implementing a vigorous programme to reduce GHG emissions. It was recommended that an initial phase focus on profitable and low cost domestic action, which would primarily, but not exclusively, occur in the developed world.

At the May 1989 Helsinki Conference parties to the Vienna Convention and the Montreal Protocol declared their intention to phase out the use of CFCs controlled by the Protocol by the year 2000. The main force for this agreement is depletion of the ozone layer, but an additional argument for immediate action relates to the greenhouse effect.

In relation to fossil fuels, most countries have opportunities for end use conservation, improved energy conversion, efficiency and fuel mix adjustments.

Forest management measures are recognized as offering a further ready opportunity to buy time whilst the more destructive sources of GHGs are tackled on a long-term programme. Forestation and a range of measures to reduce the rate of deforestation would result in carbon storage and lessen emissions. It is suggested that, particularly in the tropical zones, there is great potential for such measures. They are likely to be cost effective when compared to most other alternatives. The essential precondition is that such forestry measures, must meet local development objectives to achieve the necessary impact. Such objectives might include, increased production of wood fuel and industrial wood, combating land degradation, watershed management, and maintenance of biological diversity.

Within the broad environmental agenda, the status, use and conservation of forests has become an issue of global concern. Deforestation is not the main factor of the forecast global warming, nor for that matter will forestry development activities provide a major solution, but nonetheless, it is recognized that forestry can contribute to climatic amelioration and environmental stability.

The main global issues concern the need:

- for action to be taken to reduce deforestation and the consequent water and soil resource degradation which can irreversibly reduce the level and quality of life of associated populations;

- for sustained management of forest resources to meet the ever increasing demands of growing populations, including the many local established rights and demands; and at the same time to maintain their essential role in carbon, oxygen, nitrogen and hydrological cycles;

- to conserve and protect forests for their biodiversity;

- to take action to reduce the emission of industrial air pollutants associated with forest degradation and tree mortality.

Within the global concept the sovereignty of nations over their forests is indisputable but does not preclude responsibility to join consultation and cooperation at transboundary and international levels.

At the national level, the importance of managing forests for the benefit of people cannot be stressed too strongly. In most countries, forests and trees are of particular importance to rural communities, supplying not only wood for energy and construction materials, but also making a direct contribution to food security through the supply of fruits, nuts, food and medicinal plants, animal protein from wildlife, and through the indirect contribution of fodder for livestock and through soil and water conservation. The forests, trees and their products are major sources of economic goods, employment and marketable commodities to rural communities.

2 STATUS OF THE WORLD'S FORESTS

Since its inception in 1948, and in accordance with its mandate, FAO has been engaged in collection of data on the world's forests. The last comprehensive assessment was carried out between 1979 and 1982 in cooperation with the UN Economic Commission for Europe, for the developed countries, and with UNEP for the tropical countries. The initial stage of the tropical part of the study included 76 countries representing 97% of the total tropical land area, with an additional 52 tropical countries completing the area.

Table 1 provides a synoptic view by continent of the global forest areas subdivided into boreal, temperate and tropical forests. These climatic forest types are broadly classified and defined in Appendix I. This table shows that forests covered 3.6 million hectares or 27.7% of global land area (excluding Antarctica) in 1980, with boreal forests accounting for 920 million hectares, temperate forests 767 million and tropical forests 1 937 million. Each of these broad forest divisions will be discussed in the following three sections.

Outside of the areas classified as forests are the other wooded lands, covering some 1 696 million hectares or a significant 13% of the global land area. The distribution of other wooded land is briefly set out in Section 6.

Table 1 Areas of Forest at the End of 1980 by Continent and Main Ecological Zones (In million hectares and in percent of land areas)

Ecological Zones	Continents (with related islands):	Africa	America	Asia[a]	Pacific	Europe[d]	Total
Boreal[b]	Number of countries/territories[b]	0	2	0	0	4	6
	Total (boreal) land area	0	910	0	0	1280	2190
	Total population (millions)	0	4	0	0	39	43
	Boreal forest area (millions ha)	0	203	0	0	717	920
	(percent of boreal land area)	0	22.3	0	0	56.0	42
Temperate including mediterranean and sub-temperate	Number of countries/territories[c]	10	11[c]	22	3	32[c]	78[c]
	Total (non-boreal) land area	727.3	1331.1	1755.9	788.5	1420	6023
	Total population (millions)	119.6	290.4	1316.2	17.9	710.8	2454.9
	Non-boreal forest area (millions ha)	8.1	310.8	188.4	48.7	211.5	767.4
	(percent of temperate land area)	1.1	23.3	10.6	6.2	14.9	12.7
Tropical	Number of countries/territories	46	39	19	21	0	125
	Total land area	2237.3	1651.6	921.4	54.4	0	4864.5
	Total population (millions)	359.9	318.9	1267.1	5	0	1950.9
	Forest area (millions ha)	701.2	889.8	303.4	42.6	0	1937
	(percent of tropical land area)	31.3	53.9	33.7	78.6	0	40.0
All Countries	Number of countries/territories	56	50	41	24	32	203
	Total land area	2964.6	3892.7	2677.3	842.9	2700	13077.5
	Total population (millions)	479.5	613.3	2583.3	22.9	749.8	4448.8
	Forest area (millions ha)	709.3	1403.6	491.8	91.3	928.5	3624.7
	(percent of total land area)	23.9	36.0	18.4	10.8	34.4	27.7

a Asia includes the Middle and Near East but excludes Asian part of USSR.

b Six countries are classified as "boreal" because they have forests in the boreal zone (Canada, Finland, Norway, Sweden, USA and USSR). Greenland and Antarctic territories, which have no forests, are not included.

c Including the six countries classified as boreal, which all have temperate forests.

d Europe includes all of USSR.

3 BOREAL FORESTS

Boreal forests occupy a large circumpolar belt in the northern hemisphere. They cover some 920 million hectares. The boundaries of this belt are principally defined by the temperature regime. They coincide approximately with the 18°C and the 13°C July isotherms. The period with a daily average temperature of more than 10°C is shorter than 120 days and longer than 30 days. Within the large boreal zone a distinction should be made between an oceanic climate with a relatively small temperature amplitude and a continental climate in which the annual range of temperature is greater than that for any other climate with differences between monthly averages, in extreme cases (Siberia), of more than 40°C and with a total temperature span between +30°C and -70°C. Although the climate of the boreal zone is classed as humid, annual precipitation is low.

Soils are young due to recent glacial action (10 000 - 12 000 years since latest ice age). They are generally poor in readily available plant nutrients and acid in chemical balance. Moraines and alluvial sands and gravels dominate. Under dense forest canopies raw humus tends to accumulate. Sites with high water table and/or poor drainage tend to develop into bogs. These together with many end moraine lakes give the landscape its special character.

Conifers, the dominant forest species, are well adapted to the vigorous climatic conditions of the boreal zone. Respiration is reduced during winter dormancy to very low levels, and being evergreen, they respond readily to seasonal change. In central and eastern Siberia, subject to extreme winter conditions species of Larix

Table 2 Boreal Closed Forest by Countries/Regions (million hectares)

Countries/Regions	Closed Forest	Exploitable closed Forest
USSR	673	450
Alaska	5	5
Canada	198	144
Nordic Countries	43.8	40.2
Total	919.8	689.2

(Source: Janz, 1990)

predominate. In the other regimes the genera Pinus, Picea and Abies share dominance. Broadleaved trees of the genera Betula, Populus, Salix and Alnus can become abundant on moist and wet sites, and can establish as pioneer cover in burnt or clear felled sites.

3.1 Present Status

Some 70% of the 920 million hectares of boreal forests is classed as exploitable. The boreal zones thus include 25% of the world's closed forest and the same share of the global exploitable closed forest. There is an extensive area of 294 million hectares of other wooded land not included in Table 2 (that is land which has a tree cover between 5 and 20%, and scrub or brushland with at least 20% cover). Of the total area of closed boreal forest 73% is in the USSR, 22% in Canada and Alaska, and 5% in the Nordic countries: Finland, Sweden and Norway. If we consider Canada and Alaska as one region, the three regions distinguished have distinctly different features with regard to history, utilization and management.

3.1.1 USSR

In the USSR the total forest area is recorded as State Forest Lands, and 64% of this is forested. The forests are classified by function in three main groups:

- Group 1: comprises water conservation, protection and recreation forests covering some 22% of the total forest land.

- Group 2: forests with limited exploitation value due to such factors as high population density or low productivity. They comprise 6% of the forest area, are open to logging but conservation of valuable species and protective functions are emphasized.

- Group 3: productive forests covering the remaining 72% are subject to clear felling by strips up to 1 km. wide.

The boreal forests cover 85% of the forested land and provide some 80% of the USSR forest production. There are large unutilized resources in Siberia, although major increases in wood production are not foreseen in the near future.

3.1.2 North America

Boreal forests are the dominant vegetative formations in central and eastern Canada and the interior of Alaska, covering 202 million hectares. Some 90% of the forest is in public ownership, and whereas 72% of the Canadian forests are productive, the proportion is only 10% in Alaska.

3.1.3 The Nordic Countries

Boreal forests in central and northern Sweden and Norway, and most of Finland cover some 43 millionand of this 92% is considered productive. Historically, parts of these forests have been subject to clearance for agriculture and to depletion by local populations. Currently all forests, other than protected or unproductive forests, are subject to sustained yield management including tending and thinning. Legal provisions and/or economic incentives are used to encourage the reafforestation of suitable unused land.

3.2 Utilization

From Table 2, it can be seen that the proportion of productive/exploitable forest is 66% in USSR, 73% in North America and 92% in the Nordic countries. Globally, the Nordic countries have 1% of the world's closed forest, 2% of the productive closed forest and 5% of the removals of industrial round wood. Similarly, North America has 6% of the world's closed forest, 6% of the productive closed forest and 7% of the removals of industrial round wood. The USSR with 19% of the world's closed forest provides 16% of the industrial round wood removals. Other important uses of the boreal forests include hunting and trapping, protection, natural conservation, reindeer grazing and provision of non-wood forest products.

3.3 Trends

The boreal forests are subject to periodic damage from fire, snow, storm and insects. These natural ingredients of the ecosystem have to be accepted to a large extent as long as their character and frequency do not constitute a major threat to the forests. Indeed, forest management aims at creating forest conditions that reduce the opportunity of attack or lessen the damaging effect of such disasters. Air pollution constitutes a serious threat to the forests and the forest sites. The Nordic countries are particularly exposed to long distance airborne pollution from sulphur - and nitrogen oxides and photo oxidants. Local sources of pollution include pulp mills, fossil fuel power plants and other heavy industry. Serious damage from such emissions have been reported from the USSR.

Active management yields higher density and homogeneity of stands with consequent increases in growing stock and increment. In Sweden, in an area of 17.5 million hectares., active management raised the growing stock per from 72m^3 in 1925 to 97m^3 in 1985, and this figure is expected to reach 129m^3 in 2080.

4 TEMPERATE FORESTS

Temperate and sub-temperate forests are classified on a country by country basis within the temperate zone which comprises either of the two latitudinal zones which broadly lie between 23° and 60° North and South (the North temperate and South temperate zones respectively). The North temperate zone excludes and lies to the South of the boreal zone. The zone includes a range of climates including sub-arctic or sub-antarctic/continental with cool summer (North Canada and Central European Russia)/marine west coast (New Zealand and South Australia)/dry steppe (USSR, China and North America), desert (Australia). The areas nearest to the tropics make up the sub-temperate zone and include such climatic types as Mediterranean (South Europe and North Africa)/humid sub-tropical (Australia).

The broad temperate regime shows distinct seasonal variation with winter conditions which may include one or more months with an average temperature of 0°C. More commonly winters are not severe and summers are long and may be hot.

With such a range of climatic types, there is a wide range of forest types including:

- broadleaved forest, deciduous or evergreen (with genera Quercus, Fagus, Populus and Alnus) and coniferous forests (Sequoia, Pseudotsuga and Pinus) in the North temperate zone;

- in the South temperate zone such genera as Eucalyptus, Nothofagus, Araucaria and Podocarpus;

- in the Mediterranean sclerophyllous forests (mainly Quercus), coniferous forests (Pinus, Abies, Cedrus and Juniperus) and deciduous forests (Quercus and Fagus).

4.1 Present Status

The updated 1980 status of temperate forests is set out in Table 3. The total area of closed forest including plantations is estimated as 767.4 million hectares. The most extensive temperate (non-boreal) closed forest areas occur in USA (190.3 milliom hectares) and China (127.8 million hectares). The general history of temperate forests has been of past clearing for agriculture, so that in non-Boreal Europe, for example, only an average of 14.9% of the land area has closed forest; in China the proportion is 13%.

4.1.1 Europe

In Europe (excluding USSR) temperate closed forests cover 92 million hectares (and boreal forests 44 million hectares). Several countries have significant percentage of coniferous stands partly due to plantation development programmes. These include Bulgaria, France, Ireland, Luxembourg, Spain, Poland, and United Kingdom. More than half of Europe's closed forests 51% are publicly owned, of which 40% belong to the State. The remaining lands are privately held, and 37% is owned by farmers. The range of public ownership is from over 90% in Eastern Europe, to one third in the EEC and Central Europe, to one quarter in the Nordic countries.

Nearly 60% of the closed forests in Europe are worked under management plans, and most of the rest have controls relating to management or use. In many countries, Austria, France, Germany, Switzerland for example, forest holdings of less than 10 hectares cover some 15-25% of the forest area. 78% of Europe's forest and other wooded land have wood production as main function, while 19% are "protection forests" and the remaining 3% are mostly used for recreation.

4.1.2 USSR

The USSR has 118.6 million hectares of temperate forest, which is 15% of the forest area (tables 2 and 3). Some 21.9 million hectares of the total is classified as industrial plantations, of which 3.9 million hectares are hardwoods. A large proportion of the USSR forests are mature or over mature. The 1978 USSR estimate of "mean annual increment" of exploitable forests as 750 million m^3 o.b. is almost double the level of current removals.

4.1.3 North America (Canada and the United States)

Canada and the United States have a land area of 1 839 million hectares, almost equally divided between the two countries. Forests and other wooded lands of 735 million hectares constitute 40% of the total land area, and of that, 459 million hectares is classified as closed forest of which some 256 million hectares or 62% is temperate forest. Some 215 million hectares of Canadian closed forest (including boreal) is exploitable, and over 90% of this is in public ownership, primarily of the Provinces. By contrast, less than 30% of commercial timberland in the U.S.A. is publicly owned, and of the private forest, 28 million hectares is owned by industry, 47 million by farmers and 66 million by others.

The U.S.A. and Canada forest totals include 10.45 million hectares and 1.50 million hectares respectively of plantations, which are almost exclusively softwoods.

Table 3 Area of Forest in the Temperate Zone, by Country and Subregion (million hectares)

Country/region	Area	Country/region	Area	Country/region	Area	Country/region	Area	Country/region	Area
EUROPE		AMERICAS		AFRICA		PACIFIC		ASIA & MIDDLE EAST	
Albania	0.93	Canada	66.10	Algeria	2.20	Australia	41.66	China	127.78
Andorra	0.00	USA	190.26	Egypt	0.04	New Zealand	7.05	Japan	23.89
Austria	3.75			Libya	0.33	Norfolk Island	0.00	Korea, DPR	4.80
Belgium	0.60	North America	256.36	Morocco	3.56			Korea, Rep	6.51
Bulgaria	3.40			Tunisia	0.42	Total for Pacific	48.70	Mongolia	9.53
Czechoslovakia	4.43	Bahamas	0.32	Western Sahara	0.00				
Denmark	0.47	Bermuda	0.00					East Asia	172.51
Faroe Islands	0.00	St Pierre &	0.00	North Africa	6.55				
Finland	0.39	Miquelon						Afghanistan	1.22
France	13.88	Turks & Caicos	0.00	Lesotho	0.00			Bahrain	0.00
Germany	9.69	Islands		St Helena	0.00			Cyprus	0.15
Gibraltar	0.00	US Virgin Islands	0.00	South Africa	1.35			Gaza Strip	0.00
Greece	2.51			Swaziland	0.18			Iran	3.79
Hungary	1.61	Central America	0.32					Iraq	1.25
Iceland	0.00			Southern Africa	1.53			Israel	0.07
Ireland	0.35	Argentina	45.10					Jordan	0.07
Italy	6.36	Chile	8.37	Total for Africa	8.08			Kuwait	0.00
Liechtenstein	0.00	Falkland Islands	0.00					Lebanon	0.04
Luxembourg	0.08	Uruguay	0.63					Oman	0.00
Malta	0.00							Qatar	0.00
Netherlands	0.29	Souht America	54.10					Saudi Arabia	0.20
Norway	1.74							Syria	0.19
Poland	8.59	Total for	310.78					Turkey	8.86
Portugal	2.63	Americas						UA Emirates	0.00
Romania	6.19							Yemen	0.01
San Marino	0.00								
Spain	6.91							Middle East	15.86
Sweden	6.00								
Switzerland	0.94							Total for Asia	188.37
United Kingdom	2.03							(excl USSR, incl	
Yugoslavia	9.10							Middle East)	
Total for Europe	92.85								
USSR	118.60								
Total inc USSR	211.45								

4.1.4 China

Forests now cover some 127 million hectares or around 13% of the land area, which is an increase of 8.6% from 1949. Forest types include cold temperate coniferous forest, temperate coniferous forest, deciduous broadleaf forest, mixed evergreen deciduous forest, and tropical monsoon forest. The forests are subject to frequent fires including the major Daxinganlung Forest Fire of 1987 which destroyed almost 1 million hectares. Priority is now given to fire prevention measures. The Government is promoting forest development under five major projects:

- The "Three North" Shelterbelt System
- Farmland Protective Forestry in the Plains Area
- Coastal Shelterbelts
- Taihangshan Mountain Greening
- Shelterbelts along the Upper and Middle Yangtze River

In the longer term these enterprises broadly aim at doubling the forest cover in these areas. In the Three North project some 6 million hectares were planted during the seven years prior to 1985, in the Coastal Shelterbelt Project some 5.5 million hectares of windbreak and sand dunes have been planned, with 3 million hectares planted up to 1990. In the Farmland Protective Forestry in the Plains, some 26 million hectares of farmland have included farm trees, agroforestry and planting of barrier land.

4.2 Logging/Utilization

In Europe total removals rose by nearly 16% between 1949-51 and 1979-81, to reach 341 million m^3. The bulk of this increase occurred in the 1960's while the 1970's were marked more by cyclical fluctuations than by a trend to growth. The overall trend, however, concealed that while the removal of saw logs, veneer logs and pulpwood increased strongly (by 64% for saw logs and veneer logs and by 178% for pulpwood over 30 years) removals of other products, notably fuelwood, fell. As fuelwood which fell 56% is mainly of non-coniferous species, overall removal of hardwoods also fell in absolute terms.

Roundwood removals in the USSR (including boreal forests) were 357 million m^3 in 1980, which figure represents a downward trend after removals peaked at 395 million m^3 in 1975. Between 1970 and 1980 the only product where removals rose was pulpwood which increased to 4.8 million m^3. Extraction of fuelwood, which was 30% of total removals in 1960, has decreased steadily and was 27% lower in 1980 than in 1960.

In North America in 1980 the U.S.A. produced 327 million m^3 of industrial wood, 75 million m^3 of sawnwood, 26 million m^3 of wood based panels, 46 million m.t. of woodpulp and 57 million m.t. of paper and paper board. Despite such production, U.S.A. imports, mainly from Canada, where production at 150 million m^3 is just some 6.2 million m^3 below the accessible annual allowable cut.

In China there has been rapid development of forest industries and by 1990 there were some 600 wood based panel factories producing annually 0.83 million m^3 of plywood, 1.5 million m^3 of fibreboard and 0.48 million m^3 of particleboard.

In Australia annual roundwood removals ranged between 16.5 to 20.6 million m^3 in the period 1983-84 to 1988-89. In New Zealand removals rose from 2.5 million m^3 in 1950 to 9.6 million m^3 in 1985, with the proportion of exotics, mainly Pinus radiata, rising from 36 to 92% in the same period.

4.3 Trends in Temperate Forests

An obvious feature of temperate forests is the application of forest management or control systems. Information is more available for Europe. In Europe the general proportion of closed forest covered by management plans is 60% and most of the remaining 40% is subject to some form of control. In the USSR the entire public forest comes under some form of management, but the degree of control is not specified.

The broad trend in Europe is clear: while the area of productive closed forest has increased slightly, there are indications that growing stock (total volume of utilisable wood) and increment have increased more rapidly. The result of effective management in Sweden in significantly increasing growing stock per hectares has a wide application throughout the temperate zone. The general trend in forest change in the temperate zone over the last 50 years is mainly positive, with net gains registered by a number of countries including Finland, France, Poland, Spain and Sweden.

Finland showed a net gain in closed forest of 1.18 million hectares, over 17 years to 1981. This was due firstly to upgrading of other wooded land by drainage, and secondly to afforestation of 300 000 hectares of agricultural land. The creation of a National Forest Fund (FFN) in France in 1946, has over the years, provided a financial base for supporting development of a range of forestry activities, including protection and upgrading, employment, plantations, roading and provision of harvesting and processing equipment. So that by 1985, 1.8 million hectares of productive forest had been established, and a net forest gain 1.05 million hectares was recorded in the 17-year period to 1981. Sweden has recorded a small net forest gain, mainly on agricultural land, but losses were registered to urban and road development. In the United Kingdom substantial afforestation of upland areas and restocking of scrubland has added 1.05 million hectares over some 33 years to 1981.

The United States recorded net closed forest losses of 6.8 million hectares over 16 years to 1978.

The development of forest plantations has been significant in New Zealand and Australia. In New Zealand plantations have increased from 77 000 hectares in 1921 to 1.095 million hectares in 1985. To illustrate the economic importance of these plantations, between 1950 and 1985, the proportion of plantation roundwood removals increased from 0.9 million m³ to 8.9 million m³ (92% of the annual total). Australia has 0.973 million hectares of plantations as at 1989, with yearly planting of around 44 000 hectares

Spain and Portugal have been engaged in extensive plantation development. Spain has forest plantations totalling some 4.07 million hectares, of which 14% (0.575 million hectares) is fast growing hardwoods, with the remaining 86% softwoods. In Portugal the total is 3.08 million hectares of which 12.5% is fast growing hardwoods, 44% other hardwoods and 43% softwoods.

In the Mediterranean zone, the most serious threats combine overgrazing and fire. In the mid 1980's FAO reported between 30,000 to 40,000 fires which damage some 500 000 hectares of forest and other wooded lands annually. Fires occur but are less serious in the boreal and cool temperate zone, except when a conjunction of unfavourable factors create high hazard conditions and extensive fires.

A significant factor of temperate forest degradation in Europe is local and transboundary air pollution. Such pollutant damage to forests, is often associated with other forms of damage and it is difficult to ascribe quantitative values to particular sources. Pollutants often damage trees and foliage, but may also damage soils which may result in long lasting site degradation, and often the two types of damage are related. Research into sources has concentrated on SO_2, NOx, and photo-oxidants such as ozone or peroxyacetal nitrate.

In 1968 the First European Congress on Influence of Air Pollution on Plants and Animals met. One estimate of damaged forest was 0.4 million hectares in the Ruhr Basin, Saxony and Silesia. A 1985 study in Europe estimated 6.9 million hectares of forest were affected by air pollutants, but of this 5 million hectares showed only minor damage. Some 1.7 million hectares were classified as moderately damaged, and about 230 000 hectares as dead or dying. Thus it was estimated that 5% of European exploitable closed forest showed signs of damage and 0.2% was dead or dying, the main damage at that time being in Austria, Belgium, Czechoslovakia, France, Germany (East and West), Hungary, Luxembourg, Netherlands, Poland and Switzerland. Until the beginning of the 1980's the general opinion was that non-coniferous trees were more resistant to air pollution than conifers, but after dry summers in 1982 and 1983, such trees as beech and oak appeared to shown signs of being affected as well.

A 1988 European survey found that damage ranged from 0.6% of all trees severely defoliated or dead and 0.7% moderately defoliated in Portugal, to the same proportions being 5.4% and 22% respectively in Czechoslovakia. Serious forest damage from air pollution was noted in 18 other European countries and further reports on this subject are coming from USSR, Canada and the U.S.A.

5 TROPICAL FORESTS

Forests of the tropical countries (as at 1980) were assessed as covering 1,937 million hectares, or some 53% of the global forest area. As noted in Appendix 1, a small proportion of the forests in certain tropical countries are not tropical (for example, in Southern Brazil, Southeast Paraguay, North Mexico, and in the mountainous regions of Pakistan, India, Bhutan and Nepal). Conversely, a small proportion of forests of non-tropical countries are tropical forests (essentially in the northern part of Australia and the southern tip of China). Forests covered 40% of the total land area of tropical countries, compared to only 20% in the non-tropical world. Tropical America was by far the most forested of the three main tropical regions (53.9%), the two other regions being covered by forests in approximately one third of their total area. In the tropical zone there was almost exactly one hectare of forest per inhabitant, but only two thirds of a hectare per inhabitant in the rest of the world.

5.1 Present Status

Division is made in the tropical forests between:

1 Productive forests: the stand and terrain characteristics of these forests and the present regulations allow for the production of timber. They can be undisturbed or already logged once or more, managed or unmanaged, and they can be economically accessible or inaccessible.

2 Unproductive forests: these are the forests which cannot be used for the production of timber, either for physical reasons (i.e. because of stand characteristics and/or terrain conditions) or for legal reasons

(essentially because they are included in national parks and other protected areas).

In the tropical world 18% of the closed broadleaved forests were found in tropical Africa at the end of 1980 (Table 4). Almost all undisturbed closed broadleaved forests (undisturbed productive forests and almost all unproductive forests[3]) were found in the Central Africa subregion. Four countries of this subregion, Cameroon, Congo, Gabon and Zaire, possessed 77% of the closed broadleaved forests of the whole region, the latter having some 106 million hectares, 9% of the world total area. The eight countries of the coastal zone of West Africa, once largely covered with closed forests, accounted for only 8% of the total closed broadleaved forest area of tropical Africa. This proportion has since been reduced, given the present high annual deforestation rates particularly in Côte d'Ivoire (6.5%), Liberia (2.3%) and Nigeria (5.0%).

Africa is the continent of woodlands, and of wooded, tree and shrub savannas. The first three categories covered some 480 million hectares, and represented two thirds of the open forests of the tropical world. The other third belong to a large extent to tropical South America.

Coniferous and bamboo forests in tropical Africa (1.1 million hectares each) and forest plantations (1.8 million hectares) represented, at the end of 1980, a tiny fraction of a total forest cover of some 700 million hectares.

At the end of 1980 tropical America possessed more than 650 million hectares of closed broadleaved forests, or 56% of those of the whole tropical world (Table 4). Brazil with 356 million hectares of these forests, was by far the most important tropical country with more than 30% of the closed broadleaved forest of the tropical world. This proportion was 52% (603 million hectares) for the group of the eight Amazonian countries plus French Guyana.

Two thirds of the coniferous forests of the tropical world (some 23 million hectares) were located in Central America and Mexico. However, only about 10% of the Mexican coniferous forests, or some 2 million hectares, were stands of tropical pines. Hence the total area of tropical pine forests in the region was only 4.9 million hectares of Brazilian Araucaria forests, which in 1955 covered 4.8 million hectares, had been reduced in 1980 to 1.2 million hectares and were being converted to agriculture at an annual rate of some 100,000 hectares.

Forests covered about one-third of the total land area of tropical Asia (table 1), a proportion comparable to that of tropical Africa, which has a large part of its land mass under desert and semi-desert conditions, and is much smaller than that of tropical America. The main reason is the population density which averaged 138 inhabitants per km^2 as opposed to 16 for tropical Africa and 19 for tropical America.

Closed broadleaved forests represented 85% of the forests in tropical Asia. Open forests covered only 9%, coniferous forests 2.6%, bamboo forests and plantations 1.7% each. Of the closed broadleaved forests of the region 56% were concentrated in insular Southeast Asia, particularly in Indonesia, Malaysia, and the Philippines. With some 114 million hectares i.e. 9.8% of the total for the tropical world, Indonesia was second after Brazil for the area of its closed broadleaved forests.

Papua New Guinea had, at the end of 1980, some 34 million hectares of closed broadleaved forests. This represented about 90% of the total for the whole tropical Pacific region (excluding the tropical part of Australia). Other important islands, with forest cover, are the Solomon Islands, Fiji, New Caledonia, Vanuatu, and Samoa.

At the end of 1980, there were only 11.65 million hectares of forest plantations in the whole tropical world, an area exactly equal to 1% of that of its natural closed broadleaved forests, and to 0.6% of that of its natural forests. Three-quarters of these plantations were broadleaved and one-quarter coniferous. Three countries accounted for two-thirds of the total planted area, i.e. Brazil (33 percent), India (18 percent), and Indonesia (16%). Approximately 62% of the plantations had been established for production of industrial wood, and the rest for production of fuelwood and non-wood forest products and for protection purposes.

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3 Detailed comments on classification are given in Tho, these proceedings

Table 4 Areas of Natural Forests and Plantations at end of 1980 for Tropical Countries and Territories by Regions and Sub Regions (million hectares)

Forest Classes	Closed broadleaved forests					Fallows of closed broad leaved forests	Open broad leaved forests	Conif. forests	Bamboo forests	Total Natural forests	Plantations			Total forest area
	Productive		Unproductive		Total									
Tropical Regions and Sub-regions	Undist.	Logged	Physical reasons	Protected areas							Broad.	Conif.	Total	
West Sahelian Africa	0.8	1.0	0.4	0.1	2.3	0.2	39.6	-	-	41.9	0.05	e	0.05	41.9
East Sahelian Africa	0.7	1.2	4.0	0.4	6.3	0.9	83.9	1.1	1.0	92.3	0.35	0.15	0.50	92.8
West Coast Africa	2.7	8.2	5.3	1.1	17.3	33.9	36.3	-	-	53.6	0.35	e	0.35	54.0
Central Africa	111.7	23.5	29.4	5.8	170.4	16.8	111.9	-	0.1	282.4	0.05	e	0.05	282.4
Tropical Southern Africa	0.7	5.5	1.8	0.8	8.8	6.4	207.1	-	e	215.9	0.30	0.25	0.55	216.5
Insular Africa	1.6	5.1	2.8	0.9	10.4	3.5	2.9	-	-	13.3	0.15	0.15	0.30	13.6
Tropical Africa	118.2	44.5	43.7	9.1	215.5	61.7	481.7	1.1	1.1	699.4	1.25	0.55	1.80	701.2
Central America & Mexico	19.8	4.5	17.4	0.6	42.3	19.7	2.6	22.6	e	67.5	0.10	0.10	0.20	67.7
Caribbean subregion (incl. Guyana Belize)	31.0	4.0	9.2	0.6	44.8	2.0	0.5	0.5	e	45.8	0.10	0.10	0.20	46.0
Tropical South America	401.3	45.2	107.0	12.7	566.2	77.6	204.1	1.6	e	771.9	2.80	1.40	4.20	776.1
Tropical America	452.1	53.7	133.6	13.9	653.3	99.3	207.2	24.7	e	885.2	3.00	1.60	4.60	889.8
South Asia	6.7	36.3	3.3	6.3	52.6	9.6	5.9	6.7	1.4	66.6	2.40	0.10	2.50	69.1
Continental S.E. Asia	18.0	9.0	9.8	2.5	39.3	18.4	6.4	0.3	1.5	47.5	0.15	e	0.15	47.7
Insular S.E. Asia	49.7	46.4	41.0	7.1	144.2	22.0	3.0	0.5	-	147.7	1.55	0.70	2.25	150.0
Indochina	9.0	2.7	9.9	0.5	22.1	16.0	11.7	0.4	2.2	36.4	0.15	0.10	0.25	36.6
Tropical Asia	83.4	94.4	64.0	16.4	258.2	66.0	27.0	7.9	5.1	298.2	4.25	0.90	5.15	303.4
Pacific Islands (incl. Papua New Guinea)	14.6	0.4	22.7	0.1	37.8	1.3	4.2	0.5	-	42.5	0.05	0.05	0.10	42.6
Tropical World	668.3	193.0	264.0	39.5	1164.8	228.3	720.1	34.2	6.2	1925.3	8.55	3.10	11.65	1937.0

Source: J.P. Lanly

1 List of countries in the regions/sub-regions is given in Appendix II.

e Area less than 50,000 hectares

5.2 Logging

In the 1980 assessment, a country by country estimate was made of the areas of undisturbed closed forest being logged annually for production of wood for industry. The figures arrived at were 2.0 million hectares for tropical America, 0.65 million hectares for tropical Africa and 1.75 million hectares for tropical Asia and the Pacific, or some 4.4 million hectares in total. Average annual production of timber from natural forests of tropical countries increased by 12% from 1976-80 to 1981-88. Undisturbed closed forest logged-over for the first time has probably increased by a factor somewhat smaller, given the tendency, observed already in the 70's, of increased output per hectare.

5.3 Trends in Tropical Forests

Deforestation, in the strict sense used in this paper, involves the removal of the forest and its replacement by another use, be it shifting or permanent agriculture, ranching, mines, or dams. By extension, it is considered that there is deforestation when a natural forest is cleared to give way to a forest plantation (in this case, however, the decrease in the area of natural forest is compensated by an increase of the area of man-made forests). Logging, which is mostly selective in the tropics, does not by itself change the use of the land and is not considered a form of deforestation sensu stricto. Two observations should be made in this regard:

- Logging opens up new forest areas which are often encroached or "squatted" on by farmers in search of land. Logging is thus followed by deforestation, which explains why the areas of logged forests not subsequently cleared by agriculture are relatively small. Though both operations may follow closely and, in some cases, almost simultaneously, it is important to make a clear distinction, since their direct effects on the forests are different.

- Logging is generally done without working plans or control by the forest owner (the State in many cases). In some regions, particularly in the dipterocarp forests of South-East Asia, logging intensity is high and the forests are seriously damaged. In many cases, logging appears as a factor of degradation, to be distinguished from deforestation (which replaces a forest by a different use of the land).

No estimate is available of the large areas of forest and woody covers being degraded (except for logging in closed broadleaved forests - see below). Estimates of areas annually deforested (cleared) are given in Table 5. Around 1980, annual percentage of deforestation in the three main tropical regions was of the same order of magnitude - minus 0.5 to 0.7 percentage - for the main forest classes (closed broadleaved, open broadleaved). However, the situation varied considerably from one subregion to another, and from one country to another.

In relative terms, the situation was shown as most critical in West Coast Africa and insular Africa (mainly Madagascar), in Central America and Mexico, in Colombia, Ecuador and Paraguay, and in continental South-East Asia (Myanmar and Thailand). It was serious in the Western and Eastern Sahelian zones of Africa and in insular South-East Asia. The situation was not serious in Central Africa and in the continental part of the Caribbean subregion (particularly Guyana, Suriname and French Guyana).

With widespread and growing concern that deforestation had accelerated over the decade of the 80's, there was a persistent demand for up-to-date and reliable figures on the subject. In 1989 the Committee on Forest Development in the Tropics (CFDT) suggested that FAO provide a report on the condition of tropical forest areas, well in advance of the 1990 Forest Resource Assessment Project (due in mid-1992). Accordingly, a preliminary report was submitted by FAO in 1990, based on provisional estimates derived from the first phase of the 1990 Forest Resources Assessment Project.

The preliminary report covers 62 tropical countries, which possessed 79% of the total forest area of all tropical countries in 1980. The corresponding 1990 estimates are set out in Table 6, below.

The 62 countries are situated wholly or in part in the moist tropical zone only. It cannot be assumed that parallel developments have occurred in the dry and mountainous tropical zones, making it possible to update the rate of deforestation for the whole tropical zone. A comparison of the 1980 and 1990 assessment figures has been made for 52 of those countries included in both assessments, which indicated the estimated annual rate of deforestation of 9.2 million hectares in 1980 had risen to 16.8 million hectares in 1990. This increase reflects not only an actual increase in the rate of deforestation between the 1976-80 and 1981-90 periods, but also a possible underestimation of the rate in 1980, and overestimation in 1990.

Table 6 Provisional Estimates of forest cover and deforestation for 62 tropical countries (1990 Forest Resources Assessment Project) (areas in thousands of hectares)

Region	Number of countries studied	Total land area	Forest area 1980	Forest area 1990	Annual deforestation 1981-90	Rate of change 1981-90 % pa
Tropical Africa	15	609,800	289,700	241,800	4,800	-1.7
Tropical Latin America	32	1,263,600	825,900	753,000	7,300	-0.9
Tropical Asia	15	891,100	334,500	287,500	4,700	-1.4
Total	62	2,764,500	1,450,100	1,282,300	16,800	-1.2

source: FAO (1990a)

There are signs of a slow down in a group of densely populated Asian countries mostly because what little forest remains is mainly inaccessible. A similar slowing down has occured in West Africa (Côte d'Ivoire and Nigeria).

Estimates relating to forest clearance are well known. Shifting cultivation accounted for 45% of clearing of closed tropical forests around 1980 (approximately 70% and 50% in tropical Africa and Asia, respectively). Ranching is an important factor in Central and South America, but an insignificant one in tropical Africa and Asia. Overexploitation for fuelwood, leading to complete clearing, is another critical factor of deforestation in the dry tropics of Africa.

In Brazil the 1988 and 1989 removal of tax credits promoting land development in the Amazon basin, is reported as reducing deforestation by 25% between 1990 and 1989.

Historical records in Suriname show that fires have had significant impact at regular intervals since the beginning of this century (the last fire, in the early 1960's, burnt 160 000 hectares). However, the huge extent of the recent fires in Kalimantan, Cote d'Ivoire and Brazil, for example, is a new phenomenon. Thorough studies are needed to assess the effects of these fires, not only in the short but also in the medium term.[4]

Fires are a dominant factor of the dry tropical zone. Most of the African savannas represent fire ecosystems climax. Trials in savanna in Zambia, have shown that continuous controlled burning and protection bring about an increase in woody biomass and correspondingly decrease the grass layer, until a type of almost closed forest is achieved. There is every indication that the incidence of uncontrolled and late fires is prevalent and increasing in the dry tropical zones, with a consequent degradation of the woody cover.

It is estimated that total biomass containing 3 to 6 Pg C[5] is burned annually, and that the net CO_2 release is 1.1 to 3.6 Pg C. An important recent finding concerns the substantial loss of fixed nitrogen which may be occurring due to biomass burning, and appears to be of greatest significance for savanna and agricultural ecosystems in the tropics and sub-tropics. It is considered that the savanna regions may play an important role in the global carbon cycle due to their large productivity, and the pyrogenic formation of long lived elemental carbon.

Based on the 1980 data, forest management of productive closed forests applied to between 4 and 5% of the total productive forest area, roughly 42 million hectares, of this some 37 million occurs in South Asia, mostly in deciduous forests (such as Tectona and Shorea spp.).

A further 87 million hectares or some 4.4% of the total tropical closed and open forests is situated within

4 See Sargent and Lowcock, this report

5 1Pg (pentagram) = 10^9 Metric Tonnes

protected areas and national parks. Such areas come under some form of conservation management, the level of implementation and application of management ranging from non-existent to satisfactory in different countries.

Plantation development is a feature of forest planning in many tropical countries with an inadequate or depleted resource. As shown in Table 5, the estimated plantation development in the tropics in the five years to 1985 was 5.5 million hectares (47% of the 1980 total). The whole African continent (with the exception of South Africa) with a total of 2.99 million hectares of forest plantation in 1980 was estimated to have added 1.17 million hectares in the five years to 1985. Plantation development in the African savanna regions is illustrated by such countries as Zimbabwe, Kenya, Zambia and Tanzania where sound plantation establishment techniques, have allowed estimated proportional increases on the 1980 areas of 20 to 34% in the five years to 1980. In the moist tropics leading countries engaged in plantation development include Nigeria and Côte d'Ivoire, where extensive loss of natural forest occurs. Tropical Asia had a total forest plantation area of 5.09 million hectares in 1980 with an estimated additional plantation development up to 1985 of some 2.2 million hectares (or some 43% of the 1980 total).

6 OTHER WOODED LANDS

There are considerable areas of other wooded lands not classified as forest, with a tree stand density of less than 10% to 20%. Such areas include open woodland where the crown cover is less than 10% to 20% of the area, or scrub and brush land with shrubs covering more than 10% of the area. They comprise also all types of woody fallows deriving from the clearing of forests by shifting cultivation and constituted by various reconstitution stages ("secondary bush", "secondary growth", "young secondary forest").

The relation between the forest and the other wooded lands is dynamic. Forest area may be decreased in certain zones by clearing, by being replaced by alternative land use, most often agriculture in the developing world, and urbanization in the developed world. In similar fashion the forest area and biomass may be increased by artificial enrichment or protection and natural recolonization of shrub or thicket areas. Some of the other wooded lands, in certain territories, due mainly to soil or climatic limitations represent climax formations, with limited capacity for change of status.

Table 7 Area of "Other Wooded Lands" at end of 1980 by continent (in million hectares and percentage of total land area)

Continents	Non-tropical countries/territories			Tropical countries/territories			All countries/territories		
	Total land area	Other wooded lands		Total land area	Other wooded lands		Total land area	Other wooded lands	
		area	%		area	%		area	%
Africa	727.3	6.6	0.9	2,273.3	623.4	27.9	2,964.6	630.0	21.3
America	2,241.1	269.1	12.0	1,651.6	322.0	19.5	3,892.7	591.1	15.2
Asia	1,755.9	66.0	3.7	921.4	111.2	12.4	2,677.3	177.2	6.6
Europe (inc USSR)	2,700.0	231.4	8.6	-	-	-	2,700.0	231.4	8.6
Pacific	788.7	64.3	8.2	54.2	2.4	4.4	842.9	66.7	7.9
World	8,213.00	637.4	7.7	4,854.5	1,059.0	21.9	13,077.5	1,696.4	13.0

Table 7 shows that at 1980 other wooded lands represent a significant 13% proportion of the global land area (excluding Antarctica), with 21.9% being found in the tropical countries and territories and 7.7% occurring in the non-tropical areas. Africa and America have the largest proportions with 27.9% and 19.5%, respectively.

Whilst such areas are generally not of great forestry potential, they have some significance in relation to biomass and possible climatic influences.

7 MAIN FORESTRY ISSUES AND OPTIONS

The study of global forest status and trends sets the scene and confirms the major area of concern as the deforestation and degradation of forest areas the world over, particularly, but not only, in the tropics over the last decade. The main negative factors are clearance of forest by all forms of agriculture, by indiscriminate burning of forest lands, and by urbanization. The main positive factors are the effects of applying sound planning and forest management in natural forests, of planned plantation development including the development of agroforestry systems, of introducing fire control systems and of the benefits to be derived from carrying out adequate forest research programmes.

7.1 Deforestation and Forest Degradation

It is not easy to define and assess degradation, whose ultimate stage, in any event, is deforestation. As noted in section 5.3, the annual rate of deforestation in 52 tropical countries has increased from 9.2 million in 1980 to 16.8 million hectares in 1990. The critical concern is how to slow and eventually arrest this accelerated process.

Agricultural conversion of forests is usually a consequence of a government policy, sometimes well planned, but often expedient. The main requirement in reaching decisions is that all main options are considered, and that selection involves those least harmful to the environment and which result in sustainable agriculture. Ideally, forest lands should be converted to alternative uses only if these latter are soundly based and sustainable.

Globally, shifting cultivation accounted in 1980 for 45% by area of forest clearing, with the proportions being 70% in Africa and 50% in Asia. However, records are seldom kept of areas of fallow regenerating into forest - or of the social and biological importance of the forest fallow. Shifting cultivation, if in balance is an effective agroforestry system; although when, in response to increasing demand, the fallow period is reduced, loss of fertility and degradation may occur. An obvious approach is to develop improved shifting cultivation systems, such as improved tree fallows (using species that speed up the soil fertility regeneration phase) or other agroforestry systems which are appropriate for farmers and lead to more sustained agricultural production. Theoretically, for each year of fallow saved, between 7% and 10% of the system's land area returns to closed forests status. Considerable research has been carried out, but the translation into appropriate cropping systems in the field is slow. Since shifting cultivation utilizes such extensive areas of moist tropical forests, and the system involves several hundred million people, the upgrading and improvement of this system has to be a critical option.

Fire in the humid tropics is associated with shifting cultivation, and any interventions that reduce the area used in this farming system would correspondingly reduce fire.

Fire represents the major degradation factor in sub-temperate and dry tropical zones. Fires tend to be indiscriminate, and spread all the more easily, and are all the more destructive the later in the dry season they occur. Fires degrade all types of woody vegetation. African woodland, wooded and tree savannas and Central American coniferous forests are "pyroclimax". When fires no longer take place or are controlled, if the ecological conditions allow it, the savanna reverts to closed forests, and in Central America a closed broadleaved forest replaces the pine forests.

Systems to reduce the frequency or intensity of fires in the dry zones have been developed but seldom seem to be systematically applied. There is need for a concerted effort to introduce fire control and hazard reduction measures to reduce the intensity of dry zone forest fires.

7.2 Forest Management

Forests are critical elements in land use, a resource supplying wood for energy and building, supplying multiple other products including foods, fruits, wildlife protein, medicinal plants and fodder, and significantly contributing to conservation of essential soil and water resources. Additional forest benefit may be a contribution to slowing global climate change. Forests can act as effective carbon sinks with their capabilities to store atmospheric carbon for long periods as woody tissue.

Reference to table 1 demonstrates the general effect of past deforestation in the temperate zone, with only 12.7% of the original closed forest remaining as compared with 40% in the tropical and 42% closed forest cover in the boreal zone. The trends show that the boreal and temperate forest areas are now basically stabilised, but there are positive indications of net increases in the temperate forest area, mainly due to national afforestation programmes and the rehabilitation of degraded forest areas. This does not imply that the situation in these zones is satisfactory or cannot be improved. The results from forest management implementation in the European countries confirm that the application of sound forest management will increase increment rates and growing stock, effectively increasing the biomass and creating management options to extend rotations if the values of carbon fixing incentives are added to the equation.

In the tropics, management implementation at less than 5% of closed forest areas is slight. This low rate, coupled with the lack of incentives and benefits for local populations derived from forest management, contribute to deforestation. Without policy changes and positive action to strengthen management it is unlikely that the area of forest under sustained management could increase. This then tables the question whether sustainable management is possible. The forestry answer has to be in the affirmative, but with the proviso that the permissible cut is likely to be considerably less than many cuts currently being exercised. The balance between the economic and the silvicultural cut has to be redressed if forests are to be sustainably developed.

The wider and improved application of forest management has to be a main national option. Forest management is used in the broad sense of sustainable development which includes both wood, other products and benefits including meeting the needs of local communities. In areas of high population density, resources that are neither managed nor used are at risk, and under such conditions the conservation and protection of biodiversity can become virtually impossible. The management option to conserve forests or to recover degraded forest areas, would in many cases offer the least cost alternative.

7.3 Afforestation and Reforestation

Plantation forestry generally involves an intensively managed simplified forestry system for a selected range of wood products. The result of such intensive management is, generally, biomass increments higher (per unit area) than is found in natural forest in the same ecological zone.

The global area of plantations was 81 million hectares in 1965 and is estimated at 130 million hectares as at 1990, of which 25 to 35 million hectares are in the tropics. Although plantations occupy just over 3.7% of the total area of the world's natural forests, their annual wood increment is estimated at 800 million m^3 or 25% of the natural forest increment.

Forest plantations will continue to make a major contribution in compensating for some of the deforestation losses. In the temperate zone this process of making good past losses is already taking place. In Australia and New Zealand, for instance, large scale industrial plantation development has already contributed to national production allowing the forest authorities greater facility to control or protect remaining indigenous forests.

A particular facet of forest plantation systems is that the resource can be managed easily on a sustained basis, and objectives other than wood production can readily be incorporated in some ecosystems, e.g. environmental considerations or non-wood products. In the dry tropics for example, plantations can make good the loss of natural forest cleared for fuelwood. However, plantations will often require to be supplemented or replaced by other types of tree planting, suited to the current land use, the physical and the socio-economic environments. Farm trees or agroforestry systems may better satisfy local needs than forest plantations.

Fuelwood and charcoal provided 17% of the total energy consumption in the developing countries as at 1990. The contribution in Africa is 50% and in certain countries reaches 80% to 90%. In the less developed countries heavy dependence on fuelwood is likely to continue well beyond the year 2000. Where the supply of fuelwood is established as a free commodity by the collectors, local communities will have to be involved and committed if the wood resources are to be managed on a sustained basis.

Increasing the resource base by plantation development in the broad sense has always been viewed as a major forestry option and will remain so for a long time to come.

7.4 Tropical Forestry Action Programme (TFAP)

As a consequence of the concern for tropical deforestation in the 1980's TFAP was launched in 1985 jointly by the World Bank, the UNDP, World Resources Institute and FAO. The TFAP provides a unique framework for concerted action at national, regional and global levels by tropical countries, international organizations and development aid agencies.

TFAP recognizes conflicting demands put by the short term needs of developing nations on one side and the long term conservation of the environment on the other. It proposes priority lines of action to reconcile them through the sustainable development of forest resources, so that the sector can contribute effectively to the relief of poverty while at the same time conserving the forests. This aim obviously is compatible with the initial intentions under the Noordwijk Declaration. The state of TFAP implementation as at February 1991 is shown in Table 8. A total of 73 countries is engaged in the exercise, 29 in Latin America and the Caribbean, 30 in Africa and 14 in the Asia Pacific. A further 8 countries are about to initiate activities and a further 7 countries have made preliminary inquiries.

The response of the tropical countries to TFAP has exceeded expectations and as a consequence there have been some delays and difficulties in implementation. However, despite some criticisms and misgivings there is no comparable alternative global initiative. The countries supporting the Noordwijk Declaration (see below) should direct their energies to supporting and strengthening the TFAP and the national programmes that evolve from the planning exercises most of which aim at sound and sustainable forestry.

Table 8 Status of TFAP Exercises (as at 2/91; Number of countries)

Status	Latin America & Caribbean	Africa	Asia & Pacific	Total
Planning phase completed (inculding donors round table)	10	5	5	20
Forestry Sector Review completed	5	4	3	12
Forestry Sector Review underway	14	21	6	41
Sub Total	29	30	14	73
Exercise requested	2	4	2	8
Preliminary contacts	2	4	1	7

7.5 Forests, Forestry and Climate Change

7.5.1 Impacts of Climate Change on Forests

There is general broad agreement amongst scientists that the planet is experiencing a process of climate change - primarily global warming - induced by human activities, although there are considerable gaps in understanding the processes involved. Agriculture and the burning of tropical forests contribute to global warming, but to a much lesser degree than the combustion of fossil fuels and industrial activities in the developed world.

The first appreciable impacts of climate change may occur by the year 2000 and intensify thereafter. A major difficulty in assessing the impact of global warming on plant life results from the complex interaction of climatic effects and plant physiological processes. Climate change will not only affect crops and trees, but also their diseases, pests and weeds. The indications are that weed competition could increase because of higher temperatures and CO_2 enrichment. Pests and diseases could extend their range with the possibility of increases in the frequency and intensity of epidemics.

Most of the predictions of the effects of global climate change on forest resources are based on outputs from relatively crude climate models. These have produced a wide range of sometimes conflicting results. While some positive effects of climate change are predicted, most of the effects are negative.

Higher temperatures and increased levels of atmospheric CO_2 and precipitation could result in increased tree growth. At least one study predicts increased productivity of the boreal forests of Scandinavia under a scenario of CO_2 doubling.

One of the possible effects of global climate change is a shift in the natural ranges of tree species and forest types towards polar latitudes. Since the magnitude of climate change is expected to be more pronounced in the upper latitudes, the temperate and boreal regions of the world are expected to be more severely affected.

Some global climatic models predict that interior regions of continents will receive reduced precipitation under a doubling of CO_2. This would be accompanied by reduced soil moisture, especially during the summer growing season. One scenario predicts a virtual elimination of the closed boreal forests from the interior of the North American continent, with replacement by desert brush or steppe ecosystems.

7.5.2 Forests as Carbon Sinks and the Noordwijk Declaration

Recognising the ability of the forests to act as "carbon sinks" and contribute to the capture of CO_2, the Noordwijk Declaration proposed a world net forest growth of 12 million hectares a year in the beginning of the next century as a provisional aim. This is to be achieved through conservation of existing forests, aggressive afforestation and improved forest management.

FAO's Expert Consultation on Forestry and Climate Change held in March 1990 fully supported the general objectives of the Noordwijk Declaration, but recommended that any response should represent sound policy independent of the predicted global warming, and should produce net benefits separate from those which may ultimately arise in the climate change context. This means that tree planting for CO_2 absorption should be encouraged where it is ecologically appropriate, economically profitable and socially acceptable. This should be defined by land use plans and forest strategies as described in national forestry action plans and not by theoretical targets[6].

Activities aiming at (i) management and protection of existing areas of natural forest to provide for long-term sustained yield productivity of a wide range of goods and services including CO_2 absorption, (ii) increasing efforts in the afforestation or reforestation of appropriate sites with follow-up management and protection, and (iii) appropriate utilization of the wood produced to avoid carbon release. These activities should provide a number of benefits to human society over and above the reduction of greenhouse gases if based on sound principles of ecology and silviculture. These benefits would include soil and water conservation, increased availability of wood and non-wood forest products, improved wildlife habitat, genetic resource conservation, recreation, amenity and scenic values.

7.5.3 Global Forest Options Related to Climate Change

The TFAP offers a window for actions for the conservation and development of tropical forests. However, action concerning forests in their relation to climate change must be applied in all regions of the world. The task group on forests at the Second World Climate Conference identified the following priority fields of action:

- assessing opportunities to increase forest carbon storage commensurate with national resource development policies;

- managing the world's forests to maximise biomass and resultant carbon storage in addition to maintaining sustainable yields of forest products, biodiversity and other forest benefits;

- accelerating research to assess the added contribution that forests can make to atmospheric CO_2 reduction and the impacts of climate change on the world's forests;

6 See also Sargent and Lowcock, this report

- designing and implementing international monitoring systems to determine conditions and changes in forest ecosystems in response to anticipated climate changes;

- supporting the development of a proposed international instrument on conservation and development of the world's forests, linked with the proposed climate and biodiversity conventions.

Concerning this latter option, it is worth noting that some areas of forestry are included already under several legal instruments which relate to tropical timber trade, forestry research, and protection of endangered species and ecosystems. However, a number of important forestry fields are not covered by these instruments such as socio-economic aspects of forestry, forestry in relation to conservation of water and soil resources, amenity, the interface of forestry, agriculture and food security. All such subjects and the options noted above could be brought under an international instrument of forests which would promote sustained development and conservation of forests and provide a necessary framework to support and develop international forest related initiatives.

Developing countries have collaborated in providing data for climate change studies. They need to benefit more from the analyses developed from their contributions. So in addition to assistance in building up and managing their forest resources, further assistance is required to bring them into the climate change debate and to furnish them with the means to build up scientific, technological and institutional capacity to monitor and assess climate information relating to their countries and regions.

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APPENDIX I DEFINITIONS AND CLASSIFICATIONS

Forests are defined as all vegetation types in which the trees constitute the dominant woody element, with the crowns covering 10 to 20% of the ground. Trees are defined as (Ford-Robertson, 12), "woody perennial plants typically large and with a single well-defined stem carrying a more or less definite crown, more than 7 metres high when mature". Also included as trees are the aerial stems of monocotyledons such as bamboos and palms, though strictly speaking they have no wood. The proportion of 10% of crown cover is often used, in particular by Unesco's (1973) International Classification and Mapping of Vegetation, as the limit between the types in which the trees actually constitute a community and those where they are scattered or in lines in landscapes where woody vegetation is not the predominant element. ECE use a crown cover of more than 20% ground cover. Excluded are shrub vegetation types, though they often derive from the forests through fires and other anthropogenic factors, or constitute the adapted forms of forests in specific edaphic and climatic conditions.

The expression "natural forests" will be used to differentiate from man-made plantations. Natural forests could be either managed or unmanaged, primary forests or forests in an advanced stage of reconstitution after having been cleared at least 60 to 80 years ago (old secondary forests), or secondary forests of more than 20 to 30 years of age. Younger secondary forests or regrowth in the tropics are included in the category of "forest fallows", that is the complexes of woody vegetation deriving from the clearing by shifting cultivation and constituted by a mosaic of various successional stages. Any serious assessment of tropical forests must single out this category of secondary vegetation which can degrade to permanent grass vegetation, or, in contrast, can revert to forests if allowed to do so by the retreat agriculture.

Another important distinction to be introduced is that between undisturbed forests (forests in which there has been no logging for the last, say, 60 to 80 years) and those which have been logged (mostly selectively) one or more times during the last 60 to 80 years (the very large majority of those which have not been subsequently cleared have actually been logged in the last 50 years or so).

Other Wooded Land is defined as land which has some forestry characteristics, but with a tree stand density of less than 10 percent to 20%. It includes:

(a) Open woodland: land with trees whose crown cover less than 10 to 20% of the area.

(b) Scrub and brushland: land with shrubs or stunted trees covering more than 10% of the area.

(In the ECE/FAO Survey of temperate forests, a tree stand density of 20% separates closed forest from Other Wooded Land, rather than the 10% used by FAO).

A considerable number of detailed classifications of forests exists, based on ecological and/or physiognomic criteria. Botanists and other systemic specialists, may apply almost limitless levels of differentiation when classifying and describing forest vegetation. Forest inventory specialists, however, with responsibility for assessing forest areas at regional and global levels, have to refrain from introducing too detailed a classification because:

- the more detailed a global classification, the more difficult it is to establish simple correspondences between its categories and those of the large number of classifications used in the various countries;

- estimation of areas covered by each forest type at any given time is more consistent and reliable as the number of types is reduced, and this is particularly true in visual interpretation of remote sensing imagery, which becomes more subjective as the number of types increases;

- ecological dynamics are such that over time, areas covered by a given forest class are converted to other forest classes, and such areas have to be estimated to determine changes in forest resources. The need to estimate such periodic changes as reliably as possible is probably the major justification for a simple vegetation and land use classification in global forest resource assessments.

Editors note: There is nevertheless considerable need for classifications to be rigorously defined and agreed internationally, at present there is a very loose use of terminology, and uncertainty over definition. This has lef to misunderstanding, misinformation and confusion. See also Tho, this report.

APPENDIX II List of Countries Included in the 1990 Forest Resources Assessment

1 Subregional grouping of boreal, temperate and sub-temperate countries.

1a Boreal zone	
North America	Canada, USA (Alaska only)
Nordic Countries	Finland, Norway, Sweden.
USSR	
1b Temperate zone (inculding sub-temperate/mediterranean	
North Africa	Algeria, Egypt, Libya, Morocco, Tunisia, Western Sahara.
Southern Africa	Lesotho, Saint Helena, South Africa, Swaziland.
North America	Bahamas, Bermuda, Canada[1], St. Pierre & Miquelon, Turks & Caicos, U.S.A.[1], U.S. Virgin Islands.
South America	Argentina, Chile, Falkland Islands, Uruguay.
Asia (exculuding Asian USSR)	Afghanistan, China, Japan, Korea Rep., Korea DPR, Mongolia.
Middle and Near East	Bahrain, Cyprus, Gaza Strip, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen[2].
Pacific	Australia, New Zealand, Norfolk Island.
Europe	Albania, Andorra, Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Faroe Islands, Finland[1], France, Germany[3], Gibraltar, Greece, Hungary, Iceland, Ireland, Italy, Leichenstein, Luxembourg, Malta, Netherlands, Norway[1], Poland, Portugal, Romania, San Marino, Spain, Sweden[1], Switzerland, United Kingdom, Yugoslavia.
USSR	USSR[1] (inculding Asian Republics).

1 These temperate countries have areas of boreal forest, and are also recorded under the boreal zone

2 Republic of Yemen, combines Yemen Arab Republic and Yemen Democratic Rep.

3 Inculdes former East and West Germany.

2 Subregional grouping of tropical zone forests.

2a Africa	
West Sahelian Africa	Burkina Faso, Cape Verde, Chad, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal.
East Sahelian Africa	Djibouti, Ethiopia, Kenya, Somalia, Sudan, Uganda.
West Africa	Benin, Côte d'Ivoire, Ghana, Guinea, Liberia, Nigeria, Sierra Leone, Togo.
Central Africa	Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Sao Tome and Principe, Zaire.
Tropical Southern Africa	Angola, Botswana, Burundi, Malawi, Mozambique, Namibia, Rwanda, Tanzania, Zambia, Zimbabwe.
Insular Africa	Comoros, Madagascar, Mauritius, Reunion, Saint Helena, Seychelles.
2b Latin America and the Caribbean	
Central America	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama.
Caribbean[4]	Antigua and Barbuda, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Netherlands Antilles, Puerto Rico, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Saint Christopher and Nevis, Trinidad and Tobago.
Tropical South America	Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, Venezuela.
2c Asia	
South Asia	Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka.
Continental South East Asia	Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam.
Insular South East Asia	Brunei Darussalam, Hong Kong, Indonesia, Macau, Malaysia, Philippines, Singapore.
2d Pacific[5]	American Samoa, Canton and Enderbury, Christmas Island, Cocos Islands, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Nauru, New Caledonia, Niue Island, Other Pacific Islands[6], Papua New Guinea, Samoa, Solomon Islands, Tokelau Islands, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands.

4 Not included yet in the assessment: Anguilla, Aruba, Caicos Islands, U.S. Virgin Islands.

5 Not included yet in the assessment: Johnston Island, Midway Islands, Pitcairn, Wake Islands.

6 Consists of: Marshall Islands; Micronesia, Federated States of; Northern Mariana Islands; Palau, Republic of; and United States Minor Outlying Islands.

State of Forestry in the Asia-Pacific Region

Y.S.Rao[1]

ABSTRACT

This paper reviews the changing scenario of forestry developments in the Region. Narrative, examples and figures specific to countries have been quoted. The issues dealt with in this review are: Land Utilization, Environmental Protection and Watershed Management; Forest Resources and their Management; Forest Products; Forest Industries; Forest Products other than Wood; Forest Policies, Legislation and Development Planning; Forestry Institutions and the Implementation of the Tropical Forestry Action Plan.

The review shows that annual deforestation increased from 2 million ha. per year during 1970-1980 to 4.7 million ha. during 1980-1990. A major effort to raise forest plantations and promote tree growing in rural areas was undertaken by most countries in the Region. Current efforts, region-wide, exceed 3 million hectares. per year. There is a growing awareness and interest in conservation, resulting in the earmarking of protected areas and managing them to conserve wildlife resources and biodiversity. In many countries growth of forest industries slowed down. The TFAP is under implementation in 17 countries of the Region.

Intervention Notes

H.E. Ting Wen Lian[2]

A statement was given by HE Ting Wen Lian, Malaysian ambassador to Italy, in which she called for additional data, particularly regarding the state of forests in the developed world, to inform the forestry debate and as a prerequisite to any international instrument.

CAN Statement on Forests[3]

K Snyder[4]

ABSTRACT

The Climate Action Network introduced a draft statement on forests which had been prepared at the first meeting of countries negotiating a convention on climate change at Chantilly, Virginia, February 1991. Attaining sustainable lives and livelihoods for humanity and all other species was the preeminent concern of the NGOs represented at that meeting.

1 Regional Forestry Officer, FAO, Regional Office for Asia and the Pacific, Phra Atit Road, Bangkok, Thailand.

2 Malaysian Ambassador to Italy

3 Update: February 21, 1991 climate/forest working group of the Climate Action Network

4 Washington DC, USA.

World Wildlife Fund Statement

ABSTRACT

A statement was made by the World Wildlife Fund in which the need for a Global Convention on Forests was identified. The statement briefly outlines potential elements and indicates an appropriate procedural initiative.

2 National Forest Options
2.1 Tropical Moist Forests (Track I)

Tropical Moist Forests - Facts and Issues

Y P Tho[1]

1 INTRODUCTION

Tropical moist forests, in particular tropical rain forests, and the consequences of their continued depletion have garnered considerable international concern since the early 1950's. That the concern has been sustained for so long is not surprising. Tropical rainforests do evoke emotive responses, especially in the developed countries in Europe and North America. Classical accounts of early expeditions and discoveries, reports of scientific studies, and recent coverage of "unsustainable" exploitation have all contributed to popular appeal. Documentation can be traced to descriptions of tropical rain forests in the late 19th Century by explorer/scientists such as Darwin or Wallace. Concern was substantially heightened during the last decade by the release of the 1980 FAO statistics. It was documented that tropical forests were being deforested at the rate of slightly more than 11 million hectares per year (7.3 million hectares of closed canopy forests and 3.8 million ha of open forests). Deforestation is now increasingly linked to loss of biodiversity and implicated as one of the causes of climate change. Inevitably, international concern led to international pressure. Environmental non-government organisations in developed countries became extremely vociferous in this respect.

This paper is intended to provide a brief review of the current status of tropical moist forests. It will also focus on and summarise issues of current concern in relation to their depletion and global environmental issues, mainly climate change and loss of biodiversity. In providing this overview as a background paper for discussions and considerations of forestry options in the humid tropics, it will also seek to highlight some of the many ambiguities and contradictions that have been generated. Independent assessments and interpretations, by design or otherwise, will need to be resolved for pragmatic forestry options to be advanced and adopted.

2 CLARIFYING TERMINOLOGIES

It is surprising to note in recent popular literature and scientific reports that the terminology relating to tropical forests, tropical moist forests and tropical rain forests has been loosely used. In many published reports, for example, the term tropical moist forests has been misrepresented as being synonymous with tropical rain forests, and vice versa. All these have led to miscommunications and misrepresentations of statistics concerning forest extent, as well as in reference to associated issues. Recent statements such as "...tropical moist forests cover only 7% of the earth's surface..." (Johnson et al, 1991 in quoting Reid and Miller, 1989), "...Rainforests may cover 7% of the earth's surface..." (WWF, 1990), and "...closed tropical forests contain more than half the world's species, though they cover only 7% of the earth's surface..." (Reid & Miller, 1989: p.15) are extremely misleading. These can result in contradictory perceptions of the extent of the forests being referred to or that tropical forest, tropical moist forests, and tropical rain forests all refer to the same areas.

Such miscommunications become even more apparent when comparing world maps in recent publications showing the extent of the resource. Many of these cannot be rationalised nor can they be compatible with each other. The use of different terminologies in these maps compounds the problem even more. Reference to such maps in isolation will provide very differing conclusions on the extent of Tropical Forests. Many examples do exist. Some of these include those showing the extent of moist evergreen forests and tropical moist deciduous forests (WRI, 1986), tropical wet forests and tropical dry forests (USDA, undated), tropical rain forests (in Ooi, 1990) and tropical forests (WWF, 1990). A comparison of these maps will serve to highlight the many independent interpretations that have been provided. All these underline the need for the proper definition and more coherent usage of the terms in order that facts and figures are not misrepresented.

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Technically the tropics is the area of the world between the Tropic of Cancer and the Tropic of Capricorn. It can also be delineated in consideration of climatic factors such as the use of the mean annual 20^{0}C isotherm. However, this is seldom done and will not be used in the present context. Tropical Forests can therefore be simply defined as all forests, closed canopy or otherwise (savannas and grasslands excluded), that are located within the tropics. This is however essentially on a geographical basis and does not take into consideration plant associations, forest structure, and bioclimatic influences. This delimitation of the extent of tropical forests does present problems in resource accounting as forest inventories have largely been country based. In addition, there are many tracts of evidently closed canopy tropical forests that do exist outside of the tropical belt.

Tropical Rain Forest was a term first used by Schimer in 1898 (Whitmore, 1984) in broad reference to natural forests that were found in the humid tropics where there were no apparent dry periods in the year. This term has since been very widely adopted but loosely used. It does not specifically refer to any forest type. However, popular literature has provided descriptions and associative models of tropical rain forest which would be similar to those found in the lowland dipterocarp forests of Borneo and the Malay Peninsula. With increasing research and documentation there had been a gradual recognition that tropical forests in the three tropical regions are highly varied with respect to stature, structure, species composition, and ecological dynamics. Many classification systems have been used to separate and group the numerous forest types and, as such, different terminologies have been introduced.

The term tropical moist forests was only used recently. It does not refer to any specific forest type but was meant as a convenient term to embrace all other moist forest types (particularly moist deciduous forests) found in areas peripheral to the tropical rain forests (which includes the moist semi-evergreen forests and the moist evergreen forests). In South Asia, the term tropical moist forests would therefore refer to the monsoon forests and the tropical rain forests. Despite this simple concept, this term together with other related terminology have still been frequently misused. It is not surprising that Mathur (1990) in reviewing world forest resources and Ooi (1990) in assessing world tropical timber trade have both maintained the use of tropical rain forests although it was clear that the coverage pertained to tropical moist forests. In the American publications there is constant reference to the term tropical wet forests which may be interpreted as synonymous with tropical moist forests (United States Agricultural Service, undated) or as a distinct and separate forest type altogether (eg. Brown and Lugo, 1984).

It is apparent that many of the recently adopted terminologies are rooted in Holdridge's (1967) life zone system for the classification of plant formations in the world. This system is based on the life zones being delineated in consideration of the three interdependent variable factors of biotemperature (influenced by latitude and altitude), mean annual rainfall, and potential evapotranspiration ratio. This system does provide tangible divisions of the tropical biomes. Holdridge, in using this system, identified 30 life zones that supported tree/plant formations. Rainforests, wet forests, and moist forests were treated as separate life zones. Hence, rainforests incorporated those occurring in super-humid zones with a potential evapotranspiration ratio of less than 0.25. Wet forests included those in the perhumid zones (potential evapotranspiration ratio between 0.25 to 0.5), and the moist forests being those in the humid zones (potential evapotranspiration ratio of 0.5 to 1.0). Dry Forests would occur in those zones with the potential evapotranspiration ratio greater than 1.0.

Other existing forest classification systems that have been used to distinguish forest types are based on a combination of factors such as forest structure, floristic composition, phenological behaviour, altitude, and rainfall patterns (Wyatt-Smith, 1962; UNESCO, 1973; Van Steenis, 1975; Whitmore, 1984; Legris & Blasco, 1989). Associated with these are a wide variety of terminologies. It is, however, not the intention of this paper to provide any comprehensive nor critical review of forest and vegetation classification in the tropics. What is more important is to seek a simple and rational basis as to what constitutes tropical moist forests.

For convenience and ease of understanding, the general term tropical moist forests could be defined as inclusive of all forests that occur within the humid tropics which can be further defined as those zones with the potential evapotranspiration ratio of less than 1.0. In simple terms, it refers to zones where the annual rainfall input exceeds the amount of water lost through evaporation and transpiration.

3 WORLD TROPICAL FOREST COVER

It is these uncertainties over definitions that have given rise to the many different interpretations of the 1980 data set derived from the world forest resource inventory carried out by FAO. Numerous varying statistics have, therefore, been presented of tropical forest cover and even of world forest cover as noted by Mathur (1990). This has generated undue controversy, particularly in relation to the issue of tropical deforestation.

In a recent FAO presentation on the extent of tropical forest cover (Troensegaard, 1990), forests in all countries which are totally or for their largest part situated within the tropical belt were included. This would in many ways be a very practical and acceptable assessment. However, forests located in parts of China and Australia within the tropical belt were excluded, but forests lying outside the tropics in Brazil, India, Mexico, Paraguay, Bhutan, Nepal and Pakistan were included because they were subject to tropical monsoonal influences (Table I). This assessment of 123 countries included both closed and open forests as well as plantations. World forest cover and tropical forest cover amounted to 3,604 (27.6% of total land area) and 1,937 million hectares (14.8%), respectively as at the end of 1980. Tropical Africa (36.2%) and America (45.9%) accounted for 82% of the world tropical forest cover.

A further breakdown of the tropical forests into various categories of productive and non-productive natural forests, protected areas, forest fallows, coniferous and bamboo forests and forest plantations is given in Table II.

Table I Extent of World and Tropical Forests at end of 1980 (Area in million hectares - includes natural closed and open forests and plantations).

	TROPICAL COUNTRIES				ALL COUNTRIES			
Continents/ Regions	Number	Total land area	Total forest area	% forest to land area	Number	Total land area	Total forest area	% forest to land area (sq.km)
AFRICA	46	2,237.3	701.2	31.3	56	2,964.6	709.3	23.9
AMERICA	39	1,651.6	889.8	53.9	49	3,892.7	1,435.8	36.9
ASIA	22	900.2	303.4	33.7	42	2,677.3	491.8	18.4
EUROPE + ASIA	-	-	-	-	32	2,700.0	876.5	32.5
PACIFIC	16	54.2	42.6	78.6	24	842.9	91.3	10.8
WORLD	123	4,843.3	1,837.0	40.0	203	13,077.5	3,604.7	27.6

Source: Troensegaard, 1990 (FAO 1980 Data)

Undisturbed natural broadleaved forests (34.5%) and the protected areas (2.0%) still covered 36.5% of the total forested area - much of which (69.7%) are located in tropical America. The total closed natural broadleaved forests extend over 1,165 million hectares (60%) and open broad-leaved forest covered 720 million hectares (37.2%) of the tropical forest area. Coniferous forests are mainly found in tropical America and bamboo forests in the Asian tropics.

However, it is very difficult to reconcile this set of tropical forest statistics with those that had been summarised for 76 countries in the chapter on conclusions and recommendations of the conference on Tropical Response Options to Global Climate Change held in Sao Paulo in January 1990 (Anon, 1990) which stated that:

Table II. Areas of natural forests and plantations at end of 1980 (area in million ha)

	AFRICA	AMERICA	ASIA	PACIFIC	TOTAL TROPICS
1.Closed broad-leaved forests					
a)Productive -					
Undisturbed	118.2	452.1	83.4	14.6	668.3
Logged	445.5	53.7	94.4	0.4	193.0
b)Unproductive -					
Physical reasons	43.7	133.6	64.0	22.7	264.0
Protected	9.1	13.9	16.4	0.1	39.5
TOTAL	215.5	653.3	258.2	37.8	1164.8
2.Fallows of closed broad-leaved	61.7	99.3	66.0	1.3	228.3
3.Open broad-leaved forests	481.7	207.2	27.0	4.2	720.1
4.Coniferous forests	1.1	24.5	7.9	0.5	34.2
5.Bamboo forests	1.1	<0.5	5.1	-	6.2
TOTAL NAT. FORESTS	699.4	885.2	298.2	42.5	1925.3
6.Plantations	1.8	4.6	5.2	0.1	11.7
TOTAL FOREST AREA	701.2	889.8	303.4	42.6	1937.0

Source: Troensegaard, 1990 (FAO 1980 Data)

Note: The figures presented under this category have not been included by Troensegaard into the total forest area.

"...In 1980, closed canopy tropical moist and dry forest occupied an area of about 1.2 billion hectares. The distribution of this was 679 million, 217 million, and 306 million ha in Latin America, Asia and Africa, respectively. Ten countries ... contained 80% of closed moist forest. Open canopy forests occupied 1.4 billion hectares. The distribution of this was 929 million, 363 million, and 67 million ha in Africa, Latin America, and Asia, respectively. ...In 1980, regenerating forest fallow occupied about 408 million ha, with 169 million, 166 million, and 73 million ha of this distributed in Latin America, Africa, and Asia, respectively. Plantations occupied 11.5 million, 4.6 million, and 1.8 million ha in Asia, Latin America and Africa, respectively (FAO, 1982)..."

The discrepancies between these two sets of summaries of the statistics obtained from the same source is very evident when Tables II and III are compared. Troensegaard's figures of tropical open forest areas are significantly smaller. It is noted that he did not include the area under forest fallow into the total forest area. These examples only serve to stress the importance of a very urgent need to provide an update of the 1980 figures so as to be able to arrive at some common position and understanding of world forest cover for forestry option considerations.

In this respect, there have of course been many attempts to revise these 1980 data. Notable would be those presented by Myers (1989) through accounting for recent deforestation statistics for some tropical countries. However, a world forest resource update has yet to be truly presented. It is noted that FAO is currently in the process of finalising its 1990 tropical forest assessment report. Until this is made available, it would be more realistic for the world community to regard current world forestry statistics in terms of relative rather than absolute assessments.

Table III World Tropical Forest Cover (area in million hectares)

Region	Closed canopy moist & dry forests	Open forests	Forest fallows	Plantations	Total
Latin America	679	363	169	4.6	1215.6
Africa	306	929	166	1.8	1402.8
Asia	217	67	73	5.1	362.1
TOTAL	1202	1359	408	11.5	3005

Source: Anon (1990)

Table IV World Cover for Tropical Moist Forests (area in million hectares)

Region	All	Closed Moist	Open	Total
Africa	217	205	486	703
Asia-Pacific	306	264	31	337
Latin America	679	613	217	896
TOTAL	1202	1082	734	1936

Source: Grainger (1990)

4 TROPICAL MOIST FOREST COVER

It would be difficult to assess tropical moist forest cover given the current uncertainties and ambiguities over the interpretation of the forest resource statistics. Most assessments that have been presented and used to generate world scenarios of changes in tropical moist forest cover have been country based. Data so derived are relative to the countries included and in most cases it is assumed that all the prevalent forest areas within the included countries are moist forests. Conversely, there are many smaller countries with moist forests that are often left out. Whilst such details have not deterred and, indeed, should not deter assessments and analyses, nonetheless they are important and should be highlighted.

Using the 1980 FAO statistics Grainger (1990) had, in the development of his hypothetical models of world changes of tropical moist forest cover, included 43 countries - 15 in Africa, 10 in the Asia-Pacific, and 18 in Latin America. The Oceanic islands and Australia were not included. He also concluded that, at the end of 1980, out of the 1,201 million ha of closed canopy tropical forest in the world, 1,081 million (90%) were tropical moist forests (Table IV). Of this, 613 million ha were located in Latin America, 264 million ha in Africa. Large extents of undisturbed natural moist forests can still be found in Brazil, in Latin America, Zaire in Africa, and Indonesia in Asia.

There has also been some recent estimates of the current extent of tropical moist forests. In a forthcoming IUCN/WCMC (World Conservation Monitoring Centre) publication on the Asia-Pacific Region (Collins et al, 1991), the tropical moist forest cover of 18 countries has been estimated based on assessments of the latest forest resource maps from these countries (Table V). Myers (1989) had also carried out independent assessments of 26 countries (Table VI) and compiled statistics of deforestation as well as present forest cover. However, his estimates of deforestation were generally high and the current forest cover low. This is clearly evident when comparing the IUCN/WCMC and Myer's estimates for the ASEAN countries with the 1989 national reports of forest resources (Table VII). The comparison shows that the WCMC estimates are more consistent with what has been given in the country reports.

For the Asia-Pacific region, the WCMC estimates indicate that the extent of closed canopy moist forests had decreased from 311 million hectares at the end of 1980 to an estimated figure of 284.9 million hectares (8.4% reduction). Much of the changes recorded were from South Asia and Continental S. E. Asia.

Table V Extent of Tropical Moist Forests in Asia and the Pacific (area in square km.)

CLOSED CANOPY TROPICAL MOIST FOREST					
Country	Land Area	Approximate original extent	Remaining Extent FAO(1988) 1980 Data	Remaining Extent WCMC (1991)	% WCMC to original
India	2,973,190	910,000	504,010	228,330	25.0
Sri Lanka	64,740	26,000	16,590	12,260	47.0
Bangladesh	133,910	130,000	9,270	9,730	7.0
Myanmar	657,540	600,000	313,090	311,850	52.0
China/Taiwan	9,326,410	340,000	125,860	25,860	8.0
Lao PDR	230,800	225,000	78,100	124,600	55.0
Cambodia	176,520	160,000	71,680	113,250	71.0
Vietman	325,360	280,000	75,700	56,680	20.0
Thailand	510,890	250,000	83,350	106,900	43.0
Sub-total	14,399,360	29,510,000	1,277,650	989,460	328.0
Malaysia	328,550	320,000	209,960	200,450	63.0
Brunei	5,760	5,000	3,230	4,692	94.0
Singapore	610	500	-	20	4.0
Indonesia	1,811,570	1,700,000	1,138,950	1,179,140	69.0
Phillipines	298,170	295,000	95,100	66,020	22.0
Sub-total	2,444,660	2,320,500	1,447,240	1,450,322	252.0
Papua NG	452,860	450,000	342,300	366,750	82.0
Australia	7,617,930	11,000	10,516	10,516	96.0
Fiji	18,270	18,000	8,110	6,970	39.0
Soloman Islands	27,540	27,000	24,230	25,590	90.0
Sub-total	8,116,600	506,000	385,156	409,826	307.0
GRAND TOTAL	24,960,620	32,336,500	3,110,046	2,849,608	887.0

Source: The Conservation Atlas of Tropical Forests (Asia and the Pacific). Eds. Collins, Sayer and Whitmore

Table VI Deforestation Rate for 1989 - 26 Countries (area in million hectares)

Country	Land Area*	Deforestation (1989)**	Present Forest Cover (FAO)**
ASIA			
Indonesia	181,157	1200	860
Myanmar	65,754	800	245
Thailand	51,089	600	74
Malaysia	32,855	480	157
India	297,319	400	165
Vietnam	32,536	350	60
Papua NG	45,286	350	360
Philippines	29,817	270	50
Laos	23,080	100	68
Kampuchea	17,652	50	67
SOUTH/CENTRAL AMERICA			
Brazil	845,651	5,000	2,200
Mexico	190,869	700	166
Colombia	103,870	650	278.5
Peru	128,000	350	515
Central America	522,915	330	90
Ecuador	27,684	300	76
Bolivia	108,439	150	70
Venezuela	88,205	150	350
Guyana	19,685	50	410
AFRICA			
Nigeria	91,077	400	28
Zaire	226,760	400	1,000
Ivory Coast	31,800	250	16
Cameroons	46,540	200	164
Madagascar	58,154	200	24
Congo	34,150	70	90
Gabon	25,767	60	200

* Source: World Resource (1990 -91)
** Source: Myers (1989)

Table VII Comparison of Estimates of Total Forested Areas in the Asean Countries (area in million ha.)

Total Forest Cover					National* Reports (1989)
Country	Land Area	FAO (1980)	WCMC (1991)	Myers (1989)	
Malaysia	32.86	20.99	20.05	15.70	20.05
Indonesia	191.93	113.89	117.91	86.00	144.00
Thailand	51.31	8.33	10.69	7.40	14.40
Philippines	30.00	9.51	6.60	5.00	6.46
Brunei	0.582	0.323	0.469	N.A.	0.469

* National Forestry Status Reports presented at a Special Meeting of ASEAN-COFAF Coordinating Group on Forestry, 1989

5 INTEGRATED ECOLOGICAL STUDIES

The significant development of integrated studies on the structure and functioning, essentially ecological dynamics, of Tropical Rain Forest ecosystems began only in the 1960s. In Thailand, through a joint Thai-Japanese effort, studies on forest structure and dynamics were carried out in 1961-62. In 1963, Odum started many innovative ecological studies in El Verde in Puerto Rico. The pioneering studies at El Verde were published in a voluminous report in 1970. Odum in his summary of these studies provided some of the many basic concepts and ecological frameworks that have contributed to the advancement of the science of ecological dynamics of rain forest ecosystems. Since then, a number of similar integrated studies, with international cooperation and sponsorship, have been carried out in some countries in the three tropical regions including:

a) American Tropics - Panama (Darien, Barro Colorado Island), Puerto Rico, Cuba (Sierra del Rozario), Peru (Iquitos), Costa Rica, Mexico (Jalapa), Brazil (Manaus), French Guyana (Oyapok), Venezuela (San Carlos de Rio Negro), USA (Hawaii, Florida);

b) African Tropics - Ivory Coast (Miombo, Tai Forest), Nigeria (Omo), Gabon (Makoko), Central African Republic (Basse Lobaye), Zaire (Yangambi);

c) Asia-Pacific - Thailand (Sakaerat), China (Tinhu Mountains), Malaysia (Pasoh, Danum Valley, Mulu), Indonesia (East Kalimantan, Celebes & other sites), Papua New Guinea (Gogol), Australia (North Queensland).

Results of studies from this network of research sites, supplemented by other independent studies and assessments of long-term plots set up by local forestry authorities, have over the last 35 years contributed very significantly to the current understanding of tropical moist forest ecology. Considerable information and data have been published.

6 FOREST STRUCTURE AND DYNAMICS

Since the milestone publication of Richard (1952), increasing research and documentation of the structure, functioning and dynamics of these forests have led to the recognition that tropical moist forests within the three major tropical regions are highly variable with respect to their structure, composition and ecological dynamics.

Plant growth, form, and associations are, to a large extent, very dependent and influenced by numerous ecological and environmental factors. These have been extensively reviewed (e.g. in UNESCO, 1978; Golley, 1983; Whitmore, 1984; Jordan, 1985). Based on current state-of-the-art information and the ecological concepts that have been formulated, it is possible to summarise in a very simplistic manner some of the current general perceptions of such relationships. In essence, there are trends of decreasing forest stature (in particular, predominant height), composition (plant and animal diversity), biomass, and primary productivity with increasing latitude, altitude, aridity and interferences (natural and human).

However, it is essential to note that there are many exceptions and variations to this general trend in response to prevailing edaphic factors such as soil, geology, microclimate differences, and water availability. Major edaphic forest types include mangrove forest, swamp forest, and heath forest. Hence, in continental and insular South East Asian tropics, the various forest formations can be distinguished by geographical and ecological factors as follows:

1 Due to altitude changes,

- Tropical lowland evergreen rain forest (up to 1200m);
- Tropical lower montane rain forest (1200-1500m);
- Tropical upper montane rain forest (1500-3000m);
- Tropical subalpine forest (>3000m).

2 Influenced by edaphic factors,

- Heath forest (podzolised sands);
- Forests over limestone;
- Forests over ultrabasic rocks;
- Beach vegetation (sandy and rocky substrates);
- Mangrove swamps (coastal, estuarine, salt water);
- Brackish water forests;
- Peat swamp forests (oligotrophic peat);
- Fresh water swamp forests (permanently inundated, eutrophic substrate);
- Seasonal swamp forests (periodically inundated, eutrophic soils);

3 With increasing latitude (increasing seasonality/dry months),

- Tropical moist semi-evergreen rain forest;
- Tropical moist deciduous.

In addition, it is very well documented that even within very localised areas in the humid tropics, forest stand stature and architecture as well as composition, can vary considerably in response to slope, soils, geology and past catastrophic events (wind throw, landslips, volcanic eruptions, agriculture). This has been effectively demonstrated in Sarawak (Bruniq, 1983) and discussed in depth by Jordan (1985). It is therefore quite common in lowland evergreen rain forest to find mosaics of distinctly different forest types associated with geological formations in the area as well as ecoclines of tall dense forests grading down to forests with short, stunted, sparsely-spaced trees. Forests in riparian zones will differ considerably with forest on the ridges. Forest structure variations within forest formations contributes to heterogenity in habitat which in part accounts for the high species diversity in tropical rain forests.

It becomes important to be aware and be able to recognise that such high forest habitat diversity is prevalent in the humid tropics. This is also relevant as there is the general tendency in the mass media and even during inter-governmental negotiations to regard tropical moist forests as one homogenous forest unit. In generating world scenarios and predictive models, care must be exercised not to over-generalise from limited information.

7 BIOMASS AND PRODUCTIVITY

There have only been a few plant biomass (phytomass) measurements undertaken in closed canopy tropical moist forests (Table VIII). This is because such measurements entail enormous effort, time and supervision in order to get accurate and reliable assessments. Where they have been successfully carried out, the studies were invariably limited to small plots of less than 0.25 ha. This plot size limitation has been well recognised. However, significant correlations have been demonstrated between standing biomass and forest tree parameters such as basal area and volume. These correlations have provided the means for estimates of phytomass to be derived from detailed forest stand inventories.

Given the highly variable forest stand structure within mature forests in response to different soils, land forms, geology, altitude and geographical region, as noted earlier, the number of studies that have been carried out have not been able to encompass all the different forest habitats. This is yet another serious limitation in estimating biomass. Bruniq (1983) has indicated, based on a network of small sample plots of mature phase forest types in Brunei and Sarawak, that phytomass can vary from 195 t/ha to 1415 t/ha. Mature natural forests in Borneo can range from tall dense forests to stunted short forests more akin to open wooded areas. In such areas the phytomass will be even less than 100 t/ha. It is therefore not possible to generalise and to derive reliable estimates of the phytomass of any forest formation without having carried out a forest inventory to delineate the extent of forest types and to assess stand volume.

Brown and Lugo (1984) estimated the total biomass of the world's tropical forests to be 205 billion tons (102 billion tons of carbon - assuming 1 ton of organic matter being equivalent to 0.5 tons of carbon). Their estimate is derived from a number of assumptions. Using the forest area and volume data of the 1980 FAO statistics, the stemwood biomass was derived from stemwood volume and mean wood densities calculated for each region. A multiplier factor of 1.6 was used to estimate the total forest biomass. For undisturbed broad-leaved forests, biomass was estimated to be 155, 237, and 196 tons/ha for tropical America, Africa, and Asia respectively, with a weighted average of 175 tons/ha for the world. These estimates are considerably lower when compared with actual measurements that have been made. Grainger (1990), in developing predictive models for carbon emissions, adopted similar methodology to derive his scenarios which were based on individual estimates performed for 43 countries. Such estimates of biomass/carbon stock and carbon emissions due to deforestation in the tropics are only reliable within the assumptions that have been made.

It is now generally understood that tropical forests, more specifically tropical rain forests, are rich in plant life and luxuriant in growth due to the year long availability of solar energy inputs. Various estimates of annual net primary productivity have confirmed that it is generally much higher in tropical forests than in the temperate forests. This has led to the general belief that forest trees grow faster and wood production is greater in the tropics than in temperate regions. In his comparison and analyses of 60 studies of wood production and 135 studies of leaf litter production from the different world regions, Jordan (1983) effectively demonstrated that there was no significant differences in annual wood production between tropics and the temperate regions nor was there any trend of change (Table IX). However, with leaf litter production there was a highly significant trend of increase from temperate to tropical regions. Similarly, there was also a significant increase of net primary production (wood and litter production) which is to be expected. The higher net primary productivity recorded for the tropics is attributable to the higher litter production and not the annual addition of woody biomass. This study tends to throw caution on assumptions that tropical forests perform better as carbon sinks. Jordan also showed that wood production in tropical tree plantations (a mean of 1193+741 $gm/m^2/yr$ for 15 studies) was not significantly different from temperate plantations (mean value of 1343+892 $gm/m^2/yr$). Temperate forests in fact have much higher averages. The high variance could possibly be explained by the different species and clones used as well as by the amount of auxiliary energy inputs, in terms of management and fertilisers. The options for wood production and consequently carbon sequestration lie not only in the tropics but also in the temperate regions.

8 BIODIVERSITY AND SPECIES EXTINCTIONS

General statements made to the effect that, although covering only 7% of the earth's land surface, they contain over 50% of the world's species have associated tropical moist forests as being strategic for the conservation of global biodiversity. This association is currently being promoted further by numerous predictions of species extinctions in relation to tropical deforestation rates which is a very current issue that has engaged many conservation biologists in controversial debate. As pointed out by Lugo (1988), when reviewing estimates of projected species extinction rates, many have not incorporated any rational justification for arriving at the figures quoted. Recent projections of species extinctions have used species-area relationships as the basis for such estimates. If current tropical forest depletion rates prevail, species extinction rates estimated for the different regions (over 30 years) range from 3 to 17%. The range would be from 6 to 44% if deforestation rates were to be doubled (Reid & Miller, 1989). Reid (1990) recently revised these figures and further clarified that the predicted rates do not represent actual species loss for the time assessed but rather provide indication of the proportion of species that will eventually go extinct when the systems are in equilibrium. His predictive model was based on three scenarios of forest depletion (5,10 and 15 million ha/yr) and two time periods (to years 2015 and 2040) with separate assessments carried out for each region (Table X). Globally, the model predicts that in the next 25 years, at current rates of forest loss (10 million ha/yr), there will be 4-8% extinction rates of the world's closed forest species.

Table VIII Plant Biomass from Tropical Rain Forest Sites

	Biomass (t/ha)	
	Root	Total above ground
1. Amazon caatinga San Carlos, Venezuela	132	268
2. Oxisol forest San Carlos, Venezuela	56	264
3. Lower montane rain forest El Verde, Puerto Rico	72.3	228
4. Evergreen forest Banco, Ivory Coast	49	513
5. Dipterocarp forest Pasoh, Malaysia	20.5	475
6. Lower rain forest La Selva, Costa Rica	14.4	382
7. Moist forest Panama	11.2	326
8. Semi-evergreen forest Kao Chong, Thailand	3.3	331
9. Lower montane rain forest New Guinea	40	310
10. Broad ridge crest Mulu, Sarawak	-	650
11. Valley alluvium Mulu, Sarawak	-	210

Source: # 1 to 7 from Jordan (1985)
8 to 11 from Whitmore (1984)

Other issues revolving around the need and the actions needed for biodiversity conservation have been reviewed recently (Wilson, 1988; McNeely et al., 1990).

In consideration of biodiversity issues of tropical moist forests, there are two key concepts that must be borne in mind, species richness and species diversity. Species richness pertains only to the sum total of species for any given area without consideration of species distribution. Diversity however takes into account species numbers, populations, and distribution within a given unit area. Extending this further, diversity must be considered at three levels: within habitat diversity (alpha diversity); between habitat diversity (beta diversity) which accounts for changes along a gradient between the habitats; and overall diversity (gamma diversity) for a given large area encompassing many habitats.

It is important to recognise that in consideration of conservation of biodiversity it is the gamma diversity that

Table IX Comparisons of the rates of wood and litter production in the broad-leaved mesic forests in five latitudinal zones (based on summary of 139 studies)

FOREST TYPES	RADIATION BALANCE (kcal/cm^2/year)	PRODUCTIVITY (g/m^2/year) Wood	Litter
1. Subtundra broad-leaved mesic forests	25-40	968+399	281+133
2. Northern hardwood broad-leaved mesic forests	40-50	658+248	328+111
3. Mid-temperate hardwood broad-leaved mesic forests	50-60	610+537	367+116
4. South temperate and sub-tropical broad-leaved mesic forests	60-70	758+290	644+204
5. Tropical broad-leaved mesic forests	>70	734+275	**957+362**

Source: Jordan, 1982.

Table X Predicted Extinction Rates of Tropical Closed Forest Species at Equilibrium based on Three Scenarios of Tropical Deforestation

		Percent Decline in Species Numbers at Equilibrium Resulting from Deforestation between 1990 and Year indicated*		
Year	Region	Low Scenario (5 million ha/yr)	Mid Scenario (10 million ha/yr)	(High Scenario) (15 million ha/yr)
2015	Africa	1 to 3	3 to 6	4 to 9
	Asia	2 to 5	5 to 11	8 to 18
	Latin America	2 to 4	4 to 8	6 to 13
	All Tropics**	2 to 4	4 to 8	6 to 14
2040	Africa	3 to 6	6 to 13	10 to 21
	Asia	5 to 11	12 to 26	28 to 53
	Latin America	3 to 8	8 to 18	15 to 32
	All Tropics**	4 to 8	9 to 19	17 to 35

Notes:
* Estimates based on species-area model ($0.15 < z < 0.35$).
** Total for Tropics is the weighted regional average based on fraction of plant species in each region.

Source: Reid (1990)

must be addressed. With respect to tropical moist forests and for effective biodiversity conservation, priorities must be given and focus be directed to the identification and setting aside of representative forest habitats for each region. What is critical therefore is the loss of habitats and not how many percent of forest land is being deforested or degraded although they are in some ways related. In this habitat versus area debate, Simberloff (1990) maintains that management of fragmented forest areas instead of large tracts of forests will lead in the long term to species extinctions. However, the concept of habitat conservation does not necessarily mean that small forest fragments will only be maintained. Instead, the concept advocates that representative habitats be totally protected within large forested areas that are being managed for sustained yield and other forestry practices. These will be in addition to, and does not preclude, having large forested areas set aside as national parks and be managed as such.

Tropical moist forests are noted for their high alpha diversity. Yet, this is not generally the case as documentation of such diversity has mostly been carried out in lowland evergreen moist forest sites where integrated ecological studies were based. In these cases, the sites were selected because of their inherent high diversity. In the humid tropics, species diversity decreases considerably with altitude, aridity, and also with poor soils. Many such low diversity habitats can be found on sandy substrates or on sandstone ridges. Due in part to stability over time, there are many specialised and adapted species that become endemic to each different habitat. Specialists with restricted distribution commonly occur in mature forests of low diversity. The heterogeneity of habitats and the abundance of specialist species contribute greatly to the overall species richness of any given area or region. Hence, all habitats warrant similar priorities. Yet, current biodiversity conservation strategies still accord and advocate priorities to areas of high biodiversity (Heywood & Stuart, 1990).

9 NATURAL FOREST DEPLETION AND DEGRADATION

Deforestation has been central to all the issues related to tropical forestry and the process has been increasingly associated with loss of biodiversity and climate change. Many of the predictive models and world scenarios have been based on deforestation statistics. Yet the term deforestation has created much controversy over interpretation and application. Hamilton (1990) has even suggested that it be removed from international usage.

Deforestation has been defined as the conversion of forest land to other non-forest uses which would include, according to Rao (1990), "permanent agriculture, shifting agriculture, human settlements, mining, building of dams, etc". By this definition and its consequent interpretation in the compilation of deforestation statistics, the process of clearing of natural forests for conversion to monocultural tree plantations utilising *Pinus* spp., *Eucalyptus* spp., and *Acacia* spp. would not constitute deforestation. This is because the land is being utilised for forestry. Yet, if the cleared area were to be planted with other tree crops such as rubber, cocoa, and oil palm the land would immediately be classified under agricultural use. This process would then constitute deforestation. This interpretation has currently been used to collate the information for tropical deforestation. In the FAO forestry statistics, rubber plantations which in terms of ecological dynamics would be equivalent to any forest plantation, have not been included as forest plantations. This explains why there is no deforestation reported for all the temperate countries when it is well known that large tracts of land are clearfelled and subsequently replanted with monocultural stands of trees.

To rationalise the ambiguity, this definition should be reviewed. By referring to conversion of forest to non-forest use, the term forest should be interpreted in its broadest sense to mean an assemblage of trees irrespective of whether it be naturally established or otherwise. Non-forest use could be interpreted as land use for annual agricultural crops and urban development. Ecologically, this would be good sense. However, such a concept would make it difficult to monitor the resources.

In relation to current world forestry statistics, it might be prudent to consider the expression natural forest depletion rather than deforestation. In practice, this is exactly what the current data collected refer to. In addition, natural forest depletion should not be confused with natural forest degradation. The latter occurs when there is significant reduction in forest stature, tree volumes, standing biomass and species diversity from the original, due to human and natural interventions.

Yet, in relation to issues of carbon sequestration, there is a need for a system to assess the world tree cover, which should then include natural forests, forest fallows in various successional stages, plantation forests, and agricultural tree crops. This system should also be able to account for trees planted in urban and rural areas.

Although the report has yet to be released, preliminary results provided by FAO (Rao, 1990) indicate that almost 17 million hectares of tropical forests have been cleared each year during the assessment period of 1986-90. This is based on the assessments of 62 tropical countries which, together, contain 80% of the tropical forest area. This represents a 49% increase over the annual rates assessed in 1980.

10 CAUSES OF NATURAL FOREST DEPLETION AND DEGRADATION

The underlying cause for natural forest depletion and degradation in the tropics can be attributed mainly to underdevelopment and population pressures due to the high population growth in the tropical developing countries. This has escalated land conversion for subsistence farming and large scale agricultural practices and has aggravated demand for fuelwood. Forest resource exploitation has also contributed to the degradation of natural forest ecosystems and to a lesser extent to their depletion. This is especially acute in the Asia-Pacific region where the population, at 2800 million people, accounts for half of the world population, and where agricultural land covers approximately 500 million hectares or 30% of the total world arable land.

In general, forest depletion and degradation are caused by both natural and human interferences. Heavy floods due to supra-annual incidences of extreme weather changes, occasional volcanic activities, widespread fires during exceptional dry spells, and monsoonal storms do cause extensive damage to natural forest areas in the tropics. In addition, lightning strikes, windthrows, and landslips contribute to localised forest changes. Such natural catastrophic events are commonplace occurrences, though far apart in time and space.

It is, however, largely due to human interference that large and extensive areas of natural forests have been depleted and degraded. Human interference can be traced through historical time, in pulsed phases of increasing impacts on forested land. Ancient civilizations such as those in central America, Indo-China, and Indonesia were established in tropical humid areas long before European colonization of the regions. These were localised but nevertheless contributed to forest disappearance. In the South East Asian region, the introduction of traditional agriculture, subsistence crops, and irrigation technology from India and China, provided the momentum for extensive agriculture to be practised. This must have begun in areas where natural catastrophic events had cleared the land and enriched it for such pioneering efforts. Agricultural development also occurred early in the low-lying delta areas of large rivers, where occasional floods rejuvenated the soils such as in Bangladesh, Myanmar, Thailand and Vietnam.

It is significant to note that extensive land clearing for agriculture was not practised in Borneo or in the Malay Peninsula, which were dominated by tall closed canopy forests on podzolised soils. The reason for this can be easily deduced. Without modern agricultural technology, the poor soils under such forests, the terrain, and the difficulties of land clearance limited extensive development. Where development occurred, they were restricted to coastal areas, particularly where rivers flowed into the sea. In the interior, mainly along river banks, swidden and shifting cultivation were practised. As such, large populations could not be supported. This scenario remained until the end of the 19th century.

However, it was not as if the forest resources in the region were not tapped. The region had always been on the major trade route from the middle east to the far east and historical records do show that products derived from the forests such as resins, natural dyes, camphor and many other items were traded.

It was only after the European domination of the region that major changes took place. With the introduction of large scale agriculture, mining, timber extraction and urban development, extensive tracts of forests were cleared. This trend continued and was further escalated during the post war years when the countries in the region became independent. With increased need for socio-economic development to support a growing population and modern technology, conversion of forest land for other uses became common.

In Tropical Asia, the present major cause of extensive natural forest depletion and loss of tree cover is the demand for agricultural land. Harvesting of timbers from natural forests do not contribute to depletion but generally result in their degradation. However, harvesting is often associated with the increase of shifting cultivation areas due to facilitation of access into natural forest areas which would otherwise remain remote.

There are broadly three categories of agro-conversion of forest land (Rao, 1990). These include shifting cultivation, planned agriculture, and unorganised agriculture. Rao estimated that nearly 30 million people practise shifting cultivation in Tropical Asia, and that the extent of the forest land affected could be in the region of 75 million hectares. These areas are mainly located in Borneo, the northeastern and central states in India, the central highlands in the Philippines, and in parts of Burma, Thailand and Bangladesh.

Most planned agriculture which involves the clearing of large areas of natural forests, particularly in South East Asia, is associated with socio-economic reforms through resettlement programmes. In Indonesia, the transmigration programmes are targeted at relocating families from the over-populated islands of Java, Bali, and Madura to Sumatra and Kalimantan, where forests are cleared to provide agricultural land. In Malaysia, under the Federal Land Development Authority, natural forests not within the designated permanent forest reserves are cleared and planted with agricultural tree crops such as rubber and oil palm. Parcels of such agricultural land are then allocated to relocated families for them to manage and to derive needed income. Such resettlement schemes are also being carried out in Nepal and Sri Lanka.

Unorganised incursions into forest lands where small areas of forest are cleared for subsistence agriculture are common occurrences in areas such as Nepal, Thailand and the Philippines. Population pressure is the driving force for these landless people to encroach upon forest land.

Throughout the tropics, roundwood production during the period 1966-86, could be correlated to population increase. However, it is significant to note the high proportion of roundwood produced, which is being utilised as fuelwood and charcoal. The annual averages of the percentage fuelwood and charcoal used, to total roundwood produced for the 20 years, were 78%, 86% and 74% for tropical America, Africa, and Asia respectively. This shows the great dependence of the people in these tropical countries on wood as their energy source. In direct contrast, the reverse has been the case for developing countries where the bulk of the roundwood produced is for industrial and value added uses. Much of the wood production in developing countries is utilised directly to support daily needs. Industrial wood production in tropical countries accounts only for a small percentage of that produced in developed countries.

Forest depletion and degradation in tropical and developing countries is directly linked with the socio-economic needs of the people, and should be viewed in this perspective.

11 GLOBAL ENVIRONMENTAL ISSUES AND TROPICAL MOIST FORESTS

Some of the major global environmental issues that have commanded the attention of the world community today include ozone layer depletion, hazardous and toxic waste disposal, desertification, acid rain, nuclear fallouts, biodiversity conservation, and the related issues of increasing greenhouse gases in the atmosphere, climate change and predicted sea-level rise. International instruments have already been drawn up to control hazardous and toxic waste disposal and to prevent the further deterioration of the ozone layer through regulation of the use of chloroflourocarbons and related chemicals. Two other international instruments are being currently negotiated for the conservation of biodiversity and climate change.

In a nutshell, the current deterioration of the world environment can be attributed to the two interactive processes of (i) the over-exploitation of natural resources without adequate replacement or what we take out of the environment, and (ii) the excessive chemical pollutants being released into the waters, air and soils, or what we add into the environment. These processes have been due to current unsustainable developmental trends prevalent throughout the world and population increase.

The rapid rates of depletion and the degradation of tropical forests, in particular tropical moist forests, have now been closely linked to the issues of biodiversity and world climate change. It is important however that the extent of the linkages be clearly and objectively established in order to place them in their proper perspective in relation to these issues. In addition, tropical moist forests should not only be linked to the issues pertaining to their contributions to the developing economies of tropical countries as well. These major issues are discussed.

11.1 Biodiversity

Biodiversity is a term that has only recently been widely used. It refers to the variety of life forms and biological species, hence encompassing both intra-specific diversity and inter-specific diversity. The documented number of species in the world today is around 1.4 million and it is estimated that the total number could be anywhere between 5 to 30 million (Wilson, 1988). It has been continually quoted that tropical rain forests contain more than half the world's total number of species. Whether this is a fact or an assumption has proved difficult to determine, as most authors now quote this without any more reference to the source. With this linkage, tropical rain forest therefore becomes critical for global biodiversity conservation.

Current general subscription to the concept of species-area relationships has encouraged its wide use to estimate and generate scenarios of species extinction rates. For example, at the rate of 15 million ha/yr of forest depletion which is lower than current FAO determined rates for 1986-1990, Reid's (1990) predictive model (Table X) would project species extinctions at 6-14% of the total by the year 2015. Given the estimated total number of world species of 5-30 million, the number of species committed to extinctions would therefore range from 150,000 to 0.9 million or 350,000 to 4.2 million. These are alarming figures indeed but, as is common for all estimates and predictive models, the information generated can only be considered within the limits of the assumptions that have been made. Of relevance to note is that there are limitations to the species-area relationships as applied to large areas with considerable habitat heterogenity (Simberloff, 1990).

Forest degradation due to the harvesting of natural forest in the humid tropics has also been linked to the loss of biodiversity. There are, however, no studies that have shown this to be the case. On the contrary, Johns (1988; 1990) had shown from his studies in Amazonia (Brazil) and in Malaysia that selective harvesting of the forests does not significantly reduce the number of vertebrate species. In Amazonia, he found that much of the wildlife of the region survived in the degraded habitats as a result of low-density shifting cultivation and low levels of logging. However, these studies only pertain to vertebrates and cannot be extended to include the invertebrates and the flora for which research documentation is lacking.

In the assessment of impacts on biodiversity due to timber harvesting it is relevant that sufficient distinction be made between the diversity of small impacted areas and those over the larger management unit. Any interference, be it human or otherwise, will certainly cause some reduction in the species composition for the impacted area. The degree will depend very much on the magnitude of that interference. As opposed to clear-felling, selective logging as practised in many countries in the humid tropics results in a logged forest represented by a mosaic of forest patches of different orders of disturbance. These range from completely cleared sites which had served as log yards or landing areas to completely undisturbed forest patches. Assessment of biodiversity changes cannot be restricted to such small patches but should be based on the entire management unit.

Species survival also depends very much on maintenance of critical population levels. With many species having low numbers of individuals represented per unit area, so characteristic of high diversity tropical moist forests, it is conceivable that interferences over extended areas and the subsequent physical changes in the environment will most likely impact on these "rare" species and reduce their population levels to below what is critical for their long term survival. These are but some of the areas that much ground work will still have to be carried out. Nonetheless, natural forests being managed for timber production should be considered as habitats that could also at the same time be managed for biodiversity conservation.

11.2 Climate Change

Emissions of gases into the atmosphere, principally carbon dioxide, water vapour, methane, and ozone from natural chemical and biological processes, have maintained the world average temperature at around 15°C through the "greenhouse effect". Without these gases that "trap" the thermal energy radiated off the earth's surface, the world temperature would drastically be reduced. Global warming is now well established and documented through the IPCC (Inter-Governmental Panel on Climate Change) consultation and reports. This phenomenon is related to increases in such greenhouse gases in the atmosphere as a result of past and present human activities, and in particular to increases in CO_2, which contributes to half the total warming effect.

It is very important to recognise that the issue of global warming cannot be resolved just by carbon sequestration alone. Of greater priority is the need to reduce carbon emissions from highly industrialised countries through increased energy efficiency, the decrease in wasteful fossil fuel use, and the control of emissions of other greenhouse gases such as CFCs. These can be achieved much faster and with less socio-economic repercussions. In contrast, developing countries will find it much more difficult to respond to changes that have direct impacts on their socio-economic environment. Most developing countries, as a matter of fact, are more dependent on natural resources and natural systems for their daily subsistence and the poorer nations lack the financial and technical resources to respond.

Hence, realistic and appropriate programmes must be devised for developing countries in the tropics with respect to the sequestration of carbon dioxide emissions and planned such that they will also enhance, rather than to diminish, developmental processes. These are fundamental principles. It cannot be expected that poor tropical nations refrain from cutting down trees for fuelwood when rich nations in the temperate region continue using fossil fuel to process timber for industrial use.

The equation in relation to forest depletion and carbon dioxide emission needs further studies to consider carbon sinks and stores from other resources that have not been included in conventional forestry statistics. In this respect it should consider all standing wood biomass and production which would imply world tree cover. Most models have so far not accounted for carbon sinks of trees growing in disturbed and abandoned agricultural lands, agricultural tree crops, and the many traditional agro-forest ecosystems that are prevalent in many tropical countries. They have also not included major reforestation programmes that have already taken off as part of community forestry projects. Rao (1991) quotes an estimate of over 3 million hectares per year for the Asia-Pacific region. This has been the case because such tree cover are not accounted for as they are in "non-forest" land. These are added and important considerations.

12 FORESTRY SECTOR RESPONSE OPTIONS

The tropical forestry sector faces new challenges given the number of environmental issues being linked to natural forest resource exploitation. This is not unexpected as natural forests are dynamic ecological systems that are very much part of the global environment. This is not only applicable to tropical forests or tropical moist forests, but to all forested habitats throughout the world. In the context of this paper response options are discussed with respect to countries that are in the humid tropics.

In considering tropical forestry response options to the global environmental issues of climate change and loss of biodiversity, a more holistic and pragmatic approach will have to be adopted. Response options cannot, and indeed must not, be arrived at without due consideration and priorities being given to the role of forestry and their contributions to the developing economies of tropical countries. Tropical forestry has already become very transparent over the last decade as a result of the considerable international concerns generated over the rapid rates of resource depletion. Many response options and strategic plans have been formulated and discussed in many international forums. These have already been translated into numerous plans and programmes for action by several international organisations.

The 1980 World Conservation Strategy formulated by the World Wide Fund for Nature and the International Union for the Conservation of Nature and Natural Resources and resulted in many local conservation strategies being drawn up. The Tropical Forestry Action Plan was drawn up by FAO together with the World Bank, World Resource Institute, and United Nations Development Programme. It had then identified the following areas of priority: forestry in land use; forest-based industrial development; fuelwood and energy; conservation of tropical forest ecosystems; and strengthening the capabilities of institutions in the tropics. To date 81 have also drawn up their national tropical forestry action plans. Criticisms have however been made that the TFAP have not given sufficient priority to the issues of biodiversity conservation and climate change.

The International Tropical Timber Organisation (ITTO) was set up as an inter-governmental organisation under the International Tropical Timber Agreement, 1983. The organisation has 22 developing country members (producers) and 24 developed country members (consumers). Council and permanent committee meetings are well attended by members as well as observers from both other international organisations and non-government organisations. Over the last three years, ITTO has been actively promoting and supporting sustainable forest management practices. It has now drawn up its own plan of action and has also come up with international guidelines for natural forest management (ITTO, 1991).

Response options to both climate change and biodiversity concerns must therefore not be developed in isolation but should fully recognise the scope of these other international efforts and, more importantly, accommodate national plans of action. Essentially, what is needed is the identification of additional response options to what has been formulated. Most of all, it is not the identification of response options that will be critical but the mechanisms and means to implement actions at the national and local levels that will finally make the difference. To achieve this national economic development priorities will have to be incorporated for practical implementation.

Response options must also go beyond traditional and conventional forestry practices. They cannot be restricted to management of natural forests nor plantation forests, but should also be taken in the broader sense to include the establishment of tree cover, such as agricultural tree crops and trees in urban and rural areas.

Agricultural tree crops such as rubber, oil palm, coconut, cocoa and clove cover extensive areas in Africa and South Asia. Rubberwood is no longer burned but harvested and used for making furniture. Such agricultural forest systems are good examples of sustainable forest management. With respect to carbon dioxide sequestration, the growing phase of the rubber plantations acts as an effective carbon sink, and, during the mature phases, as a store. With the wood presently accepted as a tropical timber, this carbon store can be retained after the trees are cut.

Traditional agroforestry commonly practised in South East Asia represents an ecocline that grades from stands of mixed fruit trees underplanted with other cash crops, through mixed annual and perennial crop stands, to mixed and monocultural annual crops. All species planted have some food, medicinal or utility value (Christanty & Iskandar, 1985).

Many strategies and action plans have already been proposed for the conservation of biodiversity. In essence and with respect to tropical moist forest, actions needed are to be able to respond to the overall objective which is to establish a world network of protected areas representative of the existing natural forest habitats. The 1982 Bali Action Plan provides a comprehensive list of needed actions. However, biodiversity conservation as mentioned earlier, will also have to look beyond protected area networks and consider the management of modified and fragmented forests, focusing on species conservation.

Forestry sector response options for climate change have been considered very recently at the Tropical Forestry Sector Response Options Meeting in Sao Paulo meeting in January 1990 (Anon.) All these options are essentially strategies which need to be translated into action programmes at the international, regional and national levels. Such programmes will need to be provided with mechanisms for implementation. It should also be noted that many of these strategies are similar or complementary to those identified in the TFAP and the ITTO plan of action in the field of reforestation and forest management.

13 CONCLUSIONS

The recently reported rates of tropical forest depletion, much of which relate to tropical moist forests, provide reason for renewed concern and alarm. Before the world rushes into the anticipated rounds of international consultation and negotiations to reformulate plans to address this problem, it might be timely to reflect upon and review past programmes to assess their impact or non-impact. Many treaties, strategies, and plans have been formulated over the last decade, yet the same problems and issues are still being identified. This time round, the links between tropical moist forest depletion and industrial atmospheric pollution are better established. But, nonetheless, the problems remain as predicted a decade ago.

To progress forwards, the world should not wait for international order to be established through extended negotiations and reexamination of the problems through unending conferences. What is needed are realistic options that can be transferred into effective and practical implementation. Tropical moist forest depletion is taking place in developing countries to support their economies and development. To reduce this trend, equitable economic compensation and assistance must be provided through the alternatives identified. The basic issue is still one of meeting the real and basic needs of the people.

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Summary of Track I: Tropical Moist Forests

W J Howard[1]

1 STATUS

Tropical rainforests, tropical wet forests, and tropical moist forests are terms used in reference to different life zones. Due to inadequate definition, these terms have too often been used as synonymous. (It is suggested that tropical moist forests be defined to include all areas within the humid tropics with potential evaporation ratios of less than one). Due to different interpretations of these terms, and the limitations of the FAO 1980 data, it is difficult to determine the present extent of tropical moist forest cover. However, recent estimates on a country basis indicated that of the 1,937 million hectares of tropical forests, 1,082 million hectares could be under tropical moist forest cover. Such estimates have not included forest fallows, agricultural tree-crops and traditional agro-forests.

It is recognised that many forest types and habitats do exist within tropical moist forests throughout the world. These exhibit significant variation in structure, composition, biodiversity and biomass, which are greatly influenced by latitude, altitude, aridity and past interferences (human or otherwise). This heterogeneity has not been allowed for in current pantropical estimates of biomass, CO_2 emissions, and species extinction rates. Whilst forest primary productivity is generally higher in tropical moist forests than those at higher latitudes, wood productivity does not show any significant difference.

The preliminary FAO 1990 forest statistics estimated current tropical forest depletion at 17 million hectares per year, much of which has occurred in the humid tropics. Forest depletion is mainly attributable to conversion of land to agriculture to meet basic needs as well as the great dependence of developing countries on wood as biofuel which accounts for 80% of recorded roundwood produced in the tropics. Harvesting of timber from managed natural does not contribute to forest depletion but does cause varying degrees of disturbance resulting in their degradation.

Tropical moist forests are rich in biological diversity. Many species, especially specialists with narrow niches, can be threatened by forest depletion. Recent studies have demonstrated that no significant changes in vertebrate diversity can be detected in logged natural forests. However, these findings cannot be extended to include the invertebrate fauna and the flora until complementary research has been carried out.

Land use modification contributes to 9% of the global warming processes and, on a current basis, 18% of the total CO^2 emission. Mature natural forests do not contribute much to the carbon sink, but regenerating natural forests, forest fallows, tree plantations and agro-forests do.

In terms of tropical forest management, the TFAP exercise has already identified strategies and action programmes. To date 81 countries have responded, of which 73 countries are engaged, at various stages in the formulation of national tropical action plans. In addition, the International Tropical Timber Organisation has identified a reforestation and forest management action plan, and through its recently established international guidelines, is promoting sustainable natural forest management practices.

2 ISSUES

If we are going to clarify the issues there is a clear need for precise definition of the terms used. There is confusion about the use of terms such as tropical moist forest and deforestation. The definition of forest cover should be defined so as to include or exclude all tree crop plantations.

The present need for greater knowledge about the contribution of forestry to issues of biodiversity and climate change has raised doubts about the appropriateness of using the FAO assessment of forest cover in 1980 and again in 1990. These statistics were collected for the purposes of timber production. They may

1 Overseas Development Administration, London, United Kingdom.

not be sufficiently discerning for use in decisions about biodiversity or carbon sequestration.

From several case studies we heard that land tenure is a crucial issue. Land use decisions are taken ultimately by the people. If governments want to influence land use the views and needs of the people have to be considered. People take responsible decisions about land use when they know what their rights to the land are. If the wider roles of forestry to meet requirements to fix carbon and to preserve biodiversity are to be met, all three partners, the state, the community and the private sector have to be brought together in order to agree a common policy.

Multi-purpose management of the production of tropical moist forest will have to replace single objective management. The production of timber and non-wood products, watershed protection and the conservation of biodiversity will all have to be sustainably managed in one piece of forest.

Traditional rotational agricultural systems or swidden/fallowing systems should be reassessed. The system contributes to carbon sequestration and biodiversity and only becomes uncontrollable with insecure land tenure and rising population density.

3 DISCUSSION

To help the discussion of the above-mentioned issues, the group considered a range of land use options as follows:

Tropical moist forest for protection
Tropical moist forest for production
Swidden/fallowing systems
Tree crop plantations
Forestry plantations including traditional agroforestry systems
New technology or introduced agroforestry systems
Wasteland rehabilitation

3.1 Tropical moist forest for protection

The case studies revealed that the countries represented all have a commitment to put land aside for protection purposes. Dr Thos' paper highlighted the need for buffer zones. From France we heard that only in the mountains is forest kept solely for protective purposes. The need to manage forest for many purposes is as essential for tropical forests as it is for temperate forests and a balance has to be struck between conflicting objectives.

3.2 Tropical moist forest for production

There is a wide range of experience in managing tropical moist forest. The Dipterocarp forests of South-East Asia have been brought under management for 40 to 50 years, which contrasts with the experience in Central and South America. Comparing experiences in Bolivia and Costa Rica, in the latter, forest land in private ownership has been responsibly managed, whereas in the former, forest land ownership was vested in the government, control of concessionaires has been short-term and ineffective in encroachment by farmers. In the Philippines there was a logging boom in the period 1950-1970 in the Dipterocarp forest taking out 6-8 million m^3 in the early 1970s. Now timber production is for the internal market only and timber is imported from Sarawak and Sabak. The pressure is being taken off the natural forest by an industrial afforestation programme. The present trend in the natural forest is to place responsibility for managing and harvesting forest on the local communities themselves. In Indonesia the forest cover has shrunk from 144 million hectares in 1940 to 109 million hectares in 1990. During this period the forest resources have made a considerable contribution to the national economy. Important features of the national policy include:- developing the outer islands to relieve population pressure on Java and Bali, sustainably using the mixed tropical hardwood forest and manmade forests for national development, increasing the productivity of manmade forests and afforesting bare, unproductive lands, generating income for forest communities through multiple use forestry and conserving natural resources for present and future generations. Natural forest management, introduced since 1966, depends on a selecting felling system with a 50 cm minimum diameter and a 35 year felling cycle. The obligation to regenerate the forest naturally or artificially falls on the concessionaire.

Venezuela has 10 forest reserves covering 12 million hectares of forest land and a total forest-covered area of 50 million hectares. Two million hectares of forest reserves are under long-term concession (20-30 years) covering 40-150,000 hectares each. Although about 20 management plans have been prepared and different silvicultural systems tried, results have not been altogether successful. Concessionaires have not shown an interest in silvicultural treatment and harvesting causes unnecessary damage to the remaining forest. Control of harvesting has been inadequate

3.3 Swidden/fallowing systems

There was some consensus that the place of traditional rotational agricultural systems should be re-evaluated. In situations where the population density is low, this farming system is appropriate, sustainable and contributing to biodiversity and carbon fixing. As we heard from the Philippines and Venezuela, the appropriateness of this form of agriculture is very closely related to the issue of land tenure and the rights that people acquire by clearing land for agriculture.

3.4 Tree crop plantations

Discussion focussed on tree crops that produced timber as an end product and particularly rubber, although the timber of coconut and oil palm can be utilised. Such tree crop plantations can make a substantial contribution to the fixing of atmospheric carbon. However, large scale plantations do not contribute to the conservation of biodiversity.

3.5 Forestry Plantations (including establishment of taungya)

Vigorous plantation programmes feature in many of the case studies presented, particularly Indonesia which plans to have 25 million hectares under plantation by the year 2000 and the Philippines where 600,000 hectares of plantation are targeted by the end of 1992. The taungya system in which farmers are allowed to cultivate their crops in the first few years of plantation establishment, offers one method of establishing plantations cheaply. It has fallen into disrepute where there is land shortage because the farmers tend to settle on the land and destroy the young trees.

3.6 Agroforestry

Two kinds of agroforestry can be distinguished. Traditional agroforestry systems such as the home gardens of Java, and the new technology agroforestry systems in which multi-purpose trees are introduced into the farming system where the fallow period has shortened to such an extent that the landscape is virtually treeless and farmers are convinced of the need to plant trees. Agroforestry offers a relatively cheap way of introducing trees that can fix carbon.

3.7 Wasteland Rehabilitation

The group agreed that the first call on land should be for food production. Only when basic human needs of the people had been met would it be possible to afforest land for timber production and fixing carbon.

4 RECOMMENDATIONS AND CONCLUSIONS

FAO Forestry Department and ITTO should redefine the terms used in international forestry so as to provide precise definition of usage that is central to the discussion of international forestry. Examples are tropical moist forest, deforestation and forest cover.

The FAO 1980 and 1990 assessments of forest cover were concerned with timber production. They are not appropriate for making decisions about biodiversity or carbon fixing.

Land tenure issues are often at the root of land degradation problems. At the government level clarifying local people's right to land and trees could help to empower people to look after the environment for themselves. At the international level, more research is needed into both land and tree tenure.

Multipurpose management of the productive tropical moist forest is recommended over management for one purpose only. Such recommendations should be drafted into a country's forest policy and included in individual working plans.

We recommend that forest inventories and the analysis of permanent sample plots are given high priority with a view to bringing the forest under sustainable management. For both activities, long-term support for forest management is required.

Transfer of information and technology relating to forest management, timber processing etc. should be encouraged both 'South to South' and 'North and South'.

The objectives of national TFAP exercises in analysing forest policy and studying cross-sectoral issues, and the aims of ITTO to foster sustainable management of forests are the same, and every effort should be made to improve coordination and cooperation at the national and international level.

Forestry issues: an Indonesian perspective

H Alikodra[1]

ABSTRACT

The roles of tropical forests as carbon and heat sinks, and as repositories of bio-genetic diversity, are used to present the contrasting viewpoints of the developed and developing countries towards tropical forest use. Developed countries are perceived to be in favour of early enactment (preferably at UNCED 1992) of a legal instrument, whilst the developing countries are perceived to favour a slower process, leading to a possible convention that is morally and politically binding rather than legally binding. They also ask for compensation of earnings foregone due to non-exploitation of forests. Indonesia considers that there is need for commitment by the developed countries to reduce greenhouse gas emissions and for transfer of technology, as well as a review of trade patterns. FAO is seen to be dominated the north: developing countries are thus reluctant for a convention to be drafted by FAO.

Indonesia's position is that, whilst recognising the perceived reservations of developing countries towards a forest instrument, it realises that negotiations will be inevitable. To that end, preparations for UNCED 1992 include support for:

- the development of a global, rather than just tropical, forest action plan;
- the formulation of principles and guidelines, possibly in the form of a declaration;
- identification of ways to free or generate funds for the action plan, to be deposited into a specific fund.

Whether such actions lead towards a convention or not, Indonesia will support the necessary preparatory work. It also proposes that cooperation be established for afforestation of critical lands and other available non-forest lands, for the purpose of greenhouse gas absorption.

Indonesian Forest Resources and Management Policy

Edy Brotoisworo[2]

ABSTRACT

In this paper the current state of the forest resources, the pressures on those resources and the relevance of the forestry sector to the national economy is described. The Indonesian forest policy promotes a balance between utilization for economic benefit, set aside for conservation of ecological functions, and use for social purposes. The policy is expressed further in the goals of the Indonesian TFAP:

- to develop the Outer Islands and relieve population pressure on Java and Bali;

- to sustainably utilize the mixed tropical hardwood forests and the manmade forests for national development;

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- to develop more productive manmade forests, and convert bare and unproductive lands into productive areas in order to produce more wood for industrial processing and for energy, as well as to restore their environmental integrity;

- to generate livelihood opportunities for forest communities and the rural population through the establishment of multiple use forest;

- to conserve natural resources for the benefit of present and future generations of Indonesians.

Management of the resource is based on these imperatives, and the paper discusses particular technical methods of management for both timber and non-timber products. Approaches to conservation are described and areas gazetted for protection are tabulated.

Deforestation and Reforestation in Bolivia

J M Reyes[1]

ABSTRACT

There is no long term policy view towards forest conservation and management in Bolivia, and this encourages a national culture of mining natural resources for immediate benefit.

Forest loss is estimated at 200,000 ha. per year, and this is considered serious although there are approximately 55 million ha. of land under forest cover at present. Particular problems involve institutional weakness, poor forest management and inappropriate industrial usage, scarce technical and financial resources, and a substantial level of immigration from the uplands into the forested lowlands. This immigration is largely driven by inequitable land tenure and inadequate agricultural technologies.

Bolivia is working with the ITTO and TFAP in order to improve the situation. The country is particularly concerned with developing appropriate policies and legislation and strengthening institutional capacity aimed at "sustainable utilization and conservation of tropical forests and their genetic resources".

1 Private consultant, La Paz, Bolivia.

2 National Forest Options
2.2 Tropical Dry and Sub-Tropical Forests (Track II)

National Experiences in Managing Tropical and Subtropical Dry Forests[1]

Gill Shepherd, E Shanks and Mary Hobley[2]

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SUMMARY

The purpose of this paper is to provide representative case studies regarding the management of tropical and sub-tropical dry (savanna) forests. It is intended that these should illustrate successes, shortcomings and promising opportunities for national level planning for managing these types of forest.

The paper examines promising initiatives currently being undertaken at the cutting-edge of forest management problems; that is, in the realm of in-country forest level or regional forest management, where the dictates of national and international policy, technical feasibility and economic rationale, and the needs and aspirations of local people must be weighed against each other, and realized in definite plans for action.

The common thread which runs through each of the case studies is a growing commitment to change at the local and national levels, supported by a forestry department increasingly made aware of the need for effective legislation and for the involvement of local users in the management of forest resources. It is gradually becoming clear that the problems of forest management in the countries under review are at least as much concerned with forging good working relationships with forest users, and on forester's acquisition of the skills for doing so, as they are with the management of the biophysical resource in isolation. This is not to confer an arbitrary ascendancy on social over technical matters, but to suggest that in order to be effective in the field, foresters increasingly need to conceive of technical solutions in terms of social strategies. The paper is divided into four parts. Following the introduction, Parts Two and Three present evidence from Africa and from sub-tropical South Asia respectively. In Part Four the points made by the case studies are synthesized. This is done in such a way as to set guidelines for the possible technical and policy recommendations which may result from the workshop. Key points and questions to be taken into account when examining options for natural forest management are set forth. It is hoped that through the process of discussion, and through the integration of experience from countries other than those covered here, it will be possible to find out to what extent the priorities we have identified strike a chord with others as well.

1 Presented by Gill Shepherd.

2 Social Forestry Network, Overseas Development Institute, London, United Kingdom.

1 INTRODUCTION

1.1 Tropical and subtropical dry forests

While much of the attention of the North has been fixed on the results of the destruction of tropical rain forest, less attention has been focussed on the tropical and subtropical dry forests, which are at least as problematic, are more extensive, and are disappearing more quickly. Because such forests/woodlands[3] occur in more densely populated regions than rainforests, their disappearance may affect people living nearby more severely. Their location may mean that their disappearance has stronger implications for desertification, and they are usually key suppliers of urban fuelwood to distant markets. Yet all the interest and drama is currently attached to rainforests.

Tropical and subtropical dry forests are discussed here in the context of developing world management issues. For that reason, the extensive dry forests of Australia receive no mention here, and case studies are drawn from Africa and Asia. Tropical and subtropical dry forests are treated as a single category here from that point of view, and are therefore usually referred to in this paper, for brevity, as 'tropical dry forests'.

Table 1 Distribution of the Developing World's Forest Lands, 1985 (in millions of hectares)

Region	Closed Forest		Open Forest	Shrub land[4]	Forest Fallow	Total Wooded Area	Total Land Area	Percent Wooded
	Broad-leaved	Conif-erous						
Africa	216	2	500	450	160	1328	2966	45%
Latin America	666	26	250	150	170	1262	2054	61%
Asia (exc China) & Oceania	317	30	83	45	76	551	1640	34%
China	97	25	15	30	x	167	933	18%
All developing countries	1296	83	848	675	406	3308	7593	44%

Source: (World Resources 1986, p.62)

1.1.1 Extent

The tropical dry forests are mainly to be found today in Africa, but there are also extensive tracts in Asia, Latin America and, of course, Australia. Forests cover roughly one third of the world's surface. Worldwide, about 2.8 billion hectares are covered in closed forests, and 1.3 billion hectares in less densely wooded drier open forests. Forest regrowth on fallowed cropland covers an additional 406 million hectares and natural shrublands and degraded forests in developing countries an additional 675 million ha. Adding all these categories together, the total - 5.2 billion hectares - covers about 40% of the world's total land area. Of the world's total forest cover, 54% is closed and 46% open forest, shrubland and fallowed land. However, if investigation is narrowed to developing countries only, open forests of various categories make up 58% of the total, while closed forests make up only 42%. Africa has two thirds of the world's open tropical forests and two thirds of its shrubland, while Latin America has the largest expanses of closed tropical forests. (World Resources 1986, chapter 5). The tropical dry forest areas of the world are still vast, but are disappearing rapidly. The constraint is not their availability, but the identification of management regimes which might preserve them, and it is to this task that this paper addresses itself.

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3 The term 'forest' generally suggests a closed canopy, while 'woodland' suggests a more open scattered formation. Much dry tropical forest is open and could probably more accurately be called woodland. Furthermore, there has been a tendency for dry tropical forest to be called 'woodland' in Africa and 'forest' in Asia. The terms may be read interchangeably in this paper.

4 Shrublands, as defined in the source from which these figures are taken, mean areas with woody vegetation greater than 0.5 metres and less than 7 metres in height.

1.1.2 Importance

The tropical and subtropical dry forests are important for a mixture of reasons. Firstly, like the rainforests, they have a protective function, not only by directly protecting and cooling soil, (and in their case maintaining soil fertility) but also indirectly, by locking up quantities of carbon and give the world a breathing space in which to adapt to the implications of global warming.

Secondly, while they contribute less moisture to the atmosphere than the rainforests on a per hectare basis, their size, and their presence in lower rainfall areas, makes their moisture contribution of very great importance. When they are removed, the increased albedo effect is marked.

Thirdly, most tropical dry forests support larger numbers of people and domesticated animals than the rainforests, on a hectare for hectare basis - though the sustainable density is still relatively low. Humans have learned to live in symbiosis with these woodlands by relying both upon on the milk and meat which animals produce from tree-browse, and upon the replenishment of soil fertility which the trees bring to agriculture. As a result, their disappearance may affect people living nearby at least as severely as those living in rainforests.

Fourth, the support offered by tropical dry forests may extend several hundred kilometres away to those living in towns or in higher-rainfall agricultural areas, and who depend on them for fuelwood and poles, and for animal products obtained through trade. Recent work by the FAO has also highlighted the very important contribution of non-timber forest products in woodlands to the diets of a wide spectrum of individuals, who obtain such products by gathering or by trade. Protein, minerals and vitamins, vital to complement the carbohydrate-rich farm diet, are drawn from the woodlands.

Lastly though, in most areas, tropical dry forests make no contribution to timber exports (a fact which may mean that their vital in-country contribution to biomass and timber needs is undervalued) - they are nevertheless important hard currency earners. Not only are there modest earnings from non-timber forest products such as gums, but also the chief exports of a country like Somalia - hides, meat and live camels and cattle - are almost totally tree-generated. Dry forests can also save expenditure on imports: the commonest substitution being perhaps that of tree fodder - as manure - for imported fertilizer in countries such as Nepal, or leaf litter - as mulch - in the Sudanian zones of Africa.

1.2 The need for increased attention to natural forest management

Ever since the bench-mark of the Eighth World Forestry Congress in 1978, a slow process of change in the thinking of forestry professionals has been taking place. Where once their primary task was seen as the protection of forests and maximisation of revenue for industry and the State, it is now becoming just as important to consider the dependence of rural people upon tree products and the effect upon them of forestry activities (Cortes, 1984).

Three factors lay behind the change. Firstly, the oil price rises of the early 1970s made it clear that woodfuel was going to continue indefinitely to be the primary energy source of billions of rural people, with the implication that rapid deforestation would follow. Secondly, it became apparent that the world's forests, which in earlier decades had been assumed to be an almost infinite resource, were rapidly disappearing. Thirdly, development thinking itself was increasingly concerned with the needs of the small producer. Tree-planting projects with farmers and villagers were initiated in many parts of the world, largely in response to these concerns.

In the case of Africa, there was a further factor still. Following the severe Sahelian droughts of the early 1970s, greater recognition was given to the importance of tree-growing on the desert margins. In response to this, governments and international donors began to channel resources into rural and peri-urban afforestation projects. Emphasis was initially put on the establishment of large scale biomass and shelter plantations, usually of fast growing exotic tree species. By the mid-1970s efforts were also being made to encourage farm-level tree growing chiefly in the form of communally or individually managed woodlots. Almost without exception, these initiatives were driven by the perceived need to meet the demand for woodfuel and to help check desertification.

1.2.1 Tree-planting or tree-management?

Results were variable, however. It has gradually become clearer that rural people usually want to plant trees only on permanently-owned lands; often only as a cash-crop; and only where land in general is so short that there is no state- or community-owned forest nearby from which tree-products may be taken without the trouble of growing them. In Africa, in particular, but also in many parts of Asia, these prerequisites currently rule out the likelihood of successful villager tree-planting projects in many areas. Forests and woodland, though dwindling, still cover millions of hectares and will continue to be used by the populations who live near them for most purposes, for the foreseeable future. At the same time, plantations of exotic species were less successful in dry areas than was expected.

As a result, the management of dry tropical forest - abandoned in many areas after the 1950s in favour of plantations - began to be tried again in the 1980s, with activity in African dry savanna woodland being a particular priority. However, much had changed since it was last tried. Africa's population had greatly increased, while rainfall levels had decreased, intensifying competition for resources; agriculture had greatly increased at the expense of woodland cover; above all, the beginnings of a cooperative relationship between foresters and villagers has evolved in the drier areas as a result of the village tree-planting projects of the 1980s: this has in turn offered the opportunity of new working styles which are beginning to rule out coercive solutions to the management of natural woodland.

1.2.2 Dry Tropical Forest revalued

Although not apparent 25 years ago, it is now clear that plantations are unsuccessful in areas with less than 800mm of rainfall, except where trees can be irrigated (Lamprey 1986:125). 'Fast-growing' exotics grow scarcely faster under these conditions than the pre-existing vegetation, and are outperformed by indigenous species in drought years. As a result, the low esteem in which dry tropical forest used to be held, is beginning to give way to the recognition that previous estimates of their productivity may have been too low (Jackson 1983:12) and that, even at low increment levels, there are millions of hectares to be exploited. Most indigenous arid zone trees and shrubs continue to grow even when browsed, burned and lopped, and more protection leads to much improved productivity. However, good rains for Sahelian tree-establishment only occur every decade or two, and woodlands tend to consist of large numbers of even-aged trees. The need is to ensure that more young established seedlings and saplings survive to adulthood: such protection would probably be hundreds of times more effective in reafforesting dry areas than attempts to plant trees (Lamprey 1986:126).

1.2.3 Current research and knowledge

The increased interest in the management of dry tropical forest in recent years has been reflected in a variety of activities, though these have had a predominantly African focus. A benchmark paper was produced in 1983 for USAID and the Club Du Sahel under the title 'Management of Natural Forest in the Sahel Region' (Jackson 1983). Literature searches were conducted and national forestry institutions visited in the Sahel. The report reviews the potential for natural woodland management in the Sahelian zone. It notes that productivity levels are 'admittedly low': figures averaging 0.5 m^3 /ha /yr in the Sahel zone rising to 1 m^3 in the Sudan savanna zone are assumed. However, such figures are usually derived from unmanaged and often over-mature woodland, without fire or grazing protection. In places yields may be considerably higher than previously thought: for example in Bandin, Senegal (rainfall 600-700mm /yr) where the wood yield from Acacia seyal dominated woodland is in the order of 0.67 to 2.35 m^3 /ha /yr. This compared well with yields from a local Eucalyptus camaldulensis plantation (1.5 m^3).

An assessment was then made of the work done in eight countries: Cape Verde Islands, Mauritania, Senegal, The Gambia, Mali, Burkina Faso, Niger and Chad. The picture which emerges is generally one of neglect; and of a large number of technically based management initiatives set in motion but rarely carried through or documented in such a way as to give guidance to future practitioners. It is noted that only in Senegal had natural woodland management been undertaken on any appreciable scale. A year later, in 1984, the UK Overseas Development Administration (ODA), in an initiative intended to be complementary to the earlier survey, commissioned a similar study on semi-arid East and South-East Africa, by T J Wormald. Neither study found a great deal of earlier experience of management on which to build. Though both make mention of trying to involve local people in management activities - Jackson because such involvement would help to eke out the meagre resources of forestry services, and Wormald because he could see that management ought to be more effective with such collaboration - neither can find previous references to such styles of approach in the past.

IUFRO held a research planning workshop for Sahelian and north Sudanian countries in 1986 entitled 'Increasing the productivity of multipurpose lands'. At the workshop, the two themes voted the most important were the genetic improvement of woody plants for the Sahel, and the need for increased attention to tropical dry forest management. It was nevertheless evident from the papers presented that any management role for the farmers and pastoralists who would be most affected by it, was low on the list of topics worrying most delegates. Finally, a new generation of forest management projects have come into existence in the dry forests, and some of their experience will be reviewed here.

2 TECHNOLOGIES AND PRACTICES: CASES STUDIES OF MANAGEMENT FROM AFRICA

2.1 Introduction

Forest management in Africa is considered in terms of indigenous management techniques, focusing on proposals by agropastoralists for future management in Somalia, and two Tanzanian Government Forest Management projects. Finally, we present a brief comparison of four projects which sought to practise management by enlisting local residents in the task - the Somali case, a northern Kenyan case, and two projects in Sudan and Niger respectively - are examined to see how far they succeeded in their management aims, and how far they are likely to improve forest management in each area.

2.2 Case 1: Communal Management of Forests in the semi-arid and sub-humid regions of Africa

This case is based on an extensive literature search and analysis of indigenous forest management practices in dryland Africa, recently undertaken[5]. Management in the sense in which it is used here involves a series of mechanisms, put into practice by rural people who are coordinating their actions with others, at the command of some (ideally local) authority they regard as legitimate. In many cases, management is conducted almost entirely by people with rules in their heads and without coercion. In other cases, it is as important to know why people obey rules, as it is to know what the rules are.

Surprisingly, as the review was undertaken, it became clear that it is almost impossible to talk about the management of woodland as distinct from the management of trees on farmland[6]. Firstly, in well over a third of the case examples identified, land alternates between woodland and farmland under swidden-fallowing[7] cycles, the former replenishing the fertility of the latter. Secondly, for the herder, the woodland **is** his farm in the sense that it is daily even more essential to his animals than it is to the farmer's crops. We can expect different and more wide-ranging management of forest by herders than by agriculturalists, and must not extrapolate from the one to the other.

Thirdly, many management practices, it turns out, form a seamless continuum from management in the forest through to management on the farm. It thus seemed a pity not to give some flavour of this process, since much of the information gleaned has useful implications for any proposed formal management of woodland.

Finally, it is now standard to deplore the inability of Third World Governments, and colonial regimes before them, to distinguish between common property resources (CPRS) and open access land. We would be unwise to make the same mistake by lifting the woodland managed by local people from the matrix in which it exists - the primary economic activities of farming or herding - and treating it like a forest reserve. By and large,

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5 This article arises from research on the management of natural woodland in Africa, which is to be published in full both as an ODI Occasional paper, Communal Management of Forests in the semi-arid and sub-humid regions of Africa, Gill Shepherd, ODI, 1991 and as part of an FAO book on tree management by rural people.

6 Many of the articles used here are summarized in the ethnographic present, in line with the article itself. It is vital to check the date of the item. In this analysis, the ethnographic present is similarly used for the sections on management practices which were still extant at the time they were described. However, as the succeeding sections on change and the future make clear, we should not assume in too sanguine a way that all management practices are still functioning.

7 The hybrid term swidden-fallow has been used for two reasons. Firstly, it links two terms which, rather arbitrarily, are normally used respectively for non-African and African situations. Secondly, it stresses (in a way terms such as 'shifting cultivation' and 'slash-and-burn agriculture' do not), the fact that farmers do not abandon cleared land when they leave it to restore its fertility and plant crops on new land. They obtain other products from it, may retain continuing control over trees growing up on it, and will return to it when their own particular cycle is complete.

the tenure and authority regimes which once governed the successful use of forest, are also those that govern the use of farmland and all other local resources. It is divorced management of the two resources - by different ministries, by local and non-local people - which has led to many present-day problems. The starting point must be that ownership and management go together, and cannot be separated. Only by understanding tenure fully, will we understand the conditions for successful management.

2.2.1 Land ownership

Management of natural woodland is practised by those to whom it belongs, and as has been seen so clearly in the case of tree-planting, no serious investment of time and effort will be made unless the resource is owned. Thus the mechanism for ownership is our initial focus.

The herding lineage
In the case of many of Africa's herding groups, the genealogy of the lineage is the charter for access to land. The male descendants of one remote ancestor all share one large area, with subsets using subdivisions of it. Thus any particular area is strongly claimed by small numbers, but many people can assert secondary claims to it. Exclusive rights are most strongly asserted where a perennial asset such as water is at stake, and are vaguer where low and erratic rainfall makes it a gamble where the best grazing will be from year to year.(Barrow, 1986; Behnke, 1980).

Sedentary kinship groups
For sedentary farmers, while a knowledge of genealogical links is important, the moral community which holds land is defined by both descent and residence, rather than descent alone. Very often this is expressed as the chief or the elders holding the land on behalf of the collectivity, or as the village holding corporate rights allocated by the village headman.

The household head and the household
Just as the lineage fits within the tribe, and the village is often a subset of the lineage defined by residence, so the household has, in the past, often been seen merely as the lineage writ small. This is clear from the fact that land would revert to the next collectivity up on the owner's death, rather than to his children. However, the household head's position is gaining in importance all the time, as other levels of the kinship system cease to have political meaning and as land registration becomes the norm. In the future, user groups for particular natural resource assets are more likely to be aggregated from otherwise unrelated households, rather than already being a subsection of a larger collectivity.

Typical management actions
For chiefs and lineage elders of herding lineages, management actions most commonly undertaken are likely to be the exclusion of outsiders, adjudication between insiders, and the promulgation of new rules. For instance, Turkana elders in Kenya in the 1980s issued new instructions about the lopping of Acacia tortilis so that only side branches were taken, and the leader shoot stood a chance to grow rapidly above goat-browsing height (Kerkhof, 1990).

Many leaders have attempted to preserve the most valuable tree species in the area by linking them to the very office they have held. (Hammer, 1982; Norton, 1987). In south-eastern Botswana, village chiefs would ban the felling of village amenity trees and arranged elaborate zoning for different categories of fuelwood collector (Shepherd et al, 1985). Around Mount Kenya (and widely elsewhere in Africa) sacred groves were used as the meeting places or burial grounds of chiefs or senior age-sets.

2.2.2 The creation of tenure through labour

Several of the documents surveyed make it clear that it is the investment of labour which creates ownership. For the agriculturalist, this means being the first to clear and plant land once under forest or woodland. In all cases until present-day land registration procedures, such cultivated land reverted if it was abandoned, not to the wild but to the group to which the clearer belonged: so the individual had created rights for others as well as himself. Pastoralists keep tenure by maintaining and defending the key dry season assets of grazing/browse and water (Barrow 1986; Shepherd, 1989a). Tree-planting, because it is more work than tree-use, also creates tenure.

Individual tenure comes from the most, and the most constant, labour investment. In Senegal, for instance, (Postma, 1990), land was lost to the owner if it remained uncultivated for more than ten years. However, the investment of labour must come from its owner's own free-will. Neither slaves nor tenants can easily create ownership for themselves by their labour, since that labour belongs to another within the terms of their status, or their contract with the landowner.

2.2.3 Indigenous woodland management methods

Management is used in the sense whereby some individual or group activity organises the utilization of tree resources in such a way that the resource is more equitably shared, more likely to remain into the future (more sustainably used) or will grow better than if the management practice was not taking place. Classical planned natural woodland management, of the kind practised in European forests in the past, is somewhat different. Firstly, forest and farmland were separated at an early stage, and permitted grazing in forests has by no means been universal.

Secondly, the formal drafting of management plans for rotations of particular lengths and specified products is naturally unknown in rural Africa, though planned actions which encourage some species and eliminate others, or which encourage trees to produce different end products - thin poles, thick timber, for instance, are by no means uncommon. However, many of them take place in the context of farming, rather than dedicated forest. What African managers are doing is devising rules for sparing certain species, or certain size classes, or simply saying who may and who may not use certain tracts of woodland. They may mean management of the individual tree, but more often mean management of the space which the trees occupy, along with the grass and water there too.

Here, all and any planned and deliberate activity which enhances the quantity/quality of woodland or makes its use more sustainable, is defined as management. There is not space here to set out all the management methods investigated. The full list includes: fallowing systems; the conservative use and selective maintenance of particular species; reservation and sacred groves; the opening and closing of areas by time and season; management by taboo and religious sanction; management by fire; animal grazing and browsing as management tools; and management of the individual tree. Just two methods will be given as examples here: fallowing systems, and reservation, sacred groves and religious sanction.

Long and short fallow systems
Swidden-fallowing has been the most important method of woodland management in Africa for many hundreds of years. Patterns can be discerned in the very large literature on the subject partly by focusing on the types of fallow associated with particular tree species, and partly by attempting to identify the management procedures which governed the progression of the fallows.

In the Sahelian and Sudanian zones of Africa, for instance, where the inhabitants practise both agriculture and livestock raising, two particular fallowing systems predominate (Raison, 1988). Here, settlements create a variety of 'parklands' placed in constantly evolving concentric rings around the village. Moving out from the permanently cultivated village home-gardens, we pass through two zones before the unadapted bush is reached:

- the zone of permanent fields and short fallows set with Faidherbia albida;
- the zone of fields cleared in the bush, and of long fallows, where Butyrospermum parkii, Parkia biglobosa and Ficus platyphylla are found.

Butyrospermum parkii parkland - bush fallow (long fallow)
This formation is found throughout the sudanian zone apart from Senegal. In the untouched wooded savannah, with initially perhaps 1000 trees per hectares, all but 100 or so are burned so that they die. B. parkii are the main species preserved. Over the next four years, much of the dead wood is used up for fuelwood, as the area is cultivated, and then the whole patch is rested for 20 years and the farmer moves on outwards from his village. If one area is re-used by one village for 2-3 successive cycles, i.e.40-60 years, with the B. parkii protected all that time, the shade after sixty years will be so great that agriculture will suffer. So the whole village will move, using the earlier area for fruit gathering, and the process will start again. After 2-3 moves - 150-200 years - the B. parkii will be very elderly, and it will be time to start the whole process of major land clearance again, preserving younger trees.

While references to the political organisation of fallow management in the literature surveyed are unfortunately scanty, the Butyrospermum parkii cycle is impressive for the lengths of time involved, the coordinated nature of village planting and protection, and the extent to which the landscape in these regions is man-made.

Faidherbia albida parkland - savannah fallow (short fallow)
This is the most interesting and developed of the types of parkland created by Sahelian farmers. The tree, because it is in leaf in the dry season, and leafless in the rains, permits permanent cultivation under it, and also, at a density of 10-30/ha, fertilizes up to 50% of the area. Crop rotation is practised under the trees.

However, it is clear that F.albida alone cannot restore soil fertility - animal dung is needed too. A hectare of F.albida parkland with twenty trees on it supports six cattle in the dry season - enough to keep the area fertile; but in the rainy season the tree is leafless, there are no agricultural residues available for fodder, and the bushland is then an essential complement. If it is nearby, livestock can browse there and be tethered on currently exploited fields at night to deposit their manure. If there is no bush nearby, more labour intensive solutions must be adopted, such as sending animals north for part of the year, or growing forage for them. But more recently, with the departure of the young as labour migrants, animal herding has become too labour intensive an activity. The result is often that F. albida parkland fails and reverts to less intensively managed Butyrospermum parkii parkland. (CTFT, 1988; Houerou, 1980; Kessler, 1990; Pélissier, 1966; Postma, 1990; and Raison, 1988).

Acacia senegal gum-gardens
The literature indicates that in the central Sudan, each household would be allocated three or four plots of land, each of which was farmed for 3-6 years on a rotational basis. Acacia senegal naturally regenerated in cleared plots and was then protected as it grew up until it was ready to be tapped for gum by those whose fallows they were. Finally, when the trees were old, they were felled and sold as charcoal. The situation is now collapsing because population densities are too high to sustain such large amounts of land per household. (Hammer, 1982, 1988; Salem and van Nao, 1981; Seif el Din, 1987).

Reservation, sacred groves and religious sanction
Considering that trees are rarely set aside in indigenous management systems, but are lived among, protected and used, it is surprising that reservation exists at all. Yet it does. Some accounts make it very difficult to say whether trees are being reserved for soil conservation or watershed management reasons, or for religious and ritual purposes. But others are clear that trees are preserved in part to protect springs, to make rain, and to keep areas of original vegetation intact (Gerden and Mtallo, 1990). Some groves acquire their importance from the fact that ancestors' graves are clustered in them. It is customary to put such clusters of graves on a hilltop or ridge in some cultures - and so the trees may have an inadvertent conservation effect as well. Among the Kikuyu, such sites were commonly adorned with Ficus natalensis trees (Brokensha and Castro, 1987).

At the practical level there are a few instances here of reservation for patently economic reasons. The grazing/browse reserves of the Pokot and Turkana are one such example from primarily pastoral areas (Barrow 1986), while the hilltop grazing and woodfuel reserves of the Sukuma in Tanzania constitute an example in a more agricultural area (Shepherd, 1989b). Finally, in the past, some groups planted and guarded particular tree species as a reserve against famine (Jackson, 1983; Raison, 1988).

Religious sanctions - which are very often found - are a way of linking rulers with God and the ancestors, and using their authority to strengthen the authority of the living: of wrapping up management rules, in short. We can find examples such as the attribution among the Kikuyu of calamities to the illicit felling of trees (Brokensha and Castro, 1987); and the creation of closed and open hunting or gathering seasons by the placing of religious taboos on infringements, such as takes place among the Tswana (Schapera, 1943). While we cannot always understand these taboos it is clear that they were usually obeyed and that they had meaning for those who obeyed them. We should assume, therefore, that such sanctions are rooted in long observation, and a good understanding of local institutions and the local ecosystem. For instance, it is not infrequently reported in some parts of Africa that villagers will say anyone who plants trees will die; or that only God may plant trees and that it is impious for humans to do so. Closer investigation usually reveals that the proposed tree-planting was on village CPR land and that the trees would diminish the CPR rights of others: it is other people, not God, who would have been wronged in due course. The speakers are simply telling an ignorant outsider, in the strongest language they can muster, that elaborate arrangements are under threat.

In both these cases, trees are protected in ways superficially very different from formal forest management: in the first case, it is ultimately the agricultural cycle which protects certain species of trees; in the second, religious sanction provides intensive protection for small important pieces of reserved forest. Yet are these methods so strange? In the case of fallowed land, the boundary is secured against outsiders by inherited rights and by local residence; some trees are retained for many years, while others are felled and left to regrow on a 20-year cycle. In fact, the planning for short, medium and longterm gains is not so different from systems such as coppice with standards. In the case of sacred groves, we are merely seeing local political authority in action - backed by the supernatural rather than codified Law.

2.3 Case 2 : Management proposals from Southern Somali villagers

This case study reports on work undertaken in the Bay ('clay') Region of southern Somalia in 1988, and describes management proposals formulated by villagers whose common lands and trees were under threat from charcoal burners from the capital. During the study it became clear that the assertion and denial of common property rights to bushland were at the heart of the energy issues which were the original field of study[8]. It also describes the early stages of research aimed at returning common property rights to rural people who have lost them, and thereby helping to ensure the survival of resources which may otherwise be lost.

Bay Region is an area of southern Somalia lying 300 km inland from Mogadishu. It is a region of slightly higher rainfall than most of the rest of Somalia (averaging 500-600 mm) and consequently its best watered areas are important for rainfed agriculture. The inhabitants are agropastoralists. All households grow sorghum in years when rainfall allows it and keep some livestock. Though the numbers of animals per household are lower in Bay than in other more fully pastoral parts of Somalia, the population density is such that the region exports more livestock, as well as more sorghum, than any other region of the country.

Bay Region people survive by the complementarity of the low-risk trees and livestock component of their economy practised on the region's poorer sandy soils, and high-risk sorghum cropping on the clay ('bay') soils. The extreme unpredictability of the rains means that crop failure years are frequent, and animals represent the capital with which sorghum can be bought if necessary. It cannot be too strongly stressed that animals, and the tree-browse on which they feed, constitute the essential underpinning of the whole economy of this region.

2.3.1 The Bay Region and the charcoal trade to Mogadishu

Because of the region's slightly higher rainfall, and the fact that its capital, Baidoa, is only three hours away on a tarmac road from Mogadishu, it is also the chief supplier of charcoal for the Mogadishu market, which consumes at least 300 tonnes of charcoal a day. Charcoal production and transportation is organised by a single co-operative which transferred its headquarters to Baidoa when woodland resources nearer to Mogadishu became too depleted for further exploitation.

As a result of anxieties first expressed in 1985 about the number of trees suitable for charcoal still available in Bay Region, and off-take rates, an ODA-funded forest inventory project ran in the area until 1989. Towards the end of that period, complementary data began to be collected aimed at discovering the competing needs for trees of the inhabitants of Bay Region themselves.

2.3.2 The effect of the charcoal trade on the people of Bay Region

It was quickly discovered that there was intense conflict over trees in the region, especially on the clay plains in the north-west where the region's best soils and best rainfall have concentrated both farmers and the preferred charcoal species. Villagers were especially worried at the steady disappearance of many of the trees of a girth and durability suitable for house centre-poles and ridge-poles: Acacia bussei, Acacia senegal, Acacia tortilis and Terminalia spp. Important fodder species such as Grewia spp., Cordia spp. and Commiphora spp. were also beginning to disappear into the kilns, along with species usually selected for the

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8 The case-study is based on Bird, N.M. and G. Shepherd. 1989 Charcoal in Somalia: a woodfuel inventory in the Bay region of Somalia. Final report of the Energy Planning Study, ODA - UK, prepared for the National Range Agency, Ministry of Livestock, Forestry and Range, Mogadishu, Somalia. ODNRI, U.K. and Shepherd, G., 1989. 'The reality of the Commons: answering Hardin from Somalia' in Development Policy Review, London: Sage, Vol. 7, N° 1, March 1989, p 51-63.

lath walls of huts. Many of these species are further used in the making of water and milk containers, and other domestic and farming equipment.

2.3.3 Land tenure

But the problems as presented by the people of Bay are as much about communal land rights as they are about particular trees growing on that land. As has happened in many other countries, and in a closely parallel way in the Sudan, what used to be a triple land rights classification system has been collapsed into a dual one. Among Bay Region people in the past, land used to be classified under traditional customary arrangements as private farmland; as communal clan or village land; or as remote open access land.

In both these countries the government, in an overhasty attempt to create a modern nation-state out of a cluster of clan and tribal groupings, abolished the clan as a political entity and with it communal clan land rights. Thereafter, communal land was lumped in with open access land as State Land, and only the sanctity of private farmland was upheld. The right to manage communal lands was withdrawn and thus all previous attempts at management came to an end.

Today, two levels of land law operate in the Bay Region in an unsynchronised way. On the whole, Bay people still behave towards one another as if the old unwritten customary code of law still stands. Reciprocal grazing occurs by request, and neighbouring villages are supposed to ask each other's permission before cutting polewood in the other's terrain. There is every incentive to keep reciprocal grazing going, because rainfall is often patchy and generosity to a neighbour one year will ensure access for one's own livestock another year.

However, the people of the region are highly aware that the State takes no notice of the customary land rights they accord one another: especially as evidenced by the behaviour of the Charcoal Co-op. Co-op members, who are from other parts of Somalia originally, have been able to cut trees in Bay only because of the formal abolition of earlier clan-based customary land rights.

Village elders speak wrathfully of the government's failure to make the charcoal burners obey the rules laid down for them - which specify only two tree species which may be cut for charcoal, light harvesting of trees before moving elsewhere, and charcoal camp siting away from villages. Not only was the government's inability to patrol the area noted, but elders had discovered the futility of journeys to Baidoa to complain, or attempts to bring an official back with them to inspect bad practice. It was clear that officials in Baidoa were hesitant to offend Mogadishu and Mogadishu was reluctant to have its charcoal supply interrupted.

2.3.4 Strengthening common property rights - the villagers' solutions

The villagers had plenty of suggestions as to what was now needed. Firstly they wanted the right restored to reserve portions of woodland for the use of particular groups. In some areas, individual villages wanted reserves; in others, where an important local elder commanded the loyalty of several villages, a shared reserve for the group was preferred.

Secondly, while the driving force behind their enthusiasm for woodland management is obvious the desire for stronger rights to defend trees for their own purposes, it was clear to villagers that their traditional management practices for grazing would be insufficiently stringent to deal with non-reciprocal arrangements over poles. Poles were not in short supply twenty years ago. Village chiefs or committees would have to manage the resources of the village in such a way that self-restraint would be coupled with mechanisms for giving permission to cut poles, monitoring of the woodland, and protection of seedlings against browsing.

Thirdly, several village groups proposed that they be given the legal right (i.e. the written right) to watch the charcoal burners and make sure that only trees of the right species and ages are cut. In present day Somalia, where written documents are used for land registration and charcoal permits - that is, in negotiations with the State rather than with one another over land use - villagers are aware that government documentation is required if they are to hold the charcoal burners to the rules which are perfectly well known to both sides. Meanwhile, bows and arrows have been used successfully by villagers in the defence of trees near their villages, and there have been one or two armed confrontations. It had always been customary to use a settlement's young men as local police and it is clear that they could be used to guard the woodland if the right to do so were established.

Fourthly, villagers were well aware that the restoration of the right to manage the local resources must be cast in a new idiom. In the past, grazing areas were owned and defended in the name of clans and tribal sub-sections. Today, such groupings have no legal basis, and communal land rights would have to be ordered on another basis. Villagers suggested that, since villages and co-ops own communal property - and are the only institutions in present-day Somalia that do - communal land rights should be organised through them.

2.3.5 Conclusions

For Bay Region people, some strengthening of the right to own and control a natural resource is every bit as vital as farmland is paramount. Yet arguments on their behalf in the capital needed to be made carefully. Rural rights do not readily interest national government and may in certain circumstances be seen as a threat to the dominance of the centre. In this case, rural needs were also in direct competition with Mogadishu's need for charcoal.

Most accounts of common property resource regimes describe past or passing systems, either because national laws have undermined them or because a technological change has irretrievably altered the way in which they are exploited. It is equally rare to come across attempts to restore common property rights to their original holders, though the restoration of Panchayat Protected Forests to villagers in Nepal in 1976, after twenty years of unsuccessful nationalisation of forests, has been one such.

In the area of Bay Region in which most charcoal burning is taking place, there are only two National Range Agency offices (Ministry of Livestock, Forestry and Range), neither of which has transport. The officers are quite unable to monitor the activities of charcoal camps as they are supposed to do and there is little or no prospect of more funding being made available to them to make this possible. Where a country is as poor as Somalia, key natural resources will be far more cheaply and thoroughly protected by common property resource management than by paid government officials, as the villagers themselves argue.

There will certainly be difficulties in giving an earlier institution a new lease of life. The most starkly obvious concerns sanctions against rule-breakers. Where, as in the past, rule-breakers are local people, pressure on them to conform and practice the required self-restraint can be brought to bear because of the multitude of ties which bind them to the resource group they have offended. But Bay Region villagers find it impossible to deal with charcoal burners in this way, and need recourse to a State body such as the police or the National Range Agency which will support them when they impose sanctions on offenders.

Although there is a precedent in land registration procedures for village-level rights and duties to be part of the wider State system, the relationship of village-level natural resource management to State agencies will need time to develop and find its most appropriate form. Nevertheless, the strongest impression from discussions on natural resources with Bay Region inhabitants, is the durability of the concept of communal ownership of the woodlands, especially when one remembers that it has been a concept in exile for the last twenty-five years. It is still often too readily assumed by field practitioners that there perhaps can be no successful management of lands held in common. This case study suggests the opposite, that the real 'tragedy of the commons' arises when they are thrown open and unrestricted exploitation ensues.

2.4 Case 3 : Forest departments, local organisation and land rehabilitation - the case of the HADO and HASHI projects in Agropastoral Tanzania.

2.4.1 Introduction

The areas of Tanzania most severely affected by land degradation are in the semi-arid interior of the country, delineated by the 800mm isohyet. These dry savanna conditions prevail over 40% of the national land area, where 20% of the human population live together with the majority of the nation's vast livestock herd, estimated at 12 million livestock units in 1983. These are generally regarded as marginal lands of low agricultural productivity, in which pastoral and agropastoral economies predominate. In the debate over the role of livestock herding in land degradation, most attention has hitherto been given to the pastoral systems, which is surprising in view of the fact that more than 70% of livestock in East Africa are kept by agropastoralists (Brandstrom, Hultin and Lindstrom, 1979).

In the agropastoral systems of Tanzania, rain-fed crop cultivation forms the subsistence base, and livestock constitute capital. The specific role of cattle varies from area to area, and between cultural groups: in some areas, cattle are kept mainly at the farm or around the village, and manure is used to enrich soil organic matter on crop land, while in others spatial and temporal herding patterns vary greatly over the year, with the herds divided between the settlement and a variety of other sites in search of seasonally more favourable rangeland.

2.4.2 The Background to Land Degradation in the Region

Dramatic symptoms of land degradation have been in evidence in these parts of Tanzania for many decades and commentators have attributed the causes of this to both the bush-fallowing and livestock herding components of agropastoralism. However, while farming practices may be the primary immediate cause of land degradation, it is important to understand the historical context. In fact, in the areas of this region where it has been most severe, land degradation can be traced back largely to government policies of large scale woodland clearance for tsetse eradication which began in the 1920s and continued into the 1940s. This was undertaken in order to expand the area under crop and livestock production, which had declined in previous decades. The decline, as far as we can now tell, was ultimately linked to a series of disasters at the turn of the last century (rinderpest and famines) which triggered off woodland regrowth and an advance of the tsetse belts.

Woodland clearance soon led to accelerated land degradation, precipitated by the sheer scale and intensity of the clearance which took place. Labour intensive soil and water conservation and destocking programmes thereafter became a politically important, vigorously promoted, but socially unpopular response from the colonial administration in the 1950s.

The policy of woodland clearance had been popular with farmers because it made normal expansion into new areas easier. As in much of the rest of Africa until recently, sons took up new land when they grew up rather than dividing the land of their fathers, continuously creating new settlements as they went. A strong social network, maintained through cattle transactions and the division of herds between relatives, is a by-product of this. Destocking and labour intensive land conservation measures have been consistently resisted precisely because they are the reverse of the extensification rationale.

2.4.3 Initial Government Responses to Land Degradation - The HADO project in Dodoma Region

The Tanzanian government has since independence established a number of 'integrated' land conservation projects in the most adversely affected parts of the semi-arid region. The first of these, 'Hifadhi Ardhi, Dodoma' (Soil Conservation, Dodoma) or HADO, was initiated in 1973 as a national project under the auspices of the Forest and Beekeeping Division (FBD). The emphasis of the project was initially on reforestation, with village and local authority plantations, soil and water conservation planting, mechanical conservation methods, the development of arable agriculture and destocking. (Kilahama, 1988; MNRT, 1986; Mugasha and Nshubemuki, 1988; Ostberg, 1986; SUAS/IRDC, 1987).

Special attention was given by HADO to the Irangi Highlands in Kondoa District where soil erosion had reached alarming proportions. The initial use of heavy machinery to construct contour bunds soon became too expensive to continue, and labour intensive methods were employed, supplemented by woodlot establishment, check-dams and other methods of erosion control. Once a given area of land had been treated, livestock were removed until vegetation cover had been regained. However, only a small proportion of the total could be treated in this way.

Consequently, in 1979, in a radical move to arrest soil erosion in Kondoa District, the government completely enclosed 126,000 hectares of land, relocating farmers and removing around 90,000 head of livestock. This massive operation was carried out only six months after the initial political decision had been made. Prior contacts with villagers were limited to meetings in which they were informed of the measure and of suggested sites outside the area where, due to relatively low livestock population densities, they could safely resettle. It was only after enclosure had gone ahead that there followed a period of intense extension activity to convince villagers and local government leaders of its necessity. The essentially random nature of much of the resettlement meant that there were few channels of communication through which to assist farmers to make adjustments as even the formal contact point of the Ujamaa village government had been disrupted.

From an ecological point of view a remarkably quick transformation of the area was to be seen, and it was soon being held up as a model of how to treat heavily eroded lands in dry savanna areas. From a social point of view, however, the enclosure of such a large area of customary land had tumultuous and deeply felt consequences for the local people. Many households lost property. Some were able to send livestock away through family links, whilst others had to leave their home area entirely and start a new life in neighbouring lands. In some areas further degradation has resulted from the influx of herds from the destocked enclosure: indeed in reality the programme has done as much 're-stocking' as 'de-stocking'. For those who stayed in Kondoa there have been some benefits in cash and nutrition from the improved conditions for crop cultivation, but there have also been adverse effects, especially the lack of milk products and manure for soil enrichment.

Responsibility for policing the Kondoa protected area was handed to project staff, backed by local government laws, rather than by form of local control. Given the dramatic nature of the enclosure, HADO naturally found itself in the position of rigorously enforcing the destocking regulations if they were to have any chance of maintaining a hold on developments. This was not an easy undertaking as it put staff in the position of having to maintain regulatory and educational duties simultaneously.

Some farmers have continued to herd illegally in the area. It is not particularly difficult to determine where and when to travel to avoid detection by patrols, and the limited fines imposed represent a small proportion of the wealth locked up in the herd, in any case. Herd owners have also in some cases banded together to pay the fines collectively.

The comments of one HADO field officer, as recorded by Ostberg (1986), is revealing:

"When I was first posted here I was absolutely positive that in my area there should be no trespassing whatsoever. But some trespassing is inevitable. Already we are now using a quarter of our time for patrolling: it is impossible to guard this big area. Now I try to convince people, and ask for help from the party, and other leaders. If all cooperate we get much more result than if we only keep chasing away trespassers".

2.4.4 The 'Hifadhi Ardhi Shinyanga' (HASHI) Project

The HASHI project in Shinyanga Region, which is also run under the auspices of the FBD, was started more recently, in 1987. On paper, the project has several components, but following the experience of HADO, HASHI project staff are of the opinion that although tree planting may be appropriate in some situations, the in situ protection and management of natural vegetation by village people is by far the most cost effective option in the dry savannas. (Barrow, Kabelele, Kikula and Brandstrom, 1988).

Up to 1990 in the order of 30,000 hectares of land had been protected following negotiations with local villagers. The plots, which vary considerably in size (though all are significantly smaller than the Kondoa protected area) are left to regenerate through natural means. Enrichment planting and gap planting (chiefly of indigenous species) is undertaken where required. These enclosures have also been remarkably successful in physical terms, confirming the view that relatively simple regeneration and silvicultural operations are already at hand for management of the dry savanna vegetation.

HASHI contrasts strongly with the early HADO enclosure initiatives in a number of important ways. First, the enclosures undertaken have not involved the massive displacement of households or whole villages. Secondly, negotiations undertaken with a village are conducted more thoroughly, and involve a longer period of planning and preparation before any work begins. And third, the FBD has made the significant step of building on existing local land management practices which already serve to protect areas of woodland and grassland.

Among the Sukuma of Shinyanga Region there exists a well-established and still respected system of dry season grazing reserves, known as **ngitire**, which are set aside at the beginning of the rainy season and opened up during the dry season. These **ngitire** may be either family or common property reserves. The former can only be made on fallow arable land, whilst the latter are made on any village land that is suitable for grazing - this includes hilltops and areas of grassland in river valleys. Each reserve is opened up sequentially, one section being completely grazed before the next is opened, the aim being to maintain an area of standing pasture until the rains begin. The village leaders maintain strict control over the common property reserves and there are severe sanctions for trespassing.

The HASHI project has set out to modify this system of grazing reserves by negotiating the extension of the period of set-aside from part of a year to several years, as well as by making use of the local rules which govern their protection. The intention is that once the process of regeneration is underway and the trees have grown above grazing height, livestock will be let in for controlled periods and other products may be harvested. However, as yet, this second critical and perhaps most difficult stage of negotiating the details of new access rights has yet to be tackled.

2.4.5 Local vs State control over protected areas

Here again, the HASHI project has profited from the experience of HADO. The project made determined attempts not only to locate control over the protected areas in the village itself, but to identify groups below the level of formal village government. Sukuma society is still rich in various forms of self-help association which provide individuals and households with means of support in addition to those of kinship and formal government institutions. In one village in the north of Tabora Region project staff found that one household might be actively involved in as many as six associations at the same time.

The HASHI project has also enlisted the involvement and support of local 'vigilante' groups in Shinyanga, known as Sungusungu, in protecting the woodland reserves. The Sungusungu movement began specifically as a system of local defence against theft in the early 1980s at a time when there was widespread concern about law and order among ordinary Tanzanians in both rural and urban areas (Abrahams, 1987). Each village has its own Sungusungu organisation and leadership, and a special fund is created in each village to which all contribute in support of the activities of the youths.

Many farming communities in the savannas maintain a range of non-formal organizational mechanisms for dealing with local land use matters which, in places, may operate in virtual isolation from formal government. The risk imposed by lack of continuity in most externally determined development initiatives is surpassed only by the uncertainties of the savanna environment: and such local associations are better geared to coping with the latter when the need arises. The evidence from this case study suggests that such self help groups can be enlisted to carry on an intensification or modification of common property woodland management, provided the village at large also places a priority on the proposals made by the external authority.

2.5 Case 4 : Government Forest Reserves - the case of Tabora Region in Tanzania

2.5.1 Introduction

Tabora Region in western Tanzania covers an area of some 73,000 km^2 of gently rolling upland plateau with a unimodal rainfall of approximately 1000mm / yr. More than half the region is still under dry forest, a majority of which is semi-deciduous **miombo** woodland intersected by seasonally inundated **mbuga** grasslands in the valley-bottoms.

Patterns of land use and land holding in the **miombo** have always been extensive, associated with low population density. The infertility of the savanna soils necessitates long fallow periods, and long cycles alternate woodland clearance, settlement and cultivation, with the abandonment of settlements, woodland regrowth and the advance of tsetse belts. The presence of tsetse has always meant that smallholder farming in the area is characterised by the absence of large livestock. Cultivation on the interfluves takes the form of small plots of maize, millet, groundnuts, beans and sweet potatoes, while broadcast rice is cultivated in the **mbuga**.

Critical dry season activities are concentrated in the forest, and include work with pit-sawing, beekeeping, hunting and fishing and the collection of food and construction materials. Male householders may travel considerable distances from their homes in pursuit of such activities. The long-standing honey industry is of particular importance, employing both sexes, and providing household nutrition and income from sales of honey, beeswax and honey beer. The importance of forest food products other than honey (such as wild vegetables, fungi and fruits) has been all but ignored in past **miombo** research and management projects. These products are harvested primarily for household consumption and are therefore hidden when only cash benefits from the forest are calculated. Their importance lies in their value to poorer households, as a source of food security in times of hardship, and because they represent the major forest production activity undertaken by women.

2.5.2 Current Status of Forest Reserves in the Region

A significant feature of forest management in Tabora is that vast tracts of **miombo** woodland (3 million hectares or 45% of the land area) are formally gazetted as either central or local government forest reserves, or game protected areas. To put this in perspective, the entire reserve area of neighbouring Kenya is 1.6 million ha, roughly half that of Tabora. Significant areas of **miombo** also lie outside reserves on registered village or 'public' lands. Thus at present forest resources are generally amply sufficient to allow most users to satisfy their needs.

In the past, forest department activities in the region concentrated on the demarcation and protection of these reserves, a process which began in the 1920s. However, there is currently little effective management of the forest itself: in recent years regional and district forest offices have been almost completely without funds. Staff motivation and management under such circumstances are understandably weak. Field activities have been reduced to minimal patrolling of some boundaries, and collection of some forest revenues due to district and central government.

Management is subject to legislation set out in the 1950s and '60s and current forest policy emphasizes prohibition and the protection of forest reserves rather than the involvement of local people. Legally recognized exploitation in the **miombo** reserves includes the viable and well established beekeeping industry, the extraction of the highest quality indigenous hardwoods (Pterocarpus angolensis, Afzelia quazensis, Brachystegia spp.) and fishing.

In 1989, honey and beeswax sold through the regional Beekeepers Cooperative were 202 tonnes and 72 tonnes respectively with a value in excess of 36 million Tanzania Shillings[9]. Total production may be twice to three times greater than this, with the bulk being processed and distributed through the informal sector.

Timber contractors, the majority of whom are urban based, are provided with an annual licence to extract a certain number of trees from particular reserves, and logs are converted in the forest by local pit-sawyers working for the contractors. However, little attempt is made to control the location within reserves where the contractors operate or to ascertain the ecological status of sought-after timber species, nor are forestry staff always able to accompany loggers to ensure that felled trees conform to the set minimum diameter standards. It is likely that this is leading to localized over-exploitation in the vicinity of railway stations. Nonetheless, overall recorded production of timber has declined in recent years and the estimated current production of 15,000 m^3 may represent less than 2% of the sustainable cut.

2.5.3 Miombo Woodland in the Tanzania Forest Action Plan

In the recently produced Tanzania Forest Action Plan the national importance of **miombo**, as the largest forest ecosystem in the country, is recognized. However, it is to be expected that the forest reserves of Tabora will continue to be of lower national priority in comparison with the significant catchment and montane forest reserves in other parts of the country, and it is stated that low stocking rates and low productivity do not justify intensive management. Instead, in addition to four proposed project components which support the beekeeping industry, the Action Plan aims to bring about 50,000 hectares of forest into 'semi-intensive' management each year, starting in pilot areas within the largest forest reserve. However, management in this situation is conceived only in terms of control over timber resource: the proposed management interventions are 'controlled early burning and screefing of firelines together with harvesting for timber and woodfuel according to management plans'.

However, there are in fact a much wider set of pressing policy, technical and social management issues which need to be addressed with regard to forest management in the region. Other interest groups, with far greater **de facto** economic and political power than either the forest department or the timber traders, are exerting their influence on the destiny of the reserves.

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9 The information contained in this section has been drawn from a project preparation appraisal report prepared for the British Overseas Development Administration (ODA) in October 1990. The views expressed in the case study are those of the authors of this current report rather than representing the position of either the ODA or the Government of Tanzania.

Tobacco Farmers
Tobacco is the major cash crop in Tabora, the value of the 1987-1988 harvest from 9,700 hectares being in the order of 488 million Tsh (140 Tsh = US$1 in 1988 - about $360/ha). It is estimated that for every hectare of tobacco cultivated an equivalent area of **miombo** biomass is required to obtain fuel to cure the leaf. The rapidity of nematode infection in the area also means that farmers can only grow the crop on a piece of land for one year, with at least 3 years fallow. Thus, according to the current area under tobacco cultivation, at least 10,000 hectares of forest are cleared annually to support the industry. The precise relationship between forest clearance and regrowth, tobacco cultivation and fallow, is not known.

Tobacco cultivation is well supported by government, and farmers obtain subsidized transportation of woodfuel to their curing barns. Furthermore, the abundance of freely available forest on public land means that neither Regional Government, the Tobacco Corporation nor farmers are open to the suggestion that incentives should be offered to encourage the planting of farmer woodlots, as happens in other countries in the region. Regional government is thus in the position of supporting different sectors of production which are at odds with each other and with the conservation of natural forests.

Animal herders
There is increasing in-migration of livestock keepers from the agro-pastoral (dry savanna) farming zone to the north and east of Tabora where pressures on grazing resources are mounting. (The past problem of tsetse infestation has been somewhat reduced since herders have some access to veterinary supplies and the tsetse belts are currently at a low ebb.) Government efforts to destock in these drier areas have consistently met with stiff resistance from farmers to whom it continues to make more sense to subdivide herds and disperse them in a range of ecological niches rather than enter upon a highly risky total re-organisation of their production system.

Some of the herders moving into Tabora are in search of dry season grazing only and set up temporary camps. Others are penetrating deeper into the region for longer periods and looking for places to settle. Either way, the forest reserves are more or less an open access resource for livestock keepers.

The prospect of livestock invading forest reserves understandably fills foresters with unease. But the Tabora situation suggests that it may be unrealistic to resist it. First, the movement of herders from the dry to the moister savannas is taking place throughout Tanzania; it is a trend which, in all likelihood, cannot be halted and has to be accommodated. Secondly, it is perfectly clear that there are significant gains to be made in overall economic productivity if **miombo** is utilized as a graze and browse resource.

2.5.4 Land Reform and Village Woodland Management

The rhetoric of rural development in Tanzania in recent decades has suggested that radical policy measures have enhanced the means whereby rural people can become involved in the processes of planning. 'Decentralization' - the location of a variety of State institutions within each village - has been the major policy instrument to serve this end. While the duty to make a contribution to national level economic production has been clear, the stress has been on local level self-reliance and autonomy.

The reality has been almost literally the reverse. 'Decentralization' involved villagisation, the enforced relocation of several million people into larger nucleated settlements. The effect on land use in Tabora was to **decrease** household self-sufficiency and the ability to make forward plans, and to remove the right to control ancestrally-held land and its produce. Concerted attempts were also made to superimpose a universal collective form of land management onto the multiplicity of existing patterns of resource tenure and labour organisation. The formal contact point for all extension services, including forestry at community level, became the newly established system of village councils who, with the help of the forest service, were ultimately responsible for formulating and enforcing rules concerning management and the distribution of tree products, and collecting royalties where appropriate. Again, the State saw the granting of village-level control as decentralisation, but for those compulsorily villagised, such control was an infringement upon previous rights.

More recently, there has been a relaxation of the laws governing the allocation of land within villages, and the importance of private land holding rights for farmers has been stressed anew. The result of this is that in many parts of the country, including Tabora, people are moving away from the nucleated settlements and returning to lands vacated at the time of villagisation but over which they have, in their view, retained customary tenure. Land rights put 'on ice' twenty or more years ago are now being reactivated.

2.5.5 Ways Forward

The forest management problems in Tabora Region are in many ways unique, because such large areas are under reserve. However, it is because the issues are accentuated here that they provide such a clear illustration of the critical decisions that governments will have to make regarding dry forest reserves in the coming years in other regions and countries. In this respect, there are several key points to draw out from this case study.

- It is unrealistic to attempt to halt deforestation in the region. The demands of food and cash crop production, both locally and nationally, are simply too strong. From the point of view of most farmers, it will continue to make economic sense to clear **miombo** for agricultural purposes in the immediate future; then, in the long run, and when the need arises, to plant trees. All that can be achieved is to control the process of deforestation in such a way as to minimize environmental degradation and to ensure, where possible, that the diverse needs of rural people for forest produce can continue to be satisfied.

- From a technical and economic point of view it does not make sense to manage **miombo** for timber and woodfuel alone. In most situations future policy should be towards multiple use management with regard to both forest reserves and forest on public land. In both situations there are two fundamental problems: that of creating an appropriate organisational framework for securing people's involvement in forest management, and that of safeguarding their access to forest products.

- In sections of the Tanzania Forest Action Plan relating to farm and community forestry, the potential importance of village management of natural woodland and forest is recognized. However, as yet, few specific linkages have made between these concerns and the future of the vast reserves of **miombo** woodland particularly with regard to the changes in legislation which such management would dictate.

- The most direct means of encouraging involvement may be to prioritize exploitation by local people over outsiders - to grant them enhanced usufructuary or tenurial rights, that is to say. This will entail the registration of new rights to produce or revenue, and the waiving of current laws governing access to reserves to test new arrangements. However, this is to assume that the village in Tanzania is a cohesive community with one voice. In reality, as we have seen, there is currently a drift away from nucleated settlements in many areas, leaving State-created village officials behind. The village councils may remain the formal contact point for extension services in the foreseeable future, but viable management schemes will have to be tailored to smaller groups, perhaps to particular users of particular patches of forest, and these groups will have to be given decision making powers.

- The unit value of **miombo** woodland is low if valued in terms of timber and woodfuel production alone. But the aggregate value when non-timber products are taken into account as well is evidently appreciable. A sensitive cost benefit analysis, incorporating an appropriate weighting for the needs of household food security, may yield a more accurate picture of the true worth of the wide range of non-timber products. But the extent to which such micro-economic concerns can be built in to decision-making over future forest management activities, is of course currently uncertain.

- Lastly, there is the question of the extent to which the regional and district forest offices could handle such a radical reorientation of their duties. As already noted, the service does not currently have the resources to sustain management of all existing areas under reserve, let alone develop the capability to encourage village woodland management.

2.6 Case 5 : Technologies and practices: aims and outcomes in four dry forest projects

2.6.1 Introduction

Four projects of various kinds which have attempted dry forest management serve as case examples of the types of problems likely to be encountered: Guesselbodi Forest, Niamey, Niger, funded by USAID (Heermans, 1988); Rawashda forest, Eastern Sudan, funded by FAO (Sin and el Sammani, 1987; and Vink, 1986); Bay Region, Somalia, funded by the ODA, (Bird and Shepherd, 1989; Shepherd, 1989a); and the

Turkana rural development project, Northern Kenya, funded by the EEC (Barrow, 1986; Kerkhof, 1990). Each believed that a combination of classical forest management and local involvement was the way to proceed, but each interpreted this combination differently. A brief analysis of how each has fared on various counts is instructive.

2.6.2 Project rationale

Guesselbodi and Rawashda are forest reserves set aside for the provision of fuelwood to an urban area. Both had lost a good deal of their tree cover over the years, both were used in all kinds of ways by local people (especially for grazing and as livestock routes) and an approach involving local people was conceived of as a way of limiting the local threat to the resource by offering employment and slightly improved rights to local users. The Bay Region project began as a forest inventory project in the area from which Mogadishu's chief charcoal supplies came. Only in the course of the project did it become clear that there were serious conflicts between the herders in the area the charcoal was coming from and the State charcoal co-operative, and that the remaining potential charcoal supply was quite modest. Work was begun on a phase 2 which would pass substantial management of the resource to local people, and at the same time would lighten the burden of charcoal offtake by addressing fuel substitution in Mogadishu. The Turkana project was begun with the intention of helping the people of Turkana recover from the droughts of the 1980s. Its focus was always local.

2.6.3 Identification of the area to be managed

Guesselbodi and Rawashda are forest reserves, gazetted many years ago. The projects are making an attempt to graft local involvement and management onto a pre-delineated piece of land. In the case of Bay Region, preliminary work was done (before the Somali civil war closed the area) to identify the interests of local people in forest management and to allow them to plot the boundaries of the areas they could manage, following earlier indigenous land divisions. The Turkana project is involved in many aspects of people's lives, but as far as forestry goes, it too has identified the areas with meaning to the local people, and is building on existing management structures to enhance tree protection in the Region.

2.6.4 The interest of local people in a management role

At Rawashda, local people at the seminar reported by Vink (1986) said that they were keen for the benefits of the forest to go more to local people, and wished to see charcoal burners dealt with severely. They did not want to take part in management, which they saw as the Forestry Department's job, and were reluctant to enter into taungya arrangements.

At Guesselbodi, local interest in the project was minimal until it became clear that there would be financial benefits from the fuelwood co-operative to which villagers could sell the wood they cut, and there was then much more enthusiasm. But villagers were not prepared to do any unpaid management work until ownership and control questions were settled. In Turkana and in the Bay region, individuals are already involved in aspects of forest management, and see the respective projects as ways of enhancing their capability.

2.6.5 Project attempts to understand local tenure and management regimes

The Guesselbodi project spent almost two years on questionnaires about forest users and forest uses before management began (as well as the collection of soil and vegetation data) - but we hear not a word about tenure except the statement that there are difficulties in implementing the French Loi Forestiere because it alienates people. At Rawashda, the consultants' report of 1987 (Sin and el Sammani, 1987) points out that there is conflict locally over tenure in the forest which is seen as tribal CPR land alienated by the government when the reserve was created. There has certainly been no move to de-reserve the land during the last three years of the project, nor (to this author's knowledge) has the reserve ever been redesignated a local reserve rather than a Central reserve for the supply of city firewood. Both the Turkana and the Bay Region project, by contrast, take indigenous tenure rules and areas as their starting point as far as possible.

2.6.6 Authority structures

Predictably Guesselbodi and Rawashda start with the assumption that the project has the authority to decide on management patterns into which villagers must fit. Fortunately for the Sudan project, village sheikhs are so powerful in that country that they can deliver an actively involved village if they wish to. The seminar held in 1986, at which alternative management plans for the forest were discussed with local people, and their views taken, was an excellent event. At Guesselbodi, the management plan was presented to the people when it was already finished, rather than being evolved with them. No attempt to investigate local authority structures was apparently made, and an unwieldy nine-village cooperative was created for handling wood purchase and sale, and to collect permit fees and pay forest guards. By 1989 (Kerkhof, 1990) it was becoming apparent that a cooperative might 'not be financially or socially the best institution for local participation in forest management'. In the Turkana and Bay projects, by contrast, the project works with, or would work with, already respected local leaders and chiefs, building on their management strengths and capabilities.

2.6.7 Insights from these cases

It would seem that a project which starts with a piece of forest whose boundaries have been defined under one management regime, and which then looks for local management inputs, will have many more difficulties at every stage than a project where the need and interest of local people is the starting point, and forest management emerges from that commitment. The area to be managed has to be commensurate with the management capabilities of the target local group; that it why it is so essential that local people help to draw up boundaries within which they feel competent. If a forest is to change owners it may well have to be subdivided into smaller management units.

To put it another way, forest management projects where the real intention is to protect the forest by attempting to buy off negative local use with some local involvement (but no rights), are unlikely to succeed. As one of the officials with a responsibility for Rawashda said in conversation, 'People are not that stupid'. Reserved forests for non-local use are particularly poor candidates for local management - since by definition these are reserved **from** local people essentially. Early involvement in decision-making and planning is obviously crucial, and a relationship of equality between those who run the project and the local authority figures with whom they will work. A longterm relationship will have to be forged, of the kind that has been managed so well in Turkana.

3 TECHNOLOGIES AND PRACTICES: CASE STUDIES OF MANAGEMENT FROM ASIA

3.1 Introduction

The last decade of forestry practice has seen a shift from large scale industrial plantation projects to small-scale village and individual based programmes. Although the types of forestry intervention diversified, the profession continued to embrace those traditional practices which propelled forestry in its doctrines of 'timber primacy and sustained yield'. The profession was not ready to accept people first and trees second, and thus social forestry remained a top-down technical programme for reforestation.

The notion of community subsumed within the new doctrine of social forestry promoted policies which were directed towards the village as an undifferentiated entity, united for common action by its need for firewood and fodder. These policies ignored the differential access to both natural and political resources within a village and assumed all individuals would benefit equally from forestry programmes.

Current debates within and outside the forestry world have led to new initiatives focused on a more active role for forest users in the management of their forest resources. However, the degree to which users actually take part in decision-making varies according to local power structures and also the ideology of the organisation. For some organisations social forestry means the empowerment of poor people and women through giving them control over access to forests and decision-making, for example Gram Vikas in Orissa; for other organisations social forestry is a top-down intervention where local involvement is limited to the expenditure of labour in the creation of forests for the state. In India - West Bengal and Haryana - and Nepal, the forms of social forestry followed by the projects described lie in between these two extremes, they are neither exclusively top-down nor exclusively bottom-up. Project initiatives are based on the active involvement of forest users in the management of forest resources but with continued technical support from the state forest department. The case studies in this section review experience in India and Nepal with different forms of local forest management.

The evolution of forest land tenure: India[10]

In the 19th century up to two-thirds of the land in India were under community control (Singh, 1986). Privatisation and government appropriation have been the two main processes which reduced this proportion. The settlement process of the British as well as later revisions after Independence often missed the local distinctions in land classification so that many well-defined local resources such as pastures and forests were classified as state revenue land. Forest and revenue lands have historically been common property resources. In some cases these lands have become open access, where all may use the resource, in others access is controlled by a group, and outsiders are excluded (Hobley, 1985).

For over one hundred years a large proportion of India's land area has been under the formal custodianship of government forest departments. In 1975, state forest departments managed nearly 75 million hectares of land or 22% of the nation's territory. Forest departments attempted to fulfil their dual mandate for revenue generation and environmental protection (Poffenberger ed. 1990). However, the main focus was placed on securing the nation's needs for timber and pulp. To meet this end much of the nation's forest land was protected by forest departments against local people who were using the forests for grazing and firewood.

Under the Indian Forest Act, state governments may assign to any village the rights of governmence over forest land as a village forest. However, a December 1988 amendment to the Forest Conservation Act extended the requirement for central government approval to any state government action which assigned forest land to any private person or organisation not owned, managed or controlled by government. This has cast doubt on the validity of the large numbers of village forest agreements, and of the variety of other leasing and benefits sharing arrangements that exist between state governments and local villages and individuals.

The amended Forest Conservation Act also places the same restriction of prior approval on the planting of forest lands with non-forest crops. As this term has been defined to include horticultural crops, oil-bearing plants, palms and medicinal herbs, concern has been expressed that growing certain tree and medicinal plant species, the produce from which figures prominently among that covered by usufructuary rights, may be discouraged.

Revenue lands comprise two categories: government wastelands which are owned by the government but used by the village; and grazing lands which are vested in village bodies. There is little de facto distinction between the two categories, as both are used for grazing, and are generally considered degraded. It has been estimated that on average there are about 20 hectares of such lands per village, but there is much regional variation as well as variation between neighbouring villages (Chambers, Saxena and Shah 1989).

Tenurial rights governing the use of land may be affected at one or more of five different levels:

1 customary or traditional rights at the social custom level (eg village grazing rights);
2 administrative orders regarding use of lands (eg Forest Department rules concerning collection of headload fees);
3 court rulings regarding existing legislation;
4 state and national legislative statutes regarding rights over lands; and
5 constitutional law regarding citizens' rights in land (Singh, 1986)

In practice, the rights and practices which determine who has access to and can appropriate and use revenue lands are generally a matter of convention. The village panchayat may legally be in charge of these lands in the northern states, but as the panchayat consists of several villages, each having its own common lands, the authority of the panchayat over day-to-day control may be quite weak, and the elite of the village may exclude other villages of the same panchayat from using the commons.

In 1984 the National Remote Sensing Agency announced that between 1975 and 1982 India had lost 1.3 million hectares of forest annually. Sweeping restrictions were placed on commercial and local forest use by planners under the new draconian rules of the 1980 Forest Conservation Act (Poffenberger ed. 1990).

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10 This introduction draws on the work carried out by Arnold & Stewart in 1990. The authors wish to thank them for their permission to reproduce their findings in this study.

This marked the beginning of confrontation between environmentalists concerned at the rapid degradation of forests; individuals and organisations concerned at the local people's loss of access to forests; and the forest departments concerned that their lack of territorial staff prevented them from effectively policing the forest resource against incursions by rural people and others. Thus local and national interests were directly conflicting over the management and protection of forest resources.

The solution to the rural fuelwood and fodder problem was social forestry programmes. However, as in Nepal these programmes did not address the degrading protected and reserved forest areas. Recent innovations which form the focus of the following case studies look at methods by which local people in conjunction with forest departments can manage areas of degraded forest land. For example, in West Bengal, nearly 200,000 hectares are under joint protection, while in Orissa estimates range from 3 to 10% of all reserve and protected forest lands are under informal local protection. Nationally, it is estimated that over 500,000 hectares of reserve and protected forest land are already under local protection through joint management agreements (Poffenberger ed. 1990).

Since many of India's dominant natural forest species have high regenerative capacity they are ideal candidates for protection under local management schemes. Simple silvicultural systems including coppicing and pollarding ensure both short and long-term benefits for local people. A recent analysis of Landsat and field data indicates that nearly 30 million hectares of degraded state forest land in India, or over 40% of total forest area, has the potential to regenerate naturally with local protection (Poffenberger ed. 1990). The challenge now is to encourage the formation of mechanisms to allow effective interaction between local people and forest departments in the management of forest resources.

3.2 Case 6 : Forest Protection Committees: West Bengal[11]

3.2.1 Introduction

In the early stages of social forestry practice, the only role envisaged for local people was enhanced employment opportunities, with a bonus of access to low-priced forest products. The change in philosophy in West Bengal came about through an innovative pilot project set up by a District Forest Officer (A.K. Bannerjee) in the early 1970s. From this beginning the notion of Forest Protection Committees has spread across large areas of West Bengal.

The Forest Protection Committees of West Bengal represent a recent example of bureaucratic innovation regarding common property resource management. Most of the land now under the control of these Committees was previously a sal dominated mixed forest but had been degraded by heavy cutting.

The West Bengal Forest Protection programme aims to regenerate 259,000 hectares of sal forest. Nearly 1300 Forest Protection Committees have been organised in response to Forest Department offers to provide preferential rights to certain tracts of forest to specific villages. The Forest Department chose villages or hamlets as the user groups rather than official panchayats. The highly politicised village and panchayat level leadership often plays a major role in deciding which villages will be chosen for the scheme but no financial benefits are distributed through them. Benefits flow directly to specific users. There is a triangular rather than hierarchical relationship between the state, intermediate organisation and individuals. Originally the villages were chosen by the Forest Department alone but the selection process has gradually given a greater voice to local panchayats. Usually most, if not all, households belong to the village committee, which selects its own officials. The user groups take on more of the protection and control of harvesting in return for a substantially greater share of the eventual proceeds from the resource.

Although commercial harvesting was illegal, these forests were the source of large quantities of fuelwood required by West Bengal's large urban and industrial users. The primary harvesters were local women with few other sources of income. Firewood contractors employing local or outside labourers were also major users. This is to be a recurring feature throughout all the case studies, where external pressures threaten any local protection systems that are established.

Daily guarding done by villagers needs to be supported by a quick response to illegal use by the Forest

11 This case study material is drawn from Arnold and Stewart, 1991, and from Malhotra and Poffenberger, 1989.

Department. The impressive protection which has taken place in many villages is evidence of the considerable faith the villagers have in the state, the local political bodies and other villagers holding to the agreements. However, some committees have voiced concern about the insecurity of their position in the absence of enabling legislation. Boundary divisions between villages have gradually become more of a problem as the approach has been expanded, and the Forest Department is considering methods for the broader delineation of preferential use right zones.

3.2.2 User Rights

Use regulations depend on the management system, which varies considerably from village to village. The basic model developed at the Arabari Forest Range involved drastically reduced local use of the forest for income generating firewood cutting and animal husbandry (and reduced local fuelwood use) in return for employment in forestry activities. The costs therefore tend to bear most heavily on the poorest, who were most dependent on the output previously.

Much of the area where the FPC approach is being extended is primarily inhabited by Santhal tribals who have long and intricate traditions of forest management. The main products they collect and process are tendu leaves for bidi cigarettes, sal leaves for plates, tasaar cocoons for silk, and sal seeds for oil. As these regenerate rapidly in protected sal forest, benefits are forthcoming after only a few years. Nevertheless, villagers must still invest a considerable amount of time and labour before even these benefits are forthcoming. Benefits from pole plantations take much longer before they are available.

In the mid 1980s a decision was taken to share the benefits of the planned pole revenue, from regeneration and plantations, between the villagers and the Forest Department in a 25:75 ratio. The beneficiaries were supposed to be those households which had contributed labour to the original establishment work and had taken part in guarding. Each household was to get an equal share of the villagers' 25% portion. Income from minor forest products accrues to those villagers who collect them.

In both types of management the regulation of use is done by the beneficiaries. Unfortunately, there is little evidence about how villagers actually distribute access rights internally, and about what is done when the restrictions on local fuel and fodder collection drastically change the overall availability. In areas where minor forest products are available it would appear that it is those with the skills and interest to harvest and process them who benefit most, mainly women (in particular poor women). Guarding is less difficult in regenerating sal areas than in pole and firewood stands, as it is considerably more difficult for outsiders to remove significant amounts of produce in a short time.

The rapid spread of the FPC programme has owed much to the demonstration effect of existing Committees. Apparently villagers already committed to protection of their area have been anxious to see neighbouring villages do the same, in order to reduce poaching of forest produce across village boundaries. This spread effect shows that even with limited staff and resources it is possible to involve a large number of rural people in the protection and management of resources, if there is a clear understanding of rights and responsibilities.

The FPC approach has been most successful in villages bordering extensive tracts of degraded forest land. In these villages the forest to household ratio is much higher than the average for the region and state. FPCs have also been organised where the ratio is low but they have been considerably less successful. It would seem therefore that those villages most dependent on forest resources for their livelihoods are most willing to invest labour in their protection.

Benefits from a regenerating sal forest have been assessed and indicate the following yields of produce to FPCs and Forest Department over a 28 year rotation (Poffenberger ed. 1990):

Wood	30 tons	Sal fruit	340 kg
Fuelwood	45 tons	Mahua flow	450 kg
Twigs	9.9 tons	Mahua fruits	300 kg
Poles	1200	Kusum fruit	140 kg
Fodder	3.4 tons	Kusum flow	300 kg
Sal leaves	1 ton	Bidi leaves	150 kg
		Fibres	120 kg
		Medicinal	30 kg

3.2.3 Conclusions

There are several important points to emerge from the West Bengal case. As will be seen with the other case studies one of the most difficult problems is the resolution of conflict between competing user groups. In several cases FPCs have been successful in asserting their protection rights over an area of forest against firewood traders from urban areas. If FPCs have a legal constitution and the legal right to protect and use forests for their own specified use they are able to exclude outsiders from access. Resolutions passed by the state government recognise local people's rights of access to forests, and have succeeded in strengthening the powers of Forest Protection Committees.

3.3 Case 7 : Gram Vikas and the New Forests of the Kerandimal Khonds[12]

3.3.1 Introduction

Gram Vikas, a small non-governmental organisation working in the Kerandimal Hills in southern Orissa, began its social forestry programme in 1985. Gram Vikas employs two basic principles - active engagement with local people and the use of government owned 'wastelands', a name which belies the reality. No land in India is truly wasteland: there will always be individuals exercising use rights over it. Thus, any change in use will inevitably lead to conflict between the previous users and the new users. However, in this case use of these lands is limited, and any conflicts were resolved early in the programme.

The Kerandimal Hills are inhabited mainly by tribals of Khond and Saura origin. The tribals live in small scattered villages throughout the hills and upper plains. In the 50 villages participating in the social forestry programme, village size varies between five and 66 households. A limited form of common ownership known as khoto does exist in most villages and refers to communally owned assets or funds. The khoto may take the form of trees, cattle, land or money. However, the leaders of the village appear to have exercised full control over the khoto with very little accountability to the rest of the village.

The kerandimal tribals depend on the forest for their livelihood. About 60% are landless, and only a few households that live on the plains have irrigated land. They are mainly subsistence farmers whose main crop is ragi. They also practise podu (shifting cultivation) during the rainy season, growing a mixture of indigenous grains and vegetables, mainly jowar and maize. The produce obtained from this form of cultivation feeds a household for three months of the year. The tribals also keep livestock, mainly cattle and some goats and buffalo.

Podu cultivation practised by these forest-dwellers is a major cause of deforestation in the Kerandimal Hills. In the past the Khonds have been able to practise podu on a sustainable cycle: the podu cycle used to enable each area to regenerate for 15 years before being harvested again, but this has now reduced to just three years over the last decade. The remaining areas of podu cultivation are of low fertility, producing poor crop yields.

For the rest of the year tribals rely on the forest, from which they mainly cut and sell firewood. Minor forest produce such as fruits, nuts, roots and tubers, leaves for making leaf plates and twines for rope, among others, are also very important for meeting local needs and generating income. Cutting wood for sale from the forests is illegal; tribals only enjoy the right to cut firewood for their own needs. Firewood is traded to itinerant merchants in exchange for other commodities. Merchants sell the bundles of firewood in larger villages and towns for a gross profit of between 50-100%. The large demand and lucrative market for firewood and timber in nearby towns has encouraged the formation of gangs that illegally fell the few remaining sacred tamarind and mango trees in the degraded forests. Thus the internal and external pressures on the forest are enormous and increasing.

3.3.2 Gram Vikas: philosophy and action

Gram Vikas acts to encourage the full involvement of local people in their own development. Gram Vikas'

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12 This case study is based on a report written by Stephen Farrell for Community Aid Abroad, an Australian non-government organisation funding Gram Vikas' work in Orissa. The authors thank Stephen Farrell, Gram Vikas and CAA for permission to draw on the report in this study.

initial entry point in 1977 was through a health programme, and was followed by an adult education programme. Committees were formed in each of the villages participating in the health programme, which later became known as Village Committees. These committees replaced the traditional village decision-making bodies known as Kulas. In the early years Gram Vikas encouraged homestead tree-planting. However, this approach was inadequate in the face of massive deforestation, and the loss of subsistence livelihoods. Gram Vikas in partnership with tribal communities, decided that they needed to establish plantations on forest land. The major constraint to this approach was the lack of suitable village land. Gram Vikas suggested that the Revenue Department should be asked to release some of their land to the villagers. This was agreed to by the Revenue Department, who then surveyed and demarcated the land to be used.

The villagers held meetings to discuss their needs for forest produce, and the species types best able to meet these needs. On the basis of this information nurseries were established in the villages, and preparation for the plantations begun. Each household was required to provide an equal number of days towards plantation establishment, and records were kept by the Social Forestry Committee. One day's free labour was contributed for every seven worked during the three year plantation establishment period.

Plantations are multi-species, different species are managed on different rotation lengths according to the products they are to be used for. But in all cases management is flexible and decisions regarding harvesting of the trees is left to each Social Forestry Committee. Most plantations contain a combination of fruit, fuel and timber yielding species. Several fruit bearing species - cashew, mango and jackfruit - provide the basis of long term sustainable returns from most plantations. Fuelwood species are harvested from the 4th or 5th year after plantation establishment. Trees closest to the major fruit-bearing species are harvested first to reduce competition. Good coppicing fuelwood and timber species are managed on coppicing systems with cycles ranging from 5 to 7 years and 10 to 30 years respectively. The selection method of felling ensures adequate forest cover is maintained. Existing trees will be managed according to their major use and the needs of the village.

Although grazing is not an important factor in these areas due to the limited numbers of livestock kept by the tribals, there is provision for supervised grazing in the plantations. Some tree fodder species will be lopped, and grass grazing permitted during the early summer to prevent forest fires.

Following the establishment of the social forestry plantation each village appointed a full-time guard to protect and maintain their plantation. Each village decided the responsibilities of their guard and made a selection on this basis. Guards were paid by Gram Vikas through the village Social Forestry Committee during village meetings at which their performance was assessed by the entire village. Guards were paid on a daily wage basis and were expected to work 23 days each month. Some villages decided to appoint guards on a rotational basis which enabled several members of the village to obtain a good knowledge of social forestry operations. Nursery workers were employed and their work assessed by the same methods used for guards. Since nursery payments to villages were made on the basis of whether seedlings were available for planting, the village had a vested interest in ensuring production of good quality seedlings.

The mechanism to distribute produce and income from the plantations will be an important test for local organisation. Most villages have discussed, and tentatively decided, how the plantations produce and income will be distributed. A commonly expressed intention by villages is that they will collectively sell produce from their plantation and keep all income received in a common fund. Some villages have already harvested grasses, vegetables, crops and cashew nuts, and have placed the income received from their sale into a common fund. The use of these funds for production and consumption loans, joint activities, and other programmes has been advocated by a number of villages.

3.3.3 Rights to plantation produce

In 1986, the Government of Orissa introduced a scheme whereby tribal communities could reafforest both government owned land classified as wasteland, and areas designated as Village Forest, for the purposes of establishing social forestry plantations. But the Order did not clarify what rights people had to plantation produce once the trees planted reached maturity or fruiting age. Areas of government owned land classified as wasteland in Orissa are under the control of the Revenue Department. But within the Kerandimal Hills there are large tracts of badly degraded forest as well. Most of this degraded forest land falls under the undemarcated Protected Forest category and is therefore under the control of the Forest Department. Land covered by the Forest Department is not included in the 1986 Order. Much of the existing Revenue wasteland has now been taken up by the tribals social forestry programme, and thus negotiations are now underway to release degraded Protected Forest land held by the Forest Department for use by tribals. In many villages the area taken up under social forestry is greater than the sum total of the tribals' private and communally owned lands.

Tribal villagers have rights to use all produce grown on village (tribal) owned common land and the rights to use minor forest produce such as fruits and bamboos on areas classified as Village Forests. These land types account for 27% of the area taken up under plantation. The tribals presently have no rights over produce obtained from land with a Revenue Department owned wasteland classification. At least 63.6% of the land used under this programme is in this category. Kerandimal tribal communities have only been given official rights to use Revenue Department owned wasteland for the purpose of establishing social forestry plantations. Under an existing Government Order relating to a soil conservation programme for revegetating wasteland, communities only enjoy rights to use the land they have planted until trees reach fruiting age or maturity.

There has been a Bill before the Government of Orissa for a number of months concerning the granting of tree patta rights to villages that establish social forestry plantations on Government owned wasteland. The Bill, if passed, would entitle the tribal communities to enjoy the benefits of all forest produce derived from the plantations, apart from several commercially valuable species. For each social forestry plantation the land's title is registered in the name of the village. Thus, once the Bill is passed these socially homogenous villages as a whole will be legally entitled to the plantations benefits.

When concern over the present lack of rights has been discussed with the Kerandimal tribals, their general response has been '.....the land we have planted, just like the forests, is not in the office of the Tehsildar or that of other Government officers. It is here next to our village....How can they take it from us, we will not let them take what is ours...' (quoted in Farrell, 1989).

3.3.4 Village Social Forestry Committees

The Kerandimal social forestry programme is aimed at addressing the long and short term economic needs of Khond tribal communities. Villagers receive income under the programme through three avenues: the nursery programme; wage employment for establishment operations, and income derived from the sale of plantation produce. Some villages have already deposited income received from the sale of plantation produce into the Village Fund. Village Funds are used for expenditure incurred by village committee members, to finance development activities, and as a source of money for individual loans. Nursery workers and Regional Committees are paid from funds received by the Village Committee for the raising of seedlings, although the major portion of this money remains with the Committee.

The success of this programme lies with the Social Forestry Committees. The degree of villager participation is influenced by the quality and strength of the people's organisation at the village and regional levels. The building and strengthening of an effective people's organisation is a prime objective of the Kerandimal Integrated Tribal Development Programme. Through the process of developing a people's organisation, Khond tribals have been encouraged to manage their own social and economic development. A separate women's Social Forestry Programme has been undertaken to ensure that women's needs are more directly addressed than they were under the male-dominated Social Forestry Committees. Intrinsic to the continued success of the social forestry programmes are committed Gram Vikas field workers. Training of these workers is as important as the training of villagers.

The committees were generally slow in taking on the responsibilities and functions expected of them, and consequently the village's general committee often acted on their behalf in the early stages of the programme, With training and experience, the ability of committee members to perform the management and accounting functions expected of them improved.

The major tasks of Social Forestry Committee members included organising the various operations, arranging and convening meetings, making payments, and ensuring that attendance, plantation, nursery and financial records were kept. In some villages the concept of a Village Committee was apparent in name only, with decisions made by collectively by the village. Vocal and influential individuals, which included many of the traditional tribal leaders, played a key role in village decisions.

3.3.5 Training: village-level workshops

In early 1987, training needs of the Social Forestry Programme were discussed at the village and regional levels of the Kerandimal programme. Concern was expressed that training was limited to forest guards and nursery workers, it was felt that there was a greater need to involve whole villages and in particular the Social Forestry Committees in such training. It was recognised that the strengthening of the people's organisation and development of leadership skills was of equal, if not of greater, importance to the success of the programme than the technical guidance provided by guards and project staff. To this end a series of workshops were held in the villages aimed at training Social Forestry Committee members in techniques for establishing nurseries, keeping records, accounts and payments. Alongside the workshops there were discussions aimed at making committees more aware of their responsibilities.

3.3.6 The role of NGOs

Gram Vikas' social forestry programme illustrates the potential role to be played by the non-government sector, indigenous people's organisations, funding agencies and government, in a joint effort to ensure afforestation efforts are effective. Strengths and weaknesses of non-government organisations in undertaking social forestry programmes have been identified by De Roy and Mathew (1986). The important strengths of Gram Vikas are:

- ability to motivate people through dialogue, field demonstrations, and programmes conducted with the active involvement of local people;
- dedication, perseverance, honesty and flexibility, which cannot always be matched by government agencies;
- ability to remain in contact with the people, and to attempt to understand the people's real needs, problems and potentials;
- good understanding of people's customs and beliefs;
- long-term commmitment to the development of one area, or group of people.

Their weaknesses are:

- an infrastructure that is often too weak to undertake complicated programmes such as social forestry;
- often poor interaction and communication with other NGOs;
- inadequate financial resources;
- poor access to information regarding land, financial and technical issues.

However, a constructive union between non-government and government organisations should bring about strong and well directed action which catalyses effective local-level enthusiasm for the programme.

3.3.7 Conclusions

There are two aspects of the programme that are largely responsible for its success. These are, the existence of a fairly well developed people's organisation prior to the development of the Social Forestry Programme, and the homogeneity of the Kerandimal tribal communities.

The existing organisational framework provided by Gram Vikas organised village committees has assisted in the regional expansion of the programme. One of the most important factors in the success and spread of this programme was the use of pilot villages at the outset which served to familiarise Gram Vikas staff with the requirements of a social forestry initiative, and provided a practical demonstration of what could be achieved. The tribals of these pilot villages were also able to explain their experience of the project at local gatherings with other interested villages.

Through their earlier work with the Kerandimal tribal communities, the Gram Vikas workers had developed a relationship characterised by confidence and understanding. This made it easier to rely upon local people taking an active part in the project than outisders, for example Forest Department officers, could do.

The second major factor in the success of Gram Vikas lies in the nature of the Khond tribal communities, which are essentially communal in nature with a high degree of socio-economic equality. But, while this homogeneity of Khond communities has enabled the Social Forestry Programme to be directly linked to the development of a people's organisation that involves entire villages, there is no reason why the model cannot be modified for selected target groups within heterogenous, or class-differentiated, non-tribal villages.

Formalisation of the tribals' rights to plantation produce is critical to the continued success of this programme, particularly with increasing external pressures on the forests of the Kerandimal Hills. For example, tensions have arisen between non-tribals and tribals who have challenged the latter's exclusive rights to produce from social forestry plantations on revenue land.

The support role played by Gram Vikas in the Social Forestry Programme and overall development programme in the Kerandimal Hills is fundamental to its continued success. It is still beyond the capabilities of many tribal communities to have direct links with various support agencies, including government departments. However, over the last couple of years, Gram Vikas have been able to scale down some of their activities in the Kerandimals, and are beginning to plan their withdrawal and hand-over.

3.4 Case 8 : Hill Resource Management Societies: Haryana[13]

3.4.1 Introduction

The Hill Resource Management Societies (HRMS) in Haryana are the product of nearly 20 years of work by state government departments, external organisations and poor villages in the Shivalik Hills behind Chandigarh, the capital of Haryana and of the neighbouring state of Punjab. In an attempt to slow siltation into a large lake in Chandigarh, the government offered to build small reservoirs in certain hill villages if the villagers would stop open grazing in the watershed of the lake. From the original concept of social fencing 'whereby villagers decide to protect the hills from grazing through self restraint' (Mishra and Sarin, 1987), the process gradually evolved to one of joint management for grass, irrigation water and watershed protection.

The basic principles of the HRMSs are (Arnold & Stewart, 1991):

1 Each household has equal rights to all resources;
2 No open grazing of the catchments is allowed;
3 Irrigation fees are collected to cover operating and maintenance costs;
4 Surplus funds are reinvested to improve the natural resources or for other agreed village infrastructure;
5 The society would include a few outside members to provide technical advice, linkage to government bodies and assistance in conflict resolution;
6 Annual elections for the secretary, treasurer and other members of the executive committee.

Unlike other Himalayan states the Forest Department in Haryana actively manages the Shivaliks for revenue and puts limits on the amount of produce which local villagers can take. Grass leases were auctioned to contractors who sold grass to paper mills and fodder grass harvesting rights to neighbouring villagers. While this system reduced the workload of the Forest Department it did not promote long-term resource management as neither the contractor nor the neighbouring villagers could be assured that they would benefit from reducing the current harvest in order to enhance future regeneration. To overcome this problem the Forest Department gave five-year leases for fodder grass harvesting contracts to villagers instead of contractors, effectively allowing the village to take all benefits from increased grass production and value. The value of the leases was based on previous auction prices.

The approach of HRMSs involves greater use of auction values and fees to legitimise user group control over a certain area. Regulation by villages is closely linked to the need to raise substantial sums of money from relatively poor villagers to pay the auction related value of grass. Villagers have shown considerable innovation in developing and revising the rules governing grass harvesting. In Sukhomajri, for instance, the society decided to exempt widows and households facing economic hardship from paying anything.

Recent elections for executive positions on the HRMSs have led to considerable change in their composition. For some this has resulted in the loss of those who had been most involved, and who had demonstrated most ability. In others, it has broadened the leadership away from the original beneficiaries, who usually were

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13 This case study uses material from J.E.M. Arnold and W.C. Stewart, 1991 and Gill Shepherd, 1990.

those with relatively more irrigable land. The decreased involvement of external organisers in more recent village sites has led to a decline in the initial strength of village organisations. In some cases villagers initiated their own systems of resource allocation and conflict resolution. They also used links through local politicians and other leaders to develop parallel channels through which to lobby for increased investments from the Forest and other departments. In other villages, however, the new resources are underutilized and are dominated by the local elite.

The importance of a strong HRMS and sets of formal rules and procedures has proved to be more important in the larger heterogeneous villages with a number of different caste groups. While many of the smaller villages with one dominant caste have had some trouble with the equitable spread of irrigation water and maintenance responsibility, they generally prove to be very effective at enforcing the ban on open grazing in their catchment and the surrounding forest land. Larger more heterogeneous villages often required external arbitrators to settle disputes over resource use.

As the original project village, Sukhomajri received the greatest amount of external financial assistance and involvement. Although these villagers have unquestionably received the most benefits, the high level of external involvement seems to have stifled the long term ability of the village to mobilise internal resources for necessary maintenance activities. The next set of villages were not as internally homogenous as Sukhomajri, and also received less external investment and organising assistance. Like Sukhomajri they are also relatively near major market centres and both have functioning irrigation systems and direct grass leases. Although there have been a number of conflicts over the distribution of benefits from the irrigation water and the leases, Forest Department officials have been able to settle the more serious disputes. Serious conflicts have arisen where different groups have substantially different approaches to the use of resources, and in such circumstances it has been necessary for there to be more effective rules (SPWD '84; Arnold '90).

3.4.2 Operating constraints

Senior conservators felt the HRMS programme had difficulty expanding due to the lack of attention it received from territorial staff and because of the heavy work loads of Departmental officers. Many staff at the field level had never received orientation or training for the programme, nor did resources exist to support the efforts of field staff or coordinate their work in this area. In 1989, a group of Haryana Forest Department officers, together with a consulting team, agreed that the HRMS programme needed to be systematically integrated within the usual working of the Forest Department. There was also a need to establish better communications with the Hill Resource Management Societies. With a formal structure set up to ensure regular communication between the various levels of the Forest Department and HRMS it is hoped that there will be more effective cooperation between the various groups.

3.4.3 Conclusions

It is striking that communal management has been most effective **in single-caste villages** and ran into difficulties as soon as diverse economic and caste interests had to be accommodated in plans and meetings. Interventions had a very high failure rate in highly factionalised villages.

Although the villagers do not own the watershed lands in the Shivaliks which they are managing so carefully and from which they are drawing such benefit, they do own the dams they have built, the water they collect and the profits from so doing. The project thus represents an accommodation between a piece of government land (an open access resource) and a village management structure which controls water and the fodder grown with it (as common property resources - CPRs).

If a management structure **can** be evolved in a given village, hybrid tenure arrangements may not necessarily prove an insuperable obstacle. In the case of Sukhomajri, government-owned watersheds are kept in good condition, which in turn benefit a large government-owned dam. At the same time, local rights to benefits from the watershed have been able to come into being - benefits which protect, not diminish, government priorities. (Shepherd, m.s. 1990).

3.5 Case 9 : The Management of Forests for Local Use : Nepal[14]

3.5.1 Introduction

Nepal has furthered the ideas of local participation in management of forests through legislation and institutional change. This study of several initiatives with local forest management shows the key determinants at village, district and national level. As in India local commitment needs to be broken down to its constituent parts, and for it to be enthusiastic, mechanisms must be put in place for conflict resolution between individuals and groups (Fisher & Malla, 1987; Gronow, 1987).

3.5.2 The central role of legislation in participatory forest management

This brief introduction to the recent evolution of forestry legislation shows the critical role legislation plays in the support of any type of participatory forestry.

The early 1960s ushered in a new period of local government within Nepal, known as panchayat polity. The Forest Act of 1961, in conjunction with the institution of the panchayat system of government, had far-reaching consequences for local control of resources including a provision for handing-over 'protection' of forests to newly-formed panchayats (protection is used to designate control over, access to, and use of forests). Several categories of forest were delineated, each with different access rights assigned to them. [15]

Ownership of forest land remained with the government and control could be resumed whenever the government deemed it necessary. The panchayat had some powers to fine those who transgressed against the law. However, management decisions remained with the government forest service. Private forests that were considered to be poorly managed could be taken over by the government for a period of 30 years, and any income from the forest would be given to the owner with a sum deducted for management costs.The Forest Act legitimised panchayat control over local forests, but had little great impact in those areas distant from Kathmandu where local people continued to use forests for their subsistence needs, regardless of legislation.

Important changes in forest legislation began as a result of the Ninth Forestry Conference held in Kathmandu in 1974. This conference convened forestry officers from all over Nepal. A radical group of foresters working in the districts promoted a new form of forestry where local people were involved in management of forest resources, to be known as 'community forestry'.[16]

The proceedings of this conference, in conjunction with the results of the findings of 'A Task Force on Land Use and Erosion Control' (National Planning Commission, 1974) formed the basis of the 1976 National Forestry Plan which reinforced the rulings of the 1961 Forest Act in allocating categories of forest land to the panchayats. However, wider powers were given to District Forest Officers under the Plan to formalise the transfer of nationalised deforested land to panchayat control.

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14 This section draws on an unpublished PhD (Hobley, 1990a) and on an article, (Hobley, 1990b).

15 1. Panchayat Forests: Any government forest or any part of it, which has been kept barren or contained only stump, may be handed over by HMG (His Majesty's Government) to the village panchayat for plantation for the welfare of the village community on the prescribed terms and conditions.

2. Panchayat Protected Forests: Government forest of any area or any part of it may be handed over to any local panchayat for protection and management purposes.

3. Religious Forests: Government forest located in any religious spot or any part of it, may be handed over to any religious institution for protection and management purposes.

4. Contract Forests: Any government forest area having no trees or sporadic trees may be handed over by HMG in contract to any individual or institution for the production of forest products and their consumption.

16 From a taped interview with T.B.S. Mahat (1986) former Divisional Forest Officer for Chautara. T.B.S. Mahat was a member of this radical group of foresters, he based his views on experience gained as the Divisional Forest Officer in the Chautara Forest Division where he had already supported local initiatives including establishment of forest nurseries in two panchayats. Chautara was to become the focus of Australian forestry aid activities. The same group of foresters were also involved in the 1978 FAO/World Bank mission to identify a community forestry project in the Middle Hills of Nepal. These foresters were sent to FAO in Rome to write up part of the project preparation mission's report. Arising out of this mission was the Community Forestry Development Programme which operates in the hill districts of Nepal.

In 1982, further legislation through the Decentralisation Act formalised the duties and responsibilities of village panchayats and ward committees, and empowered them to form:

'people's consumer committees to use any specific forest area for the purpose of forest conservation and through it, conduct such tasks as afforestation, and forest conservation and management on a sustained basis.' (Regmi, 1982:403)

Local-level management principles were incorporated into legal and project practice and propelled community forestry along the path of active involvement by local forest users. This produced the legal infrastructure necessary for the control of forest land to be handed down to the panchayats and to user committees. Recent proposals under a Master Plan for forestry in Nepal encompass people's participation in the short term objectives (Roche, 1990). To attain these objectives policy, legal and institutional reform are proposed, although under the current political climate it is difficult to predict the future of any reforms.

3.5.3 The Nepal-Australia Forestry Project - from technocracy to participation

Griffin (1988), in his recent book tracing the development of the Nepal-Australia Forestry Project, shows the changing role of Australian aid to the forestry sector over a 25 year period, a change which mirrors the transition in forestry practice from resource creation to resource protection involving local people. In 1978, the Project began the course of action which was to propel it along the community forestry pathway. Actions taken by the Project included establishing nurseries in panchayats and plantations on panchayat land.

3.5.4 Deforestation and local forest management

The next sections will describe one panchayat, Tukucha, to show how local management of forest resources has emerged over time. Critically the deforestation process in Tukucha began as a result of a large earthquake in 1933, followed by a heavy snowfall in 1935 which further exacerbated the damage. The earthquake caused massive damage to buildings, and as a result an order was issued by government opening forests to local people to supply timber for rebuilding. However, contractors were said to have used the forests as a mine for timber, and were responsible for cutting large areas of unbroken trees to be sold in Kathmandu to repair damage sustained there.

Freeing of access to forests led to further destruction with many people cutting and selling firewood to neighbouring towns. Government controls could not be sustained when demand for forest products outstripped supply.

There was no significant increase in forest cover until 1961-1962. The advent of the panchayat system and delegation of responsibility for local resources to the panchayat led to a changed forest usage pattern. Upland forests that had been open to villagers in this panchayat were now protected by neighbouring villages, and effectively closed to outsiders - the beginning of a shift from an open access to a common property regime. This forced villages within Tukucha panchayat to look to alternative resources to supply their needs of firewood, fodder, leaf litter and green bedding. The decision was taken by village elders to protect forests that lay within their ward boundaries (the lowest level of panchayat administration) and to exclude outsiders; each ward would have access rights and control over forests within their boundaries:

'With the administrative division of the panchayats, the forests were divided among the panchayats. The forest that lies in a certain panchayat area belongs to that panchayat. The panchayats take care of the forests that are within their boundary. Previously it was not like this: forests were free to all and people could go to any forest.' (Bahadur Thapa, 1986)

Villagers formed forest committees and appointed forest guards to protect their forest areas. In some cases villagers were forced to sign a paper to say that 'they and their descendants would go to hell if they destroyed the forest' (Maya Panday, 1986). Strict controls were placed on access to forests, and villagers instituted closed seasons, when no-one was permitted access to the forest. In several cases, such protection systems continued for 20 years. However, conflicts between individuals led to the demise of such systems. Cases were cited of forest guards being bribed by wealthy villagers and in other areas of unregulated stealing during the night.

Trees on private land
Whilst access to forest resources was effectively unregulated and forests were easily accessible there was no need for individuals to invest labour and land in tree cultivation, but after the 1930s degradation of the forests continued, and access became more difficult. In consequence trees were allowed to regenerate on agricultural land and in some cases men would plant wild seedlings on their land to ensure a supply of timber. The need to rely on locally protected forest for a supply of firewood, fodder and leaf litter has continued to force a change in land use. Since surrounding forests cannot supply all the needs of villagers, those with sufficient agricultural land have increased the planting and protection of trees on private land. So the change in the tenure of land has proceeded from open access, to common property, to private ownership.

3.5.5 Participation

The emergence of new notions of global forestry practice - social forestry and the introduction of national forestry legislation influenced and determined the actions of NAFP at village level. From 1985, the Project moved from creation of forest resources to instituting management systems for forests used by villagers. This change required the foresters, both government and project, to embrace a whole new set of skills and understanding. This new form of forestry requires time and restructuring of the decision-making and problem-solving processes with the Project, Department of Forests and village. In 1985, new forms of social forestry were begun in selected panchayats within the NAFP working area. The panchayats were chosen on the basis of already having existing local forest protection systems and thus explicit signs of a collective sympathy and understanding of the need to protect forests. It was felt that this was a necessary precondition from which to start local forest management.

Tukucha, one of the first panchayats to be involved in the local forest management initiative, is a group of caste-differentiated settlements, with several locally-protected forest areas within its boundaries. After it was decided by the Project and the Department of Forests that the forest management process should begin in Tukucha, a panchayat-level meeting was called by the District Forest Controller through the Pradhan Pancha (the panchayat leader) to discuss management. The meeting brought together panchayat leaders and local men with a few women sitting on the periphery of the meeting. Decisions were made at this meeting to manage all the forests within the panchayat at the panchayat level through a forest committee. This committee was composed of panchayat members and one woman who was voted onto the committee in her absence. However, the committee was unable to function as it had no clear understanding of what it was supposed to do.

Further initiatives in Tukucha did not take place for another 6 months, during which time a reassessment of the initial approach was made. It was decided to move from the panchayat level to the forest and concentrate on management of one small area of forest. It became obvious at this stage that the following implicit assumptions had guided action in the wrong way:

1 There is a 'local community' - ie a group of people with clear social boundaries capable of acting together cohesively.
2 The local community and local forest users were synonymous.
3 The forest users would come to a public meeting about forest management
4 All people who attend a meeting about forest management would speak openly and honestly at that meeting.
5 The meeting would be able to provide the information necessary for management plan formulation.
6 The forest committee formed at the meeting would be able to determine and understand its duties, authority and responsibility. (King et al, 1990a. and 1990b.)

3.5.6 Towards Participatory Forestry

The initiation of ideas, actions and reflection on actions produced a change within the project, with a move away from the imposition of ideas and solutions towards a greater emphasis on seeking the ideas and opinions of forest users. New methodologies for action emerged from the questioning of previous action. These methodologies focused on ways in which to involve the people who use forests for their daily sustenance in the forest management process. The first problem the project and forest department faced was how to identify the forest users; the second, how to build a rapport with them. Previously, all contacts at the village level had been made with male panchayat leaders and thus the skills needed to communicate with women and low castes had not been developed.

To support this changing understanding of village level forestry the project sought advice on methods of building rapport with villagers. In conjunction with social scientists trained in focus group methods, project and forest department staff spent several days in the vicinity of the forest identifying different forest user groups. The next important stage of the process was to bring the forest users together into a non-threatening situation where they could voice their needs. Accordingly, the users said that they would be able to discuss their problems in homogenous groups divided on the basis of gender and caste. Each group was brought together separately to discuss its needs, access to forests, conflicts between individuals over resource use, and any other issues which were considered relevant to collective management of the forest.

The outcome of this process of forest user group formation and discussion was the realisation that the different groups represented forest users with varying needs and influence. The information provided by these groups was at odds with the information obtained from previous meetings: other villages claimed that they had equal rights of access to the forest; priorities for different forest products given by men were disputed by women; prices for firewood, decided by wealthy male leaders, were questioned by poor people in the villages. It was concluded, therefore, that it was necessary to provided a forum in which these groups could present their views and ensure that they were heard. A new committee was formed from members of the different user groups. Conflicts over access rights and boundaries were resolved through negotiation and consensus.

The intervention in this area by the project and forest department continued over a period of eight months, at the end of which a management plan was written by the villagers. The plan described the way in which the forest was to be managed, the harvesting systems, the distribution of products and a statement on rights of access to the forest. The implementation of the plan was left to the members of the forest committee, who were able to contact forest department field staff if technical advice was needed. In one case the forest committee asked for arbitration by the District Forest Controller over a boundary dispute between two villages.

4 PROBLEMS AND OPPORTUNITIES FOR IMPROVED MANAGEMENT

4.1 Introduction

While some common themes emerge, others are specific to the countries and areas in which management is to be practised. For example, dry forest management is more promising in much of Africa due to the low population density (compared to Asia) and the so far almost complete lack of landlessness.

4.2 Dry forest management prospects in Africa

4.2.1 Woodland management and the State

One of the facts which emerged from the research conducted by Shepherd (in press) is the tremendous paucity of formal forester knowledge about the management of tropical dry forests, particularly in light of the enormous changes wrought upon them in the name of better management and State control.

Key survey articles from the last few years hammer the first point home. According to Bonkoungou and Catinot (1986), there is only very slight experience of silvopastoral management based on natural regeneration techniques for mixed forest and grassland. Much indigenous knowledge waits to be collected. According to Jackson (1983), who did the biggest-ever survey of the sahelian literature on woodland management, there were only two examples, up to 1980, of formal forest management in the Sahel: that of Bandin forest, Senegal (which failed in its aims) and the relatively successful management of Acacia nilotica on the Blue Nile in the Sudan. Other activities have apparently failed because they neglected to build on the much longer technical experience of local people.

Set against this thin knowledge, we find the imposition of European concepts of property and land tenure, with disastrous effect. The most important gap was the failure to understand the fallowing systems, which had used the landscape sustainably for hundreds of years. The systems were simply invisible to outsiders (Shepherd, 1986), land being fallowed often looking abandoned and ownerless to the northern forester's eye. As a result, fallows, rested for years, well-wooded, and almost ready to be felled again, were gazetted by the state and turned into forest reserves. This turned intensively managed CPRs into open access land at a stroke, and as far as villagers were concerned, it was to be poached rather than managed. In consequence people became wary of fallowing their land and overworked it instead (Thomson, 1983).

4.2.2 Woodland management and other change

Tenure and land use changes

Villagers have also been turned from land owners into leaseholders in many countries e.g. Senegal (Postma, 1990), or Sudan (Seif el Din, 1987); or indeed from land owners to landless wanderers in the case of pastoralists. Barrow points out that customary tenure was taken into account in Kenya when agricultural land was demarcated, but neither investigated nor recorded in the dry areas (1988). The best solution offered to Kenya pastoralists has been that of group ranches, which lack the flexibility in area of lineage range management and begin to look like some of Africa's other tenure ghettos, such as the Communal lands in Zimbabwe.

Political changes affecting land tenure frequently destroy CPRs. For instance, during the Ujamaa period in Tanzania, the Sukuma were told to leave their dispersed granite outcrops and to cluster in villages. Unoccupied, the small hilltop forests rapidly fell prey to urban charcoal burners (Shepherd, 1989b).

The diminished authority of local leaders

Much good local natural resource management has depended upon the understanding and political authority of locally born leaders. Central government has deliberately undermined their authority, but cannot replace them effectively. The substitutes are always centrally appointed officials who are not dependent on local economic realities for their livelihood, and who will shortly move on.

Population growth

Better health conditions and food security for humans, and the increased use of veterinary drugs, have increased both human and animal pressure on rangeland and farmland. More people - and their animals - have been encouraged to live in settled rather than semi-mobile conditions, with a corresponding heavy local intensification of land use and biomass offtake, increases which have not been incorporated into land management strategies. Many parts of Africa, too, have experienced bigger influxes of people than they can easily absorb because of those moving away from drought areas, because of refugee problems, or because of the artificial withdrawal of large tracts of grazing land, as in the mechanized farming schemes of the Central Sudan (Wormald, 1984).

As populations rise, and increased sedentarization occurs, the household grows in importance while clan and lineage structures - and the elders in charge of them - lose their importance. Grazing is privatized or shared by a much smaller subsection of a larger entity. All such actions tend to sound the death-knell of successful woodland management. It is a truism that rising population pressure on forests will cause deforestation. In fact, in areas with sufficient rainfall, the inevitable longterm result of population pressure, is in fact a move to tree-planting. In Rwanda (Gibson and Muller, 1987), a survey revealed that people plant trees most where there is the most pressure on land and much cash-cropping.

The shortening of fallows

Population pressure seems to have led to the shortening of fallow periods throughout semi-arid Africa (Seif el Din, 1987; Wormald, 1984). In the western Sudan the whole cycle has halved in length, and the fallow period is less than a third of what it was (Hammer, 1988). The tendency is for the fallowing system to shrink to the point where it is replaced by a crop rotation of alternating millet and peanuts (Raison, 1988). Ironically, although the overall population has grown, more men and more young people have left the Sahel for ever and this out-migration of labour has prompted extensification of agricultural techniques. Instead people are trying to cultivate the most land they can in the least time, at the very beginning of the rainy season. Shortage of labour has meant that older practices such as manuring, intensive sowing and weeding, planned fallowing and water conservation, have all had to be replaced by quick easy farming (Thomson, 1983).

The growth of towns

The growth of towns is one of the largest threats to the dry tropical forests, because the clustering of large numbers of people who will need rural biomass for fuel, and the low annual increment of that rural biomass, mean that the fuelwood shadow from a large town or city spreads hundreds of km. out into already hard-pressed rural areas. Yet population growth in the Sahel is of the order of 2% or less in rural areas and 6-8-10% in urban areas. In addition, urban entrepreneurs are keeping cattle for cash near towns, whereas formerly they would have travelled widely with them. (Bertrand, 1985; Hammer, 1982; Kerkhof, 1990).

Roads are built from towns to rural areas, and these then facilitate more commercial transactions, such as the sale of charcoal to town, or wood-cured tobacco (Castro and Brokensha, 1987). Labour migration to towns hamstrings the effective farming of those left behind; low producer prices discourage complex husbandry. Thus towns grow at the expense of rural people, undermining their resource base and extracting huge quantities of precious biomass from them (Shepherd, 1989a).

The State itself, as an urban-based institution, has exploited but failed to understand the dynamics of rural systems, has seen its own urban needs as paramount, and in sum has made it harder for rural people to build a surplus of animals, of grain (because of labour shortages), or of fallowing land. The result has been much increased vulnerability to cyclical droughts, let alone the more substantial dry phase we are witnessing at the moment.

4.2.3 Conclusions: key features of indigenous forest management systems

Although this paper has given a broad definition of management, certain themes stand out. These are relevant to any kind of effective management.

Firstly, in the past there have been strong capable managers in charge of woodlands and the exploitation of trees, in many of these areas: managers with a lifetime commitment since they, like the people they administer, are making their living from the resource. Most management rules, as a result, are very well attuned to local needs and constraints, and have arisen in apt response to some perceived problem.

Secondly, management is as simple as possible. Unless the resource has some value or some scarcity, management will not be undertaken. Rules are quite flexible, and can be modified as need arises.

Thirdly, management is for a set of interlocking benefits. It is quite hard to separate out woodland management from swidden-fallow management, herd management, and annual crop management. Moreover wood is far from being the only resource for which woodlands are managed.

Fourthly, rising population density is turning pastoralists into farmers, long swidden-fallow into short, the usufruct of clan land into individual title. So the management focus has narrowed and in many areas the numbers of locally born and locally significant decision-makers above the level of household head are dwindling.

Finally, formal political and economic authority has passed, in most places, to the State over the last 30-40 years. With local authority removed, unregulated exploitation increasingly takes over (C.T.F.T., 1988). Indeed centralized political authorities still continue to deny, on the whole, the very ability of local decision-making bodies to manage their environment, though there is ample evidence to the contrary. Yet if local management structures are not identified, forestry becomes no more than forest reserves and village forestry schemes, neither of which replicate the integration with trees practised in the past.

The prognosis for adaptive change looks poor, from many points of view. Many previous woodland management practices can only work if managers are also owners, yet it is rare for control over reserved forest land to be returned to the people who are being asked to co-operate in its management.

There is also the question of size. It would seem that rural people only want to manage a resource if all can benefit to some extent. Small patches of hilltop forest can be managed by small numbers of people, or be designated a local no-go area (along the lines of earlier sacred groves) for a larger number if there is a political institution which can guard it. Otherwise, rural people often prefer such small patches to be looked after by the Forestry department, so that they are not involved in high social costs for a low return.

Ironically, of course, tree management increases, the less forest there is. Under certain especial circumstances it is managed as forest, but increasingly the preferred management is on farms. A publicly owned forest is an anachronism in a tightly farmed landscape, and represents the superimposition of the will of outsiders on the local population, in many cases.

4.2.4 Lessons for the future

The most fundamental management technique which emerges from research on indigenous management systems is so obvious that it gets overlooked: it is that there should be some recognition of ownership of the resource - by descent, residence, or any other principle so long as all agree to it. No cooperation by local people in management will take place without it. There should be public recognition of these owners - by formal tenure registration, as well as by allowing their views on management to be heard, is essential.

Another lesson to emerge from the study of indigenous management systems is that the area to be managed must be consonant with the scale of the management entities available. Pastoralists have always had reason either to be mobile themselves, or to make sure that their animals can have access to a wide and diverse area through carefully maintained kinship ties. They can manage quite large areas under certain circumstances. Villagers can most happily manage the fallowed and protected land which radiates out from their village. Neighbours can manage the valley grazing resources which run between their privately farmed fields - or the small wooded hills which rise from among them. It is very difficult for any of these categories to manage large state forest reserves - for the reasons that the State cannot manage them either - the resource is too diffuse and guarding is too costly.

The implications of this are that more successful management demands the breaking up of many large reserved areas into smaller and more intensively protectable segments. The more that overarching structures such as clans and lineages disappear, the smaller the entities which it is feasible to try to protect become. In nearly all other cases, the most promising focus for local people is on the creation of tree resources on the farm, leaving patches of environmental reserve to the State - the successor of the leaders who managed sacred groves. Only in rarer cases can management be passed to small local user groups whose internal composition and whose resources are clearly defined and felt by them to be manageable.

4.3 Forest Management prospects in India

4.3.1 A new role for forester-villager relations

Despite an apparently only moderately successful Social Forestry era, the last decade in India has seen a tremendous amount of experimentation with tree-planting and management arrangements between villagers and officialdom. The success of the various innovations in West Bengal, Orissa and Haryana, among others, has led to the passing of an important resolution by the central government Ministry of Environment and Forestry, encouraging cooperation between state departments, NGOs and local people in forest management. It outlines guidelines for the development of legally binding working arrangements between the various parties, so that a more positive era of forest management can get underway. The main recommendations of the resolution are as follows:

- developing partnerships: between villages and forest departments, facilitated by NGOs when helpful;

- access and benefits: only to organised villages undertaking regeneration, with equal opportunity based on willing participation;

- rights to usufruct: all non-wood forest products and percentage share of final tree harvest to villages, subject to successful protection and conditions approved by the State;

- 10 year working scheme: microplans detailing forest management institutional and technical operations should be developed by village management organisations with local foresters;

- funding: from Forest Department social forestry programmes for nursery-raising with encouragement to villages to seek additional funds from other agencies;

- use rules: strict adherence to no grazing, agriculture or cutting trees before maturity except as outlined in working scheme. (From Poffenberger ed. 1990).

4.3.2 Guidelines for forest management policy and programmes

At a recent workshop held in Delhi with senior Indian policy makers, foresters, NGO leaders and social scientists, the following steps were suggested to provide an appropriate framework for local involvement in forest management. It admirably summarizes the interesting directions in which forest management thinking is now proceeding in India, and offers helpful discussion points (Poffenberger ed. 1990):

1. State-level resolutions:
The issuance of a state-level resolution encouraging the forest department to work with villages in the management of forest lands through formation and/or recognition and empowerment of communities protecting forest lands. It was felt this should be an enabling provision rather than a directive. State forest departments and rural communities should be allowed to move at their own speed in establishing decentralised management systems. Joint management programmes should build on existing groups and local management systems if these organisations are functioning effectively and allowing broad-based participation.

2. Terms of management partnership:
The resolution should provide a framework for joint management agreements, specifying resource sharing rights and protection responsibilities, so that forestry field staff and rural inhabitants have a clear understanding regarding the terms of the management partnership. At the same time, the resolution should allow community organisations flexibility to determine operational procedures for managing production and protection activities.

3. Communication systems:
Experience made it clear that good communications between foresters and villages lead to more effective joint management systems. Some departments find this dialogue to be effectively initiated through a micro-level planning process for each joint management area, where officials and villagers formulate a local management plan together. The need for some type of jointly prepared management plan should be indicated in the resolution.

4. Benefits for rural poor:
For low income rural families to take part in joint management programmes it is essential that material benefits begin flowing as soon as possible. Harvesting of regenerating grasses and leaves can begin during the first year. Enrichment planting activities should emphasise fast growing species, especially those providing raw materials needed for village industries.

5. Budget provision:
Some budget provisions may also be necessary to support forest management groups who are losing income during the early phases of forest regeneration. These allocations should support employment which will speed ecological recovery and enhance forest productivity. Funding for improving coppice growth, enrichment planting, and nurseries are particularly important in the first years of protection. Micro-level plans should chart employment requirements over a minimum period of five years, but avoid creating heavy dependencies based on employment subsidies.

6. Forest Department - NGO coordinating committees:
To help sustain the community forest management groups, it may be useful for the resolution to encourage forest departments and NGOs to help management groups establish coordinating committees with representation from their members. These 'federations' could be endorsed by appropriate local government institutions.

7. Formal recognition of a role for NGOs:
Government orders should allow NGO participation in assisting forest departments and villages to establish joint protection and management systems.

8. Local-level grazing controls:
Uncontrolled grazing, mostly by cattle and goats, suppresses the regeneration of India's forests. Resolutions should require villages taking part in joint management activities to develop methods to control grazing through social fencing and stall feeding. Village micro-plans should assess fodder requirements and identify ways to meet fodder needs through regeneration and enrichment grass planting, while developing strategies to reduce low quality livestock.

9. Budgetary flexibility:
In order to enlist village involvement in joint forest management programmes, forest departments need

greater budgetary flexibility both within routine budgets and special allocations, to respond to village priorities and emergency situations such as acute water shortage, irrigation system problems and the disruption of infrastructure and communications.

10. Reorientation and training:
As departments expand joint forest management systems and activities, extensive staff reorientation and training is necessary to develop attitudes and approaches which engender supportive interactions with community management groups. A national committee should be formed to identify and develop useful training materials and case examples from forest departments and NGOs in India and other developing countries. Emphasis should be placed on helping foresters develop creative problem solving skills with villages, rather than rigid manuals and procedures for project implementation. Existing training programmes should be reviewed to determine how they could be improved to better prepare staff.

4.4 Forest Management prospects in Nepal

4.4.1 Introduction

Nepal has advanced further than India in the process of finding new forest management styles, having accepted that local people should be involved in the management of forest resources for their own needs. The pioneering work of NAFP and the Kosi Hills Development Programme has focused on reorienting field-level forestry staff and villagers to bring them together in the management of forest resources.

4.4.2 Reorientation and its central role in forest management for local users[17]

Early experiences in establishing forest committees and identifying forest users led both projects and the Forest Department to realise that they did not have the necessary skills to facilitate widespread forestry with local users. To institutionalise the changes necessary within villages and the Forest Department, it was necessary to set up a systematic programme of reorientation and training.

Legally, before a user group can use a community forest it has to submit an Operational Plan for that forest. The plan is prepared by the users of the forest: not by professional foresters or natural resource planners. Sufficient time has be allowed for all members of the user group, weak and strong, to reach a consensus on the management of the forest. As has been seen this process rarely takes less than three months. The users regard their plan 'as rules for our forest' detailing, for example, access to the forest and forest products as well as protection and decision-making mechanisms. The plan is sanctioned by the district forester and, until the recent political change, by the local pradhan pancha (chairman of the village or town panchayat). An executive forest user group committee is then elected by the user group members to oversee the implementation of their plan (Gronow & Shrestha, 1990).

Mechanisms for facilitating involvement at the local level have been implemented in Nepal through Forest Department field staff. However, prior to involving local people in forest management a major reorientation of field staff was required. To ensure changes promoted in Forest Department implementation are sustained it is necessary to:

- change government forest policy away from policing and towards collaborative forestry;
- change the value systems and hierarchies government officials and project advisers impose on the field staff;
- establish relationships of respect and trust between policy-makers and field staff and devolve more decision-making responsibility to the field staff;
- promote experience-recounting, reflection and confidence-building among field staff;

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17 This section draws heavily on the pioneering work of two social forestry projects: the Nepal-Australia Forestry Project, a bilateral project between the Government of Nepal and the Government of Australia and the Kosi Hills Development Programme, a bilateral programme between the Government of Nepal and the Government of the UK.

- help field staff to identify problems and define new approaches; and

- support field staff and applaud their efforts (Gronow and Shrestha, 1990).

Field staff are expected to adopt a new people-based approach to forestry which is alien to their previous training. To help field staff acquire the necessary skills several fundamental changes need to occur. The following discussion draws on the work of two facilitators of reorientation programmes, Gronow and Shrestha (1990). The practical steps followed include:

Workshops
Workshops encourage a democratic, two-way learning approach. Each person participating in the workshop is encouraged to share their experience and knowledge with others there, including the facilitators. Workshop location is of central importance to this process of change within the Forest Department, hence all workshops are held in district forest offices and involve representatives from all levels of the district hierarchy from Ranger to District Forest Officer. If field-level staff are to have the support of officers higher in the hierarchy it is essential that these officers are part of the training process, and fully understand the need for local management of forests (King et al., 1990a and 1990b).

Field support
Field support is essential if the reorientation process begun in the workshop is to be sustained. Gronow and Shrestha (1990) stress the importance field staff place on this continued support:

> The field staff have repeatedly said that working on their own presents difficulties with regard to security, credibility, confidence and political pressure. Their youth in relation to the villagers, low official status and the negative reputation of the Department of Forests make them feel insecure. The villagers'..lack of faith in the Department works not only against their participating in community forestry but also against the field staff's attempts to adopt the new role of facilitators.

4.4.3 Institutional change for forest management

Institutional change is another key factor in sustaining these new forms of forestry. As has already been mentioned it is essential for all levels of the forestry hierarchy to support these new initiatives. The target-oriented philosophy of Forest Departments does not provide the supportive framework necessary for the more service-oriented role to be played by field level staff. If staff are only rewarded on the basis of the number of nurseries built, or seedlings distributed, there are no incentives for staff to pursue the more difficult role of village-level facilitators. Local level management of forest resources cannot happen without the institutional capacity to support it.

Although institutional development is a prerequisite for change, this must be supported by policy and legislation. As has been seen from the brief description of Nepal's forest legislation considerable power has been handed over to the user group level. If user group rights are embodied in law, members of user groups are more able to defend their rights against outsiders, and therefore there will be a greater incentive to protect resources for the long term.

The Nepal case material reinforces the understanding gained in India. The major constraints to successful local management of forest resources lie at several different levels. The first level of constraint begins with the resolution of conflict between different forest user groups. Sukhomajri and Gram Vikas both had a large degree of success when they worked with homogenous groups - one caste or one tribal group. In Nepal, it was necessary to work below the level of the village to ensure that low castes and women were able to represent their views at the village level.

In all cases it was essential to define local people's rights with respect to the forest resource, so that they could defend their rights against other local people, and also uphold their rights against forest departments. A large degree of uncertainty is still apparent in Orissa since the government has not yet formally agreed to give the Kerandimal tribals rights over the areas of forest they have replanted. In West Bengal, a recent resolution passed by the state has ensured that local people do have rights to protect and use local forests.

Without an institutional structure to support the legislative and local changes, such local forest management initiatives cannot be sustained. In Nepal, reorientation and appropriate training of the Forest Department has begun to secure the future of local forest management. Skilled Forest Department facilitators are beginning to catalyse change at the local level, as well as reinforcing institutional change within the Forest Department itself.

Non-government organisations obviously have a role to play as intermediaries between local people and forest departments in certain circumstances. In Orissa, the experience of Gram Vikas has shown how effective an NGO can be in negotiating agreements on behalf of local people with government departments. However, in Nepal, where there is no history of non-government organisations, it appears that forest department staff themselves are able to acquire the necessary skills to facilitate effective local management systems. Above all flexibility in approach must be built into any such local management initiative (Arnold, 1989). National legislation needs to be supportive of such approaches, but should, in the case of India, also allow for regional differences.

5 CONCLUSIONS

5.1 Introduction

As this paper has demonstrated, alongside the gloomy deforestation figures we obtain from Land Satellite imagery, and the worldwide loss of tree-cover, we should note some of the interesting changes going on in forest management approaches in the tropical dry forest areas.

While resources were ample, dry forests were only slightingly regarded especially by comparison with the riches of the tropical moist forest hardwoods. However, we are now seeing a variety of moves which suggest that dry forest is being more highly valued as it becomes scarcer, and therefore more hotly competed for.

When forests were first reserved, there was no question but that they were being reserved **from** local people, for the needs of the State. Models for forest management were taken from European models for forests, and assumed as givens private land-tenure, the exclusion of those who lived nearby for all but minor usufruct access, and the management of the forest for timber - and perhaps some fuelwood.

This model has never reflected the developing world reality, but while there were fewer people and more trees, the contradictions were less acute. Now, the question is constantly raised, 'what is forest to be managed for - and for whom?' There is debate in all three of the areas reported on about the devolution of forest management to local people, and more interest in management for locally important products, many of which are in fact non-timber products.

Many countries which would once have unflinchingly asserted state rights to forest in perpetuity are now looking for arrangements which relieve them of some of the expense and of management, particularly in drier, lower value areas. Finally, foresters' experience of working with farmers in farm and social forestry programmes has undoubtedly paved the way to more friendly and informal working styles in the area of forest management as well.

Thus we have a situation where local people are asking for stronger tenure rights in forest resources, where in some places there is already a sufficient shortage to make planting worthwhile, and where the forestry profession is in many cases more prepared to entertain the idea of local people's forest management than it has ever been before.

5.2 Acting to maintain and increase tree cover

In the circumstances, we should be striking while the iron is hot. It becomes possible to propose plans for environmental management which address protection and the enhancement of tree cover through one of the following mechanisms:

- through Farm Forestry programmes on clearly owned and usually private land;
- through management of land to which local people have clear locally devised and legally recognised common property rights, and where such land - be it forest or watershed - has sufficient importance for local people and their needs to be worth protecting from their point of view;

- by government protection where neither of these two other situations applies.

Government land and the environment
Often, government finds itself in a situation where it cannot manage all the land it owns effectively, yet will not relinquish it either. Such contradictions should be faced. Where individuals or groups are keen to own and manage natural resources (and this will by no means happen everywhere) government would often be better off giving up some of its sovereignty, and concentrating state resources on lands which for whatever reasons must be protected but will never attract more specific ownership.

All too often, however, government seriously expects that while it continues to own the land, local people should manage it voluntarily. Needless to say, such hybrid arrangements, in which the party which owns the resource experiences no expense, while the party which does not faces costs, can never work.

Strengthening the rights of local people to practice communal management
For the best environmental management, land rights for local people are probably the best solution - and this is now an area of great experimentation, as our cases show. Where the rights offered are too limited, or bring no obvious benefits, local people decline them, yet governments in many countries are plainly too weak or too corrupt to have much success either. More documentation is gradually becoming available which points to the elaborate traditional woodland management practices of local people, in many parts of the world. Not many projects are as yet building on this experience, though under the right conditions, the approach holds promise, and is likely to be much experimented with in the next few years. Land rights, as always, will be the key.

Adapting resources to the capabilities of new managers
Several of the cases set out here show that communities manage small resources best. This means that well-intentioned forestry departments cannot hand over tracts of forest which they have been managing without working through a process of defining with the would-be managers the area they in turn feel capable of managing.

Training foresters
The top priority for forest management by the many is training in extension methods and in more informal work-styles for professional foresters. This, in conjunction with improved tenure, is essential if more effective styles of forest protection and management are to become widespread. Foresters working in the tropical dry forests of Africa and Asia now have a several-year lead in these newer working styles, but more work is needed to develop norms for action which will in time spread to the tropical moist forest areas too.

5.3 Tailpiece

Paradoxically the deforestation which, in the dry forests, led to a panic about fuelwood shortages and to the social forestry programmes of the 1980s, has taken us in the direction of new solutions. Social forestry's contribution has ended up being, not the provision of more fuelwood, but a strenuous training ground for foresters in more participatory approaches to rural people; approaches which are essential now if sustainable forest management activities are to be the order of the day, and for which they were on the whole ill-equipped in the early 1980s. What began as a large-scale rural tree-planting programme based on plantation models popular since the 1960s has thus, over the past decade, set in motion the makings of an inevitable and major paradigm shift in the discipline of tropical forestry, as it struggles to respond to dwindling forests, rising populations - and growing numbers of securely owned and protected trees.

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Summary of Track II: Dry Tropical and Subtropical Forests

Gill Shepherd and R K Dixon

The track paper[1], and supporting research reports and interventions by track participants are summarized as follows:

1 Current Status

Dry tropical forests cover approximately 1.7-1.9 billion hectares of land[2], and their areal distribution includes Africa, Asia, Latin America, Australia and North America, with the bulk in Africa and South Asia. Their potential for carbon fixation is significant. They also, unlike the moist forests, play a vital role in the conservation of soil fertility.

Dry tropical forests provide a steady and affordable flow of timber and non-timber products (food, forage, fibre, medicines, etc.) for billions of people: indeed, their surprisingly rich biodiversity is only now beginning to be realized. However, they are at risk because of agricultural clearance, urban fuel needs, desertification, population growth and land accumulation in adjacent more favoured areas. Only limited land use intensification is possible in these areas without significant resource inputs.

2 National Experiences, and National Planning Needs for the Future

The issues from a national level standpoint resolve themselves into: stemming the rate of deforestation; conserving the remaining natural forest areas and if possible improving them; and building a new sustainable resource through tree planting. Past approaches have shown that it has been very difficult to stop deforestation; and that though some areas have been reserved, they have on the whole not improved in quality.

More recently, in many countries there has been an increasing recognition of the importance of addressing local as well as State needs in forest planning activities: indeed, the most successful interventions have tended to be ones in which there has been an attempt to engage with rural people closer to the forest. Planning plainly works best when strategies make economic sense at village level - and can address the short-term time-frame of the poor - as well as meeting longer-term imperatives at ecosystem, national or even transnational level.

There is now a continuum of experience from independent communal forest management in lower population density situations through to farm forestry where people cluster more densely, complemented by areas often best managed as state reserves. In the last few years, farm forestry projects have been a special feature of the more densely settled of the dry tropical forest areas, together with experiments in Joint (State-Community user group) management, especially where landlessness is a feature. Case studies presented illustrate the continuum from lower to higher population density contexts: Somalia, Sudan, Niger, Kenya, Tanzania, Nepal, Orissa (India), Haryana (India), and West Bengal (India).

An urgent further planning need is for the conflicting interaction of other sectors (agriculture, livestock, irrigation) with the forestry sector to be explicitly addressed. Forestry has now assumed tremendous importance as its global role becomes clearer, but it has hitherto occupied a lowly position in state planning in many countries. Some countries now plan to use the Tropical Forestry Action Programme (TFAP) as the forum for this multi-sectoral approach.

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1 National experiences in managing tropical and subtropical forests, G Shepherd et. al., Overseas Development Institute, London.

2 This figure is derived from FAO's 1985 world forest cover statistics, quoted in World Resources, 1986, p. 62, calculated by adding figures for open forest, shrubland and fallow. Note that LandSat imagery can identify closed forest, but not open forest, and scattered trees on farmland. Some sampling at higher levels of resolution has been undertaken to offset these defficulties, but there are likely to be serious underestimates for these categories of tree cover.

3 Land Availability for Further Forestry Interventions

A range of estimates (of around 200-300 million hectares) exist regarding land potentially still available for forestry in dry forest areas, though ultimate decisions regarding suitable land will be based upon many factors. The least complex will be the biological and edaphic features; the most, the selection of interventions appropriate to demographic, political, economic and social givens. Land tenure is probably the most important of all. Both individual and community tenure (of grazing lands, for example) create potential incentives for tree planting or managing, and community lands or common property resources (CPRs) are of especial importance where landlessness is high and where they represent a key resource for the poor. Indeed the importance of restoring and strengthening communal tenure rights for good management is a key point to emerge from the track paper.

Thus the overriding constraint will be not the availability of land, but the availability of forestry staff who can identify and implement appropriate planting and management interventions, together with the millions of local people interested in doing so, subject to tenure conditions.

4 Technologies

There exists a range of forest establishment and management options, both on- and off-farm, that can be relatively cheaply implemented at site level, and in many (though not all) situations, financial cost/benefit ratios are favourable. However, prescriptions are extremely site specific, and must meet local needs and priorities.

Of the approaches we were asked to consider, sustainable **community** forest management, followed by farm forestry, are potentially by far the most important interventions, whether for sustainable forestry or for climate change mitigation. State management of reserves which cannot be better managed by local users is naturally of great importance, though secondary to other approaches. Conservation will naturally flow from all these activities. The history and economics of conventional plantations in dry forest areas suggest on the whole that they have a far more limited role to play in future global forest management than is often believed. Promising technologies cited in the main paper and commented upon by track participants include the following:

- much of the swidden-fallowing found in lower density areas is shown to be more elaborate and sustainable than had been supposed; village bush fallow in Sahelian Africa sweeps out through a concentric circle for three 20-year cycles, then abandons it for 120 years until two other 60-year cycles in adjacent areas are complete; a reassessment of some of these systems is long overdue in many areas;

- often, local people can manage forest sustainably as a common property resource if the area is small enough to patrol as part of their daily lives. Dividing larger reserves into manageable village entities holds much promise, as the Tanzanian and Somali cases show;

- Forest Protection Committees to regenerate 'sal' forest with the help of the Forestry Department have been set up in 1,300 villages in West Bengal, India. Both share the profits accruing from villager protection and Forestry Department punishment of trespassers;

- Hill Resource Management Societies in Haryana, North India protect the watersheds which feed the city dam of Chandigarh, by forbidding open grazing, and stall-feeding their buffaloes. Instead, they have built their own small dams in the hills, and use the communal water to grow irrigated fodder and other crops. Villages in the scheme have greatly grown in wealth - and the city dam's useful life has been extended. Tremendous regeneration of trees has occurred in the hills.

5 Targets and Costs

Where dry forests decrease in area through conversion to agricultural land - which will take place in the more favourable sites - biomass targets will increasingly have to focus on farm forestry. There are currently also millions of hectares of manageable dry forest, especially in Africa, if management options can be employed to protect them.

Low-cost interventions to make tree management and tree planting more likely include:

- strengthening and tightening the land tenure rights of those interested in tree planting or management, and recognising, where appropriate, communal rights rather than open access regimes;

- reviewing and adapting forest legislation and forest policy where events have shown that they present stumbling blocks to responsible dry forest management by local people;

Higher-cost interventions to make tree management and tree planting more likely include research, training and recruitment of staff, together with monitoring and infrastructure development. More specifically:

For on-farm tree-planting:

- the creation of an effective, decentralized, forestry extension service, which can identify the needs of richer and poorer, male and female villagers, and respond to them; services would include offering the full range of species traditionally raised in home-garden and farm, newer species of commercial interest, and grafted fruit trees (usually keenly desired). Effective extension services are always expensive because they involve the hiring of large numbers of additional field staff;

- the creation and expansion of in-country markets for wood and wood products, to create the economic incentives for more intensive tree growing; in remoter deforested areas, this may involve the creation of special purpose factories for e.g. woodpulp or fruit drying;

For communal tree management:

- the retraining of forestry officials and guards for support to, and work with, communities and user groups interested in a management role vis-a-vis local forest.

6 Other Important Dry Forest Management Issues Raised by Participants

Fire: All forestry options considered would dramatically benefit from the elimination of uncontrollable fires. Local tenure may help to involve local inhabitants in better prevention, detection, and suppression.

Livestock: Livestock have an important economic role to play in all rural societies dependent on dry forests, but they may also cause damage. The group recommends that in projects in relatively densely settled dry forest areas, the following issues are always investigated: the feasibility of enhancing - rather than reducing - fodder and pasture availability; the upgrading of livestock and their stall-feeding where appropriate;

The rights of forest dwellers in forest reserve land: Although the group held varying views according to their own country experience, it was agreed that where the total volume of forest reserve land is low, it should not usually be diverted to non-forest uses. It was recognised that long-time forest dwellers - but not more recent squatters - had a right to continue in their traditional economic niche, but that they should be given written documentation of their rights. Their best chance of continued residence might well be to take on the role of forest protection, in collaboration with local foresters.

Convert All Forest Users into Managers of Forest Lands

Rauno Laitalainen and Manuel Boita[1]

ABSTRACT

Classical forestry, as practised in many developing tropical countries, centers on concessionaires and/or enterprises whose main objective is to harvest timber from government-owned natural forests. Social forestry has drawn attention to other purposes and forms of management of public forest lands. Forest administration must not only place social forestry side-by-side with classical forestry, but actually give priority to social forestry for social justice to prevail. The process does not have to be one of conflict, but of planned accommodation of a wide range of potential managers or types of management objectives. The focus should be less on the issue of resource ownership and more on the issue of helping to improve living standards of forest users through sustainable management of forest resources. The short paper describes a matrix relating forest managers to mnaagement objectives. The matrix can serve as a base for policy, legal, and institutional changes to accommodate various forms of management of public forest lands.

Involvement of Village Communities and Voluntary Agencies for Regeneration of Forest Lands

Department of Environment, Forests and Wildlife,
Ministry of Environment and Forests, India

ABSTRACT

This document is the text of a letter sent to Forest Secretaries in all states of India. Included in the text are the following directions:

- fuelwood, fodder and small timber requirements of villagers living in and near the forests should be met from forest produce. It is considered essential that forest communities are involved in the development and protection of the forests from which they derive benefit;
- the expertise and experience of voluntary agencies and NGOs should be used as an interface between State Forest Departments and the local village communities for the protection and development of degraded forest lands. The following conditions are laid down:-
  - no ownership or lease rights over the forest land is to be given to the beneficiaries or the NGO;
  - the villagers, unlike the NGOs, are entitled to a share in the usufructs - such as grasses, lops and tops of branches and minor forest produce, with a share in the sale of mature trees provided the forest is successfully protected;
  - access to forest land and benefits is restricted to those who are organised into a village institution specifically for forest regeneration and protection;
  - a selected site should follow a working scheme approved by the State government. This scheme should be prepared after consultation with villagers and should prescribe forest management conditions;
  - there should be no grazing in the forest land protected by the village community, but grass cutting for stall feeding is permitted; neither is agriculture permitted;
  - villagers are permitted to fruit trees, shrubs, grasses and medicinal plants, provided these are suitable for the local environment and needs;
  - cutting of trees before they are ripe for harvesting is forbidden.

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1 Royal Forest Department, Thailand.

Forests of India

C Pandeya[1]

ABSTRACT

This document gives detailed statistics of land use in India, including descriptions and extent of major forest types, forest cover according to 1989 satellite imagery, fuelwood, fodder and timber needs, and area of farm forestry and afforestation. The history of forest management in India from the early British period (1800) to the present day is summarised, and salient features of the 1988 National Forest Policy are given to indicate current approaches. For example, this policy aims for at least one third of the land area of the country to be under forest or tree cover, and calls for participation of local people, the protection of environmental stability over economic benefit, the discouragement of shifting cultivation and 'rehabilitation' of those practising it, and the research base to be strengthened.

Steps taken to implement the 1988 National Forest Policy are outlined: these include the establishment, in 1985, of the National Wastelands Development Board with the aim of bringing about massive afforestation and social forestry on wastelands and degraded forests; the discouraging of felling of green timber above 1000m altitude; the banning of clear felling of forests in the hills over an area of 10 hectares; the implementation of the National Wildlife Action Plan, with a consequent increase in the area under national parks and sanctuaries; economic support for tribal peoples inhabiting forest lands; the establishment of five new forestry research institutes; and the implementation of a National Forestry Action Plan under the TFAP.

Kenyan Statement

Crispus R J Nyaga[2]

ABSTRACT

The Kenyan statement lists general causes of deforestation and suggests a number of options which need to be examined globally in preparation for a forest convention. A good database, and consideration of the sections of the climate and biodiversity conventions relevant to forests, are considered necessary.

Deforestation generally arises from the following actions:

- indiscriminate and uncontrolled exploitation of the forests;
- overharvesting;
- pressure from human settlements;
- overdependence on fuelwood;
- damage from forest fires, wildlife, pests and diseases;
- clearing of forests for infrastructural and other development activities.

The Kenyan statement suggests the following options for consideration:

- development and promotion of agroforestry, social forestry, afforestation and reforestation programmes;
- formulation of National Forestry Master Plans and Action Plans;
- establishment and strengthening of national and regional forestry research institutions and programmes;
- development and promotion of alternative sources of energy and of means of energy conservation;

1 Inspector General of Forests, Government of India.

2 Director of Forestry, Ministry of Environment and Natural Resources, Nairobi, Kenya.

- establishment of funding mechanisms for programme implementation and the transfer of appropriate technology to developing countries;
- quantification of economic values of forests in terms of their multiple uses.

It is suggested that more time be devoted to assembling baseline information, possibly through more national and regional meetings, before a forestry convention can be prepared.

Kenyan Experiences in Forest Management: Dry Tropical Forest

Crispus R J Nyaga[1]

ABSTRACT

Kenya's forest cover stands at 2.2 million hectares, 3% of the land area. The extent of formal forest cover is restricted by the need for more agricultural land for the country's rapidly increasing population. Since independence in 1963, Kenya's population has risen from 8 to 24 million people.

Formerly, forestry activities were restricted to the formal forest reserves, some of which are in isolated areas such that the forest products are accessible only with difficulty. But in 1971, the Rural Afforestation Programme or farm forestry extension programme was started to give greater emphasis to farm forestry and agroforestry. This programme now covers all areas of the country.

Plantation forestry covers 170,000 hectares and mainly consists of quick maturing species such as cypress (45%), pine (35%), eucalyptus (10%) and mixed indigenous and exotic varieties (10%). However, Kenya's present self-sufficiency in industrial wood production is threatened by the invasion of the European aphid (Cinara cuppressi). Since its first sighting in March 1990, this pest has spread to all parts of the country where the host tree species (cedar and cypress) are found. In addition to the threat to the industrial wood supply, important water catchment areas, presently covered with the valuable indigenous cedar forest reserves, are at risk. Kenya has made an international appeal for assistance, through either chemical or biological control.

The World Bank has supported the development of industrial forestry since 1970, and phase IV of the National Forestry First Development Programme is due to be implemented in July 1991. This will cover the entire forestry sector and will include:

- industrial forestry development;
- conservation and management of natural forests;
- development of agroforestry or farm forestry;
- forestry research and institutional strengthening and development.

Kenya appeals for donor support, particularly for institutional strengthening and forest protection work.

The Kenya Forestry Master Plan has just been initiated: the intention is to produce a management plan to cover a 25 year cycle period. Until a resource inventory is undertaken and a sustainable management plan prepared, Kenya has banned commercial exploitation of its indigenous forests.

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1 Director of Forestry, Ministry of Environment and Natural Resources, Nairobi, Kenya.

Ethiopian Statement

E Bekele[1]

Of the total area of 124,834,000 hectares in Ethiopia, an estimated 14,608,900 hectares (11.7% of total land area) is known to be covered with forest, bush and shrubs. However, the closed high forests are estimated to cover not more than 2.8% of the country at present, compared to 15-20% in the 1940's.

Expanding cultivation and cutting for the purpose of woodfuel and construction materials are the two most fundamental causes of the continuing disappearance of the Ethiopian forest cover. In the recent past, development efforts on the part of the government by way of state farms, coffee and tea estates as well as resettlement schemes are also known to have contributed to deforestation, particularly in more fragile areas such as the Western lowlands.

The history of Ethiopian Forest Management can be traced back to the days of Emperor Zera Yacob of the 15th Century, who is known to have ordered the preservation of the still pristine forests of Wofwasha, Wochecha/Menagesha, Yerer and Jibat. He is reported as being one "who recognised the beneficial effects of forests and named some of the known forests of today such as Wochecha/Menagecha as Crown forest". Likewise, Emperor Menelik II is also famous for having recognised the key role which forestry can play within the national economy; accordingly in the mid-19th Century he contributed towards the introduction of forest management in the country, through the employment of foreign forestry experts to set up the first independent forest policy. Thus all forest was declared state forest reserve and reforestation was organised.

This was further reinforced through the establishment of boundaries, demarcation of the crown forest lands and organization of the reservation of forests, together with the eventual introduction of perpetual management by way of selective cutting and natural regeneration, which in turn led to industrial utilization. To enhance the reforestation programme, importation of fast-growing species such as eucalyptus, acacia and pine was also carried out. Indeed, given the versatile nature of eucalyptus and its outstanding contribution to the forest products needs of a significant proportion of Ethiopian households today, its introduction by Emperor Menelik will remain a cornerstone in the history of Ethiopian forestry and forest management.

Prior to the 1974 revolution, a large proportion of Ethiopia's natural forests were owned by the private sector. At that time, individuals also played a key role in exercising and maintaining the planting of eucalyptus species on their farm land, homesteads and along roads, under a system in which commerical utilization was given precedence over other management objectives. However, the forest management exercises in government, as well as private sectors, were not based on any available resource information, until the first reconnaisance forest inventory of the Ethiopian natural forests was taken during 1975-1979. The inventory, which covered areas within a 400 km radius of the city of Addis Ababa, provided substantial information about the country's natural high forests and resulted in a 1:250,000 map of these forest areas.

This inventory also resulted in a three-pronged development programme by way of reafforestation efforts. These included:

- the regular programme, financed by the government and carried out throughout the country;
- priority projects, financed by SIDA and carried out on a few selected natural forests;
- planting in degraded highland areas, under the World Food Programme.

With the generation of further information from remotely sensed data both by the Assistance to Land Use Planning Project of the Ministry of Agriculture and FAO in 1984, and the detailed findings of the Ministry of Mines and Energy by the Italian CESEN Consulting Firm in 1986, a desk study was carried out by experts of the Natural Resources Conservation and Development Main Department of the Ministry of Agriculture

1 Ethiopian Forestry Action Programme, Addis Abeda, Ethiopia.

in 1990. This study resulted in the emergence of the current 57 National Forest Priority Areas (NFPAs) as a management framework.

The major aim of organising the nation's remaining natural forests on NFPAs was to identify and locate all the existing natural forest areas, put them in order of priority and concentrate available resources on these areas. The aim was also to further identify and assess in detail the existing forest resources within the respective NFPA and to introduce an autonomous entity and integrated management approach to development, as well as conservation and protection, utilization and marketing of forest resources, with the ultimate goal of promoting a self-financing and sustainable enterprise.

Hence, forest management concepts and thoughts in Ethiopia are presently restricted to development and implementation within the 57 identified NFPAs, which comprise approximately 3.5 million hectares. Little or no thought has been given to the development of a management plan for the rest of Ethiopia's woody biomass potential, estimated at 23 million hectares. Recently, however, the Woody Biomass Inventory and Strategic Planning Project, under a World Bank Loan, have been initiated to effect the inventory and management plan development as well as proper utilisation of these woody biomass potentials.

Although there are no written forestry management plan guidelines at present, forestry management plans exist for three peri-urban fuelwood plantations and for four of the NFPAs. Management plans are also being developed for an additional six NFPAs and one peri-urban fuelwood plantation. Major factors impeding the achievement of forest management objectives include lack of effective forest policy, technological constraints and institutional inadequacies.

Possible strategies being proposed for future management of forests include:

- the formulation and implementation of an effective forest policy, a draft of which has been finalised;

- the restructuring and strengthening of forestry institutions, particularly regarding forest management;

- the encouragement of the private sector to participate effectively in conservation and development of forest resources;

- enhancement of forestry education, research and extension to overcome technological constraints.

Thus, with the objective of fully addressing constraints of the Ethiopian Forestry sub-sector and producing a national framework, the Ethiopian Forestry Action Programme (EFAP) was initiated in July 1990. EFAP is an 18 month study of the Government of Ethiopia, with UNDP funding and World Bank execution. Ultimate development and implementation of the various investment projects are expected during a later phase and will be implemented by the Ministry of Agriculture and the corresponding collaborating donor agency. The study part of EFAP is presently being coordinated by the Office of the National Committee for Central Planning (ONCCP), with support from the Ministry of Agriculture through secondment of personnel and the provision of office space for the EFAP secretariat.

To date, EFAP has managed to develop a draft issues paper, terms of reference for national task forces/working groups and international consultants, and an EFAP work programme. The work of the national task forces is also being finalised, and comprises three objectives:

- to ensure active and full participation of nationals in the identification of constraints and alternative courses of action, and in the ultimate formulation of the strategy for the Ethiopian Forestry sub-sector under the aegis of EFAP;

- to ensure maximum representation of the disciplines and sectors that have influence on, or are influenced by, the forestry sub-sector and hence try to strengthen these inter-sectoral linkages;

- to prepare EFAP working papers which not only serve as a starting point for the EFAP international consultants, but which also result in dialogue among all partners.

Twelve task forces were mobilised for a period of about six weeks each and these focused on land use, farm forestry, soil and water conservation, livestock/fodder, forest economics, forest management, forest industries, woodfuel and energy, ecosystem conservation, organisation and management, forestry education, research and extension, and policy and legislation. Each task force consisted of four to six professionals, with over sixty professionals being involved overall. These came from over twenty government agencies, seven NGOs, five international agencies and three mass organisations/private citizen groups.

The twelve national task forces produced main reports, each 60-80 pages, and synthesized versions each of 15-20 pages. The findings of each task force are being further consolidated into three thematic areas by National Working Groups consisting of experts in the twelve disciplines listed above. These areas include Forestry's Role in Land Use, Conservation and Development of Forestry Resources, and Forestry Institutions. The final analysis is expected to present the central issues and associated options that will serve as a springboard for the strategic development of the Ethiopian Forestry sub-sector. The work of the various national task forces/working groups will be completed by holding 2-3 day workshops on their findings. These will lead towards a final consensus building process on the issues and alternative courses of action by way of strategy and future action programmes.

Mobilization of the twelve EFAP international consultants is expected to follow soon, and is planned to run for about 4-6 months altogether, and to be mounted in three overlapping phases which correspond to the three thematic areas of the National Working Groups. The international consultants' output will feed into the first draft version of the EFAP strategy paper which will be discussed during a national seminar, at which all partners concerned are to be present. Based on the feedback received at the national seminar, the second EFAP draft strategy document will be prepared and a round table Conference, with all concerned members concerned of the donor community, will be called in March 1992.

The experience gained so far, particularly with regard to the task forces/working groups, has been extremely interesting and very productive for all concerned. It has not only been a path breaker for the EFAP exercise as a whole, but above all, a solid foundation for the formulation of the strategy and future implementation of EFAP projects.

Pakistan Statement

B A Waui[1]

ABSTRACT

As in other developing countries, forest environment is rapidy deteriorating in Pakistan under a rapidly growing population which now stands at 110 million. Out of 88 million hectares, 11 million hectares experience water erosion and falling productivity. The total annual soil loss is 47 million tons, which is intercepted by two major reservoirs, shortening their life and affecting the efficiency of irrigation conveyance systems.

Waterlogging and salinity are posing a threat of alarming dimensions to the country and have already led to the deterioration of 4.7 million hectares in Punjab and Sindh provinces. Forests in Pakistan are spread over 4.7 million hectares and are exposed to intensive exploitation to meet the ever increasing demand of human and livestock populations. Because of these pressures, watersheds in the uplands are fast degrading, in spite of a number of reforestation and watershed rehabilitation programmes. Our two main multipurpose reservoirs, Tarbela and Mangla, are silting up at the rate of 48.27 million m^3 and 167 million m^3 per year respectively, resulting in a net loss of Rs 3000 million every year as a result of the loss of fertile soil, power generation and agricultural productivity. Overgrazing of rangelands beyond their carrying capacity results in desertification. Every year about 1 million hectares of productive drylands are converted into desert. If the current trend continues, the 26.9 million hectares of arid land will slip into the desert category.

1 Deputy Inspector General of Forests, Ministry of Food and Agriculture, Pakistan.

The greatest environmental problem in Pakistan is the effects of the uncontrolled rate of population growth (3%). From a population of 16.6 million in 1901, and 31.5 million at the time of independence in 1947, today it is estimated at about 110 million. The population will reach over 150 million by 2000.

The draft Forest Policy recently formulated by the Government, focussing attention on promotion of farm forestry, is enclosed.

Pakistan National Policy for Forests, Wildlife, Watersheds and Rangelands, 1991

ABSTRACT

Since Independence in 1947, forest area in Pakistan has increased from 2% to 5.4% of total land area. The resource has been depleted due to population pressure and lack of policy initiatives and input, and therefore the National Forestry Policy has been reviewed.

The Basic Objectives of the Policy include: raising the percentage of afforested areas to 10% in the next 10 years; conserving existing forest, watershed, rangeland and wildlife to meet the ever-increasing demand; promoting social forestry programmes; encouraging the planting of fast-growing multi-purpose tree species; conserving biodiversity and maintaining ecological balance through conservation and reforestation; containing environmental degradation and desertification; providing self-employment and income opportunities in rural areas; and increasing public awareness of the need for environmental improvement.

The Plan of Action details work in management of hill forests, including the use of pilot projects as models, departmentalisation of timber exploitation, central nurseries, and road densities. Watershed management is highlighted, covering the planning of projects, inventories, measures to prevent soil erosion on gradients over 30%, and the control of grazing rights in reforested areas. Other areas of work include the management of irrigated plantations and the use of social forestry, the management of rangelands and wildlife habitats, forest extension, research and education, and resource surveys.

2 National Forest Options
2.3 Temperate and Boreal Forests (Track III)

Assessment of potential, feasibility and costs of forestry options in the temperate and boreal zones[1]

H Volz[2], W U Kriebitzsch[3] and T W Schneider[2]

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EXECUTIVE SUMMARY

i Introduction

Forests provide mankind with many ecological and socio-economic benefits. One of these benefits is the essential importance of forest ecosystems for atmospheric dynamics and for global circulation processes of air, water and carbon. The reduction of fossil fuel consumption and air pollution control is the most effective way to combat or mitigate the effects of global climate change, although forests have an important role to play.

The analysis which follows gives an overview of the potential, feasibility and costs of forestry options in temperate and boreal zones with special emphasis on the mitigation of the effects of global climate change. An assessment of valid figures on forestry options at a global scale is difficult. Thus, the approach used to get meaningful estimates is to gather and collate information on regional scenarios or national case studies. The global scope of the options discussed are based on data from 14 case studies.

The ranking, or the choice of forestry options should be based on an evaluation of costing the full range of economic, ecological, social and spiritual values and services associated with forests. Further work is necessary to provide a consistent basis especially for costing global forest options. In order to give some indication of comparative costs, the options have been costed using market values of direct costs.

ii Status of forests in temperate and boreal zones

Available information of the status of existing forests is contradictory. According to FAO data approximately 767 million ha of forest belong to the temperate zones (13% of total land area). Forest area in boreal zones amounts to about 920 million ha (47% of total land area). The total amount of carbon stored in temperate forests is estimated to be about 25,000 million tons, approximately half of it fixed in growing stock. This equals approximately 30 tons of carbon per hectare in commercial growing stock. Compared to this, the carbon storage of boreal forests is high: for example in Canada, the growing stock average is about 106 m^3 wood/ha. The total carbon storage recorded is about 209 tons of carbon per hectare (total). Boreal zones

1 Presented by H A Volz.

2 Federal Ministry of Food, Agriculture and Forestry, Bonn, Germany.

3 Bundesforschungsanstalt, Forst- und Holzwirtschaft, Hamburg, Germany.

store approximately 190,000 million tons of carbon (total), one third of which is in growing stock.

iii Forestry options in temperate and boreal zones

It has not been possible to include potential impacts of global climate change on forest ecosystems and their beneficial functions (including the potential to fix carbon) in this assessment. However, preliminary assessments of potential and costs of forestry options in temperate and boreal zones to mitigate global warming are summarized below.

iii.i Slowing deforestation and forest degradation - Preserving existing forests

Status: Despite all uncertainties it would seem that management and maintenance of existing forests is the most effective approach within the forestry sector in terms of ecological aspects, costs, and maintaining carbon reservoirs. Strategies to manage and maintain forests have the advantage of immediate beneficial impacts compared to other options. Consequently, all strategies to strengthen this aim should be taken and/or continued.

Potential: Slowing deforestation and forest degradation bears an enormous potential to keep carbon stored in biomass. For temperate zones there are about 25,000 million tons of carbon (total), for boreal zones there are additionally 190,000 million tons. This can be achieved by:

- implementation of sustainable forest management systems;
- halting conversion of forest areas to non-forestry purposes;
- conservation, or ecologically appropriate management, of boreal and temperate primary forests.

Costs : Maintaining forest ecosystems requires programmes to cope with threats such as forest fire, pests, air pollution etc. For such programmes hundreds of million US$ are spent annually. Climate change itself is likely to increase both the severity of these threats and the costs of management programmes. For an accurate assessment of cost-effectiveness it would be necessary to quantify the reduction of the amount of carbon released to the atmosphere as a result of these programmes. At present, such calculations are not available. Further research into the allocation of carbon in different components of the forest ecosystem, as well as improved monitoring and assessment, are required.

iii.ii Afforestation

For the boreal zones, the potential to increase the forest area is marginal. In these zones the forests cover on average about 47% of total land area. Most of the remaining land area is environmentally incapable of supporting forest ecosystems.

In the temperate zones, substantial areas might theoretically be available for afforestation during the next several decades. A conservative estimate indicates an annual afforestation rate of about 4 million hectares might be feasible. An average yield of about 1.0 m^3/ha/year assumed, this would result in an additional uptake of carbon of about 220 million tons in the first decade. In some countries considerable opportunity exists for tree planting outside the forest estate on lands where forestry is not the prime land use. Examples include urban plantings for improved amenity, agroforestry, and plantings on rural lands for shelter belts or to address land degradation. At present only very few estimates on these options are available.

Costs: At present, plantations account for most of the afforestation in temperate zones. Plantation costs (excluding management and road construction) differ considerably from region to region. Consequently, any reliable cost estimate for afforestation has to take these factors into account. However, plantation costs in China and in the United States are calculated about 400 US$/ha. For Eastern Europe, no data are available at present, but may be estimated to be the same. For Western Europe around 3,000 US$/ha are reported on average.

A conservative estimate could be done on the above assumption that an annual afforestation rate of about 4 million hectares might be feasible. If this is assumed funds might be needed of the order of about 2,300 million US$ per year. If these costs are calculated per ton of fixed carbon the calculations are around 100 US$/t/year for the temperate zones.

Costs for afforestation are relatively high compared with costs for activities to maintain existing forests. However, afforestation is important for other reasons. Another option is to allow natural succession, making use of natural regeneration. This approach can substantially reduce costs but it is limited by certain conditions. One point which should be noted is that the market for wood could be affected by the creation of new forests. Increasing the supply of timber above the level of demand will have an impact on prices.

iii.iii Increasing biomass in existing forests

Status: The biomass and carbon content of boreal and temperate forests was previously described in section 2.

Potential and costs: In general, there is significant potential for increasing biomass in existing forests, especially in young, understocked, overlogged and/or misused forests. Nevertheless, the potential for increased storage of carbon can be estimated as approximately 15-20 million tC/yr in boreal ecosystems and 100 to 150 million tC/yr in temperate forests.

iii.iv Increasing yields of existing forests

As a conservative estimate, it is pointed out that the approach to increase yields of actual forests is not a feasible option for large areas within the next decades.

iii.v Improved use of wood

Status: In relation to the global carbon cycle, it is essential not to destroy forest ecosystems through overcutting or other unsuitable practices. Any wood to be used within this option should be produced and harvested in a sustainable manner. The use of wood for long-lived products provides benefits in terms of carbon fixation and timber supply, as well as for sustainable forest increment. The development and application of technologies for more efficient use of wood residues and lower grades of timber should be encouraged.

Potential and Costs: Wood from sustainably managed sources is an environmentally friendly raw material and fuel. The forecasted increase in world demand for wood may best be met through increased wood production in combination with more effective use of wood, rather than by substitution with non-renewable materials such as concrete, plastics, steel and aluminium. Case studies indicate that maximising the use of wood in construction results in a reduction of 50% in CO_2 production and 20% in N_2O production, compared with other materials. The use of wood as an energy source to replace fossil fuels also holds enormous potential. Studies have indicated that up to 25% of total energy needs of Canada could be supplied by biomass from forests. Recycling of paper and paperboard is a potentially valuable option. Wood also has the potential to replace more energy-intensive raw-materials.

iv Further evaluation and research

There is still a lack of essential information on potential, feasibility, and costs and benefits of forestry options to mitigate the global climate change at national as well as global levels. This report identifies priority areas for further investigation. Countries are asked to evaluate relevant national data and additional basic research is needed. Results should be assembled and analyses at the global level should be revised and completed.

This report assesses the potential and feasibility of forestry options in temperate and boreal zones. How these options compare, in terms of their cost-effectiveness, with the same or other options in different zones is beyond the scope of the report. Further, essential information is required on the potential, feasibility, costs and benefits of forest management options in the temperate and boreal zones to address the wider range of economic, environmental, social and spiritual values and services associated with forests.

1 INTRODUCTION

1.1 Objectives

Forest ecosystems play a prominent role in the global carbon cycle. This report gives an overview of the potential, feasibility and costs of forestry options in temperate and boreal zones to mitigate and combat the effects of global climate change.

An assessment of valid figures on forestry options at a global scale is difficult. This is due to the fact that forests, forestry measures, and therefore their potential, feasibility and costs depend on local environmental and socio-economic conditions which are known to differ from region to region and from country to country. Thus, the approach chosen to get acceptable estimates is to complete information on regional scenarios or national case studies. On this basis a global assessment should be carried out.

The realization of forestry options outlined in this paper depends mainly on the framework of feasible political decisions in the individual countries participating in this programme. In countries with market economies, major changes in land use could be accomplished if substantial financial stimulants were given to private landowners. Different situations in countries with other economic systems have to be considered.

The national case studies presented in this paper have been assembled within a very short time, and the statements reflect individual opinions and assessments of the experts rather than official governmental programmes or plans. Many gaps in the knowledge have been identified and a variety of uncertainties remain. The data and estimates given require further research and review.

1.2 The importance of forests in the context of climate change

Apart from marine ecosystems, forests are the most important primary producers converting CO_2 and water into phytomass. 82% of the phytomass on continents is found in forests covering, at present, approximately 28% of the land area. The forests contain an estimated 500,000 and 800,000 million tons of carbon, approximately the same amount that is presently contained in the entire atmosphere in the form of CO_2.

Destruction of forests releases the carbon stored in vegetation and humus, whereas forestry measures such as afforestation expand forest biomass and contribute to fixing and storing CO_2 from the atmosphere. A variety of options can be identified in using forests as a response strategy to global climate change. These options are applicable to temperate, boreal and tropical forests.

Besides the important role in the global CO_2 balance, forests serve a multitude of functions and preserve benefits to mankind. Apart from supplying raw materials they have important protective and recreational functions. The world's forest ecosystems are essential for global circulation of air and water. Wood is an important renewable resource for construction and energy supply. Forests filter water and air. Especially in mountainous areas, forests serve as protection against erosion, avalanches and flooding. Furthermore, forests are a final refuge for flora and fauna. In densely populated urban areas the recreational function is particularly important. Last but not least, forests are important as the habitat of indigenous populations.

1.3 What forestry options are available?

Slowing current deforestation and forest degradation: first priority should be given to this option of maintaining existing biomass in natural as well as in managed forests. In temperate and boreal zones, this refers especially to forest decline attributed to man-made air pollution. This option requires:

- air pollution control by means of preventive environmental policy instruments, and by changes in environmental legislation concerning liability; and
- silvicultural measures to improve the overall resistance of forest ecosystems and thus mitigate the impacts of pollution effects.

Further it is important to:

- stop or at least slow a conversion of forest areas to other non-forestry purposes;
- protect primary forests in temperate and boreal zones (development and implementation of sound

management practices included);
- implement sustainable forest management in areas where it is not yet practised.

Apart from these options, an increase of forest biomass should be envisaged through:

- expanding the existing forest area by afforestation and reforestation of land currently not covered by forests;
- underplanting of understocked stands;
- increasing the length of rotation periods; and
- increasing the yield of existing forests, especially by improved forest management.

Extension of the rotation period: since the carbon fixing process in even-aged forest stands is declining beyond the point of maximum average volume increment, the extension of the rotation period seems inefficient at first glance. The important fact about this is, however, that the short term effect of increasing the length of rotation leads to a reduced rate of timber harvesting, and thus, a reduced export and release of carbon. Consequently, the carbon stored in these forests increases immediately. However, it should not be forgotten, that timber used for construction and other long-term purposes can sequester carbon for a long time. In the meantime, the other above-mentioned methods of reducing the carbon release into the atmosphere, e.g. the reduced consumption of fossil fuels, should be fostered.

Improved forest management: selective logging is superior to clear cutting, in terms of carbon fixation as well as in ecological effects. This is because a sudden removal of the canopy leading to a total change in ecological conditions is avoided. In terms of carbon fixation, keeping the canopy will reduce the release of carbon from humus into the atmosphere, whereas clear-felling will increase this process. It is possible to combine the aims of biomass increase and the production of timber at the same time and in the same stand. Vital and stable individual trees should be allowed to attain larger diameters in order to continue storing carbon, whilst the understorey has begun to grow and fix carbon. Accordingly, the rotation age of unstable stands should be lower. By the same token, the increase in volume of young stands through neglect of tending and thinning operations is counter-productive.

Also, important options might be feasible by making greater use of wood where appropriate, especially through:

- improved efficiency while burning wood for energy supply;
- replacement of fossil energy sources; and
- replacement of energy-intensive raw materials (such as aluminium etc.).

Looking at the global carbon cycle it is essential not to destroy forest ecosystems through overcutting or other unsuitable practices. Any wood to be used within this option should be produced and harvested in a sustainable manner. However, the consumption of wood is the interactive factor between wood-production and fixing carbon in forest ecosystems on the one hand, and the long-term storage of carbon on the other. If wood remains in forests, it deteriorates and releases carbon stored. If wood is removed and used for long-term products, such as construction or furniture, carbon is sequestered for decades and sometimes centuries. Further, removal of wood is an important factor in forming vital and stable stands of high productivity.

Last but not least, it is important to point out that the control and reduction of the consumption of fossil fuels, and thus the release of man-made greenhouse gases into the atmosphere, is the most effective way to combat or mitigate the effects of global climate change. This is a particular challenge for industrialized countries with high energy consumption per capita.

2 TEMPERATE ZONES: CASE STUDIES

2.1 The Federal Republic of Germany[4]

2.1.1 Status of forests

The total land area of the Federal Republic of Germany is about 35.7 million hectares. The total forest area amounts to 10.4 million hectares or 29% of the land area. Furthermore, there are 0.5 million hectares of other wooded areas. The total wooded area (including forest areas) amounts to 10.9 million hectares or 30% of the land area. The forest area in Germany increased by afforestation of land formerly not covered by forests, by 36,000 hectares, or 0.1% of total land area, between 1979 and 1988. For the coming decades, a further increase of the total forest area is expected as a result of:

- a restrictive policy aimed at maintaining existing forests, implemented by a forestry legislation, which:
  - requires sustainable management of forests, including the obligation to reforest harvested forest within a certain time;
  - promotes afforestation of currently unforested land; and
  - allows the conversion of forest area for other purposes only with the permission of the forest administration;
- a financial promotion of afforestation, especially aimed at setting aside agricultural land permanently; and
- an efficient forest administration and management responsible for the proper management of all forests, including supervision of private and community forests.

The average standing stock in German forests is estimated to be about 270 m^3 per hectare. At a national scale this sums up to 2,800 million m^3 (over bark). This equals 70 tons of carbon per hectare or 700 million tons at a national scale stored in the standing stock[5]. Additionally, the same amount of carbon is stored in the form of other biomass fractions such as branches, leaves, roots and humus. Thus, the total amount of carbon stored in German forests is estimated at about 130 to 140 tons per hectare or 1,400 million tons at a national scale. The carbon stored in these materials accumulates forming a carbon sink, or decreases releasing carbon, depending on a variety of circumstances. To facilitate calculations, it is assumed that these processes offset each other in existing forests.

Although the annual volume increment of timber in Germany is estimated to be about 64 million m^3/year (6 m^3/ha/year), the annual removal is only about 42 million m^3/year (4 m^3/ha/year). However, a considerable amount (20 to 50%) of the timber remains in forest ecosystems as a residue of felling, where it rots and releases CO_2 . The difference between increment, removal, and residue, leads to an annual increase of about 11 to 18 million m^3/year. In terms of carbon storage, this means an annual increase of about 3 to 5 million tons of carbon at a national scale[6].

2.1.2 Forestry options

Forestry option: Slowing the new type of forest damage

Status: (The following data are valid for the Federal Republic of Germany before 1990): To slow currently ongoing forest degradation, air pollution control is being implemented. The results are:

- national emissions of SO_2 are cut down from 2.9 million tons (1982) to 1.1 million tons in 1989. This is a reduction of 63%. This level is expected to be maintained at least during this decade. However, further reductions are hoped for;

- the increase of NO_x emissions was stopped in 1986 at 3.0 million tons and a reduction to 2.7 million tons

4 Submitted by Hans-Albert Volz, Federal Ministry of Food, Agriculture and Forestry (Bonn), Dr. W.U. Kriebitzsch and Dr. T. W. Schneider, Bundesforschungsanstalt für Forst- und Holzwirtschaft (Hamburg).

5 1[m^3 wood] = 0.5[t wood/m^3 oven-dry] = 0.25[t C/m^3]

6 22{mio m^3 wood/yr]*0.5[t/m^3oven-dry]*0.5t[tC/t wood] = 5.5[mio. tC/yr],
5.5[mio.t C/yr[-{5.5[mio. tC/yr]*0.5 or 0.2[residues factor]} = 2.75 to 4.4{mio.t C/yr]

was reached in 1989. Until 1998 an annual emission target of 2.0 million tons of NO_x is set. However, further efforts have to be made, especially in the transportation sector;

- the level of volatile organic compounds (VOC) emissions was reduced from 2.6 million tons in 1970 to 2.4 million tons in 1982. This level was maintained until 1989. For 1998 a reduction to 1.6 million tons is the goal.

To slow forest damage, additional programmes have been implemented since 1984 to enable forest owners to take silvicultural measures to improve overall resistance in order to mitigate the impacts of pollution. In particular, the government provides subsidies of up to 80% of the costs for the following measures:

- forest fertilization in critical areas to buffer acid inputs from the air in accordance with the special requirements of forest sites, and remedial action in the case of nutrient deficiencies;
- underplanting of patchy and understocked stands to stabilize the forest ecosystem as a whole;
- reforestation of dead or dying stands; and
- ecological adopted silvicultural regimes to establish optimum stand structures.

Since 1991 air pollution control and additional forestry programmes have become valid for Germany as a whole. Despite this, the damage to forest ecosystems caused by emissions remains at a high level. In general, no major improvement of forest health can be reported.

Potential: the impact of forest decline on carbon fixation in forests has not been investigated so far. The generally observed loss of needles or leaves is not correlated with declining increment of forest stands. For example, reductions of tree growth of spruce (Picea abies L.) are reported to start at around a loss of 30% of needle mass. Therefore, the following calculations are based on the assumption that carbon fixation in forests has not been substantially reduced by impacts of pollution.

Costs: to introduce such silvicultural measures and programmes in Germany approximately US$ 80 to 90 million[7] will be necessary. Costs of air pollution control are not included in this assessment. However, silvicultural programmes can only mitigate but not compensate the effects of pollution. Therefore, investment in these programmes only makes sense if they are part of an overall approach which includes air pollution control. In Germany (before 1990) investment in air pollution control is estimated to be about US$ 19,000 million. To maintain this standard in the new Laender, preliminary estimates calculate that investments of about US$ 15,000 million are needed. It is assumed that these investments depreciate within a 20-year period, and that only 30% might be needed to maintain forest ecosystems. Thus about US$ 500 million annually might be needed to maintain forests in Germany. However, costs for research and bio-monitoring in forests have not been included.

Forestry option: Afforestation

Status: between 1979 and 1988 about 36,000 hectares of land were afforested in Germany. This corresponds with an annual increase of the forest area of about 0.1%. Figures for the former GDR are at present under investigation. To promote afforestation, there is a programme which reimburses land owners for part of the costs. During the last decade subsidies were granted some 20,000 hectares, on average 2,000 hectares per year.

Potential: Socio-economic changes in agriculture will entail major changes in land use in the near future. It is estimated that apart from other options in Germany (since 1991) about 0.6 to 0.7 million hectares of agricultural land will be available for afforestation and long term carbon fixation. This would lead to an increase of forest area by 6% and, in a long run (100-year period) to an equal increase of total carbon storage.

Taking into account the uncertainty of the time lag between the availability of agricultural land for afforestation and the actual planting of trees on these areas, a mean annual afforestation rate of 10,000 hectares within the next decade might be feasible. Compared with agricultural production, where the carbon fixing process is more or less in balance with the carbon release process, forests have a gross production of

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7 1 US$ = 1.50 DM

about 4 tons of oven-dry wood/ha/year in stems, roots and branches, with a net fixation of roughly 2 tons of carbon/ha/year[8].

In addition to these biological aspects, the energy and carbon input of forest management systems is much lower than the input of agricultural management systems (machines, fertilizers, pesticides), resulting in an additional reduction of carbon release into the atmosphere. Since no comparative energy and carbon balances of agricultural and forest management systems are available at present, further research will be necessary.

Accordingly, up to the year 2005 about 140,000 hectares could be converted into forests being capable of fixing about 0.15 million tons of carbon per year on an average[9]. It is estimated that in the year 2050 when all of the 0.6 to 0.7 million hectares of available lands are likely to be converted into forests, this would result in an estimated additional annual carbon fixation of 1.3 million tons of woody material or 2.6 million tons of total biomass[10].

Costs: The costs for the above-mentioned programmes are equivalent to US$ 5.7 million per year. During the last decade each hectare of afforestation was subsidized with an equivalent of US$ 2,700 on average. To achieve a mean annual afforestation rate of 10,000 hectares as assumed above, additional programmes to subsidize land owners would have to be implemented. These programmes would have to cover, during a 20-year period, most of the investment costs for afforestation as well as a reimbursement for losses of agricultural income (on average around US$ 330 ha/year). The minimum costs for planting one hectare of forest that has to fulfil the sole purpose of fixing carbon can be comparatively low (about US$ 1,300/ha). If other functions are to be fulfilled as well, the investment costs rise considerably to about US$ 6,000/ha.

If US$ 3,300/ha were assumed for the planting of one hectare of forest stand plus around US$ 330 (reimbursement of income loss, paid during the next 20 years), the additional annual costs for such a programme would range from about 40 million US$/yr in the beginning of the period to at least 100 million US$/yr at the end of the period[11].

Forestry option: Increasing biomass in existing forests

Status: Biomass of existing German forests is already relatively high. Approximately 270 m^3 of growing stock per hectare equals to 540 m^3 of biomass or 135 tons of carbon. At a national scale approximately 1,400 million tons of carbon are stored in forest biomass. Average rotation periods are around 120 years.

Potential: In general, forests react very slowly to modification of silvicultural regimes, due to slow tree growth. However, to increase biomass in existing forests, one has to renounce harvesting wood by final cut so that harvesting does not offset increment (net growth). Young stands need to be thinned to grow to stable stands as well as to keep high increments. This is why this option results in renouncing the harvest in old stands, thus expanding the rotation period.

Theoretically, an extension of the rotation period of 20 years of all German forests (to 140 years) could lead to an increase of the standing volume of about 4% within 20 years. The additional carbon storing capacity of the above ground biomass amounts to roughly 0.2 t C/ha/yr, equivalent to about 2 million tons of carbon per year. But in reality, a general extension of the rotation period cannot be recommended. In some cases it is limited by natural factors like aging of trees, instability of stands and/or events like storm, fire, pollution, insects etc. Therefore, it is estimated that only 10% of the above-mentioned theoretical potential will be feasible. This would mean an annual renunciation of the harvest of about 0.8 million m^3 of wood/year equivalent to about 0.14 million tons of carbon.

Underplanting of understocked forests: Apart from areas with severe forest decline caused by air pollution,

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8 6 to 8 [m^3/ha/yr]*0.5[t/$m^3$0ven-dry]*0.5[t C/t wood] = 2.0[t]

9 (10,000 ha + 20,000 ha + ... + 140,000 ha)/14*2[t C/ha/yr] = 0.15[mio.t C/yr]

10 0.6 to 0.7[mio.ha]*2[t c/ha/yr] = 1.2 to 1.4[mio.t C] wood, the same amount in non-woody biomass

11 1st year: 10,000[ha]*3,300[US$ investment] + 10,000[ha]*330[US$ investment] = US$ 33mio;
20th year 10,000[ha]*3,300[US$ investment] + 140,000[ha]*330[US$ investment] = US$ 80mio,however, costs for afforestation are likely to increase within a 20 year period.

increasing the standing volume of understocked forests in terms of carbon fixation is not a realistic option in German forests. However, in many cases it makes sense for other reasons.

Costs: It is estimated that a renunciation of the harvest of about 1 million m^3 of wood per year would cost around US$ 40 million[12].

Forestry option: Increasing the yield of existing forests

Status: The net growth of German forests is estimated to be about 11 to 18 million m^3 per year, increasing the carbon storage annually by approximately 3 to 5 million tons.

However, to push the yield of existing forests by changes in silvicultural regimes, fertilization, and/or change to fast growing tree species would be required.

Potential: German forests are growing already by a considerable amount. It is assumed that the annual mean net growth will continue during the next decades.

In general, forest management already has reached a high standard in Germany. Possible effects of fertilization would be compensated by the high energy inputs (production and application) required. Finally, stability of forest ecosystems depends on the correct and site-specific choice of tree species. Further, genetic diversity would be affected by changing to only a few fast growing tree species. Although genetically improved material is used in German forestry, there is also an interest in the conservation of genetic diversity. As a consequence, all attempts to increase the yield or the net growth rate of existing forests are not feasible options for German forests.

Costs: Since there is a considerable net growth in German forests causing no costs, and additional attempts to increase the yield of existing forests are no feasible options to German forests, no cost estimates have been made.

Forestry option: Keeping the status of wood consumption

Status: In Germany, the annual consumption of wood and wood products is about 87 million m^3 (r). This figure includes roundwood, sawn wood, plywood as well as wood-based products, wood-pulp, paper and paperboard. With exception of the three last mentioned products, they are long-term and store therefore considerable amounts of carbon for decades and sometimes centuries.

Potential: For Germany, specific statistics of the consumption of long-term wood products (some decades) do not exist. It is estimated that annual amounts range about 10 to 15 million m^3 (r), storing approximately 3 to 4 million tons of carbon per year.

However, the competition to substitute wood by other raw materials, such as steel, aluminium, plastics and concrete require strengthened marketing activities.

Costs: The current marketing programmes for wood amount to about US$ 7 million annually.

Forestry option: Making greater use of wood to replace fossil energy sources

Status: In Germany no reliable statistics are available for the annual utilization of fuelwood. Conservative estimates range from 1.5 to 2 million tons of wood. In addition, at least 5 million tons (oven-dry) of wood residues probably are burnt in the forest product industries annually.

Potential: At present, in the framework of forest operations about 3 to 5 million tons of woody residues are left in forest ecosystems. They remain due to ecological, technical and economic reasons. Since about a third of Germany's timber and timber product consumption has to be imported, it is not likely that more timber might be used as fuelwood rather than for construction and other purposes.

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12 Loss of net income by renunciation is calculated to be about US$ 40/m^3

However, the production of biomass by fast growing tree species in a coppice system with short rotations has only a chance on the energy sector. Experiments on this subject are under way. In pilot projects, an annual production of 12 to 15 tons (oven-dry) has been realized, fixing 6 to 7 tons of carbon per year. Costs for establishment vary between US$ 2,000 and 5,000/ha. Compared to conventional plantations with long rotations returns will be available after a shorter time period (5 to 10 years), and for several rotations reforestation costs are not incurred. Cost effectiveness of this renewable energy source depends on prices for fossil fuels. As long as oil prices are low, an increased utilization of forest biomass seems to be uneconomic. However, several existing plants producing heat and energy for local networks operate economically. Although this biomass is not yet available in larger quantities and though it has to compete with fossil fuels there might be a prospective potential in the long term. However, no estimates on potential and costs can be made.

Forestry option: Making greater use of wood to replace energy intensive raw materials

Status: For Germany (before 1991), the annual consumption of subsequent construction materials is about: 0.3 million tons concrete, 0.5 million tons plastics, 1.8 million tons steel and 0.1 million tons aluminium (all these figures are rough estimates). The energy consumption for the production of these materials is quite high. On average, the necessary energy input for the production of construction timber is about 450 kWh/t, cement around 1,000 kWh/t, plastics around 1,800 kWh/t, iron around 3,700 kWh/t, steel around 3,800 kWh/t and aluminium around 20,000 kWh/t.

Potential: In the long term, additional wood produced through existing forests and through afforestation can contribute to the replacement of these energy-consuming materials. There is the prospect of increased use of wood in the building and construction sector, e.g. more wooden constructions, doors, window frames etc.

If it is assumed that this timber would be used to replace 10% of the above-mentioned production or 30,000 tons of concrete, 50,000 tons of plastics, 180,000 tons of steel and 10,000 tons of aluminium, respectively, about 800 million kWh could be saved. Thus, the release of some 72,000 tons of carbon could be prevented annually[13]. Further, the carbon stored in this timber would be fixed in buildings and other constructions for long periods. This might reach up to 2 or 3 million tons per year. However, further investigations will be necessary.

Costs: The costs of additional utilization of wood as a substitute for other materials cannot be estimated at present.

2.1.3 Summary: Potential and costs of forestry options to mitigate global warming in the Federal Republic of Germany

The results of this preliminary assessment of potential and costs of forestry options in the Federal Republic of Germany to mitigate global warming are summarized in Table 1. For the next 20 years the following options might be feasible:

- The actual forest biomass contains about 1,400 million tons of carbon. Additionally, there is an annual net increase of about 5 to 6 million tons of carbon. Measures and programmes to maintain this existing potential range about US$ 600 million per year (air pollution control included, research not included). This means annual investment costs of about US$ 0.4 per ton of carbon fixed in forests;

- Additionally, forestry carbon storage might be increased within the next 20 years to about 0.36 million tons of carbon per year, mainly through afforestation and longer rotation periods. To realize this aim, additionally investments of about US$ 80 to 90 million respectively US$ 330 to 390 per ton of carbon are calculated;

- Wood used for long-lived products, like construction timber for buildings and furniture etc. actually fixes about 3 to 5 million tons of carbon annually. Because of hard competition with other raw materials, marketing programmes are necessary of about US$ 7 million per year to hold this status. Calculations

13 To generate the energy of one kWh through combustion of fossil fuel roughly 0.122 kg SKE are needed of 73% pure carbon, thus releasing 0.0897kg of carbon/kWh or 0.33kg CO_2/kWh into the atmosphere.

for this approach eradicate costs of about US$ 2 per ton of carbon fixed by long-lived products;

- In the future, additionally produced wood could be used to increase the consumption of wood products especially for the construction and energy sector. The options on this sector might be prospective but actually the available estimates are limited and further investigations are required.

Despite all the uncertainties it is obvious that the strategy to maintain existing forests is by far the most effective approach in terms of carbon fixation as well as in terms of costs. The great advantage is that the effects of this strategy acts immediately. Consequently, any means to strengthen this aim should be taken and/or continued. The same applies for measures to keep the recent level of wood consumption.

Table 1: Potentials and costs of forestry options in Germany

Options	Potential in the next 20 years							
	Area	Carbon stored in biomass			Increment of Carbon		Costs	
	m ha	t/ha	m t	t/ha/yr	m t/yr	m t	m $	$/t c
1. save current status								
a. growing stock	10.9	70	700				600	0.4
b. other biomass	10.9	70	700					
2. increase biomass								
a. net growth	10.9			0.5	5-6	?		
b. afforestation	0.2			2.0	0.21	4.2	60-70	280-340
c. rotation periods					0.2	4	ca. 40	ca. 200
d. trees in rural and urban areas (no assessment available)								
3. increase yields (not a feasible option)								
4. wood consumption								
a. save current status					3-4	?	7	2
b. increase combustion (not a feasible option)								
c. increase for construction					0.1	?		

Uncertainties arise with regard to additional measures to increase carbon uptake and/or storage. For Germany, these options are small (approximately 0.4 million tons of carbon) compared to the annual emissions of CO_2 (200 million tons of carbon). Further, these options need some time until they could be fully realized and developed. However, these options include important aspects not only of importance for the purpose of carbon fixation. Therefore, they should be subject further investigations.

2.2 The Kingdom of the Netherlands[14]

2.2.1 Status of forests

Total land area: 3.39 million hectares, total forest area: 0.334 million ha or 9.8% of land area, trees outside the forests: 0.169 million ha. Since 1977 the total wooded area has increased by approximately 14,000 ha or 0.4% of the total land area. This is due to:

- forest law;
- financial support of sustainable management of forests and of reforestation;
- promotion of afforestation;
- restriction on conversion of forest land for other purposes.

14 Submitted by Cor von Meijenfeldt, Ministerie van Landbouw en Visserij, Utrecht, Netherlands.

Mean growing stock in Dutch forests is about 104 m^3 per hectare or 34 million m^3 (over bark) nationally. The fixed amount of carbon is 28 tons per hectare or 9 million tons for the whole Dutch forest area. Other biomass fractions also contain carbon, thus the total amount of carbon stored in the Dutch forests is approximately 55 tons of carbon per hectare or 18 million tons of carbon at a national scale. Total standing volume of trees outside forests: 11.5 million m^3 (over bark).

Annual increment in forests: around 4.6 m^3 per ha or 1.5 million m^3 at national scale. Annual felling in forests at a national scale: 1.1 million m^3 (over bark). This means a net increase of 0.4 million m^3 per year and a total storage of carbon of 0.2 million tons of carbon. Annual increment of trees outside forests: 1.2 m^3 per ha or 0.4 million m^3 per year.

2.2.2 Forest options

Slowing the new type of forest damage

Air pollution control: air pollution control is a very important and an ongoing political issue, thus there is much research and many adaptations of measurements, laws etc.

- SO_2: emissions in 1980 of 465 ktons; in 1987 of 282 ktons. The Dutch policy aims at a reduction of SO_2 emissions in 2000 to 80% of 1980 levels.

- NO_x: emissions in 1980 of 549 ktons; in 1987 of 559 ktons. The Dutch policy aims at a reduction of NO_x emissions in 2000 to 50% of 1980 levels.

- NH_3: emissions in 1980 of 251 ktons; in 1986 of 253 ktons. The Dutch policy aims at a reduction of NH_3 emissions in 2000 to 70% of 1980 levels.

- VOC: emissions in 1980 of 492 ktons; in 1987 of 453 ktons. The Dutch policy aims at a reduction of NH_3 emissions in 2000 to 60% of 1980 levels.

There is financial support for forest owners to take measures to improve the overall resistance of the forests:

- selective forest fertilization (including analysis of the soil and leaves);
- extra financial support to reforest in case of necessary felling;
- reforestation to re-establish dead stands.

Every year a forest health survey is made; the further deterioration of the forest health has apparently come to a halt, but a serious improvement of the forests seems not yet to take place; besides there are different results for the various species. The impacts of forest decline on carbon fixation in forests has not been investigated so far.

Afforestation

Over the last 14 years an increase of 14,000 ha or 0.4% of the land area; this is approximately 1,000 ha per year. Financial support for afforestation (around 80% of the costs) and extra support if the owner plants fast-growing species. There is also an extra support for farmers if they afforest a part of their lands (set-aside regulation).

Till 2000 there should be an increase of the forest area of about 40,000 hectares according to the several governmental programmes. Because of economic development in the agricultural sector more land will be available for afforestation within the coming years. The increase of the forest area is politically motivated by the increase of wood production, the increase of open air recreation areas, development and conservation of nature and landscape, protection of soils and water systems and of course for the fixation of carbon.

Increasing biomass in existing forests

Biomass in existing forests in the Netherlands is relatively low compared with forests of other countries. This is mainly a result of the fact that most of the Dutch forests are young and on poor soils. Fertilization of the forests is not a good option, because that requires a high input and there is also no significant increase of the biomass by extension of the rotation periods.

Increasing yields of existing forests

This is possible by improved silvicultural regimes and maybe by planting of other tree species: in the Netherlands there is a need for better-structures forest organizations; more co-operation is needed between governmental organizations, private organizations, private forest owners, timber trade organizations, etc. A more economical management of the forests is needed, of course with consideration of the stability of the forest ecosystem. The government tries to stimulate all this.

Making greater use of wood to replace fossil energy sources

In the Netherlands the production of wood for energy is of marginal importance. Not a feasible option.

Making greater use of wood to replace energy-intensive raw materials

The replacement of materials like concrete, plastics, steel, etc. by wood is partly possible, but no data are available. Actually, about 90% of the Dutch timber supply has to be imported. Replacement of these materials by wood will therefore cause problems. The estimation of costs has not yet been given by Dutch experts, as it requires further research and assessment to give a reliable review. Indications for some costs for forestry are given in Table 2.

Table 2: Global review of some costs for forestry of the Ministry of Agriculture, Nature Management and Fisheries.

Costs of [million Dutch guiders]	Year				
	1986	1987	1988	1989	Total
afforestation					
- permanent forests	7.6	7.4	8.7	11.7	35.4
- fast-growing forests	0.3	1.2	1.0	0.8	3.3
maintenance, management reforestation (subsidy)	26.3	25.9	21.0	23.5	118.0
Subsidy to improve the overall resistance of the forests	5.0	5.0	5.0	5.0	20.0

Notes: The Ministry of Agriculture, Nature Management and Fisheries also funds research that can benefit the forests. Other departments also fund forestry activities, directly (e.g. the Ministry of Economic Affairs subsides fast-growing forests), or indirectly in case of air pollution control and research (Ministry of Housing, Physical Planning and Environment).

2.3 The United Kingdom[15]

2.3.1 Status of Forests

The UK has a total land area of about 24 million hectares. The total area of forests and woodlands amounts to 2.4 million hectares, or 10% of the land area. During the past 30 years, the total wooded area has increased by 845,000 hectares or 50%. This is due to:

- legislation which allows the Forestry Commission to control the felling of trees and require the restocking of felled areas as a condition of felling;

- establishment of 438,000 hectares of new plantations by the Forestry Commission (and Northern Ireland

15 Submitted by Mike Garforth, Forestry Commission, Edinburgh, United Kingdom.

Forest Service);

- new planting by other landowners of 407,000 hectares, much of which was grant-aided.

It is expected that the new planting programmes will be continued. In 1989-90, 16,500 hectares of new plantation on privately owned land was grant-aided, and a further 4,000 hectares have been established by the Forestry Commission. The mean growing stock in UK forests is estimated to be around 100 cubic metres per hectare, or a total of about 240 million cubic metres (over bark). Assuming 0.26 tons carbon per cubic metre, 62 million tons of carbon are stored in the form of timber.

In addition, about the same amount of carbon is stored in the form of other biomass fractions such as branches, leaves, roots and humus. Thus the total amount of carbon stored in UK forests is estimated to be about 120 million tons. The net annual increment is estimated to average 6 cubic metres per hectare or 14.4 million cubic metres (total). In contrast, the annual thinning and felling amounts to 6.6 million cubic metres. At a national level, this results in a net increase of 7.8 million cubic metres of growing stock or 3% per year. In terms of carbon storage, this means an annual increase of growth (before deducting felling and thinnings) of 4 million tons.

2.3.2 Forest Options

Afforestation

While the official target for new planting remains at 33,000 hectares per year (excluding planting under the Farm Woodland Scheme), there is no official target for the total woodland and forest area in the UK.

In the 1980s new planting in the UK was undertaken at the rate of 20,000 to 30,000 hectares per year. Higher rates were achieved in the 1970s. Table 3 shows the scope for absorbing carbon under a range of policy options. The rate of carbon storage would continue to increase to 2040 and beyond. The estimates assume planting of species with growth rates similar to the present average. The rates would be higher if the programme concentrated on the faster growing species. Storage in products would extend the period over which carbon was taken out of the atmosphere (and this has not been allowed for in these estimates).

Cost effectiveness: In addition to producing wood for processing and fuel, forests produce non-market benefits (and efforts to value these are in their infancy). This analysis takes account of the value of wood production. The cost effectiveness of carbon uptake depends upon the distribution of new planting between different types of forest. Assuming current land prices, the costs (that is discounted expenditure less discounted revenue from wood, using a 6% discount rate) would be approximately US $1,100 per hectare for production forest in the uplands, US$ 4,500 per hectare for production forest in the lowlands and US$ 7,500 per hectare for amenity woodlands in the lowlands.

Table 3 Carbon Fixed by Trees in Years Shown (million tons carbon per year before deducting felling and thinnings)

Option	1990	2005	2020	2040
Planting 500,000 hectares 1991-2000	4.0	4.9	5.2	6.0
Planting 700,000 hectares 1991-2000	4.0	5.2	5.7	6.8
Planting 2 million hectares 1991-2000	4.0	5.4	7.2	10.9

Thus, for example, to achieve a planting programme of 100,000 hectares of production forests in the uplands, 300,000 hectares of production forests in the lowlands and 100,000 hectares of amenity woodlands in the lowlands by the year 2000 would cost US$ 221 million per year. These costs include the purchase of land and this is assumed to compensate owners for loss of income from agriculture.

Forest Health

This is monitored on a regular basis but there is no indication at present of a significant decline in forest health adversely affecting production in UK forests.

Increasing Biomass in Existing Forests

The age structure of UK forests is such that the biomass in existing forests will increase in the short term even if no more new planting is undertaken. If timber is felled at normal rotation ages, however, it is expected that the carbon fixed by trees will fluctuate, reflecting the changing age structure of the forests. Thus in the absence of any new planting, 4.0 million tons of carbon per year would be fixed in 1990, 4.6 million tons in 2000, 3.8 million tons in 2020 and 4.1 million tons in 2040. There may be scope for increasing the biomass in existing forests by extending rotation periods but this will be limited due to natural ageing and (over much of upland Britain) the constraints on rotation age imposed by wind.

Increasing Yields from Existing Forests

Yields from existing forests could in theory be improved by, for example, additional fertilization and/or changes to more rapidly growing species. This option is not considered attractive. The possible benefits of fertilization might well be offset by the high energy inputs required for production and application and, given pressure for greater multiple use of forests, scope for increasing yields of existing forests through a change to more rapidly growing species is limited.

Making Greater Use of Wood to Replace Fossil Energy Sources

The greater use of wood to replace fossil energy sources would only become likely on any scale if the cost of fossil fuel rose significantly (perhaps through imposition of a carbon tax). The physical availability of land for growing wood for this purpose would, however, be a constraint. Even if one million hectares became available, this would produce only about 10 million tons per year from short rotation coppice (providing in theory only about 3% of total UK energy requirements in the non-transport sector).

Making Greater Use of Wood to Replace Energy-Intensive Raw Materials

In the UK, manufacturing industry emits 45 million tons of carbon. Of this 7.5 million tons of carbon are emitted by the iron and steel industry and 2 million tons in the production of cement, lime and plaster. While there might be some scope for substituting wood for these products in, for example, the construction industry the overall impact is likely to be small given the constraints on wood production referred to previously.

The conclusion, therefore, is that the most appropriate way for UK forestry to contribute to amelioration of the greenhouse effect would be to sustain and increase rates of new planting. Programmes are most likely to be cost effective if they promote multiple purpose forests providing landscape, recreation and conservation benefits as well as wood production and CO_2 lockup.

2.4 The Republic of Austria[16]

2.4.1 Status of forests

The total area of forest cover in Austria is estimated to be around 3.86 million hectares or 46% of the total land area. According to the Austrian Forest Inventory in the period 1961-1985 the total forest area extended from 3.61 million hectares to 3.86 million hectares corresponding to an annual rate of 10.000 ha. The expansion of the forested land is mainly based on the afforestation (30%) and natural regeneration (70%) of abandoned farm land and pasture ground.

The Austrian forest law heavily restricts the clearing of forest land. Therefore, on average only 1,000 hectares have been stocked up per year in the last two decades. In the period between 1961-85 a considerable increase in growing stock could be observed. It increased 180 million cubic metres from 750 million m^3 (inventory period 1961-70) to 930 million m^3 (inventory period 1981-85). The mean growing stock of the Austrian forests is estimated to range around 280 m^3 per hectare.

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16 Submitted by Dr. Siegel, Bundesministerium für Land- und Forstwirtschaft, Vienna, Austria.

For the period 1971-80 the reports of the Austrian Forest Inventory presented a mean annual increment of 6.5 m^3 per hectare. The total annual increment amounted to 19 million m^3. Based on the figures of the Forest Inventory, the Austrian forests store approximately 280 million tons of carbon. The forests take 21 million tons of carbon dioxide from the air annually.

2.4.2 Forest options

Slowing the new type of forest damage

Status: Since 1983 the Austrian authorities have monitored the forests annually to assess the new type of forest damage. The results from last year have revealed that 77% of all sample trees are not defoliated. 19% of the trees show slight, 3% modest and 1% severe defoliations. Regarding the crown conditions all species except Scotch and Austrian pine have improved slightly in comparison with the results from 1989.

In addition to the crown condition assessment, soil from sample plots has been analysed. In 1990, an acidity lower than pH 3.8 was detected in more than 35% of the soil samples taken from one of the soil horizons. High surface concentrations combined with low values in the subsoil may indicate long distance pollution.

In 1984 the federal government decided to issue a programme of appropriate measures for fighting air pollution which was destroying forest areas. The programme included the improvement of legal instruments for imposing a reduction of emissions of substances harmful to forests. The positive effects of these measures comprise:

- permanent desulphurisation of fuel oil and diesel oil;
- reduction of sulphur and nitrogen emitted by caloric power stations by using waste gas filters;
- reductions in several stages of exhaust gases of motor vehicles by the introduction of more stringent regulations and lead free petrol as well as the installation of three-way catalytic converters.

The most important principles of the Austrian forest policy are the conservation of the forests and the permanent maintenance of its four effects (utilization effect, protective effect, environmental effect and recreational effect).

Taking into consideration these principles further objectives of forest policy would be:

- Reduction of air pollutants on a national and international level;
- Regulation of the stocks of game according to requirements of forestry;
- Separation of forest from pasture;
- Intensification of the silvicultural management of protection forests to stimulate natural regeneration;
- Promotion of the natural silviculture to ensure biodiversity and to conserve genetic resources;
- Minimization of damage to growing stock;
- Promotion of the conversion of agricultural areas capable of yield into forests.

Potential: The impact of forest decline on the current increment is subject to several research activities. First results show that only modest defoliation leads to considerable increment losses.

Costs: In the last years on average the forest authorities have annually subsidized site improvement and conversion of stands on an area of 5,000 ha costing US$ 2 million.

Afforestation:

Status: Since 1970 the annually afforested areas have decreased from 5,800 to 2,700 hectares. Currently the area forested by natural seeding increased by the equivalent amount, so that in the last two decades the Austrian total forest land has expanded at a constant rate of 10,000 hectares a year.

Potential: Due to the continuous abandonment of farm land and pasture grounds an extension of the Austrian forests by 10,000 hectares a year may be expected up until the year 2005. Based on a mean biomass crop of 15 tons per hectare and the additional forest area of 150,000 ha by the year 2005, 2.5 million tons of carbon dioxide are estimated to be taken from the air annually.

Costs: The annual afforestation will be subsidized by an amount of 3 million US$ a year.

Increasing biomass in existing forests

Status: The mean growing stock of the Austrian forests amounts to 280 m^3 per hectare. This corresponds to a storage of 70 tons of carbon per hectare. Taking into account roots, bark and branches this quantity of carbon grows by 30% to 100 tons per hectare.

Potential: Although the mean growing stock is considerably high it differs remarkably in each of the three ownership categories of the high forests in production such as smaller forests with less than 200 ha production area, private forests with more than 200 ha production area and public forests. In the inventory period 1981-85 the mean growing stock of smaller forests (262 m^3) lay 47 m^3 below that one of the private forests (309 m^3). Within the next 15 years it is intended to increase the mean growing stock of smaller forests by 20 m^3 per hectare through intensified silvicultural advice for small forest owners. This measure will fix 3 million tons of carbon dioxide a year.

The Austrian forests are characterized by an uneven age class structure with a lower part to be found in older age classes. Therefore an increase in the rotation period cannot be achieved within the next 15 years.

More than 16% of the Austrian forests in production, corresponding to an area of 520,000 hectares, have impoverished soils with a humus layer less than 2 centimetres. Raising of the humus layer by 2 centimetres, an objective which might be attained by the year 2005, would take approximately 2 million tons of carbon dioxide annually from the air.

More than 80,000 hectares are unstocked due to the prevailing clear cutting system. In addition stands with an extent of approximately 200,000 ha are poorly stocked. According to the Austrian Forest Inventory on these areas the canopy density varies between being discontinuous and light. By conversion of the present silvicultural system to a more natural one, a better utilization of the growing space may be achieved.

Costs: Programmes are being planned but cost estimates are not available at present.

Increasing yields of existing forests

Status: Increased yields of existing forests could be reached by improved forest management, fertilization and change to fast growing tree species.

Potential: In Austria 2,000 hectares are stocked by faster growing foreign conifers, mainly Douglas fir and Weymouth pine. Due to the climatic conditions in Austria the planting area for these species is very limited. For reasons of cost and environmental impacts it is not intended to establish large scale fertilization programmes in Austria.

In the last decade natural silviculture has been promoted by the authorities to establish stable stands, furthermore to ensure the biodiversity and to conserve the gene resources.

Costs: No particular programmes for these purposes have been developed on a national scale to date.

Making greater use of wood to replace fossil energy sources

Status: In Austria the portion of fuelwood (2 million m^3) amounts to 15% of the total yield (14 million m^3). Fuelwood is especially used in rural areas. Additional 1.5 million m^3 of residual wood from wood processing industries and sawmills is mainly used to produce energy. Momentarily in Austria the annual consumption of all kinds of fuelwood corresponds to an energy equivalent of 85 PJ/year or 8.5 % of the total energy consumption.

Potential: It is estimated that through increased use of residual wood and the reduction of thinning reserves (4-5 million m^3/year) additional energy in the proportions of 35 to 50 PJ/year can be produced from forestry biomass.

2.5 The Republic of Cyprus[17]

Cyprus is the third largest island in the Mediterranean with an area of 925,148 hectares. Forests cover an area of 175,398 hectares which represent about 19% of the total area of Cyprus. The forests of Cyprus are natural forests and are found mainly on the two mountain ranges of the country, namely the Troodos or Southern Range of mountains and the Pendadactylos or Northern Range. The majority of the forests of Cyprus, are state forests (161,820 hectares) and only about 13,578 hectares are private forests.

The predominant forest tree species is Pinus brutia (Brutia pine) which grows from almost sea level up to 1500 metres above sea level. It comprises more than 90% by volume of the total growing stock of the Cyprus forest. Above 1500 meters Pinus nigra (Black pine) replaces Pinus brutia and grows to the top of Mount Olympus which is 1952 meters above sea level. Other coniferous trees are the famous Cyprus Cedars (Cedrus brevifolia) and the Cypress (Cypressus sempervirens). Of the broadleaved species the most common are the Plane (Platanus orientalis) and the Alder (Alnus orientalis) which grow along the few riverine sites. Also important is the Golden Oak (Quercus alnifolia), an endemic species which grows as an understorey to the Pines or even in pure crops.

The growing stock in forests of Cyprus is 3,13 million m^3 (over bark) or 17.8 m^3 per hectare. Taking into account the total biomass this equals approximately 8 tons of carbon per hectare. Net annual increment is about 58,000 m^3, removals are about 45,000 m^3.

Potential: An afforestation rate of 200 ha would be feasible during the coming decades. Costs for afforestation are US$ 1,000 to 1,200 per hectare. No assessment is available on the possible carbon fixation rate and the possible potential of other forestry options.

2.6 The Republic of Bulgaria[18]

2.6.1 Status of forests

The total area of the forest resource (forests with state importance) is 3.8 million hectares. The afforested area is 3.3 million hectares, of which 1.2 million hectares are coniferous and 2.1 million hectares broadleaved. Forest cover of the country: 34.0%. Total stock of the forests 395.6 million m^3. Average stock per hectare 121.4 m^3. Average stand density of the plantations 0.77, average age of the forests: 38 years. Average total increase of the forests: 9.2 million m^3, or 2.81 m^3 per hectare.

Expected use was 6.4 million m^3, actual use 4.7 million m^3. Percentage of the actual use from the average growth 51.1%. Expected use according to the planned forest structure is 69.5 of the growth. The obtained wood is 1.18% of the total stock, and the use is 1.44 m^3 per hectare.

Water conservative, ameliorative, anti-erosion, recreative woods and protected natural areas comprise 30.9% of all the woods in the forest resource.

Annually, 30,000 to 40,000 hectares are afforested, of which 60% are coniferous and mainly on erosive terrains. 4.7 million m^3 of wood are obtained annually. Felling is carried out on 120,000 hectares of young plants. Roundwood for 1990:

- Local production 4.1 million m^3, of which 1.1 million m^3 coniferous and 3.0 million m^3 broadleaved.
- Importation from the USSR 1.3 million m^3, of which 1.2 million m^3 is coniferous.
- Importation from other countries 20,000 m^3.

2.6.2 Forest damage

The forests in the Republic of Bulgaria are subject to attack by insect pests of the order Lepidoptera. In the years of larger reproduction, 30,000 to 50,000 hectares broad-leaved and coniferous forest plantations were attacked to a high degree. As a result of the defoliation caused by these insect pests, the forest suffers

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17 Submitted by Al. Christodoulou, Ministry of Agriculture and Natural Resources, Forestry Departement, Nicosia, Cyprus.

18 Submitted by V. Karamfilov, Committee on Forests at the Council of Ministers of Republic of Bulgaria.

great damage, expressed in a reduction of 30 to 60% of the wood growth, physiological weakness of the trees and appearance of some mushroom and other illness which might become a cause for marasmus.

With a view to protecting nature from pollution the use of chemical preparations were absolutely banned from the 1970's onwards. Bacteriological preparations are used, which are produced on the basis of Bacillus thurigiensis, and they are very effective against the phyllophagous caterpillars. It is established that there is a great need to conduct autobiological combat on 20,000 hectares of broad-leaved forests, which are overrun by the gipsy moth (Limantria dispar L), Tortrix viridana L, some species of the family Geometridal and over 12,000 hectares of coniferous plantations (mainly forest crops of white and black pine). Wasted timber due to defoliation of the afflicted plantations is calculated at over 650,000 m^3. To carry out the struggle against the above-mentioned pests about 70,000 kg/l of bacteriological preparations are necessary, costing about US$ 560,000. But the State does not have such resources.

2.7 The Czech Republic[19]

2.7.1 Status of forests

The area of the Czech Republic is 7,886,400 hectares; forested land was 2,629,418 hectares (33,3% of land area). From 1970 this area has risen to 23,480 hectares (0.9% of land area). Mainly agricultural land of small use has been reforested. Due to effective legislative protection no significant changes in area of forested land are expected. It is supposed that the acreage of forest land is stable now and will not rise in future.

Forest resources are estimated at 558.2 million m^3 of wood of which softwood comprises 483.2 mill. m^3 (86.6%). The annual current increment is 17.1 million m^3 of wood (6.5 m^3 per ha per year). In 1988, the regular planned cutting was 12.2 million m^3, actual cutting was 12.6 mill. m^3, mainly due to salvage felling. The average growing stock is about 212 m^3 of wood under bark per hectare and it is slowly increasing. Supposing the volume of 70 ton of carbon in biomass of forest stand of area of 1 hectare, in the forests of Czech Republic there is about 0.184 billion ton of carbon.

In the Czech Republic forests have been badly damaged both by abiotic and biotic agents in the recent period. For instance the salvage felling in 1988 was about 5.7 million m^3 (45% of annual cutting). The most important negative agents are wind and wet snow, which caused salvage felling of 3.1 million m^3 of timber. The salvage felling of stands damaged by air pollution represent now only 0.6 million m^3, but damage caused by air pollution is much higher and it is the main danger for the productivity of the forests in the future. On 30 June 1990 in the Czech Republic about 57.1% of forested area was damaged by pollution, i.e. 61.5% of forest resources. Air pollution results in losses in productivity and also losses in non-productive forest functions.

2.7.2 Forestry options

Lowering of negative agents influence and damage caused by air pollution: The aim of tending improvement and forest management is to increase forest stand stability and consequently limit the volume of salvage felling. Great efforts are made to keep forest stands in mountainous regions badly damaged by air pollution (Krusné hory, Krkonose, Jizerské a Orlické hory etc.) Nevertheless, forest management is not able to resolve the problem. The government has promised to lower emissions by 30%, but still is not sure if it will be enacted. At the same time the investigation of many scientists shows that 30% lowering of pollution is insufficient. In badly polluted regions liming is applied: in 1988 it was applied on an area of 30,000 hectares. The fertilization of forest cultures took place on 9,000 hectares. Costs of this activity are about 1,800 Czech crowns per hectares.

Afforestation: in 1989 about 35,016 hectares of land was reforested, a 29.5% increase in comparison with 1980 (for spruce 20,121 ha). Costs of reforestation of 1 hectare are on average 19,000 Czech crowns. In emission zones the costs may be 2 – 3 times higher.

Society is interested in the development of non-productive forest functions. This interest is met by increasing

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19 Submitted by Bohumil Kuhitz, Ministr Zemedelstvi CR, Prague.

the acreage of forests with special functions. These are forests important for hydrology, and as national parks, protected areas, town and recreational forests. The acreage of such stands is 36% of the forested area.

During 1991 significant changes in forest ownership will take place. It is expected that the acreage of private forests will increase from the present 4% to 30 - 40%. The rest will be divided among holding companies interested in long-term efficiency, and in improving forest resources. Increasing demands for non-productive forest functions will be supported by the state.

2.8 The People's Republic of China[20]

Status: total land area of the People's Republic of China (Taiwan and part of Tibet excluded) is 960.3 million hectares, the wooded area being about 119.5 million hectares. The total forest stock is about 9,500 million m^3, and mean annual growth is about 275.3 million m^3. Forest covers about 12.5% of total land area, with a current net increase of 3.86 million hectares per year. The net growth rate is 2.3 m^3/ha/yr, and about 2,800 million tons of carbon is stored in total forest biomass. Net absorption by forest activities was calculated at 2.5 million tons of carbon per year.

The **potential** land area available for afforestation or reforestation is estimated to be 86.6 million hectares. If shelter belts are developed - an increasing trend in recent years - and a mosaic in farm fields is considered, the total potential of forest coverage will roughly be 25%. This approximates to the upper limit of land availability for afforestation (240 million hectares).

Since the establishment of P.R.China (1949) the percentage of land area covered by forest declined until the 1970's, since which time it has increased slowly. The reason for rising forest cover is the awareness of society as well as authorities of the importance of forests in protecting the environment. Although the forested area increased by 3.86 million ha/yr, it seems unlikely that this will continue. A realistic estimate of the afforestation rate is about 2.5 million ha/yr over the next 10 years. At the end of this century, the forest cover percentage will be roughly 15%.

Costs: the costs of establishing, managing and harvesting forests were calculated for 7 species which are the main species for afforestation in China. The costs of forest establishment range from US$ 270 to 440/per hectare depending on species and climatic conditions (average US$ 400/ha). The costs of managerial activities are about US$ 350/ha/yr. If forest lane and road building is included the total average costs will be US$ 3,200/ha for the 7 fast growing species. Broadleaved and mixed stands are more expensive than monospecific stands. The costs for establishment and management only are 1,000 US$/ha, the total costs are estimated to be US$ 25,000 million for the coming 10 years for afforestation.

Limitations: China being a developing country, the limiting factor for afforestation is the shortage of money. In the past few years, the World Bank has given financial support for afforestation in China. However, the policy of the World Bank was to invest in fast growing species, especially in southern China. The World Bank funds only those forestry projects where the internal rate of interest is higher than 13%. As long as China does not receive additional financial support for the afforestation programme, the increase in rate of forest cover will be lower than expected.

2.9 Japan[21]

2.9.1 Status of Forests

Japan has a total land area of about 37.8 million hectares, and a total forest area of about 25.3 million hectares. The forest area includes 10.2 million hectares of artificial forest (40.5% of total land), 13.7 million ha of natural forest (54.1% of total land), and 1.4 million hectares of unplanted areas, rocky areas etc., (5.4% of total land). These figures are from 1986. During the past 20 years, the total forest area was stable.

20 Submitted by Xu Dejing, Research Institute of Forestry, Chinese Academy of Forestry, Beijing, China.

21 Submitted by Toshizumi Sakai, International Forestry Cooperation Office, Forestry Agency, Japan. (Editor's note this paper was also submitted separately at the Workshop).

2.9.2 Forestry Options

Slowing deforestation

It has not been clear that forests have been damaged by acid rain or other air pollutants in Japan. Acid rain has been monitored, and the influence of acid rain upon forests has been investigated and researched (the Forest Agency started acid rain forest damage monitoring in 1990.)

Afforestation

During the past 20 years, the total forest area has not changed. The forest consists of planted forests and natural forests.

	artificial forests	natural forests
1966	7.9 million ha (32%)	15.5 million ha (62%)
1986	10.2 million ha (41%)	13.7 million ha (54%).

86% of planted forests are less than 35 years old. 59% of the total comprises 16 - 35 year old trees that have to be thinned. Most of forests are too young to harvest, but growing stock increases steadily (increase to 129% of the stock of 1966). On the other hand, in 1986 the area of natural forest had decreased to 88% of the area in 1966.

Forests do not only supply timber and other products, but also have various other benefits. For example, soil and water conservation, prevention of disasters, conservation of natural environment; and forests supply facilities for health and education. All products and effects are connected with national economy and life. Those have to be given full work through suitable forest management.

Therefore, it is planned that the total forest area should be 25.4 million hectares (increase of 0.09 million ha) by the year 2014 (National Basic Plan of Forest Resources in Japan). The total cost is two million yen per hectare for afforesting Sugi (Cryptomeria japonica) until 50-years old (Sugi is one of the most important planting species in Japan).

Increasing biomass in existing forests

The total growing stock is 2,862 million m^3. This consists of 1,361 million m^3 planted forests, and 1,502 million m^3 natural forests (in 1986). During the past 20 years, the total growing stock increased steadily. It rose from 1,887 million m^3 in 1966 to 2,862 million m^3 in 1986.

	artificial forests	natural forests	[million ha]
1966	558	1,329	
1986	1,361	1,502	

The growing stock of planted forests increased greatly, and that of natural forests increased steadily in spite of the decrease in area. Total biomass, which includes branches, leaves, and roots is estimated as follows:

1966	1,415 million tons (3,145 million m^3)
1986	2,147 million tons (4,770 million m^3)

During the past 20 years, the total biomass increased by 732 million tons (1,625 million m^3), which is equivalent to 37 million tons (19 million tons of carbon) per year. By the year 2014 it is estimated to reach about 2,858 million tons of biomass (6,350 million m^3) or 1,429 million tons of carbon. The carbon storage will increase by 355 million to 1,429 million tons of carbon, which is equivalent to an increase of 13 million tons carbon per year.

Biomass per hectare:

1986	85 tons/ha (189 m^3/ha)	43 tons C/ha
2014	113 tons/ha (250 m^3/ha)	56 tons C/ha

(Growth of biomass will decrease slowly year by year because of forest ageing, but total biomass will increase steadily.)

Yield

Timber production for the five years (1982 - 1986) was 161 million m^3 (about 32 million m^3 per year). Forest resources, mainly planted forests that had amounted to 10 million hectare, increased steadily. Most forests are too young to be harvested, but it is expected that timber supply will increase slowly to 45 - 52 million m^3 in 2004.

Use of wood to replace fossil energy resources

The total supply of firewood and charcoal is 0.4 million m^3 in 1986. But it is less than 1% of all domestic timber supply (34 million m^3).

Use of wood to replace energy-intensive raw materials

Timber that is produced in forests is sustainable. Timber can store carbon for long periods if used for construction purposes or materials for houses, furniture, etc. Timber requires less energy than other materials (aluminium, steel, plastics etc.) to be processed. Therefore, promotion of improved timber use will contribute to both energy conservation and carbon storage.

3 BOREAL ZONES: CASE STUDIES

3.1 Canada - Climate change and forests[22]

Issues[23]

1 The effect of Canadian forests on atmospheric concentrations of greenhouse gases, and
2 Whether to commit Canada to actions related to forests as a source of emissions or as a carbon sink.

Canadian Context

Existing forests comprise an enormous reservoir of carbon. For example, it has been estimated that forest biomass in Ontario amounts to the equivalent of at least 90 times the annual carbon emissions from the province. The preservation of this reservoir by avoiding net deforestation is therefore vitally important in preventing further contributions to atmospheric greenhouse gas concentrations. The issue of forests as a reservoir of carbon is clearly related to, but should be distinguished from action designed to enhance the potential for forests to "sequester" carbon. The capacity of a forest as a sink depends on the growth rate and is limited by the natural life cycle of trees.

In dealing with net productivity or biomass of forest ecosystems, most research and inventory work has concentrated only on trees. Caution must be exercised, therefore, in comparing different studies or databases. Because of the enormous diversity of forest ecosystems, and the paucity of published information on productivity and biomass of all forest components, any estimation of totals for Canadian forests must be considered to be speculative. Further research is required to understand better these processes and to define these values more accurately.

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22 Submitted by Tim Boyle and K. Vineberg, Forestry Canada, Quebec, Canada. (Editor's note, this paper was presented separately at the Workshop).

23 This is not intended to be a comprehensive discussion of forest issues in relation to climate change.

Multiple Functions of Forests

Forests provide an immense range of goods and services, of which amelioration of global change effects is merely one. Preservation of biological diversity, regulation of water quantity and quality and contributions to social and economic stability are some of the other benefits of forests. Measures to expand or improve one of the functions of forests will affect all of the other functions. For this reason it is illogical to consider specific options affecting one function independently of all the other functions.

Status of Forests

Canada has a total land area of 997 million hectares. The total forest area amounts to 453 million ha (45%), of which 244 million ha (54% of forest, 24% of total land area is classified as "productive"). Statistics for the period 1977-86 indicate that the change in forested area due to changes in land use is negligible. However, over the same period there was a net decrease in commercially stocked forested area of 4.7 million ha (2%) due to a shortfall in regeneration following harvesting or destruction by fires and pests as well as by withdrawing productive forest into parks or reserves.

Despite this net loss of commercially stocked forested area, the growing stock on productive forest land increased by 693 million m^3 (3%) during the period 1977-86. In 1986, the total commercial standing volume on productive forest lands amounted to 24,630 million m^3, or 106 m^3/ha. In 1986, estimates for the total forested area, and taking into account all forms of biomass in forested ecosystems (commercial and non-commercial timber, non-timber biomass and soils) and the net accumulation of forest products, indicate that approximately 88 billion tonnes of carbon are stored by Canada's forests, or approximately 200 tonnes/ha. Of this total, about 14% is in the form of tree biomass, about 85% in soils and about 1% in forest products. Peatlands are estimated to account for an additional 135 billion tonnes.

The average annual increment of the productive forested area, adjusted to take account of all biomass, amounts to 3.0 m^3/ha, which corresponds to about 0.86 tonnes of carbon/ha/y. The net increase in growing stock, similarly adjusted, indicates that approximately 33.8 million additional tonnes of carbon were stored annually during the period 1977-86, or 0.15 tonnes/ha/yr. Preliminary results from a study to model the fluxes of carbon into and out of Canada's forested ecosystems, suggest that the carbon stock increased by about 0.1% for the reference year (1986).

Forest Options

Curbing Net Forest Losses

Status: over the period 1977-86, about 1.9 million hectares of productive forest were harvested or were destroyed each year. Of this total, 44% is due to harvesting, and 56% due to fires and pests. In 1988, regeneration by planting accounted for 30% of the area harvested, natural regeneration amounted to 50% of the total, and 20% remained unstocked (ie. an average net loss of 0.47 million ha/yr over the period 1977-86).

Losses due to changes in land use are negligible. In the boreal zone, despite tree deaths near point sources of pollution and at high elevation, forest decline due to aerial pollution is not at present considered to be significant. The potential for damage, however, is immense should pollution increase in future.

While the provinces own about 80% of the forests, harvesting is usually carried out by private companies. During the last decade, most provinces have introduced legislation designed to place greater responsibility on companies harvesting timber on crown land to ensure adequate regeneration, in an effort to reduce the regeneration shortfall.

Over the last ten years, successive federal-provincial Forest Resource Development Agreements (FRDAs) have levered about a billion dollars in additional funding for forest development. Canadian governments now invest over $1.6 billion per year for forest development and management and this is having a major impact on maintaining and improving our forest stock.

Improved prediction and management regimes for fires and pest outbreaks, making use of "expert system" technology, have been developed and are being refined. A regional pilot project for predicting and controlling fires has been underway since the early 1980's.

Potential: initiatives on fire and pest control may reduce annual losses over the next decade and subsequently. The effects of global warming will act against such efforts. Increased temperatures will increase the likelihood of fires and will also disrupt ecological relationships, resulting in greater potential for pest epidemics. Warmer climates might also lead to pressure to convert some forest areas to agricultural uses.

Improved regulation of regeneration and continued FRDAs should ensure full regeneration of annual harvests and other losses. With this basis, the federal government has established a target of eliminating the regeneration shortfall by the year 2000, dependent, naturally, on provincial management practices.

Costs: given that approximately 4 to 5 million hectares needs to be regenerated, with a cost of approximately $1500 (US $1300/ha), the total cost of eliminating regeneration shortfall will amount to around $6 billion (US $5 billion). Part of the strategy for elimination of regeneration shortfall involves the system of federal-provincial development agreements (FRDAs) in which federal and provincial funds are jointly utilised to tackle specific problems in forest management.

NOTE: there is, as yet, no generally accepted definition of "not satisfactorily restocked" (NSR) land. This is one element of the National Data Base to be developed under the auspices of the Canadian Council of Forest Ministers (CCFM). For example, some land classified as NSR due to hardwood growth is now considered productive.

Afforestation:

Status: as noted previously, afforestation of unforested area in recent years has been negligible. This is because, especially in the boreal zone, there is little unforested land that is capable of supporting a forested ecosystem. Some marginal agricultural land in the boreal zone could be afforested, but most such land lies in the temperate zone. It is estimated that there may be up to 27 M ha of marginal agricultural land, mostly on the Canadian prairies.

Potential: the federal government has set a target of planting an additional 325 million trees over the next six years, in both rural and urban areas. The tree-planting programme will mitigate the impact of global warming through increasing carbon sequestration. Initial studies indicate that up to 84 M ha might be suitable for increasing the forest area. On site studies will be required to confirm this figure. The potential may be as high as 10.4 M tonnes/yr. by the year 2000.

Urban trees have a greater impact on global warming than rural trees largely because they reduce energy demands; however, they may also respond to higher urban CO_2 concentrations by absorbing more CO_2. Therefore, the effect of the urban tree-planting programme is likely to be greater than simply the equivalent of planting in rural areas.

Canada is a leading contributor to tropical afforestation. The forest development expenditures of the Canadian International Development Agency amount to $115 million (US $100 million) annually. Other agencies have also recognised the potential of tropical afforestation to compensate for the lack of opportunity for afforestation in Canada. For example, the City of Toronto has recently considered spending $2.4 million (US 2.1M) a year for the next ten years on tropical afforestation with the goal to sequester the equivalent of up 20% of the city's CO_2 emissions. In addition to cheaper land and labour costs, the greater productivity of tropical plantations results in much lower unit costs of sequestration. (This option, of course, will have no direct effect on Toronto's CO_2 emissions).

Costs: the federal government has allocated $75 million (US $65 million) for tree-planting over six years. These funds are specifically to cover the additional 325 million seedlings and trees, and do not affect the existing expenditure associated with reforestation of approximately one billion trees each year. Short term comparisons of tropical and Canadian afforestation costs indicate a ten times greater efficiency in tropical carbon sequestration due to rapid growth rates in the tropics. However tropical trees reach maturity faster and progressively sequester less carbon as they mature.

Increasing Biomass in Existing Forests

Status: as noted previously, the period 1977-86 saw an increase in biomass of Canadian forests despite a loss of forested area. This is a result of the age-class distribution of Canadian forests and of improved forest management, through which the proportion of productive replanted forests and natural stands has increased.

Such improvements are likely to continue in the short term, although accessibility and the costs of intensive management in the boreal forest zone will limit future improvements.

Potential: a similar increase in forest biomass to that seen in the period 1977-86 (3%) would result in an additional 5.6 million tonnes of carbon being absorbed by Canadian forests each year.

Costs: The increases in biomass have been achieved through natural forest growth of young age classes and from normal forest management operations. Given that the present age class distribution of our forests will allow for rapid growth over several decades and that other improvements were obtained merely through applying the same operations on an increasing scale, the costs could be considered as zero.

Increasing Yields of Existing Forests

Status: Improvement of yields through intensive forest management in Canada faces the problems outlined above, namely the cost effectiveness of such operations when conducted on a resource of the size of the Canadian forest.

Increasing the proportion of plantations will have a beneficial effect, but that was included previously as an increase in standing volume. Fertilization in the boreal zone will have only limited and local impacts. Conversion of forests to faster growing species is one possible approach, but the benefits to global warming must be weighed against negative impacts related to loss of biodiversity.

Potential: improving yields of Canadian forests beyond the greater use of plantations does not appear to offer major potential to increase fixation of CO_2. However, utilisation efficiencies can be increased, with a resulting increased, with a resulting increase in effective yields. Also, increased recycling of existing forest products (newsprint etc) can reduce the demands on additional harvesting.

Costs: no comprehensive cost estimates for these various initiatives are available.

Use of Wood to Replace Fossil Fuels

Status: estimates for the early 1980's indicated that biomass accounted for about 4% of energy consumption in Canada.

Potential: full use of the non-merchantable portion of merchantable trees on productive forest lands for energy consumption could deliver about 25% of Canada's energy demands. However, this benefit needs to be weighed against the nutrient value of this biomass being returned to the soil after harvesting.

In addition, short-rotation plantations designed specifically for fuelwood production may be beneficial in a number of ways. Considerations of strategic locations for such plantations can ensure that transportation is minimised and can contribute to net afforestation targets. As an alternative to direct use of fuelwood, such plantations may be utilised for ethanol production as a transportation fuel additive in the short term, with the potential to become a sole energy source once the cost of production is decreased or appropriate incentives are provided.

Costs: although costs of switching from fossil to renewable fuels may be quite high in general, there are a number of specific examples of where such a switch can be made at little or no cost. One example of this is in the pulp and paper industry. Canada produces about 15% of the total world output of wood pulp, and about 31% of the world's newsprint. The pulp and paper industry in Canada is a huge energy user, accounting for about 10% of the country's CO_2 emissions. Since the early 1970's, the Canadian pulp and paper industry has been attempting to reduce CO_2 emissions through increased fuel efficiency and fuel substitution.

The result has seen an increase in the use of biomass as a fuel source from 50% of the total energy consumption to 75%, and a reduction in fossil fuel usage per tonne of production by 50%. The overall costs of such measures have been negligible. It should be noted that burning wood returns the CO_2 previously sequestered to the atmosphere. Burning wood, however, replaces burning of fossil fuels which only result in release of CO_2.

Use of Wood to Replace Energy-intensive Materials

Status: although a large majority of residential buildings in Canada are constructed predominantly of wood, the proportion of wood products used in non-residential buildings is quite low. Construction of residential buildings with wood constitutes a carbon sink. Preliminary estimates suggest that construction of the equivalent buildings with other materials, such as steel, constitutes a net source of CO_2.

The median life span of residential buildings in Canada is 67 years. Upon demolition, more than 90% of the wood goes to landfill sites. Wood products with relatively short life spans include paper products and pallets.

Potential: the overall potential for substitution of energy-intensive materials by wood in non-residential wooden and steel buildings, when the structure is compatible to both materials, has been examined. Up to the completion of construction, harvesting, transportation and manufacture of the wooden building results in emissions of 60% less CO_2 than the steel building. Subsequent impacts of maintenance, heating and life-span are currently being investigated.

Recycling programmes for paper products and pallets have greatly increased over the last decade, although the potential still exists for expansion. Recycling of construction timber is clearly possible and highly desirable. Wooden demolition waste is a clear candidate for burning for energy production.

Costs: under favourable circumstances, recycling programmes may yield substantial profits. Recycling of pallets to produce materials that replace plastics in automobile construction can yield up to a 200% return on investment. However, studies indicate that for a similar recycling programme of residential building timber, a population base of at least 10 million would be required.

Other Greenhouse Gases

Status: information concerning other greenhouse gases is minimal. Certainly methane is emitted from wet organic soils, so the Canadian boreal forest would be expected to be a major source, although non-forested wetlands are probably a far more significant source.

Under some circumstances, nitrous oxide may be a dominant denitrification product following harvesting. However, the end products of denitrification are strongly dependent on complex interactions of solid chemical and physical conditions. Some studies have shown no increase in N_2O emissions from non-forested, compared with forested soils. The net contribution of Canadian forests has not therefore been quantified. Construction with wood, compared with steel, results in 20% less N_2O emissions. Volatile organic compound emissions are slightly higher for wooden buildings, but absolute amounts are negligible. Greater amounts of nitrous oxide will be generated by burning of biomass, compared with some fossil fuels.

Potential and costs: due to inadequate data, the potential for manipulating other greenhouse gases, and costs associated with possible measures have not been quantified.

Technical Considerations

Research on the carbon cycle is still in a very formative stage. Understanding of Canadian forest carbon budgets is continually evolving. Therefore the data on the carbon budget quoted in this paper should be considered as speculative rather than factual.

3.2 Sweden[24]

3.2.1 Status of forests

Sweden has a forest area (according to the National Forest Survey) of 26.7 million hectares which is 65% of total land area. Change in forest land over 40 years is plus 700,000 hectares mostly by conversion of agriculture land. For the next 10 - 20 years a further increase of forest area in the order of up to one million hectares can be foreseen due to conversion of agricultural land.

The total growing stock on all land is nearly 3,000 million m^3 (stem volume including bark). Similar relations as shown for Germany exist with respect to total forest biomass. Total biomass is at least double that of the stem volume of the growing stock. The annual increase of growing stock (over the last 30 years) is about 25 million m^3 per year. Thus total increment is about 95 million m^3, potential cut is about 75 million m^3 and felling about 70 million m^3.

3.2.2 Forest options

Slowing forest damage

Status: there is no evidence of decreased growth due to forest decline so far. A problem of high priority is the acidification of soils in south west Sweden. Estimates of CO_2, NO_x, and VOC situation are not readily available now. Liming programs for slowing the acidification of forest ecosystems are being implemented on a practical scale trial basis using experience from Germany.

Potential: a continued increase in forest biomass according to existing trends can be expected. This is definitely not an action to combat climate change but a development of the forest wealth aimed at (partly) satisfying the predicted increasing demand for forest products at the global level.

Costs: the costs for preventing acidification are high. Decrease of emissions is the only valid long term strategy. The Swedish forest industry is very clean at a global comparison.

Afforestation

Status: the basic policy principle is that land should be used for forestry if it is suitable for forestry and is not used for other more important land uses such as agriculture or provided that forests are not desirable for environmental reasons. Promotion programmes like the German one have existed for a long time.

Potential: a further increase of forest area is foreseen. The German statement on the carbonization effect might relate to an annual estimate. A possible approach to a rough calculation model is that a successful plantation of one hectare might yield about 500 m^3 of growing stock or 1,000 m^3 of biomass over time. This might take 100 years in Sweden but only 10 years in Brazil. It is a possible approach if it is deemed that an annual plantation target is something to use as a criterion. A Swedish belief is, however, that plantations must be justified for other reasons than just for sinking carbon. We believe that the Nordwijk demand target would be reached easily if it was possible to solve the crucial land use and ownership problems. Unless these problems are solved it is difficult to achieve sustainable development based on agriculture and forestry. (Forestry for subsistence and for industrial use.)

Costs: the Swedish forest sector can pay the necessary costs for investment in new production. Out of the total value of industrial wood at mill site 15% is used for investments in new production. About 9% is for replacement and 6% for increased future production.

Increasing biomass in existing forests

Potential: increasing forest biomass is an option for most countries. The reported increase in Sweden is mainly due to increased growing stock per hectare. There are fairly simple models for calculating the options in the case of an even-aged, clearcutting type of forests. The decisive parameters are mean annual increment

24 Submitted by Nilsson, National Board on Forestry, Krylbo, Sweden.

(I), rotation (R) and the fraction which is left for final felling (F). Approximately the following formula can be used:

Mean volume per hectare (in the long run) is equal to I*R*F*0.42. Assume in middle Sweden that I = 7 m^3/hectare/year, that R = 80 years, that F 0.70 (30% is taken out as thinnings). Then the "target volume" per hectare would be 7*80*0.7*0.42 = 165 m^3. Actual volume is 121 m^3. Under these assumptions there is a potential for a further increase of forest biomass. However, there is no reason why an extremely large volume per hectare should be a target. By increasing the rotation period the forests may get too old and become damaged by storm, fungi and other diseases. The damage situation in Europe might to some extent depend on these factors rather than on air pollution. Active thinnings and rotations that are not too long would contribute to healthier forests.

Costs for forestry should be justified mainly by benefits other than the carbonization effect. The problems are how to relate costs to environmental benefits in a wide sense. The more of the costs that can be borne by wood production, the less important it is to find a solution to this very difficult problem.

Increasing yield of existing forests

There is a high standard of forest management in Sweden. However, no sign of decreased adaptation of the management to the actual sites can be seen which would both increase the yield and improve the maintenance of biodiversity. The rapid development towards less harmful technologies and smaller machines offers an important potential. Increased knowledge of ecology and economy with the forest owners is maybe the most important line of action.

Increased use of wood as fuel

The intentions for increased use of wood as fuel are there but the problem is difficult since fossil fuel is relatively cheap. By introducing CO_2 taxes it is possible to influence the development to some extent. There is a high degree of utilization of wood residues in Sweden for energy purposes and discussion is continuing.

Use of wood to substitute energy-intensive raw materials

Replacing other material with wood is an important option in Sweden. A programme to introduce plastics in construction has been started and big disadvantages have been found with that, not least due to the fire risks. Wood is to be considered to be more resistant against fires than most other materials.

3.3 USSR[25]

3.3.1 Status of forests

The USSR has a total land area of 22,403,000 km^2 (= 2,240.3 million hectares). The total forest area amounts to 1,245.2 million ha lands under forest administration, of it 127 million ha are open forests and 814.3 million ha covered with forest vegetation ("closed forests"), corresponding to 36.6%.

Since 1975 the total area covered with forest vegetation increased by about 44 million ha or 1.6% of the total land area. This is due to;

- improved forest resource inventories;
- allocation of lands to the closed forest category;
- afforestation and reforestation of about 2.2 million ha per annum (total about 33 million ha).

The rate of afforestation and reforestation is expected to increase by 4 - 5% per annum over the next two decades. The mean growing stock is estimated to range around 106 m^3 per ha. At a national scale this sums up to 86,000 million m^3. This may correspond with 21 to 22,000 million tons of carbon (26 - 27 t per ha) stored in form of timber.

25 Submitted by von Maydell, Institut für Weltforstwirtschaft und Ökologie, Bundesforschungsanstalt für Forst- und Holzwirtschaft, Hamburg, Germany.

The amount of carbon stored additionally in form of other biomass such as branches, leaves, roots, humus and dead wood should be comparable with figures from Canada. The annual increment ranges around 930 million m^3 or 1.1 - 1.2 m^3 per ha. Annual removals lie around 390 million m^3 (thereof 300 million m^3 industrial wood) in total or 0.5 m^3 per ha annually. This may, however, not be used to calculate an increase of the growing stock, because felling (not removed commercially) and natural losses will have to be considered. However, official figures indicate an increase from about 82,000 million m^3 in 1975 to 86,000 million m^3 in 1990, i.e. 4,000 million m^3 in 15 years or 267 million m^3 per annum. To the storage rate of carbon, this would mean an annual increase of 66 million t at the national scale.

3.3.2 Forestry options

Afforestation: forest area (covered with forest vegetation) in the USSR increased by afforestation and reforestation activities since 1975 by 33 million ha. However, the main part is due to reforestation (natural regeneration about 1.2 million ha per annum, direct seeding or planting about 1,0 million ha are the only indicators). The trend is likely to increase slightly by 4 - 5% per annum. No reliable figures are as yet available on the real net expansion of forests. Afforestation costs are - due to the economic system - not suitable for comparison with other countries.

Increase of forest biomass: biomass of existing forests in USSR forests is relatively low, especially in the northern regions of tundra to boreal forests, in the southern steppe to semi-desert regions, vast parts of Siberia, and at high elevations. In the USSR about 90 to 100 million m^3 of wood (forest) fuelwood and an unknown amount of industrial wood waste, recycled wood, etc. are used to produce energy. This is well over a quarter of all wood harvested annually (unrecorded fuelwood harvest not included).

4 SUMMARY AND CONCLUSIONS: ASSESSMENT OF FOREST OPTIONS FOR TEMPERATE AND BOREAL ZONES AT A GLOBAL SCALE[26]

4.1 Introduction

Forests provide mankind with many ecological and socio-economic benefits. They supply raw materials, such as wood which is an important renewable resource for construction and energy supply as well as other non-wood products such as food. Forests have important protective and recreational functions and the purpose of preserving natural living conditions. This is true for flora and fauna for which forests in many cases are a final refuge as well as for indigenous populations living in forests: it is also true for industrialized populations who depend on the benefits of forests such as filtering of air and water, protection against erosion, avalanches and flooding (especially in mountainous areas). Furthermore, in densely populated urban areas the recreational and environmental function is particularly important. In addition, the forest ecosystems of the world are of essential importance for atmospheric dynamics and for global circulation processes of air, water and carbon. The analysis which follows gives an overview of the potential, feasibility and costs of forestry options in temperate and boreal zones with special emphasis on the mitigation of the effects of global climate change.

An assessment of valid figures on forestry options at a global scale is difficult. This is due to the fact that forests, forestry measures, and therefore their potential, feasibility and costs depend on local environmental and socio-economic conditions which differ from region to region and from country to country. Thus, the approach which we have used to get meaningful estimates is to gather and collate information on regional scenarios or national case studies. Questionnaires were sent to 35 countries and to date 14 responses have been received. The global scope of the options discussed are based on data from these responses. Further data are needed to improve the precision of the information. At present, information has not been received from the USSR and the southern hemisphere, among others.

The ranking, or the choice of forestry options should be based on an evaluation of costing the full range of economic, ecological, social and spiritual values and services associated with forests. However, economic science is not, at the moment, able to value some of these elements (e.g. conservation of biodiversity), although it has made significant progress in recent years. Individual countries assign values to different forms of forest use on the basis of national priorities. Individual countries are at different stages in the

26 Editors note: This section was revised after the discussions during Track 1 in Bangkok.

development of methodology for costing forest options. However, further work is necessary to provide a consistent basis especially for costing global forest options. In order to give some indication of comparative costs, the options have been costed using market values.

It is important to stress that, although forests have an important role to play in managing climate change, the control and reduction of the consumption of fossil fuels and thus the release of man-made greenhouse gases into the atmosphere is the most effective way to combat or mitigate the effects of global climate change. This is especially a challenge for the industrialized countries with an extremely high energy consumption per capita.

4.2 Status of forests in temperate and boreal zones

Available information of the status of existing forests is contradictory. FAO data differ considerably from data provided in national case studies. For example, the Canadian forest authorities state a total forest area in Canada of about 441 million hectares (boreal and temperate) and a productive forest area of about 233 million hectares. The FAO quotes about 264 million hectares of productive forests for Canada. The same is likely to be true for the USSR. Experts quantify the boreal forest area of the USSR of approximately 800 million hectares. FAO states 673 million hectares. The reasons for these considerable differences need to be examined. The calculations relating to forest area are based on FAO data.

According to FAO data approximately 767 million ha of forest belong to the temperate zones. This equals 13% of the total land area of temperate zones. Forest area in boreal zones amounts to about 920 million hectares, which is 47% of the total land area of boreal zones. It is estimated that over the last 10 years the total wooded area in the temperate and boreal zones increased by about 12 million hectares or 0.6% of forest area, respectively.

The mean growing stock of temperate forests is estimated to be about 50,000 million m^3, and 50% of it is fixed carbon. The same amount of carbon is additionally stored in branches, leaves and humus etc. The total amount of carbon stored in temperate forests is estimated to be about 25,000 million tons. This equals approximately 30 tons of carbon per hectare in commercial growing stock.

Compared to this, the carbon storage of boreal forests is high: for example in Canada, the growing stock average is about 106 m^3 wood/ha. The total carbon storage is recorded about 209 tons of carbon per hectare. This is due to the high carbon fixation in humus and peatlands. If these figures are representative for the whole boreal zones, approximately 190,000 million tons of carbon (total) are stored. At the moment information about the net change of biomass and stored carbon in temperate and boreal forests is incomplete.

4.3 Forestry options in temperate and boreal zones

Preliminary assessments of potential and costs of forestry options in temperate and boreal zones to mitigate global warming can be summarized as follows (estimates are based on the best data available, figures of carbon storage refer to the carbon fraction stored in growing stock). It is pointed out that it has not been possible to include potential impacts of global climate change on forest ecosystems and their beneficial functions (including the potential to fix carbon) in this assessment.

4.3.1 Slowing deforestation and forest degradation - Preserving existing forests

Status: despite all uncertainties it would seem that management and maintenance of existing forests is the most effective approach in terms of carbon fixation, costs, and ecological aspects. Strategies to manage and maintain forests have the advantage of immediate beneficial impacts compared to other options. Consequently, all strategies to strengthen this aim should be taken and/or continued.

Potential: slowing deforestation and forest degradation bears an enormous potential to keep carbon stored in biomass. For temperate zones there are about 25,000 million tons of carbon (total), for boreal zones there are additionally 190,000 million tons. This can be achieved by:

- implementation of sustainable forest management systems;
- halting conversion of forest areas to non-forestry purposes;

- conservation or ecologically appropriate management of boreal and temperate primary forests.

The first step to implement sustainable forest management is to reforest areas which have been felled or destroyed (e.g. by fires or pests). Reforestation includes natural regeneration as well as planted regeneration such as tree planting. Intervention management should be based on the principles of ecological sustainability and should be supported by sound scientific data on the local forest ecosystem.

Deforestation can result from loss in forest quality, as well as loss of forest area. Regeneration of low productivity forests should therefore be avoided. Due to the large areas destroyed annually by fires and pests in the boreal zone, the potential for major losses of biomass is immense but temporary. Fires are an essential component of boreal ecosystems.

Costs: maintaining forest ecosystems requires programmes to cope with threats such as forest fire, pests, air pollution etc. For example, in the United States, over US$ 500 million were spent to prevent and control forest fires in 1989. Programmes to stabilize the German forests with regard to the new type of forest decline cost about 80 to 90 million US$ per year. When calculated on the basis of cost per ton of carbon remaining fixed the relative costs appear much more reasonable. However, for an accurate assessment of cost-effectiveness it would be necessary to quantify the reduction of the amount of carbon released to the atmosphere as a result of these programmes. At present, such calculations are not available.

Further research into the allocation of carbon in different components of the forest ecosystem, as well as improved monitoring and assessment are required.

4.3.2 Afforestation

Status: at present, the data available on the recent afforestation rate in temperate and boreal zones are incomplete and of variable precision. Figures of afforestation and reforestation in many cases are mixed. Therefore, some definitions should be given for clarification: Afforestation is the establishment of new forest on land not covered with forests in the recent past. Reforestation is the regeneration of forests that have been destroyed (e.g. by fires, pests, etc.) or felled. The aspect of reforestation is covered in the option dealing with preserving the status of existing forests.

Potential: the feasibility for afforestation of potential areas differs from region to region and from country to country.

For the boreal zones, the potential to increase the forest area is marginal. In these zones the forests cover on average about 47% of total land area. Most of the remaining land area is environmentally incapable of supporting forest ecosystems.

In the temperate zones, substantial areas might theoretically be available for afforestation during the next several decades. A conservative estimate indicates that an annual afforestation rate of about 4 million hectares might be feasible. An average yield of about 1.0 m3/ha/year assumed this would result in an additional uptake of carbon of about 22 million tons per year (averaged over a decade).

In some countries considerable opportunity exists for tree planting outside the forest estate on lands where forestry is not the prime land use. Examples include urban plantings for improved amenity, agroforestry, and plantings on rural lands for shelter belts or to address land degradation.

Costs: at present, plantations account for most of the afforestation in temperate zones. Plantation costs (excluding management and road construction) differ considerably from region to region, depending on site conditions, tree species, and socio-economic factors (i.e. wages). Consequently, any reliable cost estimate for afforestation has to take these factors into account.

Plantation costs in China and in the United States are calculated about US$ 400/ha. For Eastern Europe, no data are available at present, but may be estimated to be the same. For Western Europe around US$ 3,000/ha are reported on average. However, a conservative estimate could be done on the above assumption that an annual afforestation rate of about 4 million hectares might be feasible, although this figure requires further analysis. If this is assumed, funds might be needed of the order of about US$ 2,300 million per year.

If these costs are calculated per ton of fixed carbon the calculations are around US$ 100/t/year for the temperate zones. Costs for afforestation are relatively high compared with costs for activities to maintain existing forests.

However, afforestation is important for other reasons. For example to produce additional wood to substitute fossil fuels or raw materials such as steel, aluminium etc. as well as for the multiple beneficial functions forests can fulfil. Another option is to allow natural succession, making use of natural regeneration. This approach can substantially reduce costs, although the time taken to derive benefits may be longer. Implementation of this option depends on production and ecological targets. Often control of fires, weeds and livestock is needed to accomplish this option.

4.3.3 Increasing biomass in existing forests

Status: the existing forests in temperate zones store about 50,000 million m^3 of wood in total and contain 25,000 million tons of carbon for the whole biomass. This corresponds to approximately 36 tons of carbon per hectare (total), or approximately 70 m^3 wood/ha on average. For example, in China the total carbon storage of the forests is estimated around 46 tons of carbon/ha, in Germany around 140 tons. This situation corresponds with the actual age and use of the forests in the different regions and countries.

Compared to this, the carbon storage of some boreal forest ecosystems is high: in Canada the total carbon storage is recorded about 395 tons of carbon per hectare (total). This is largely due to a high carbon fixation in humus and peatlands. Although these figures are as yet tentative, if it is used as a basis for the whole boreal forest ecosystem, approximately 180,000 million tons of carbon are stored.

Potential and costs: In general, there is significant potential for increasing biomass in existing forests, especially in young, understocked, overlogged and/or misused forests. Nevertheless, the potential for increased storage of carbon can be estimated as approximately 15-20 million tC/yr in boreal ecosystems and 100 to 150 million tC/yr in temperate forests. It is important to note, however, that increases in biomass resulting from a better balance of age classes will be temporally limited.

4.3.4 Increasing yields of existing forests

Status: insufficient information is available on the yields of actual forests in order to allow the potential of increasing yields to be adequately assessed.

Potential: as a conservative estimate it is pointed out that the approach to increase yields of actual forests is not a feasible option for large areas within the next decades. This is due to the actual tree species, age classes, silvicultural regimes, site conditions etc. to be found in forest ecosystems. Additionally, adverse effects on ecosystems have to be considered (monoculture, loss of genetic resources etc.).

Costs: since this is not a feasible option for large areas no cost estimates have been done.

4.3.5 Improved use of wood

Status: looking at the global carbon cycle it is essential not to destroy forest ecosystems through overcutting or other unsuitable practices. Any wood to be used within this option should be produced and harvested in a sustainable manner.

The use of wood is the interactive factor between wood production and fixing carbon in forest ecosystems on the one hand, and the long-term storage of carbon on the other. If wood remains in forests, it deteriorates and releases the carbon stored after a few vegetation periods, and the long-term carbon storage is balanced. If wood is removed and used for long-term products, such as construction or furniture, carbon is sequestered for decades and sometimes centuries. Further, management involving thinning is important for maintaining stands of high productivity and stability.

Value adding processes which maximize the proportion of long-term products derived from harvested wood can further increase the carbon store. The development and application of technologies for more efficient use of wood residues and lower grades of timber should be encouraged.

Potential: wood is an environmentally friendly raw material and fuel. The forecasted increase in world demand for wood may best be met through increased wood production in combination with a more effective use of wood, rather than substitution by non-renewable materials such as concrete, plastics, steel and aluminium.

Case studies in Canada have indicated that maximising the use of wood in construction results in a reduction of 50% in CO^2 production and 20% in NO^2 production, compared with traditionally used materials. These figures incorporate all aspects of production, transportation and processing, but do not include subsequent maintenance. Similar studies have been conducted in Japan.

The use of wood as an energy source to replace fossil fuels also holds enormous potential. Studies have indicated that up to 25% of total energy needs of Canada could be supplied by biomass from forests. This assumes no wastage during harvesting, transport and processing. However, this may have adverse effects such as reducing subsequent productivity of the forest.

Recycling of paper and paperboard is a potentially valuable option in temperate and boreal zones, especially North America. For example, the American Paper Institute has announced a target recovery rate of 40% for paper and paperboard consumption by 1995. If this 40% goal is achieved and maintained through 2040, the demand for pulpwood will be reduced and plantations may be allowed to grow longer for sawn timber rather than pulpwood use.

Wood also has the potential to replace more energy intensive raw materials. For example, recycled wood fibre from non-paper products such as hardwood pallets is already replacing plastics in the Canadian automobile industry. This initiative has resulted in a 200% return on investment. The success of the previously mentioned options will result in more wood from temperate and boreal zones in the long term. At present, estimates of neither the possible amounts nor the costs are available. However, this option will add to the benefits of increased carbon fixation.

4.4 Needed evaluation and research

There still is a lack of essential information on potential, feasibility and costs and benefits of forestry options to mitigate the global climate change at a national as well as at the global level. Due to gaps of information and lack of knowledge the data given within this report are not sufficient to get reliable estimates at a global level. This report identifies priority areas for further investigations and evaluations to close identified gaps.

Therefore, countries are asked to evaluate the data in question first at national level. Additionally, research should start to clear some essential scientific questions. The results should be collected and on this basis the above analysis at global level should be revised and completed.

This report assesses the potential and feasibility of forestry options in temperate and boreal zones. How these options compare, in terms of their cost-effectiveness, with the same or other options in different zones is beyond the scope of the report. This is, however, an important issue, which raises other questions about the national and international mechanisms which might be used to implement options in the various zones. Further, essential information is also required on the potential, feasibility, costs and benefits of forest management options in the temperate and boreal zones to address the wider range of priority economic, environmental, social and spiritual values and services associated with forests.

Table 4: Current status of forests in temperate and boreal zones (Figures summarize only carbon fraction fixed in growing stock; adverse effects of global climate change not integrated)

	Potential/year			Costs		
	m ha	tC/ha	m tC	$/ha	m $/yr	$/tC
Canada & Alaska	203	34[28]	6,900			
Nordic Countries	44	30	1,300			
USSR[27]	673	27	18,300			
Boreal zones	920		26,400	[29]	[26]	[26]
America	311	40[24]	12,400			
Asia (excl USSR)	188	20	3,800			
Western Europe	59	43[30]	2,500			
Eastern Europe (incl USSR)	152	33[24]	5,000			
Others	57	30[24]	1,700			
Temperate zones	767		25,400	[26]	[26]	[26]

Table 5 Afforestation options in temperate and boreal zones (Figures summarize only carbon fraction fixed in growing stock; adverse effects of global climate change not integrated)

	Potential/year[31]			Costs[32]		
	m ha	tC/ha	m tC	$/ha	m $/yr	$/tC
Canada & Alaska	+/- 0.0					
Nordic Countries	0.01					
USSR	+/- 0.0					
Boreal zones	+/- 0.0	-	-	(700)	-	-
America	+ 0.06	2.0	6.6	400	240	36
Asia (excl USSR)	+ 3.0	0.6	9.9	400	1,200	121
Western Europe	+ 0.25	2.0	2.8	3,000	750	272
Eastern Europe (incl USSR)[33]	+/- 0.0	-	-	(400)	-	-
Others	+ 0.2	2.0	2.2	400	80	36
Temperate zones	+ 4.0		22.0		2,300	100

27 Experts estimate

28 Canadian studies carried out a 8 to 12 times higher carbon fixation in total biomass of boreal forest ecosystems.

29 At present no assessment possible.

30 German studies within the International Biological Programme (IGB) carried out a 2 times higher carbon fixation in total biomass of temperate forest ecosystems.

31 Tree planting outside forests (i.e. urban tree planting) not considered.

32 Establishment costs only, not included: management, road construction, ground fees etc.

33 Experts judgement: At present, afforestation seems not a feasible option as a result of the complex environmental situation in Eastern Europe.

Table 6: **Increase forest biomass in temperate and boreal zones - mainly by improved silvicultural management (Figures summarize only carbon fraction fixed in growing stock; adverse effects of global climate change not integrated)**

	Potential/year			Costs[34]		
	m ha	tC/ha	m tC	$/ha	m $/yr	$/tC
Canada & Alaska		0.03	5-6			
Nordic Countries		0.15	6-7			
USSR[35]		0.01	6-7			
Boreal zones			17-20	?	?	?
America		0.2[32]	50-70			
Asia (excl USSR)		0.1[32]	15-20			
Western Europe		0.4	22-27			
Eastern Europe (incl USSR)[36]		0.1[32]	13-17			
Others		0.15	10-14			
Temperate zones			110-150	?	?	?

34 At present no assessment possible.

35 Experts judgement.

36 Experts judgement: At present, afforestation seems not a feasible option as a result of the complex environmental situation in Eastern Europe.

Summary of Track III: Temperate and Boreal Forests

T Boyle[1]

1 German position paper

Mr Volz described the methodology and results of the German survey of temperate and boreal forests. Questionnaires had been sent to 35 countries having significant areas of temperate and boreal forests, and responses received from 14. Significant omissions were the US, the USSR and China.

Considerable time was spent discussing the problems of data comparison. Definitions and methods of storing data vary from country to country, making it difficult to compare data from different countries. For example, Canada reported surprisingly high figures for carbon stored per hectare, but this is because totals for all biomass were estimated, in contrast to other countries for which only tree biomass, or only above-ground biomass, was reported.

At this point, the question arose as to whether forest management options were being considered only for climate change, or for all functions of the forests. The Canadian view was that forest options for climate change made little sense if other functions of forests were ignored. Alternative views were expressed by the UK and Germany. It was agreed to discuss climate change in isolation, but note that policies with regard to other functions might significantly affect the feasibility of the options.

2 US situation

Mr Kaiser provided an illustrated summary of the situation and options in the US for forest management to alleviate climate change. A major opportunity stems from the abandonment of large areas of marginal agricultural land in the south and south east. Taking into account technical limitations on the rate of afforestation, there would appear to be the potential to afforest several million hectares over the next ten years. The government's programme to plant a billion trees over ten years will also make a significant contribution.

3 USSR situation

Mr Dixon provided some information on the forests of the USSR, based on information received from US/USSR exchange visits. Yields of Soviet forests are very similar to those of other boreal areas, and the harvest expressed on the basis of forest area is also comparable. A surprisingly small area is apparently lost to fires, and a high proportion of harvested area is artificially restocked. Mr Dixon emphasised that because of the different economic system of the USSR, and uncertainties over exchange rates, economic comparisons of cost effective forest options are not really possible. Some present also questioned the accuracy of the figures reported. Nevertheless, it appears that while the forests of the USSR obviously account for an enormous amount of stored carbon, there is comparatively little opportunity for afforestation or otherwise increasing the yield of forests.

4 Japanese situation

Mr Aoyagi described the potential for forest management in Japan to ameliorate climate change. Much of the forest cover of Japan remains intact, but substantial improvements in productivity have been achieved through improved forest management techniques. Because of this, the opportunities for further progress are limited.

5 Review of German paper/Formulation of report

Each paragraph of the German paper was reviewed, incorporating new information where available, and this

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was used as the basis of the working group report.

For the introduction, it was concluded that four critical points should be emphasised:

- forests fulfil an immense variety of functions;
- forest options are not an alternative to reducing emissions in ameliorating climate change;
- the assessment of options is incomplete - further analysis is necessary;
- there is at present inconsistency in reporting of data.

Five types of options were recognised as being most promising for forest amelioration of climate change:

a) Slowing deforestation and forest degradation. Due to the enormous carbon reserves of existing forests, maintenance of these is very important to avoid even greater climate change.

b) Afforestation. Possibility of up to 4 million ha/yr, mainly in US and China - for other countries, possibilities are limited to competition from other land uses (temperate zone) or lack of environmentally suitable land (boreal zone).

c) Increasing biomass. Intensification of management could yield benefits in terms of increased biomass.

d) Increasing yields. Only locally possible - not a major contribution.

e) Improved use of wood. Potentially a major contribution, but little data is available. Most of the detailed studies have been conducted in Canada (FORINTEK), and have shown substantial improvements in net CO_2 emissions by increased use of wood in construction. Also, use of discarded pallets in producing substitutes for plastic is commercially viable. Recycling studies in US also demonstrate economic viability.

For all of these options, the costs and financial benefits were discussed as fully as possible. Lack of data and problems of comparability limited conclusions.

The working group concluded that further work was required in obtaining more national case studies and improving the quality and consistency of the data. It was decided that the authors of the original German paper would seek further information and incorporate it into a new and improved version. The need to consider the impact of these options on the other functions of forests was also noted.

The RPA Assessment and Program: Forest Planning in the USA

Fred Kaiser[1]

ABSTRACT

US forestlands are a valuable resource, not only for raw materials for paper and building industries, but also as a source of high-quality water, for tourism and recreation,as a habitat for fish and wildlife, and to ensure biodiversity and carbonsequestering. There has been little political awareness of the important role of the forestlands in the US, and until recently there were no long-term goals or consideration in the Federal Government's annual budget process. US Congress passed the Forest and Rangeland Renewable Resource Planning Act (RPA) to provide a framework for the future. The Act requires the US Forest Service every five years to conduct an ASSESSMENT of the condition and use of the nation's forestlands and prepare a long-term PROGRAM in response to this assessment. The objectives are:

- to gather and assess facts on the forest lands;
- to set goals for the use of the lands;
- to keep long-term needs in focus;
- to revise the plan regularly;
- and to commit sufficient funds to programs to implement plans.

The RPA Act calls for an overall planning system for the forestlands. The Assessment and Program chart the long-term course of management of national forests, assistance to State and private forest landowners, and research. The Assessment primarily deals with trends in supply and demand of renewable resources, evaluates the impact of these trends, and identifies improvements in forestland management in response to these trends. The Assessment revealed issues needing immediate attention including threatened species, biodiversity, global climate change, and the compatibility and conflict of multiple resource uses. To develop a Program in response to the Assessment, it was necessary to:

- review current direction of existing plans;
- establish the role of Federal Government, the principal natural resource issues of public concern; and the long-term strategy guiding Federal Government actions to 2040.

From this process, four high-priority themes were developed:

- enhancing recreation, wildlife and fisheries resources;
- ensuring that commodity production in environmentally acceptable;
- improving scientific knowledge of the natural resources;
- responding to global resource issues.

Caring for forestlands is an evolving process, combining the long-term rhythms of nature with the changing needs of people. The RPA provides a framework within which both aspects can be dealt with. It was a step forward in the US, and is worthy of consideration elsewhere.

1 USDA Forest Service, Washington DC, USA

3 International and Global Issues
3.1 Options

Options for the Coordination of International Action on Forest Conservation and Management

Caroline Sargent[1 2], M Lowcock[3 4]

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1 INTRODUCTION

This paper assesses international forest options identified by the Preparatory Committee, and examines the international approaches currently being used and developed to address them. The issues identified were: forest conservation including fire management, under which heading we have also included a short section on climate; reforestation of degraded lands; natural forest management; trade issues for sustainable development; forestry guidelines as prepared by ITTO; the financial and technical assistance needs of developing countries; the reforestation and afforestation targets set out in the Noordwijk Declaration; the TFAP as a coordinating mechanism; and the potential for an international forestry instrument. We have considered it important that the contributions of such organisations as the International Panel on Climate Change, the World Food Programme and the activities of international NGOs towards rational use of forests should also be discussed, and have included short sections on these.

2 FOREST CONSERVATION

In this section we outline the issues to be considered in developing rational international strategies for conserving forests. We take as our precept that costs and benefits of environmental conservation must be identified and quantified carefully. It is essential that there are international economic incentives for forest conservation, in view of the fact that countries with large amounts of biologically-diverse forests are usually poor. As other countries take advantage of the global benefits, a share of the net costs of incentives need to be borne by these other countries. Incentives should recognize that - even if there are national benefits to be gained from conserved forests - the costs of global services must also be met. The draft revision of the World Conservation Strategy (June 1990) estimates a requirement of US$ 52 billion over 10 years to 2000 to "reduce deforestation and conserve biodiversity". Such assessments are perhaps of limited value: the main need is to identify costs and priorities at a country level, for example through national forest action plans.

2.1 Climate Change

The report of the Intergovernmental Panel on Climate Change (IPCC) in August 1990 concluded that emissions of greenhouse gases from human activities will result in additional global warming. The main greenhouse gases are carbon dioxide, methane, CFCs and nitrous oxide. Of these, CO_2, principally from the burning of fossil fuels and deforestation contributes about half the total effect. Increases in the atmospheric concentrations of greenhouse gases are thought to have contributed to an increase in global mean temperature of around 0.5°C since the start of the industrial revolution. If no actions are taken to limit emissions or to increase sequestration, the IPCC estimate that global temperatures will rise by 1°C by 2025

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and 3°C by the end of the next century. This would be the hottest the earth has been for some 100,000 years. However, it is not only the maximum temperature which is of concern. It is the rate at which temperatures rise which will determine the ability of the biota to adapt to the changes. The IPCC estimate the rate of increase to be 0.3°C per decade, which would be faster than anything we have experienced within the last 100,000 years. Estimates of the ability of boreal forests to adapt to increase in temperature suggest that the rate of increase would need to be restrained to 0.1°C to avoid significant loss of forest areas.

There is a great deal of uncertainty about global warming. It is not known how sensitive climate is to changing atmospheric pressures of radiative (greenhouse) gases; there are insufficient data or understanding of sequestering processes of the relative 'sink' efficiencies of temperate or tropical forests, grasslands or oceans - indeed most calculations of the global carbon balance indicate that there is a 'missing sink'; it is not known how warming will change climatic patterns or the distribution of vegetation; there is little certainty about the rates at which biological species and systems will be able to evolve or respond to rates of change. Nevertheless, it is established that any climate change is likely to be irreversible except in the very long term, and it is clear that whatever effects such change may have will have to be borne by future generations.

2.2 Biological Diversity

Biological diversity (biodiversity) is the variety and variability of all animals, plants and microorganisms on earth. It can be expressed as the number of different items and their relative frequency at three main levels; ecosystem, species and gene. Tropical forests are the most diverse of the terrestrial ecosystems on all three counts; they may account for 50% - and perhaps as much as 90% - of all species on Earth. Indeed, all of the dozen so-called "megadiversity" countries, which harbour about 70% of all known species, contain tropical forests. Forests outside the tropics are also amongst the richest ecosystems in those areas. Temperate rain forests, tropical dry forests and tropical moist forests are amongst the most threatened ecosystems in the world.

Tropical forests are being rapidly degraded and destroyed, and have the lowest proportion in protected areas of any major biome. One global estimate is that approximately 4.5% of tropical forests are protected worldwide in national parks or nature reserves (WWF, 1989); lately, further areas of tropical rain forest have been gazetted - perhaps 6-7% of tropical rain forest is now under legal protection (Sayer, IUCN, pers comm 1989). Climate change will also threaten biodiversity, especially the security of existing protected areas; it is important to consider this in taking decisions on the siting of new areas. However, even the limited system of protected areas is highly insecure - while many exist in legislation, there are severe problems of implementation. Although protected area establishment and management are priorities, biodiversity must also be conserved in managed forests outside this network. The protection of a few very large areas alone cannot secure the tremendous diversity of the biome as a whole.

Forest biodiversity is important globally to sustain economic productivity, for human life support and welfare, for response to global and local climate change, and for ethical and aesthetic reasons - the survival of a multitude of life forms is given particular attention in the World Charter for Nature. Since forest generate global benefits, there is a sound rationale for international collaboration in conservation. Because deforestation and the loss of biodiversity resulting from physical mistreatment of the forest at the local level may be affected by economic and policy signals at the international level, there is a further rationale for international collaboration. We can depict seven main constituent tasks of forest biodiversity conservation - protection, inventory, screening for potential uses, the development of those uses, management of the biodiverse resource, and monitoring. International efforts at standard- and goal-setting, co-ordination, information sharing, and material/technical/financial support to individual nations can play a useful role in each of these areas.

In addition to direct provision of resources by donors, efforts should be made to maximise possible direct income from biodiversity conservation in forest countries. Another approach is to realise the latent "existence" and "option" values held by the public for "wild" forests into usable revenue. Wildlife charities have been doing this for years. In any event, it is widely agreed that resources need to be channelled to the biologically-rich, financially-poor tropical countries if they are to tackle biodiversity loss successfully.

2.3 Human cultural conservation

Tropical forests are important human and cultural environments. Between 1.4 to 2.8 million indigenous forest peoples depend upon tropical forests for their living and working environment, as do between tens of millions of other people who do not claim ancestral ties to the forest, but who make their home there today. Their many cultures and wide knowledge of habitats are a global asset. Not least is their often unparalleled knowledge of how to sustain life in all respects through the management of tropical forests, which is invaluable for biodiversity conservation.

2.4 Fire Management

Fire destroys an average annual 3 million hectares of forest globally, with significant consequent increases in atmospheric CO_2, NO_x, N_2O, CH_4, non-methane hydrocarbons and other gaseous, aerosol and particulate air pollutants. Smog-like photochemical reactions produce high ozone concentrations comparable to those of polluted industrial areas. Large fires produce atmospheric change of regional significance, and the greater areas of forest burned globally in the last two decades has increasing consequences for the global atmosphere and climate.

Although forest fires now appear to influence the global climate they do not appear to be **globally** significant causes of loss of biodiversity. Indeed, many woodland ecosystems depend upon occasional fire to maintain diversity. Fire must not therefore be considered solely as a problem, for it is also a useful forestry and agricultural management tool.

Statistics on forest fires are not kept systematically in Asia, Africa and Latin America. In any one year, great forest fires are likely to occur, but they will be concentrated in different countries each year - unless there are prevailing economic and policy circumstances that encourage deliberate fire from year to year (as has been the case in the Amazon until recently). In 1982-3, an estimated 3.6 million hectares were burned in Kalimantan, and 0.35 million hectares in Italy; in 1985, 0.5 million hectares in Spain; in 1987, about 8 million hectares were burned in the Brazilian Amazon, and 1.2 million hectares in China. In the USA and Canada - despite highly sophisticated prevention and control methods - more than 2.3 million hectares burn annually (in 1990 over 7 million hectares burnt in Canada.

Forest fires may be the consequence variously of climatic factors, such as drought and lightning; of deliberate human activity, like land clearance, hunting and slash and burn farming; or of human activities that predispose the forest to fire, such as poor forest management and recreational fires. Increasing concern with the conservation and wise use of forest resources in recent years has been paralleled by improved efforts to control fire. Almost all countries now have a national forest fire service. Large countries clearly can afford fire protection, expecting a significant fire at frequent intervals. Yet figures show that only in the very large countries is fire control financially cost-effective (FAO, UNECE quoted in World Resources 1988-89); estimates of environmental losses are rarely included in cost-benefit analysis.

Further work is required on strategies for international intervention in wildfires of global significance. Such strategies might cover inter alia: minimum size and global importance of the site; earliest and latest permissible timing of intervention; when to intervene in fire-dependent forest types of biodiversity (where small fires are required for biodiversity/forest management, but where wildfires can lead to destruction). There are many limits to the possible scope of global co-operation in practical field situations. In Europe, however, there has been significant international co-operation in fighting wildfires, and a European multinational fire-fighting force is being considered. In general, this is an area where there may be a role for remote sensing techniques;

A key issue is how to reconcile the marginal cost of global co-operation in forest fire management with the marginal benefit of extra global forest services conserved (CO_2 store/sequestration and biodiversity). The notion of global fire insurance might be examined and consideration might be given to whether there is scope for action under the GEF and other assistance programmes for the prevention and control of fires. There is also need for better dissemination of guidelines on fire as a management tool and fire as a problem; and on how to balance equipment-intensive fire-fighting strategies with fire prevention strategies. FAO's forest fire technical assistance and forest fire statistics service may have important lessons here. Regional schemes might be developed to reinforce national institutional capabilities for fire-fighting capabilities.

3 FOREST LAND DEGRADATION

Land degradation may be defined as the diminution of the biological productivity and diversity expected of a given tract of land. Little progress has been made towards a global assessment of the extent of land degradation, although efforts have been made through the UN Plan of Action to Combat Desertification. The indications are, however, that land degradation is increasing, particularly in both dry and moist tropical forests (WRI: World Resources 1988-89). Thus far, the problem has often been ignored because many nations have sufficient land available to meet increasing demands. However, by 2025, the global population is likely to have increased by 3 billion, over 90% of whom will live in the tropics. The limits of current land-degrading development activities are likely to become apparent soon - with the potential consequences including famine, impoverishment and insecurity that could effect the stability of societies and ecosystems globally.

Principal land degradation threats are:

- over exploitation of carrying capacity, population pressures, and shifts in weather patterns;
- deforestation and overgrazing in dry lands (causing an estimated annual loss of US$ 26 billion in agricultural output alone); this is frequently termed "desertification";
- soil erosion and infertility in areas which have been completely cleared of tropical moist forest;
- extensive damage to much of the remaining tropical moist forest, through, inter alia, poor logging practices and itinerant cultivation;
- degradation of temperate forests and forest soils through, inter alia, industrial air pollution;
- erosion in mountainous areas, through both natural geological activity and agriculture;
- soil degradation in irrigated land (waterlogging, salinisation and mineralization);
- soil sterilization as a result of mine and industrial operations and the disposal of solid waste, including hazardous waste.

All the above forms of land degradation are already of considerable regional consequence and there is a clear role for the international community to help address this problem through aid programmes. The fact that land degradation usually affects poorer and less influential people in remote areas has contributed to neglect of the problem by national leaders. However when land degradation precipitates a transnational crisis (as in the Sahel) substantial resources have been invested in tackling it.

Land degradation may have global aspects where:

- it is a direct result of policy and economic signals set globally;
- it results in such a massive erosion of soil, degradation of the watershed, and extinction of biological productivity that (a) the agricultural resource base of large populations is undermined, threatening famine, civil unrest and environmental refugee problems - and hence possible consequences for international security; (b) alterations in global climate are precipitated; and (c) biodiversity is severely diminished in areas of global importance;
- the needs for land rehabilitation and restoration, for humanitarian reasons, are so greatly beyond the means of an individual country that international assistance is called for. This will especially be the case where major climatic factors have been responsible for triggering degradation.

Tackling land degradation will involve: **preventing** continuing syndromes of degradation; regaining and maintaining the **productivity** of the land; ensuring **sustainability** in future resource/land use; and establishing **equity** in distributing the benefits. Only in certain respects will this demand global co-operation.

GEMS and FAO have made very modest beginnings at monitoring land degradation, but global monitoring needs to be made more effective. Monitoring is essential for governments to assess the extent of the problem. Technical guidance is also required: IUCN has issued Guidelines for Recovering Degraded Land (1987), but efforts are needed to co-ordinate technical assistance work with respect to land degradation, rehabilitation and restoration.

4 TRADE

Harvesting of both timber and non-timber products from the natural tropical moist forest has too often mined the resource, with inadequate re-investment of profits in future productivity of the resource. In some cases, buoyant markets for forest products may have facilitated over-harvesting and sometimes even (near) extinction in the wild: over-exploitation of islands rosewoods in the Caribbean in the 18th century and slaughter tapping during the *Landolphia heudelottii* rubber boom in Africa in the late 19th century, may be examples of this.

In others, markets have helped foresters to intensify management. Strong domestic markets for charcoal and local sawnwood in Trinidad and Uganda, for instance, allowed forest managers to manipulate the canopy in order to concentrate forest growth on the desired timber species in a cost-effective way.

The implications are clear: where a management infrastructure is in place, strong markets for forest products can be conducive to good resource management, but where such an infrastructure is absent they may provoke overharvesting. Therefore, there are two questions that need to be addressed:

- how can the trade contribute to increasing the amount of forest under sustainable operational management?

- how can the risk of possible negative impacts of trade be minimised?

It must be in the long-term interest of developing countries to manage their forest resources sustainably, but importing countries might:

- establish criteria to define the term "sustainably produced timber" (or other forest products);

- distinguish sustainably produced timber from non-sustainably produced timber in the market; either by labelling the former to allow the consumer to take an informed decision on what to buy, or by more centralised measures to restrict access to markets of the latter.

The disadvantages to this approach are numerous. Firstly, there are many factors that are important in the sustainable production of tropical timber, and assessment of all the parameters governing these factors would not yield a simple 'yes' or 'no' answer.

Secondly, unilateral moves to judge the forest management record of a producer country and restrict access for its timber to the market might be counterproductive in many ways. Such moves might be in conflict with international agreements such as GATT; they might obstruct constructive dialogue; and they might not have the desired impact, considering the size of producer country domestic markets and new importing markets such as India and China.

Thirdly, a recent report for the ITTO has concluded that tracing and authentication of tropical timber is extremely difficult, especially in the case of processed products, and devising a system for doing this might imply the creation of costly and laborious bureaucracies. Given the complex structure of the trade, it would be very difficult to rule out malfeasance.

A solution that has been advocated in relation to tracing and authentication is to pay a premium price for sustainably produced tropical timber and other forest products. There are many problems associated with this idea. Firstly, it might be in conflict with GATT, which seeks to reduce tariffs on global imports and exports. Secondly, earlier proposals by the Dutch and British Timber Trade Federations to put a levy on all tropical hardwood imports to generate money that could be reinvested in forest management have not found wide favour. Some market analysis has concluded that a 25% drop in supply since 1979 has had no noticeable price effect. In such a "buyer's market", levies imposed in consumer countries may end up being paid by the producers. Finally, such a price increase would provide extra incentives for malfeasance. What are the alternatives?

An alternative approach is action on a country by country basis. The ITTO Mission that went to Sarawak to look at the sustainability of the State's forest management found that it had to examine separately a number of aspects of sustainability, which together add up to a comprehensive interpretation of sustainability'. The Mission used the following five aspects in its interpretation:

- the capacity of the forests of Sarawak to provide and maintain a supply of timber in the medium and long term, both for domestic use and export;
- forest management for this sustainable timber supply;
- the maintenance of soil and water quality;
- the maintenance of biological diversity in the forests of Sarawak;
- the continuing economic viability of forestry and the forest industry.

Management was found to be good on certain aspects, and less than acceptable on others. A number of recommendations were made for improvement. Obviously, time is needed to execute the recommendations made. Therefore, the most constructive approach may be to assess Sarawak's progress towards sustainability in two or three years time, and then consider whether progress has been sufficient. Generally speaking, trend assessment over a certain period of time is more appropriate than "point" assessment in the case of complicated issues such as sustainability.

The Sarawak approach might be usefully extended to other producer countries, provided international assistance is available to back up the recommendations of the review teams. A constructive response to the lack of operational tropical moist forest management may be for consumers and donors to work with tropical timber supplier countries to:

- jointly agree criteria to assess sustainability, and establish a base-line on the status of forest management in the producer country;
- jointly identify weaknesses in the forest management infrastructure, and establish priorities for change;
- provide assistance in critical areas, especially in developing the local capacity to manage forests better and assessing the potential role of plantations and agroforestry;
- measure progress towards sustainability using the criteria agreed under 1 at regular intervals;
- jointly agree on the way incentives and penalties should be linked to progress or regress.

5 INTERNATIONAL GUIDELINES ON NATURAL FOREST MANAGEMENT

An underlying question remains why natural tropical moist forest (TMF) management for timber production is such an attractive option, given that the most important contributions of TMF to developing country economies (expressed mainly in replacement values, as most forest produce does not enter national accounts), would seem to be the non-industrial goods and benefits derived from trees and forests, rather than merely the timber. These benefits include the best upland soils, a variety of foods including bushmeat, fuelwood and charcoal, framing, panelling and thatching materials for rural houses, agricultural and household implements, and a host of environmental services.

TMF management for sustained timber production is attractive because it can be managed for **multiple uses**, as it is wholly or largely compatible with soil and water conservation, with production of most non-timber forest products, and even to a certain extent with nature conservation, depending on the intensity of management practised. Four conditions that need to be fulfilled for sustainable timber production to be possible are:

- **Long-term security of operation:** the main obstacle to long-term security of operations is encroachment by farming in combination with the inability of governments to demarcate and protect a Permanent Forest Estate. The latter problem is related to the fact that the benefits of natural forest management seem to be undervalued, and the benefits of conversion of natural forest to other land uses overvalued by decision makers. There are important issues relating to the time horizon decision makers plan for;

- **Operational control:** preventing encroachment: the main impact of TMF timber exploitation is not its direct effect on the forest vegetation, but rather the access it provides to farmers and hunters. Therefore, control of access is the single most important measure needed. As more intensive agricultural practices in rainforest areas are often unfeasible or unattractive to farmers, the only way to safeguard production forests against encroachment is to plan the development of the infrastructure so as to minimise access. Exclusively repressive approaches, however, are neither socio-economically desirable nor efficient, and therefore measures restricting access should be complemented by positive interventions supporting local livelihoods; and improving harvesting operations: intensive silviculture is not an economically viable proposal for most of the TMF. Therefore, the harvesting operation is, and is likely to remain, the most important intervention in the forest. Minimising its negative impact thus has a high priority. Timber harvesting and its impact on the forest can only be regulated by adhering to guidelines concerning planning and execution of inventory, road building, marking, harvesting, extraction and silvicultural treatment, reinforced by adequate incentives and monitoring and control facilities, as prescribed by sound forest management systems;

- **Suitable financial environment:** forest land use options should be evaluated through extended cost-benefit analysis, fully including social and environmental factors. This will facilitate more economically rational decision making on forest land use. In cases where forests are managed for multiple uses such as timber production, watershed protection and buffer zone for conservation areas, the trade-offs between the various management objectives should be established as far as possible. Risk analysis should play an important role in economic assessment, as the risks of both fire and encroachment are known to be higher in logged-over forests.

- **Adequate information:** for informing decision making at all levels from land use and forest policy down to operational management. There may be scope for further guidelines to be developed.

There is much uncertainty and concern about the impact of different forms of human interference on forest ecosystems. Reducing this uncertainty is important to ascertain whether or not forest management practices are likely to be sustainable. A considerable amount of information has been generated by research studies on the subject, but their findings are often so site-specific that they are not very useful to forest managers outside the (small) geographical area where the studies were carried out.

The effects of most forms of human interference may be uncertain, but the way to minimise the risks of possible negative impacts occurring often is not. The latter can only be done by carrying out practices based on 'best available knowledge' in an orderly fashion, and by systematically recording the activities carried out and monitoring their impact on the forest ecosystem in any given site.

Guidelines assembling such 'best available knowledge' practices can be extremely useful tools for the forest manager. They cannot tell the latter **what** to think, but they can explain **how** to think and which factors to take into account when making forest management decisions. An important characteristic of 'best available knowledge' guidelines is that they can and should be changed or supplemented as more information becomes available.

The felling and extraction of more trees increases the damage caused to soil and vegetation in the remaining stand, all other factors - site, planning and operational skills, etc. - being equal. In management systems based on selective felling, it is clear that there must be limits to harvesting intensity above which felling and skidding damage will be so high as to jeopardise the forest's regenerative capacity.

The figure of ten trees per hectare has been quoted as an order of magnitude for such an upper limit to harvesting intensity, and it is probably true that harvesting more than ten trees per hectare without seriously endangering a stand's future potential demands planning and operational skills that are sadly lacking with most concessionaires in the producer countries.

It is impossible, however, to set **universal** threshold values for logging intensity, for two reasons. Firstly, damage to the remaining stand depends much more on **managerial variables** such as skid trail planning and machine operator skills than on the number of trees harvested per se (Jonsson and Lindgren 1990). Secondly, acceptable damage limits vary according to the physical and biological characteristics of the forest site under consideration, and the management objectives that have been set for it.

In many forests in South America for instance, the quantities of valuable timber species capable of responding to fairly heavy canopy opening appear to be restricted, whereas in South East Asia and Africa heavier canopy opening is almost always desirable (Whitmore 1988 in Plumptre 1990).

Secure in the knowledge that its country has an extensive network of protected areas, a government might deem it acceptable that a certain number of species will not be conserved in those parts of the Permanent Forest Estate that are being intensively managed for timber production. However, harvesting intensities and management practices that are standard in intensively managed timber production forest might be unacceptable in multiple use forests that yield important non-timber benefits to local communities or have a wildlife conservation function in addition to their timber production objective.

Relatively few tropical forests that are being subjected to harvesting have been brought under operational management systems. Wider application of such systems becomes more urgent as the intensity of timber harvesting and therefore the risk of irreversible damage to the forest increases. The environmental effects of intensifying timber harvesting - or indeed any change in management - can only be regulated by adhering to guidelines concerning planning and execution of inventory, road building, marking, harvesting, extraction and silvicultural treatment, reinforced by adequate incentives and control facilities.

These guidelines need not be restricted to technical issues only: they can and should also include principles and recommendations for involving local communities depending on the forest for (part of) their livelihood in decisions on intensification of timber harvesting. The needs and aspirations of local communities differ widely, and involving sedentary farmers practising rotational forest fallowing is different from involving nomadic hunter gatherers, but the principle involved is the same.

Furthermore, prospects for intensified timber harvesting (more species, lesser qualities and smaller sizes of commercial species) must be inserted in any models for yield prediction on which management will be based. Such guidelines concerning the intensification of timber harvesting could usefully supplement the ITTO Guidelines for sustainable management of natural tropical forests.

5.1 Donor assistance for developing national guidelines

International guidelines should be formulated in fairly general terms, allowing some flexibility for adaption to national, regional and local conditions. At the same time they should be stated so clearly that any misunderstanding about their intentions is avoided.

Table 1 Indicative scheme of prerequisites for sustainable management at various levels, including guidelines

	National level	Management unit level	Local level
Land use policy	• establishing a permanent forest base	• demarcating forest boundaries and buffer zones	
Forest policy including forest use planning	• national inventory • assuring a balanced use of forests • concession legislation • assuring conditions for implementation	• designating categories of forest land • inventory	
Forest planning and management	• providing guidelines for management units	• adaptation of national guidelines • choice of silvicultural system • providing operational guidelines	• adaption of operational guidelines • preparation of working plan
Operation responsibilities		• designing roads	• machine operator

from ITTO Guidelines for the Sustainable Management of Natural Tropical Forests (appendix 6)

Examples of such international guidelines are the ITTO Guidelines for the sustainable management of natural forests adopted by ITTO in 1990; the Guidelines for in-country TFAP implementation, adopted by the TFAP advisers in 1991; and the Guidelines for biodiversity conservation that are being developed by IUCN and ITTO.

In national and lower-level guidelines in Table 1 the general principles and recommendations stated at the international level can be translated into programmes of activities for government departments and regional forest officers down to the local forest management staff. The table shows actions and output at different levels which in combination constitute the prerequisite for sustainable management. Some of the outputs are the consequence of other higher ranking outputs, others are complementary to each other.

Development aid can be used to assist this process of translation and adaptation. In principle, national and lower-level guidelines should be drafted through a consultative process within tropical timber producer countries. Donors should facilitate South-South exchanges of expertise to encourage this process, supplemented by Northern expertise as required. Where bilateral contacts do not exist, ITTO and TFAP can function as a clearing-house for matching donors and developing countries that want to develop their own guidelines.

6 FINANCIAL AND TECHNICAL ASSISTANCE NEEDS OF DEVELOPING COUNTRIES

It is widely accepted that developing countries will continue to need external financial and technical assistance if they are to tackle the problems they face in managing their forest resources effectively. As in all aspects of the development process, the bulk of investment and other resources will, for most countries, continue to be generated internally. There is, however, a need to increase the volume and quality of donor assistance to the forest sector above the levels prevailing in the mid to late 1980s. This need has been recognised, and acted upon, by a wide variety of multilateral, bilateral and non-governmental development assistance agencies.

The framework of the TFAP provides one approach for assessing the volume of external assistance required on a country by country basis. When the TFAP was first developed in the mid 1980s, some estimates suggested that the external assistance requirements of developing countries might total of the order of $8 billion over 5 years. Such global assessments tend to be of only limited use. The critical issue, for both donors and recipients is to assess the volume and types of needs on a country by country basis. An assessment of the external assistance needs should be one of the outputs of a national forest sector review carried out under TFAP arrangements. Such assessments can be used by donors and recipients at country co-ordination meetings or Round Tables as a basis for donors to indicate the scale of assistance which they may each be able to provide, and the particular areas in which they wish to focus. Where it works well, this process should enable developing countries to meet a variety of different needs in the sector with each donor assisting in areas in which it has comparative advantage. The process does, however, require commitment from both donors and recipient country institutions. Constraints include inadequate information flows, the limited capacity of some recipients to undertake detailed planning, organisation and management of the sector review process, difficulties of co-ordination between aid agencies, and the difficulty of setting priorities where the total funds available are insufficient to meet all the needs identified (which will tend to be the case). One consequence of this is that in order to better understand financial and technical assistance requirements, donors should assist developing countries by strengthening the local capacity to examine forest policy, to prepare appropriate legislation and to develop a sector plan with fully considered projects and activities for external financing.

It is difficult to compile accurate data on the volume of assistance channelled to developing countries in the forest sector. Data compiled by the World Bank, DAC and FAO indicate approximate funding levels; but there are differences between the different sources on definitions and coverage. Sargent (1990) estimates that in 1984 total donor assistance to the forest sector approximated US$ 606 million; and that by 1988 the comparable figure was US $1,001 million. A number of donors have indicated an intention to increase substantially assistance to the forest sector. The World Bank has undertaken that it will triple lending from its concessional arm, the International Development Association, between 1990 and 1992. Bilateral agencies have taken similar action. The UK Overseas Development Administration, for example, was, in October 1988, funding some 80 forestry projects at a cost to the aid programme of £45 million; by early 1991 it had ongoing or in preparation some 200 projects at a cost of approximately £160 million. For most aid agencies, substantial time is spent in preparing projects in the forest sector. One consequence of this is that in the early period of a project expenditure may typically be very low. In later years it will typically rise. Official statistics on aid expenditure in the forest sector may be expected to show increases in expenditure over the next several years, as commitments made in the last few years and over the next few years are translated with a time lag into expenditures.

While donor assistance in the forest sector is increasing, it is clear that it is being directed increasingly towards conservation, sustainable management and development and institution building activities, rather than towards industrial forestry. There is also an increased emphasis on providing assistance through non-governmental organisations. There remains a balance to be struck between, on the one hand, developing forest activities primarily towards national long-term economic goals, as part of which a number of developing countries will continue to place a high emphasis on the generation of foreign exchange, and, on the other hand, ensuring that the wider ecological services (eg watershed protection, maintenance of soil fertility) and conservation objectives in the forest sector are met. Special effort will be required from both donors and recipients to ensure that the right balance is struck in each case.

6.1 Constraints in deploying funds effectively

In times when independent bodies scrutinise aid activity closely and donors are themselves concerned to ensure that aid funds are spent in a cost effective manner, increasing attention is given to appraisal standards (especially with respect to environmental and social safeguards). It is clear that the lead time on new forestry projects is now much longer than was typical five years ago. A number of appraisal problems are common in the sector including long payback periods and hence some degree of economic uncertainty, determining ecological costs and benefits, undertaking land valuations, identifying income distribution implications associated with particular objects etc.

There are subsequent design difficulties too. Long investment and payback periods may minimise early benefits and generate relatively little employment. The risks of investing and the opportunity costs of forestry in terms of alternative land use are often deemed to be high; finally those benefits which do accrue immediately may be to society as a whole and not directly to residents of an area in question. Careful thought on the part of project designers is necessary to ameliorate these potential difficulties.

Securing the co-operation of local people who may be destroying forests (shifting cultivators, nomadic pastoralists, "squatters" etc) also presents formidable sociological problems. Measures to reduce forest encroachment may seem straightforward - reduce animal stocking, provide incentives for migration or resettlement - but success in implementing these may be both costly and politically unpopular.

Developing countries' absorptive capacity is also a limiting factor especially if many donors are trying to inject resources into the sector simultaneously. Donors are conscious of this constraint and have tried to improve administrative capabilities through institutional strengthening and staff training programmes. Implications of institutional weaknesses are wide reaching. Forestry Departments are often at a disadvantage vis a vis more powerful segments of government and are frequently allocated an inadequate recurrent budget. Staff often do not have sufficient experience to see their way through financial procedures involving tenders for project equipment. They lack the necessary legal skills to define and negotiate long-term timber concession agreements so as to ensure governments earn a fair share of the economic benefits from extraction. And aspects such as calculating appropriate levels of royalty rates, clauses relating to reforestation or forest management obligations of the licensee, arrangements for cost sharing in relation to forest road and infrastructure programmes, are all difficult and time-consuming issues requiring expert advice if good programmes are to be formulated.

Last, but by no means least, is the absence of an appropriate policy framework, and effective monitoring and enforcement systems, in many countries. Some major donors have attempted to introduce necessary reforms by making loan or grant aid conditional on policy change. But donor driven insistence on reforms may result in obstruction and lack of co-operation unless governments fully internalise the messages, and believe in them themselves. Without government ownership of policies which donors are advocating, provision of new offices, staff quarters, vehicles and equipment will not be sufficient inducement to secure meaningful change.

7 NOORDWIJK RE- AND AFFORESTATION TARGETS

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 jointly by UNEP and the

World Meteorological Organisation to assess the science of climate change, its possible impacts and possible response strategies. At the Second World Climate Conference in 1990, the IPCC submitted a report on the correlation between global deforestation and climatic changes and also presented a strategy for forest conservation. At the UN General Assembly in December 1990 a Resolution was passed to establish an Intergovernmental Negotiating Committee for a Framework Convention on Climate Change. In recognition of the important contribution of deforestation to the climate change problem, at its first meeting, the INC established working groups which will consider "appropriate commitments beyond those required by existing agreements for limiting and reducing net emissions of carbon dioxide and other greenhouse gases and on the protection, enhancement and increase of sinks and reservoirs...". These commitments would be supported by discussion of legal and institutional mechanisms related to financial and technical support to developing countries.

In the light of the IPCC report, the Ministerial declaration for the SWCC concluded that "the potential impact of such climate change could pose an environmental threat of an up to now unknown magnitude; and could jeopardise the social and economic development of some areas. It could even threaten survival in some small island states and in low-lying coastal, arid and semi-arid areas." At the Ministerial Conference on Atmospheric Pollution and Climate change held in Noordwijk, the Netherlands, in December 1989, a declaration was signed calling for all countries "to initiate actions, (to) develop and maintain effective and operational strategies to control, limit or reduce emissions of greenhouse gases".

The Noordwijk Conference was not only concerned with emissions, but also looked at sequestration, concentrating particularly on the role of forests and setting a target of a global net increase in forest cover of 12 million hectares per annum by the year 2000. It has been estimated that the area of additional rapidly growing plantation forest needed to fully sequester the 3 billion tons of excess carbon currently being emitted each year is of the order of 400 - 500 million hectares, which might be established at a minimum cost of about US$ 400 per hectare. At a rate of 12 million hectares per annum this would take of the order of 40 years to achieve. However, such an equation assumes that emission levels will be comparable in 2000 to present levels and neglects compensating the lag for emissions accumulated between the present time and that future date, or for cumulative emissions during the 40 odd year establishment period.

Furthermore, the Noordwijk target of a net increase in forest cover implies compensating for forest losses. In the developing world these are now established at between 14 and 20 million hectares per year - although there are net increases in the industrial world. The 12 million target for net increase implies an annual target of the order of 30 million hectares, and it is clear, if effects of time lag and accumulation are taken into consideration, that even such a target may not have the desired effect. A number of commentators have questioned how the Noordwijk target is to be achieved. In particular, the following questions have been raised:

- what is the scientific basis for developing such targets? There is a growing consensus amongst scientists that change will occur and that it will be irreversible. But in assessing possible response strategies, how are judgements on the relative cost effectiveness of action on forests rather than, say, energy efficiency, to be taken?

- where were such forest to be established? Issues of land tenure and patterns of use and management in many countries in the developing world indicate that the establishment of substantial areas of plantation might be achieved with less social disturbance in the industrialised temperate world. Nevertheless, the extensive tracts of degraded land in the tropics, where fragile soils have been unable to sustain conversion from forest use, could be rehabilitated by the establishment of appropriate tree species.

- what would the costs be and how would they be met? It is clear that the responsibility for tackling climate change belongs to the global community acting together. Nevertheless, there is considerable sympathy for the idea that those countries who are major producers of radiative gases should accept a special financial responsibility. The majority of such countries are highly industrially developed, although producers are not strictly limited to temperate parts of the world.

- what are the biological and environmental consequences of committing such large areas to genetic uniformity? Plants can be modified and selected to tolerate different climates, and could be and are established over significant areas of the world, but in so doing they replace the genetic variability of the existing vegetation cover which enables those biota to respond naturally to change.

- could not the target be reduced through conservation and appropriate management of existing forest lands? It is very clear that an approach to carbon sequestration which involves management of existing, bio-diverse, forest lands is extremely important. Not only does appropriate management protect those lands from unplanned conversion, and hence lower the net target, but it holds the critical added benefit of conservation of genetic information and the ability to respond to the selection pressures of change. Natural forest management is discussed in paragraphs 51-53.

- what effects would the timber produced have on existing trade? A simple calculation suggests that if Noordwijk targets are achieved, by about the year 2030 there could be an increased annual production of the order of 7 billion cubic metres of wood. It is clear that it is often sensible to use wood as a construction material. Unlike the majority of building materials, wood sequesters rather than emits carbon during its production. There is considerable scope for the increased utilisation of wood, although it will be crucial to assess changes in the cost effectiveness of wood relative to other materials and it is necessary to re-evaluate many design and construction activities and policies, and considerable adaption will be required within the timber trade. At the IUCN General Assembly (Perth 1990), a recommendation was made that the IUCN Forestry Programme should advocate the use of non-timber products and very careful selective logging. In light of wider environmental concerns, such a recommendation must be viewed with extreme caution.

- most particularly, how do we strike a fair and cost effective balance between action by developing countries and action by developed countries in meeting the Noordwijk target?

The Soviet Union increased her forest cover from 738 to 811 million hectares in the period 1961 to 1984, and clearly there is considerable scope for establishment of temperate and boreal forests. Although forest growth rates, and hence rates of carbon sequestration, are slower in temperate than in tropical areas, there are particular benefits to be gained from establishing plantations in more temperate regions. These range from the biological (humic soils developed under forest in cooler regions are themselves important carbon sinks), to the social (patterns of land tenure and transfer to be legally established, enabling fully costed acquisition of land, without provoking concern over alternative land use rights). In developed countries, the institutional capability for forest management and establishment is generally strong and will be supported by appropriate policies and the political pressure of an environmentally aware and concerned public.

However, there is also an important role for tropical countries. Current land use changes in the tropics are estimated to give rise to a net emission of between 0.5 and 0.8 billion tons of carbon (about 20% of the total) per year, although, partly because of uncertainties over land tenure and increasing demand for land, success in the establishment of plantations has been variable. A number of developing countries have set their own targets for forests areas, including India, Thailand and others. The key problem has not tended to be the setting of the target, but the effective implementation of programmes to meet it.

Conversion of substantial areas of forest where fragile, infertile forest soils have not yet been able to support sustainable agricultural practice, has led to substantial areas of degraded land which might appropriately be used for plantation establishment. Whether the subsequent plantation crops are used for structural timber or furniture, for paper or board, or for fuel, the result will be a net sequestration of carbon, provided that the forest is allowed to regenerate and produce further crops.

There is a need for a more balanced approach to the climate change problem, taking account of economic instruments as well as 'regulatory' measures. More information is needed about the carbon budget, not only of individual nations to enable them to accept their particular responsibility (three countries, Netherlands, Finland and Sweden, already impose a domestic carbon tax) but also internationally, to improve the quality of scientific prediction and to facilitate informed international negotiation. A global carbon tax might prove more effective than abatement targets in reducing levels of emission and encouraging appropriate action towards sequestration. The absence of good scientific data makes it difficult to determine the level at which a tax should be set; but his need not present an insuperable barrier to its introduction because the level of the tax could be changed as our understanding of its impact grows. There will, however, be difficulties in persuading all countries to co-operate, and not merely to consider national effects; and further, "the polluter is not always rich, anonymous and asocial - hence we may want some polluters to pay less than the full damage associated with their actions." (Markandya, 1991).

An alternative approach is the development of carbon trading permits. Permits could relate to the cost to a particular country of reducing emissions by a given amount, and each country would be issued with a particular number of permits relating to levels of reduction required which could be traded internationally. Considerable work would be required in setting permit levels and costs and in developing allocation and trading mechanisms. It is unlikely that such a system could be brought into use in the near future, but it is certainly worthy of further investigation and development. Such measures must also be pursued in order to provide incentives for carbon sequestration, and would clearly bring most pressure on those countries who pollute most actively.

8 THE TROPICAL FOREST ACTION PROGRAMME

The Tropical Forestry Action Programme (TFAP) has become the principal mechanism used by multilateral and bilateral donors to co-ordinate aid and assistance to the forestry sector in the developing world. By April 1991 it is in various stages of implementation in a total of 81 countries and assistance has been offered to most countries.

"TFAP grew out of a desire to respond more effectively to the accelerating loss of tropical forests. The most recent data, however, indicate that this goal is still far from being achieved. Some 14 to 20 million hectares of tropical forest are being lost every year, compared to an estimated 11 million hectares a year in 1980" (Winterbottom 1990). Although it has had a considerable effect in bringing the problems of deforestation to the forefront of political conscience in both developing and developed countries, it has not yet had sufficient influence or impact to reduce substantially rates of deforestation, or to develop international understanding or consensus on what the best uses of forests should be.

TFAP must be considered an evolving process. There have been a number of recent reviews, which have strengthened the concept that TFAP needs to address issues primarily at a policy level and within a framework of understanding and interaction with the macro and other economic processes that determine the development of a country. Further, there is a growing awareness of the need for TFAP to take account of human rights issues to become a participatory process in which the concerns and potential contribution of the private and non-governmental sectors are brought more firmly to bear on the issues. Recent criticisms have been aimed at the extent to which TFAP have focused on the industrial sector, tending to overlook the needs of conservation. This criticism is not particularly valid. In cases where the reviews appear to have overemphasised industrial projects, these have not been funded by donors, who have preferred to support work with direct conservation objectives. However, this is not to say that all reviews have examined or adequately analysed the breadth of influences on loss of forests which are of conservation or environmental importance: a disturbing number have not.

Underlying such criticisms are the often serious differences of opinion about what the best use of the forests should be. There are very different assumptions about what is desirable and there is often confusion and action at cross purpose between, for example, environmental lobbyists and developing world governments, or donors or recipients of aid. To clarify what TFAP is attempting, a set of aims and objectives are being developed, which are basic to a revision of guidelines for the process. The guidelines are presently in draft. They do not yet provide a full and adequate basis for monitoring the process, which is now recognised as critical, but which has, in the past, been given little attention and less funding. It is fundamental that the guidelines should provide a framework for analysis of the following areas and issues:

- **Macroeconomics.** It is important that such areas as population growth and GNP targets, inter alia be analysed in relation to the forestry sector. To what extent, if any, will these underlying factors affect implementation of forest policy? What are the contributions or expectations from the forest sector?

- **Policy.** Increasing emphasis has been placed on the need to analyse forest policy and how it interacts with policies in other sectors during TFAP implementation. Appropriate strategies are needed for conservation, industry and wise land use. Such policy review has now become an integral part of the TFAP process, and is increasingly taking into account interaction with agricultural and economic planning sectors. Nevertheless, no TFAP exercises have properly evaluated or even considered the consequences and impacts of national forest policies, such as logging bans, on the sustainability of the forest resource of trading partners.

- **Microeconomics.** The importance of rural credit to enable essential investment in forest management and sustainable use or re-establishment of cleared and degraded land must be emphasised during TFAP. Diversification of trade and forest production is important, and insufficient resources have been given to the placing of economic value on forests and lands to be used for diverse purposes and towards creating rural employment.

- **Participation.** It is now widely accepted that the needs and interests of those whose livelihoods are directly and indirectly dependent on the forests must be taken more fully into account, and that relevant and accessible information and opportunity to comment and criticise must be made available to such people and their representatives.

- **International concerns.** Comparatively few TFAP's have looked at national concerns in relation to global environmental change. It is clear that any large-scale plantation development or resource conservation effort aimed at carbon sequestration must be rooted in national policy and planning activities, and that TFAP can provide an effective mechanism for assisting this process.

Further, it is essential that the guidelines should provide an appropriate basis for quality control and monitoring. Over the past 6 years 14 TFAP's have passed the international round table stage (at which donors commit, or declare their intention to commit, funds), and the results have been variable. There is a need to look at each process objectively, from the scope of issues paper to the effectiveness of the international round table, and to ensure that the new guidelines, particularly as they relate to critical areas such as policy analysis and public participation, have been given adequate attention.

Monitoring must be included in any ongoing TFAP activity. To the extent that the TFAP planning process is undertaken by the country involved, it must be the responsibility of that country although there are proposals that the International NGO's, together with bilateral and multilateral donors, should lend objective (and financial) assistance to the process.

Overriding all these factors, however, has been the concern and recognition that the institutional arrangements governing TFAP are in need of reform and reinforcement. A small co-ordination unit for TFAP exists within the FAO Forestry Department, and although it is said that all the resources of this Department are available for TFAP, it is increasingly realised that the process has become overstretched. This is not only because of the number of countries involved, it is also the recognition that the reviews need to become more concerned with planning and with a wider spectrum of causal factors. Either there will need to be a concentration on areas where the process is likely to be most effective, or there will need to be a massive increase in support for TFAP. The aims and objectives of TFAP are all-encompassing and do not give guidance on whether, for example, it is more important to assist a country such as Zaire, which retains a substantial forest resource which might be conserved, or to help countries like Bangladesh, with little forest resource but where a major concern is the establishment of plantations and the development of agroforestry.

New institutional arrangements for organising and coordinating TFAP are currently being developed in response to the FAO-sponsored Independent Review, which called upon the co-founders (FAO, World Bank, WRI and UNDP) of TFAP to work out appropriate organisational arrangements to give the programme leadership and authority in order to improve quality and so set priorities.

It seems likely that these will lead to a more considered, transparent and more country-based approach towards wise forest use for the benefit of peoples both directly and indirectly dependent on forests, but it remains important to define more closely the roles and interactions of the proliferating international processes and institutions which seek to give assistance in these areas. In particular it will be very important to look at the relationship between TFAP, ITTO, IUFRO and the World Bank EAP, and to ask whether and to what extent these should be better coordinated. A meeting of the co-founders of TFAP and others in Geneva in March 1991 discussed the revised goals and objectives of TFAP.

The observation has frequently been made that none of these initiatives have legal powers to set and enforce such environmental standards as would reflect the needs and interests of countries concerned. As yet there is no real agreement as to what the critical issues (Sargent 1990) relating to forests are, or how they should be addressed. There is increasing discussion as to whether a legal international instrument should, or could, be developed to serve this purpose.

9 PROPOSALS FOR AN INTERNATIONAL INSTRUMENT ON FORESTS

A number of proposals have been made in the last year for an international convention, charter, protocol or other agreement to safeguard the future of temperate, boreal and tropical forests. An early proposal was made by a workshop on tropical forests held under the Inter-governmental Panel on Climate Change in Sao Paulo, Brazil in January 1990. The group of seven leading industrialised countries meeting in Houston in July 1990 called for an international convention or agreement covering all forests to be agreed by 1992. FAO has prepared proposals for a forest convention, which were discussed at its Committee on Forestry in September 1990 and at its Governing Council in November 1990. The International Tropical Timber Organisation also had a general discussion on this issue at its Council meeting in November 1990. Discussions are also taking place within the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change addressing the role of forests as carbon sinks.

The leading forum for the discussion of this issue has become the Preparatory Committee for the 1992 UN Conference on Environment and Development. At the first session of the Preparatory Committee, in Nairobi in August 1990, a decision was taken asking the Conference Secretariat to prepare a detailed report on a wide range of forest issues, and to suggest options for the co-ordination of national, regional and international action to promote better management of forest resources.

The Preparatory Committee discussed this issue further at its second session in Geneva in March/April 1991. A report by the Secretary General suggested that the Committee "may wish to consider discussing the development of an international legal instrument for the conservation and development of forests. It may wish to discuss how an instrument of this sort could provide the mechanism to address the rate of deforestation which is affecting in particular all developing countries in temperate and tropical regions while including aspects of conservation and management of forest in developed and developing countries." The Secretary General's paper suggested further that such an instrument should:

- fully integrate all aspects of environmental protection and economic development as they relate to all forests whether boreal, temperate or tropical;

- ensure a vital increase in international co-operation for policies and programmes aimed at forest conservation and sustainable use.

- complement other international initiatives with implications for aspects of forestry, notably the climate change and biodiversity conventions.

- ensure the incorporation of the concept of sustainable management of forests and its relation with food, fuel, shelter and timber.

- provide a framework for increased national efforts and bring together both the ecological and economic approaches to the use of forest resources.

- provide a mechanism to monitor its implementation, to assess progress and to co-ordinate international action."

There was a wide-ranging discussion at the Preparatory Committee. Among the issues discussed were the legal nature of any agreement on forests, with a large number of countries suggesting that, at least as a first step, the goal should be to agree to a non-legally binding statement of general principles. Other countries expressed a preference for working towards a legally binding instrument from the outset. There was also a discussion on the timetable for developing such an instrument and over the extent to which it may be possible to encapsulate progress in a formal authoritative document by the time of the UNCED in Rio in June 1992.

The Preparatory Committee also requested the Secretariat to analyse as fully and comprehensively as possible the following issues in its further work on forests:

1 "the historical loss of boreal, temperate, subtropical and tropical forest worldwide, its causes and its respective contribution to global environmental degradation;

2 recent initiatives in the management, conservation and sustainable development of forests;

3 the roles of forests in relation to soil and water conservation and socio-economic development in providing food security and domestic energy, eradicating poverty and raising standards of living and quality of life at the local and national levels;

4 suggestions regarding details of the requirements of funds and funding mechanisms;

5 analysis and quantification of the respective economic values of boreal, temperate, subtropical and tropical forests in terms of: timber and forest produce; watersheds protection; flood prevention and control; soil protection and conservation; sanctuary and habitats for wildlife; recreation and eco-tourism; repositories for genetic resources; carbon and heat sinks; sources of fuel wood for developing countries; food and other basic needs of forest dwellers and local communities;

6 the current levels and structure of world trade in timber and timber products;

7 the important role that women, especially in developing countries, play in the conservation and sustainable development of forests and other land resources;

8 the interlinkages with work on climate change and biodiversity."

The Preparatory Committee decided that it would "it its third session be in a position to examine all steps towards and options including at a minimum, taking into account the special situation and needs of developing countries, a non-legally binding authoritative statement of principles for a global consensus on the management, conservation and development of all types of forests...". The Committee also proposed a number of principles for further consideration including the following:

1 A reaffirmation of principle 21 of the Stockholm Declaration, which balances states sovereignty over their natural resources with certain obligations to avoid causing environmental damage, including the avoidance of damage to neighbouring states or wider eco-systems;

2 the principle that all types of forests play a major role in economic development including subsistence needs in developing countries;

3 the principle that all types of forests play a major role in maintaining the ecological balance at local, national, regional and global levels;

4 the principle that all types of forests perform a wide range of social functions, including for forest dwellers, local communities and indigenous people who use and sustain forest resources and systems;

5 the principle that b-d above should be balanced to ensure that forests continue to play multiple roles in a sustainable manner;

6 the need to address issues crucial to sustainable development, including developing countries' needs for technical and financial assistance and technology transfer; the role of supportive national, social, economic and environmental policies aimed at the sustainable development of forests; the role of a supportive international economic environment which promotes growth and development, and the role of issues such as the terms of trade, the need to address debt problems and the alleviation of poverty;

7 the need to address the interlinkages between forests, climate change and biodiversity conservation, including implicitly the linkages between discussions on forests in the UNCED and the ongoing negotiations for conventions on climate change and biological diversity.

The Preparatory Committee also affirmed that the UNCED process was the most appropriate forum for conclusive decisions towards a global consensus on forests (and implicitly any forest instrument) in the period leading up to the Rio Conference. It would therefore not be appropriate for the workshop to seek to take forward the political discussion on these issues, since this is firmly the responsibility of the UNCED Preparatory Committee. The workshop may, however, be able to contribute technical information to assist the Preparatory Committee in its further work. One aspect of this should be the submission of all the papers prepared for the workshop, and a summary of the discussion on each issue, to the Secretariat of the UNCED for their consideration in their further work on this issue. A second aspect could be technical information on what further principles the Preparatory Committee may wish to consider as it works towards a global consensus on forests; and technical questions related to any institutional arrangements that may arise, implementation and monitoring of principles or other agreements, in whatever way they are embodied, towards a global consensus on forests.

On the question of what further principles may be considered, technical judgements on the scope and need for addressing some of the following issues might usefully be exchanged at the workshop:

- the scope for addressing issues related to the trade of timber and other forest products;

- the scope for adopting guidelines on the sustainable management of forests, perhaps drawing on the guidelines agreed by the ITTO in 1990;

- what provisions, if any, should be made on monitoring the status of forests;

- what provisions, if any, should be made for research to improve the sustainable productivity and other benefits generated from forests;

- what provisions, if any, should be made regarding public information, awareness raising and education;

- what scope there is to take up proposals made by some countries for national targets for forest area and quality;

- the technical issues to be resolved in delineating between the role of forests as sinks for greenhouse gases and wider forest questions.

A variety of issues arise on the institutional arrangements, implementation and monitoring of any principles emerging as part of a global consensus on forests. These issues will tend to arise regardless of the form of which any global consensus is embodied, though it is likely that more formal institution arrangements would be required for any legally binding agreement. Among the issues to be considered are the following:

- how would the principles be promulgated through national action in developed and developing countries?;

- how would they be promulgated through the activities of the international organisations? In particular, what would be the respective roles of the TFAP, the ITTO and the variety of multilateral, bilateral and NGO sources of funding for developing countries be?;

- how will actions in line with the principles embodies in the global consensus be monitored? What, if any, machinery would be required for assessing compliance? Is this something best left to the national level, or are wider provisions required?

10 OTHER CURRENT INITIATIVES

There is a spectrum of other current initiatives towards wise forest use being undertaken by international organisations. Internationally-applicable incentives for tropical forest countries could include: collecting taxes on the use or trade of some forms of biodiversity, as well as on the use of the biosphere as a waste dispersal and disposal system; "credits" earned for forest conservation, which can pay for imported technology; direct conservation grants disbursed from a global fund; and a range of bilateral arrangements (debt-for-nature, renting special forest "conservation concessions" by international bodies for a given period).

The World Heritage Convention is an example of an international "competitive" incentive where US$ 1 million is available annually to support the conservation of the world's most significant national and cultural heritage. Several of the **UNEP Regional Seas Conventions** have Trust Funds for expenditure on significant projects; this may provide a model. The proposed **Biodiversity Convention** will similarly address issues of funding for the Conservation of Biological Diversity. For each type of incentive, we must assess where it is most applicable and how cost-effective it is. Global incentives may be particularly expensive in their administration and monitoring.

The International Union for Conservation of Nature and Natural Resources (IUCN) has suggested a national target for all tropical forest nations to set aside 5 to 20% of national territory under protected natural forest, which should be surrounded by modified forest covering a further 30 to 60% of national territory. The global target is to set up 500 selected species-rich tropical forest protected areas, each of an average 200,000 hectares in the 57 countries that contain tropical moist forests, half of these areas being totally protected and the other half managed sustainably for economic yields. IUCN's global target would amount to approximately 100 million hectares, or a 100% protection of 10% of tropical moist forests.

The World Wide Fund for Nature (WWF)'s goal is based on a doubling of protection for tropical moist forests: the aim is to select the reserves by 1994 and ensure protection by 1999.

International environment and development NGOs, such as the **World Resources Institute (WRI)** and the **International Institute for Environment and Development (IIED),** can contribute much in terms of policy advice, synthesis of viewpoints from local and national (southern) NGOs, representation of those viewpoints at the policy level, field research, etc. International NGOs can assist in giving policy makers guidance to the array of information with which they are faced.

The United Nations Environment Programme (UNEP) has supported the TFAP since 1988, and has established a project to investigate ways of supporting ongoing activities which identify forest decline and conserve tropical forests, to develop environmental awareness and improve forest management in tropical forest countries. Efforts to control forest destruction are now a priority task of UNEP.

United Nations Educational, Scientific and Cultural Organisation (UNESCO) 'Man and Biosphere' (MAB) programme was set up in 1971, and carries out the following work relating to tropical forests:

- basic research into the impact of human activities on ecosystems;
- support of the establishment of 30 biosphere reserves worldwide (in co-operation with UNEP, FAO and IUCN);
- support of the establishment of World Heritage sites through the World Heritage Trust Fund. The Fund gives financial support to member countries in protecting such marked areas when they cannot finance such activities from their own resources.

World Bank Environmental Action Plans. Since 1987, the World Bank has been developing the concept of Environmental Action Plans (EAPs) and providing assistance to developing countries in drawing up such EAPs. These plans are based on a comprehensive country study, with the participation of NGOs, the local population and the private sector, and an action plan is devised. The Bank, together with other donors, assists in financing a corresponding Environmental Investment Programme. Typically, EAPs aim to strengthen environmental policy/legislation, strengthen those institutions responsible for environmental protection, set up assessment and monitoring systems and develop human resources. Where both an EAP and a TFAP have been developed, the TFAP is intended to be the detailed elaboration of the EAP in the forest sector. In some countries, however, the intended complementarity has not been achieved.

There are in addition important international research efforts, involving, among others the International Union of Forestry Research Organisations, the CGIAR, which has been studying the issue of forest research, and the International Council on Agroforestry.

11 DISCUSSION OF PAPER

11.1 Introduction

Although the fate of forests will be largely determined by the policies and activities of peoples and their governments, external international factors may be influential. In this paper we have been asked to examine certain international actions which could make a beneficial contribution to the wise use of forests. Of the topics considered in our background paper, we chose to discuss six during the workshop. We felt that these were either particularly relevant, or had not been given sufficient attention.

11.2 Trade

Harvesting of both timber and non-timber products from the natural tropical moist forest has too often mined the resource with inadequate reinvestment. However, where an effective management infrastructure is in place, strong markets for forest produce can be conducive to good management; where such an infrastructure is absent, they are likely to provoke overharvesting. The questions that need to be addressed are:

- how can the trade contribute to increasing the amount of forest under operational management?

- how can the risk of possible negative impacts of trade be minimised?

Any unilateral attempts to control markets are likely to be seen as punitive and could be ineffective. Introduction of labelling schemes by consumers could be understood as punitive, would be bureaucratically difficult and could lead to malfeasance. Alternative markets for timber production exist.

During the ITTO mission to Sarawak, recommendations for evaluation of sustainable production were made. Such recommendations, implemented nationally and jointly agreed internationally, could provide an acceptable basis for sustainable trade and forest industries. Such an approach should be tried in other producer countries throughout the world.

DISCUSSION: Such standards must also apply to the production of timber from non-tropical zones. There is a danger that temperate timbers will capture more of the market, and it is clear that trade restrictions are likely to be counter-productive to cooperation with tropical producer countries in attempts to improve forest management. Additional incentives towards wise forest management could develop from improved producer processing capacity; a more rational use of tropical timbers; and international monitoring of trade.

11.3 Guidelines on Forest Management

There is uncertainty about the impact of different forms of human interference on forest ecosystems. Where there are insufficient data or analysis the only way to minimise risks of possible negative impacts is by carrying out practices based on best available knowledge. Guidelines assembling such knowledge cannot tell the forest manager what to think, but they can explain how to think and which factors to take into account when making forest management decisions.

Examples of international guidelines are those introduced by ITTO for sustainable natural forest management, and in preparation together with IUCN for conservation of biodiversity.

DISCUSSION: The ITTO guidelines were discussed in some detail it was said that a number of countries are undertaking studies to prepare national guidelines, reflecting the international consensus developed. Continuing work by ITTO was introduced, including guidelines currently in preparation for sustainable management of man made forests.

11.4 Noordwijk Targets

The setting of international targets without full national consultation may be unrealistic. The Noordwijk Declaration called for a net increase in global forest cover of 12 million hectares per annum by the year 2000. Given forest loss rates estimated at between 14 and 20 million hectares each year, this implies an annual target of the order of 30 million hectares.

How is this to be achieved? Amongst uncertainties are:

- The scientific and economic basis of the target. Would not alternative approaches, such as energy efficiency, be more cost effective?

- Where would such plantations be established? Who owns the land? What is the importance of its current use? How would conversion relate to national development policies?

- Would it not be more appropriate to undertake such activities in temperate industrial areas, where such issues as opportunity cost and land tenure, may be less in conflict.

- What are the biological and environmental consequences of committing such large areas to genetic uniformity?

- What effects would the timber produced have on existing trade and markets?

- What would the costs be, and how would they be met? How do we strike a fair and cost effective balance between action by more and less developed countries?

DISCUSSION: A paper was given by Trexler in which more detailed analysis and recommendations were presented. The two presentations were in broad general agreement, WRI responding to some of the questions we raised.

The question of the energy costs of establishing such plantations was also raised, and estimated at about 10% of output. It was pointed out that in Kenya and Nepal, although area of forest may be in decline, area of tree cover is almost certainly increasing.

11.5 Fire Management

Fire destroys an average 300 million hectares of forest globally each year, although, unless there is a particular underlying social or economic reason, the distribution of these fires will not be consistent, and hence fire-fighting in most countries is not cost effective. However, it should be noted that estimates of environmental losses are rarely included in cost benefit analysis. Although fire may have a very deleterious local effect on biodiversity, this is not usually seen to be of global significance; however fire does appear to have an important impact on global climate.

The overriding issue is how to reconcile the marginal price of global cooperation in forest fire management with the marginal benefit of extra global forest services conserved. There is also a need for better dissemination of guidelines on fire as a management tool and fire as a problem; and on how to balance equipment intensive fire-fighting strategies with fire prevention strategies. Regional schemes might be developed to reinforce national institutional capabilities.

DISCUSSION: Australia identified problems with regional cooperation in fire fighting. In countries such as India, with massive underemployment, use of the local population might be preferred.

The causes and effects of fires are very variable, although fire-fighting and socio-economic approaches towards prevention must be based on better information. An underlying difficulty is in the decision as to when to use fire as a management tool. Public perception is very often in conflict with scientific advice.

11.6 Tropical Forestry Action Plan (Programme)

There are serious differences of opinion about what the best use of forests should be. The TFAP, which is an evolving international process seeking to create partnership between more and less developed nations to address the spectrum of causes of deforestation, has come under considerable criticism because there are very different assumptions about what is desirable. Moreover, there is often confusion and action at cross purposes between, for example, environmental lobbyists and developing world governments, or donors and recipients of aid.

Aims and objectives are currently being defined, and new institutional arrangements for organising and coordinating TFAP are being developed which it is hoped will give the programme leadership and authority in order to improve quality and to set priorities. It seems likely that these will lead to a more considered, transparent and country-based approach.

DISCUSSION: TFAP has been welcomed by many developing world countries. In Ethiopia the programme has attracted much national support, with governmental and intergovernmental agencies, NGOs and community organisations contributing actively. India welcomes financial support via TFAP, and has her own capacity to undertake planning and implementation activities. In certain countries, such as Bolivia, revisions have reflected changes and adjustments in priorities for national development. Developing countries should set the agenda for TFAP.

11.7 Financial and Technical Assistance Needs

It is widely accepted that developing countries will continue to need external financial and technical assistance if they are to tackle the problems they face in managing their forest resources effectively. Donors have been increasing levels of aid to the sector, however there are constraints to flows: these include appraisal and design difficulties; securing the cooperation of local people; the absorptive capacity of a particular country; and, in some cases, the absence of an appropriate policy framework and effective monitoring and enforcement systems. The TFAP provided one mechanism with which it was hoped to address these difficulties. The ITTO may also coordinate aid activities.

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Annex: The Role of NGOs

The participation of NGOs is now recognised as being an essential feature of the consultative process by such international forestry initiatives as the TFAP and ITTO. Increasingly over recent years, such organisations have sought, or have been persuaded, to ascertain the views and encourage the participation of international and national NGOs while developing projects and formulating policy. There is still much call for increased NGO participation - particularly for better mechanisms to facilitate such participation and for greater exchange of information. But increasingly, international NGOs are gaining a higher profile and gaining the respectability for them to be seen as an authoritative voice in the international fora, whether as representatives of local interests, or as independent contributors to policy formulation.

This particular section of the workshop is concerned with the assessment of international options for coordinating, exchanging information on and reinforcing national options. The issue of NGO involvement is one that cuts across all themes in this paper, and this appendix presents a brief summary of the issues and the contributions that NGOs can make. Whilst the term 'NGO' covers a broad spectrum of organisations with widely differing ideologies, objectives and functioning, in this context we refer to an NGO primarily as an international environment and/or development organisation (including non-governmental aid agencies/charities), or an international coalition or network.

The roles that national and international NGOs can play in international mechanisms for co-ordination and exchange of information and in reinforcing of national options may be summarised as follows:

- policy research, including policy dialogue with host governments (NGOs have the advantage of field experience - in many cases - and can work through less formal channels than many official agencies)

- development of overviews and action plans

- dissemination of information

- assistance to establish networks

- many international NGOs try to build on the work of national NGOs and to assist in voicing their concerns (the latter particularly if the NGO sector in-country is weak)

- ensuring effective representation of all concerned national NGOs. NGOs can assist forestry departments in contacting and consulting with local NGOs and forest-dwelling groups who have not previously been involved in any central government political or planning process

- NGOs can play a vital 'watchdog' role as independent observers and commentators

- contradictory perceptions, far from being negative and destructive to debate, can be used to deepen understanding of the issues involved. There are also vitally important issues and work which can be constructively and jointly addressed. The width of opinion and capacity of the NGO community as a valuable adjunct to democracy has not always been conceded or recognised

- NGOs, with more streamlined procedures than many large governmental institutions, can often respond very quickly to emerging needs.

An example of the potential roles of NGOs may be illustrated by the weaknesses in the TFAP process perceived to be a result of the lack of NGO participation (Carrillo, Falkenburg and Sandvoss, 1990):

- "the non-participation of the rural groups in the preparation of the TFAP sector plan will prevent the long-term implementation of the TFAP (this participation could be facilitated by national NGOs);

- due to the inadequate account taken of the ecological and political aspects involved, the sustainability of all the proposed measures will be jeopardised;

- the concentration of promotional measures on the classic, sector-specific forest institutions will prevent significant reforms (NGOs can assist in providing a broader, non-sector specific perspective);

- conceptual weaknesses of an ideological kind eg. reducing the entire problem to the poverty of the rural population, which is erroneously regarded as the primary cause of forest destruction, will prevent the necessary changes (eg. agricultural reforms as a precondition for a reorganisation of the forest sector) from taking place."

NGOs can also serve to introduce and highlight human rights issues, which have tended to receive scant attention in some international initiatives, and which inevitably directly concern forest-dwelling peoples. Because of the sensitive character of this issue, it should be included in high level policy dialogues. At the same time, this question should be considered carefully within any forest sector study when NGO involvement is being analysed.

NGO initiatives that need reinforcement

Networks can be effective in breaking down the blockages in bottom-up information flow in the south, by collating, disseminating and exchanging indigenous knowledge, the results of both informal and formal research, and individuals and NGO's viewpoints and experiences. Networks that increase south-south information flow are particularly useful in view of the difficulty of communication.

For example, the ODI Social Forestry Network comprises known individuals, not institutions. A big response from network members to a recent request for forestry extension materials indicated the effectiveness and 'outreach capacity' of such a network. Recognising that, collectively and informally, farmers/villagers have done the most research, ODI are showing that it is possible to elicit and exchange that information without large amounts of funding.

Other networks operate through the electronic mail system eg. Greennet, Siglet (a free EEC data base).

Capacity building. For NGOs to be effectively involved in international forestry initiatives, their capacity needs to be increased in many cases. In a number of cases where NGOs have been invited to TFAP roundtable conferences and similar meetings, their real influence on the outcome of the discussions has been doubtful. Renowned international NGOs have the best chances of participating in the process, while local groups defending the interests of indigenous peoples, on the other hand, have the smallest chances. This further emphasises the need for improved participation and information flow.

NGO/policy maker interface. Provision needs to be made for an interface between NGOs and policy/decision makers in order to improve information flow, facilitate representation of NGO viewpoints at the policy level, and identify issues of importance. Without such an interface, public participation will be limited, and will be unlikely to reach the policy level. New institutional structures would probably need to be established in order to allow this interface to function. Creating such structures and conditions for participation are long-term tasks but are essential for improving in-country capacity for consultation.

Possible initiatives to allow this interface to exist are:

- 'Postbox/clearing house' facility for feeding in NGO contributions to the debate. This would aim to ensure effective representation of all concerned national NGOs, as well as facilitating the provision of information to them. A central information exchange facility would be a successful means of transferring information to and from NGOs and policy makers only if it was perceived to be independent, apolitical, impartial and if information flowed freely in both directions. In view of the number of cross-cutting issues between the various international initiatives, such a clearing house would be most effective if it operated for all initiatives, although it might be more manageable institutionally and financially if a separate clearing house were established for each international initiative.

- National fora - such as the recently established UK tropical Forest Forum - are useful for bringing together viewpoints from NGOs, other organisations and individuals. Such fora can aim to reach consensus on those points on which there is general agreement, and to allow enriched discussion and deeper understanding of the issues, through the airing of what may be contradictory viewpoints. National fora can also act as a kind of postbox or clearing house, as described above. Again, such a structure must be open and available to all participants for it to function properly and credibly. It would, of course, be up to each nation to establish the kind of facility appropriate to its particular circumstances - but could be based on an international 'model'. In any international forum, it would be essential that there is very strong developing world and NGO representation.

Exploring Institutional Options for Global Forest Management

J Romm[1]

1 INTRODUCTION

Human actions that affect forests now are thought to have global impacts. The impacts are thought to be changes in climate, in genetic, species and ecosystem diversity, and in the distributions and qualities of habitats, watersheds, settlements, riparian zones and other critical landscape units. Although the nature and extent of these impacts are matters of scientific debate, the debate itself displays the social fact that people throughout the world increasingly perceive an interdependence in their lives which they express through their mutual interests in the world's forests.

Current discussion of a possible international forestry protocol is intended to increase the likelihood of forest actions that improve global outcomes. The success of these endeavours depends upon the extent to which the causes of human actions on forests are appreciated and the means to modify them comply with the national interests and capacities through which these means must be exercised. In other words, success depends upon attaining agreements that respect the diversity among and scope within national situations, while facilitating national actions that improve international outcomes.

This paper offers a basis for assessing institutional options for global forest management. Its thesis is simple. People determine what happens in the forest; the context for their actions is always unique. National policies affect what people do while expressing distinctive social realities of a larger scale that contain limited opportunities for change. Global institutions can be assessed in terms of how they may affect actions in the forest by modifying the realities from which public policies and people's actions derive. They may be assessed for the equitability of their impacts among nations and people. Perhaps most importantly, they may be assessed for their responsiveness to diversity and rapid change in the conditions within which different nations and people must act.

In this paper, I first summarize several social issues that dominate current discussions of forest policy and possible international agreements. Next, I review findings regarding social patterns of forest change and consider potential policy implications of these patterns. Third, I briefly differentiate conditions among nations that would appear to also differentiate their positions on an international forestry agreement. Finally, I suggest some tentative propositions about the nature of a forestry protocol that might satisfy criteria of flexibility, fairness and impact.

2 ISSUES

Four grand issues indicate the social realities with which forest policy and global forest interests must contend. These realities involve fundamental tensions in social behaviour that global institutions, if effective, would resolve in some degree.

2.1 Forests: International interests vs. localized control

The globalization of forestry issues draws attention to the aggregate effects of forest actions. But while the aggregates can be viewed in apparently manageable unitary terms - some global models even put them in one box - the actions creating them are those of hundreds of millions of people spread over the earth, virtually all of whom operate beyond the scrutiny and awareness of anyone else. The social distance between an international interest and a local action is immense. This fact is the primary challenge to effectiveness in forest policy, even at national and sub-national levels. It is awesome when viewed on a global scale.

Individual people plant, grow, protect, hack and cut trees. They do so as loggers, government workers,

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swiddeners, subsistence and commercial farmers, as road builders, developers, suburbanites and city dwellers. They do so in large swaths, small patches, or with single plants. They do for very diverse and generally virtuous reasons. The conditions of forests depend upon why people do what they do. The effectiveness of policy depends upon how it influences these diverse human actions. Matching forest policies with the diversely motivated people they are to affect is another fundamental challenge.

Forest policy traditionally has been understood to mean the policy of the sovereign state. In most circumstances, the gap between sovereign intent and ground action has been daunting. The internationalization of forestry issues raises the daunt by a magnitude and thrusts the state into an historically new role as mediator between international and local interests. An international protocol, if it is to be beneficial, would need to enable rather than to constrain the growth of this role.

2.2 Forests: Functional vs. territorial definitions

The globalization of forestry issues sharply challenges the customary definitions of forests. Forests conventionally are viewed as territories that display certain forms of vegetation, use and jurisdiction; forest policy typically is defined in such terms. Global forest attributes are defined instead in terms of the functions trees satisfy - as banks for carbon, genes, species, water, radiation, and human effort, as public utilities for the generation of basic human subsistence, wildlife, diversity, good soils, beauty, pure air, and moderate climate.

A functional forest is defined more by what aggregations of trees do, and by who sustains them, than by whether they satisfy certain customs of placement, form and control. An aggregation may better satisfy various functions if its trees are scattered or patched evenly across the landscape, clustered around settlements, or lined along roads, streams and shores, than if placed as one reservation of trees on distant hills. The functional forest comprehends any and all aggregations of trees, wherever and by whomever they are grown, protected, and shaped. It is this kind of forest toward which interests in global forest management are turned.

The functional forest contrasts starkly with the territorial definitions that dominate forest policy discourse, including the discourse about global concerns. Failure to confront the difference typically confuses discussion by treating forest functions in territorial and jurisdictional terms. "Hectares" of forest, governmental by implication, are counted as if hectares rather than trees store carbon, as if policies rather than people grow or cut trees.

The contrast in forest vision is a significant social fact. It expresses the different social perceptions of forests among global, national and local levels of interest. It expresses the difference between forests as property jurisdictions and as attributes of landscapes that people shape through the full force of their motivations. It is the difference between a map of "forest" ownerships and a pattern of all perennial vegetation in a sharp image from space. Recognizing, allowing for, and possibly resolving, the disparity are fundamental needs in the framing of global forestry arrangements.

2.3 Forest policies vs. policies that shape forests

Forest policies traditionally have been designed to regulate human actions within governmentally-defined forest jurisdictions. But the functional forest, the forest as an element of landscape, is shaped by whatever policies affect land use. Their names notwithstanding, policies that encourage people to carve, slice, clear, and plant forests for agricultural and urban development are at least as forceful as those which, called "forest" policies, are intended to bound, protect and ration the jurisdictional forest territory.

There is a tremendous disparity between the policies that determine nations' forest conditions - e.g. macroeconomic and trade policy, public investment and social policies - and those that nations call their "forest" policies. In the vast areas of the tropics which were forested prior to settlement, for example, forest cover today is like a photographic negative of the "positive" imprint of social history, shaped as much by the forces driving development as by those that may restrain it. The full picture is formed by both types of forces and the policies affecting them. The challenge today is to capture the capacity of both to form the landscape aggregations of trees that best serve national interests. International arrangements are likely to succeed to the extent they help to achieve landscapes that satisfy national aspirations as well as fulfil global functions.

2.4 Interdependence and weak modes of exchange

The topic of this meeting, "Options for Global Forest Management," reflects the growing perception of interdependence among national patterns of sustainable resource use and wellbeing and the relative absence of means for negotiation and exchange among nations to attain mutually more satisfying outcomes. For example, the banking and public utility functions of forests provide no economic benefit to their suppliers although saving others the costs of regulating carbon or toxic discharges and mitigating their climatic or biological effects. Deltaic nations that absorb the effects of sea level rise have no way to gain compensation from those who may cause it. At a minimum, global arrangements would increase opportunities for mutually beneficial negotiation and exchange of such kinds.

This issue has become confused by the tendency to classify nations as "developed" and "developing," tropical and temperate, agrarian-industrial, "North-South," or whatever other dichotomy seems to satisfy. The differences and commonalities among national interests, capacities, and cultures are more complex. When nations are classified in terms of their relative jeopardy to global phenomena and their relative capacities to modify or respond to these phenomena, for example, the mixes of nations with common interests become much more interesting.

As in the "Law of the Sea" Conference and UNCTAD, the development of an international forestry protocol would be expected to display numerous issue-sensitive shifts among rather diverse transitory coalitions of interest. Global arrangements appropriately would include a system of brokerage that can manage the exchange requirements of these shifting possibilities, as well as a system of knowledge generation that overcomes the disparities and diversifies the limited opportunities that characterize all of the above issues.

3 PATTERNS

I have discussed the functional forest as an expression of human motives and the policies which may affect them. In this section, I summarize and interpret studies of these dynamics. I provide examples of patterns that researchers have identified in Asia and the United States. These hypothetical patterns, and the causes underlying them, offer indications of potential sources of policy influence on forest cover.

3.1 The U-Curve Hypothesis

The following propositions were developed through empirical research on the social forests of India, Nepal, Bangladesh, Thailand, Indonesia, China, Philippines, and California.

> The proportion of land in forest cover has a U-shaped relation with population density (Romm and Washburn 1985) and a direct relation with income level (Govil 1991). The area of forest depends upon the sufficiency of protection against threats of theft and encroachment in a place, i.e. on the resources and authorities available there for boundary enforcement relative to the extent of the threat (Menzies 1988; Malayang 1990).
>
> The strength of forest protection in a place depends upon the cohesion and wealth of those in control of forest and land use, the value of the forest relative to competing land uses, and the strength of supportive governmental or religious authority there (Baker 1989; Ghimire 1989; Chandrakanth and Romm 1991). The strength of authority relates directly to access to centres of governmental, political or religious enforcement capacity (Romm 1986; Ghimire 1989; Moench 1990).
>
> The rate of hinterland deforestation is related directly to the governmental need for revenue, capital, or foreign exchange, and inversely to the strength of social cohesion (Romm 1972, 1986).
>
> The proportion of trees relative to other plants in a place is related directly to the opportunities for non-farm employment, the values of perennial relative to annual vegetation, the availability of credit, and the security against theft, prevailing in a place (Thomas 1988; Menzies 1988; Romm 1989; Govil 1991).
>
> Species diversity depends upon the degree to which non-market forces govern those who control the forest and upon the diversity of market access available to them for forest goods. The commercial proportion of species relates directly to the degree of market integration, inversely to the degree of economic autonomy (Moench 1990; Malayang 1990).

Biological productivity of a forest depends upon the quality of its site and the effort invested in its protection and production. The amount of the investment is related directly to the value of the yields and inversely to the worth of other possible uses of the effort (Thomas 1988). The value of yields and the opportunity costs of investment are directly related to the degree of urban integration (Wollenberg 1991).

These relations may be used as testable hypotheses about forest distributions or as preliminary criteria with which to "map" forestry possibilities and to project or evaluate policy effects.

3.2 The Radial Forest Model

The relations may be used to form a model of the forest dynamics of a nation as its social landscape develops over time. The following hypothetical patterns are observable in India, Thailand, and California:

Initially, the classic hinterland forest disappears at an increasing rate as roads penetrate it for commerce, settlement and control; social forests begin to rise near population centres and roads emanating from them, where authorities are strong enough to protect them and where urban markets increase their values.

Over time, the social forest spreads starlike from population centres and roads as the wealth, power and urban base of the nation increase; the expanding cover coalesces outward into a relatively continuous and increasingly diverse forest; the hinterland forest still recedes but at a slowing rate.

At a mature stage, the economic wellbeing of the population increases at an acceptable rate while the land requirements for production decline; political and social cohesion grows sufficiently to keep within controllable limits the pressures for escape to the hinterland forest. The retreat of the classical forest stops; the social forest approaches and now protects its legal boundaries by satisfying the needs that otherwise would breach them.

In any one place during this hypothetical process, the growth of the social forest occurs first in areas where boundaries are enforcible - within homesteads, on lands of wealthier and more secure owners and of public agencies - and on sites where, for ecological or institutional reasons, trees are the sole, the superior, or a complementary potential use; it occurs last in the absence of social cohesion and compensatory external powers for protection. The hypothetical relations and the process as a whole demonstrate the empirical identification of links between forest patterns and national policy instruments. They also suggest the possibility of identifying policy instruments that negotiation and exchange among nations might most fruitfully address.

3.3 Interests, capacities and diverse national responses

Even if the above generalizations are valid, no two nations display the same forest processes, conditions, and policy options. On this basis alone, no two nations can be expected to want the same global forestry arrangements or to respond similarly to whatever arrangements may be adopted.

But the differences go further. Nations face differential probabilities of damage from global change; they have different capacities to moderate change by means additional to the modification of their forest cover; they tend to use their capacities in characteristically different ways. By these criteria alone, nations that are grouped together for other reasons would be expected to respond rather differently to alternative international arrangements.

If sea level rise were the sole aspect of global change that is of concern, for example, the densely populated deltaic nations of the world would seem to face the greatest potential losses and therefore to have the greatest interest in alleviating their cause. The construction of dams has demonstrated that even a one-inch seasonal shift in the relative levels of fresh and marine waters can have profound effects on delta economies. But some deltaic nations are in a better position than others to moderate the causes of sea level rise and therefore to negotiate actions by other nations on their behalf. Nations that are industrializing rapidly or are able to regulate their vegetative cover, for example, seem in a better position to adopt carbon emission controls or to increase carbon banking than those facing severe poverty or lack of forest control. Nations that prefer market- or administration-mediated policy regimes would respond differently despite apparently similar objectives and circumstances.

Even these three criteria - interest, capacity, propensity - demonstrate the large differences between nations that exist for only one among the many issues to which a viable forestry protocol process must be able to respond. Tables 1 to 3 offer rough illustrations of the possible diverse coalitions of interest that the three criteria alone suggest.

Table 1 Sea Level Rise

Capacities to Modify	Potential Relative Losses	
	High	Low
High	Thailand Netherlands Japan	North America Scandinavia Malaysia
Low	Bangladesh Vietnam Egypt	Brazil Zaire Nepal

Table 2 Forest Banking of Carbon

Reduce Carbon Emissions	Increase Forest Banking of Carbon	
	High	Low
High	North America USSR Australia	Middle East Japan Europe
Low	India China Brazil	Burma Egypt Sub-Sahara

Table 3 Policy Preferences

Emissions Reduction	Forest Banking	
	Market	Administration
Market	&&&	***
Administration	+ + +	###

Whatever errors the above may contain, the point is straightforward: the institutional options for global forest management must contain sufficient scope and diversity to satisfy a rather broad array of national conditions. Except by coincidence, no one arrangement will be optimal for any two nations today or for any one nation tomorrow as well.

4 IMPLICATIONS

The move for a forestry protocol acknowledges the environmental banking and public utility services that the world's forests provide. It implies as well the need for evaluation of these services through a complementary system of finance that generates and transfers credits of various kinds to sustain required global levels of investment. The finance system presumably would have some relation to the value of losses, or the costs of alternative means to mitigate them, that forest improvements can help to avoid and reverse.

The functional rather than the territorial or jurisdictional forest provides environmental banking and public utility services and is the appropriate focus for evaluation and finance. Using the functional forest in this way requires improved knowledge about the content and the consequences of diverse landscape aggregations of trees and people and about the effects of different policy mixes on the shapes of these aggregations. There is a major international opportunity to combine the techniques of global modelling, geographic information systems, and dynamic economic and policy analysis, in ways that create significant advantages for all participating nations. A forestry protocol might create such a facility and its educational processes.

The functional forest also directs attention to the people who form it. People plant, grow and cut trees for reasons that in many circumstances have little to do with "block plantation" presumptions of motive, capacity and opportunity. Planting targets of "x trees/person" and "y hectares" have profoundly different economic, political, social and ecological implications, and there is as yet no basis for the generalized preference granted to the family of corporate strategies the area-type target implies. The densest growth of perennial vegetation often is located in the most densely settled conditions (Romm et al. 1991).

Expanding the range of policy instruments that can be used knowledgeably to regulate forest aggregations is an international service that offers immense potential benefit. In addition to values of a national sort, such expansion will diversify the possibilities for beneficial exchanges that serve nation's complementary needs, interests and capacities. The more diverse the institutional options become, the greater the likelihood that all nations will avail of forms of exchange that suit their various situations.

A forestry protocol might be used to create a knowledgeable system of brokerage that links nations together for mutually beneficial reasons. Such relations need not be global or extensive as long as they create opportunity for joint actions that enhance global interests. Experience with such an enterprise might provide basis for larger forms of agreement in the future.

Recognizing the diversity of national conditions and interests, the difficulties of ground control, and the weakness of reliable scientific understanding, a forestry protocol appropriately would form common objectives and expand opportunities to satisfy them rather than to specify common means. As objectives, rates of improvement are superior to fixed targets because they serve and are consistent with possibilities for institutional learning and growth. For analogous reasons, uniform rates are less viable than rates that are appropriately conditioned to suit national circumstance and the extent of international support for their attainment.

I began this paper by describing some fundamental tensions in social behaviour that global forestry institutions, if effective, would need to resolve. The internationalization and diversification of forestry interests are forcing a rapid transition toward broader, more interesting, and possibly more effective concepts of forests and how government policies affect them. Alternative global forestry arrangements appropriately are judged by their enrichment of the transition: their potential to mobilize finance, to generate learning, to support institutional experimentation and growth, and generally to expand opportunities for beneficial exchange among nations. A worthy arrangement would advance these processes in ways that strengthen, not displace, national capacities to sustain progress in both the domestic and the international realms.

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Towards an International Instrument on Forests

J.S. Maini[1][2]

ABSTRACT

This backround document attempts to provide a broad context within which the issue of the sustainable development and conservation of forests has emerged as a priority on the international policy agendas. The challenge facing the world community today is to meet the anticipated increase in demand for forest products while conserving forest environment worldwide.

International approach to forest-related issued is currently fractionated and piecemeal. A patchwork of legal instruments at global or regional levels focus on trade in tropical timber, forestry research, protection of certain species and habitats, etc. What is needed is a forests framework that is cohesive, comprehensive and deals with both the economic and environmental dimensions.

Considering the economic, social and environmental significance of forests and the growing momentum supporting an International Instrument on Forests (IIF), an international agreement to address a wide range of forest-related issues and opportunities will likely evolve in the near future. Conservation and sustainable development of forests worldwide, that harmonizes socio-economic and environmental objectives, is at the heart of an International Instrument on Forests (IIF). An IIF will provide a cohesive and comprehensive approach to address forest-related issues and opportunities which are national, regional and global in scope, through collaboration at national, multinational and international levels respectively. An IIF will reinforce mutually supportive economic and environmental objectives. It will also provide a policy and institutional framework to: facilitate international trade of forest products, particularly those derived from forests managed in accordance with internationally accepted norms; international transfer of assistance in terms of funds and technology; exchange of expertise, knowledge and credible information; informed priority setting process; collective action to address issues and opportunities of common interest, including science and technology; improve forest management worldwide; and strengthened forestry agencies.

An IIF will provide complementarity with other international initiatives such as the Biodiversity and Climate Change Conventions. The forest components, which will form part of the proposed Climate Change and Biodiversity Conventions, and the proposed International Instrument on Forests, are mutually supportive. This process towards an IIF should not impede that of the other two main initiatives.

The need to establish a formal intergovernmental consultation process, leading to an IIF, is urgent, and the active involvement of the forestry community in this process crucial to its success.

Biomass Energy Conservation Options for Forest Conservation

N H Ravindranath[3]

ABSTRACT

Fuelwood use for cooking in developing countries is one of the factors contributing to degradation and loss of forests, especially the urban requirements of firewood. Two of the options for conserving forest resource is to conserve wood used for cooking through alternative sources of energy like biogas and through fuel efficient wood stoves. A case study of India shows that if all the biogas potential is used and if all the

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remaining biomass using households are provided with fuel efficient stoves, nearly 98 million tonnes of biomass (mainly wood) could be saved from burning. Such a programme would lead to reduction in pressure on village trees and on forests. This would necessitate appropriate technologies or designs, dissemination strategies and funding. Any forest management option in developing countries must consider strategies to meet the local needs of biomass, especially energy needs of cooking.

3 International and Global Issues
3.2 Climate Change

Constraints on Increasing Tropical Forest Area to Combat Global Climate Change

Alan Grainger[1]

1 SUMMARY

Previous assessments have shown the potential for forest-based strategies to help mitigate global climate change by controlling tropical deforestation in order to cut carbon dioxide emissions and by expanding forest area to increase the carbon sequestration rate. The afforestation scenarios proposed so far ignore various practical constraints on the rate at which forest area can be increased. These include: uncertainty about suitable and available land areas; social, political and organizational factors; economic factors, e.g. planting costs and timber prices; having to rely on social forestry/agroforestry schemes, many of which have a lower biomass density than intensive plantations; and lack of coordination with local needs and national and global forest policy priorities. This paper discusses these constraints, suggests how they can be included when modelling planting rate scenarios, and identifies research priorities.

2 INTRODUCTION

Tropical forests contain a major proportion of all carbon stored in the terrestrial biota and the current rapid rates of clearance and burning are causing both a substantial net transfer of carbon from biosphere to atmosphere and a reduction in the carbon sequestration capacity of regenerating forest. Both processes contribute to global climate change through the greenhouse effect. Proposed forest-based responses in climate change mitigation programmes mainly involve a large increase in global forest area (Sedjo and Solomon, 1989) but an alternative is to combine this with efforts to control tropical deforestation (Grainger, 1990a). It has been widely assumed that most forest expansion would be in the tropics, where there is a large area of unused degraded land, and compared with temperate countries growth rates are higher and costs lower. Present expectations of increased afforestation rates are often unrealistic, and if policy makers are to be presented with feasible options then more attention should be given to the likely constraints on tree planting. This paper discusses five of these from a global modelling perspective: inaccurate estimates of areas of suitable and available land; social, political and organizational factors; economic factors, e.g. planting costs and timber prices; the probability that a significant proportion of the increase in tree cover have a lower biomass density than intensive plantations; and lack of coordination between forest response programmes and international and national forest policies and programmes. It suggests how to incorporate these constraints in the next generation of forest response assessment models and identifies research priorities for data collection and technique development.

3 AN OVERVIEW OF POSSIBLE STRATEGIES

3.1 The Need for a Multi-Sectoral Approach

Previous studies by this author discussed the potential for forest-based strategies to mitigate global climate change (Grainger, 1990a, 1990b, 1990c). This section briefly reviews the main findings of those studies. An examination of strategies to control deforestation and carbon dioxide emissions concluded that it is insufficient to rely on action by foresters and conservationists alone. Since most deforestation is caused by agricultural expansion, a multi-sectoral approach is vital, involving action in the agriculture sector as well as in the forestry and conservation sectors and giving high priority to improving agricultural productivity and sustainability. Greater productivity on lands best suited to farming would reduce demand for new farmland. As a lot of deforestation is a result of forest land being replaced with unsustainable land uses, and more forest has to be cleared to maintain overall food production it is also important to increase sustainability by better farming and land use planning techniques (Grainger, 1990b). A multi-sectoral approach involving agroforestry as well as forest plantations is also essential to increase tree planting rates, as discussed below.

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Alternative deforestation control strategies can be evaluated more rigorously by means of mathematical models. Assuming alternative rates of increase in agricultural yield per hectare, food consumption per capita and population (based on past trends) and that (for convenience) all land use is sustainable, simulations with a deforestation model for 43 countries in the humid tropics accounting for 96% of the total area of tropical moist forest showed deforestation rates falling over the period 1980-2020 from 6.6 to 3.7 million hectares per annum in the High Scenario, and from 4.1 to 0.9 million ha per annum in the Low Scenario, resulting in reductions of 20% and 10% respectively in the total area of tropical moist forest by 2020 (Grainger, 1990d).

This model was later adapted to simulate trends in net carbon emissions from deforestation. Alternative scenarios corresponding to the High and Low deforestation scenarios showed carbon emissions for the humid tropics falling between 1980 and 2020 from 0.7 to 0.4 gigatonnes of carbon (gt C) per annum in the High Scenario and from 0.4 to 0.1 gt C per annum in the Low Scenario (Table 1). If emissions from deforestation in the dry tropics were included, overall emissions from tropical deforestation fell from 0.8 to 0.5 gt C per annum (High Scenario) and 0.5 to 0.2 gt C per annum (Low Scenario) (Table 2) (Grainger, 1990c).

Table 1 Trends in carbon emissions from deforestation in the humid tropics (gt C per annum)

	High Scenario					Low Scenario				
	1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
Africa	0.192	0.187	0.158	0.131	0.125	0.132	0.122	0.902	0.756	0.609
Asia	0.211	0.193	0.164	0.157	0.151	0.138	0.120	0.949	0.712	0.557
Latin America	0.298	0.281	0.250	0.208	0.158	0.179	0.150	0.106	0.578	0.089
Humid Tropics	0.702	0.661	0.572	0.495	0.434	0.449	0.391	0.291	0.205	0.126

Source: Grainger (1990c)

Table 2 Trends in carbon emissions from deforestation in the dry and humid tropics (gt C per annum)

	High Scenario					Low Scenario				
	1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
Africa	0.235	0.230	0.201	0.174	0.168	0.174	0.164	0.133	0.118	0.104
Asia	0.220	0.202	0.173	0.166	0.160	0.147	0.129	0.104	0.080	0.065
Latin America	0.342	0.325	0.294	0.252	0.202	0.223	0.193	0.150	0.102	0.053
All Tropics	0.797	0.757	0.668	0.591	0.530	0.544	0.486	0.387	0.300	0.221

Source: Grainger (1990c).

NB. Simulations include the following constant values of emissions from the dry tropics: Africa 0.043, Asia 0.009, Latin America 0.044, Total 0.096 (gt C per annum). 1 gigatonne (gt) C = 1015 g C.

3.2 Setting Feasible Planting Targets

A large area of new forest, called a "carbonforest" by this author (Grainger, 1990a), would be needed to make any impact on the rise in the level of carbon dioxide in the atmosphere. According to Sedjo and Solomon (1989) an extra 465 million hectares of forest with annual stemwood growth rate of 15 cubic metres per hectare per annum would absorb the entire current annual net increase in atmospheric carbon dioxide content from all sources (2.9 gt C per annum). But taking into account the variation in plantation growth rates in different tropical regions a much larger area, almost 600 million hectares, would probably be needed in practice (Grainger, 1990a).

How fast can the carbonforest be established? No formal targets for planting rates have yet been agreed at international level, although the declaration of the Noordwijk Conference in 1989 proposed a rate of 12 million hectares per annum as a provisional aim for the early years of the next century (Anon, 1989). The justification for this rate is uncertain, and while it may have simply been designed to compensate for the annual rate of tropical deforestation of about 11 million hectares in the humid and dry tropics in the late 1970s (Lanly, 1981), if it were maintained for 50 years the result would be the 600 million hectares carbonforest proposed above. However, 12 million hectares per annum is twelve times the average tropical afforestation rate in 1976-80 and also exceeds the total area of tropical forest plantations in 1980 (11.5 million hectares) (Lanly, 1981), so the feasibility of attaining it, even within ten years, is in some doubt and it must be treated as a High Planting Scenario. A planting rate of 3 million hectares per annum (which we will take as a Low Planting Scenario) is more realistic, would cut the present net annual carbon dioxide increment by 25% by 2020, and - if it were combined with a programme to reduce deforestation rates according to either of the above deforestation scenarios - then by 2020 net carbon emissions from tropical forests would be close to zero (Table 4) (Grainger, 1990a).

Table 3 Afforestation scenarios to achieve a range of reductions in present annual atmospheric carbon dioxide increment over a fifty year period

CO_2 Increase Reduction (%)	Total Planted Area (million hectares)	Target Planting rates (million ha per annum)
100	600	12
50	300	6
42	250	5
25	150	3
10	60	1

Source Grainger (1990a)

Table 4 Net carbon emissions resulting from the combination of carbon emissions by all tropical deforestation (High and Low Scenarios) and carbon uptake by the carbonforest.

Planting Rate (million ha per annum)	Net Carbon Emissions (gt C per annum)									
	High Scenario					Low Scenario				
	1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
12	0.757	0.699	0.030	-0.628	-1.269	0.544	0.486	-0.152	-0.832	-1.499
6	0.757	0.728	0.349	-0.018	-0.370	0.544	0.515	0.167	-0.223	-0.599
5	0.757	0.733	0.402	0.083	-0.220	0.544	0.520	0.220	-0.121	-0.449
3	0.757	0.742	0.508	0.286	0.080	0.544	0.530	0.327	0.082	-0.150
2	0.757	0.747	0.562	0.388	0.230	0.544	0.535	0.380	0.184	0.000
1	0.757	0.752	0.615	0.489	0.380	0.544	0.539	0.433	0.285	0.150

Source: Grainger (1990a)

It is now important to go beyond these simplistic assessments of afforestation potential and examine how feasible large increases in the global forest area and afforestation rate would be in practice. This first generation model generated a range of total planted areas and target planting rates, the latter being constant over a fifty-year period. Growth rates were assumed to vary from one climate zone to another - 20 cubic metres per annum for humid tropical areas and 7.5 cubic metres per annum for dry and montane tropical areas - but to be constant in each zone throughout the tropics (Grainger, 1990a). In the next generation of models areas of land suitable for planting will need to be more differentiated according to degree of land suitability, as determined by climate, soil quality, terrain, growth rate etc., and then by their availability for planting. Current estimates of land suitability and availability are highly inaccurate. The assumptions of constant target planting rates should also be relaxed to accord more with reality, for our ability to raise present planting rates is constrained by social, economic, organizational and political factors which already operate to keep down the present rate to about 1 million hectares per annum (although this probably excludes a significant amount of tree planting on farms and in social forestry projects generally). A key social constraint is lack of trained personnel; many countries do not have the necessary capital to invest in forest expansion; and even tripling the present planting rate to 3 million per annum (the Low Planting Scenario) would mean considerable organizational strains as government forestry departments and non-governmental organizations (NGOs) tried to cope with personnel shortages and the demands of operating on a much larger scale than before. Political constraints also exist, e.g. some governments are likely to object to participating in a carbonforest programme on the grounds that it contravenes national sovereignty. Government personnel limitations could be overcome by a social forestry approach that relied heavily on tree planting by non-professionals, such as farmers, but it would be difficult to predict the rate at which planting rates and biomass would increase, since there would probably be a large number of small plantations; a significant proportion of all trees planted would be integrated with agricultural crops and livestock raising in agroforestry systems having a lower biomass per unit area than intensive plantations; and there would necessarily be long delays in starting the programmes. The rest of this paper discusses these issues in more detail, and the implications for assessing afforestation potential.

4 AREAS OF SUITABLE AND AVAILABLE DEGRADED TROPICAL LANDS

An extra 600 million hectares of forest in the tropics would increase tropical closed forest area by a half, global forest area by a fifth and require a land area equivalent to two thirds the size of the USA. But land by itself is not enough. Crucial to the success of the programme is site quality - determined by environmental factors such as soil fertility, climate etc. - on which depend the potential mean annual rates of growth and net carbon uptake. The large areas of unused and/or degraded land in the tropics therefore need to be differentiated by site quality to assess their suitability for planting; they then need to go through a further selection process according to whether they are available for tree planting or whether their owners/managers wish to retain current uses. Estimating areas of suitable and available degraded lands is now a major priority for planners of possible forest response strategies, but there are a number of data and methodology problems.

4.1 Previous Estimates of Areas of Degraded Tropical Lands

This author previously estimated the area of degraded tropical lands with potential for plantation establishment as 621 million hectares in three tropical zones: 331 million hectares of desertified drylands, 203 million hectares of forest fallows in the humid tropics, and 87 million hectares of deforested watersheds in the montane tropics (Table 5) (Grainger, 1990a) This was a conservative estimate, bearing in mind that altogether there could be more than 2,000 million hectares of degraded land in the tropics (Grainger, 1988). There would seem to be sufficient land for the carbonforest programme outlined above but such estimates are very unreliable, as the remainder of this section will show.

Table 5 Tropical degraded lands with potential for plantation establishment (thousand ha)

	Forest Fallows	Deforested Watersheds	Degraded Drylands	Total
Africa	59,292	3,126	110,333	172,751
Asia	58,770	56,494	110,333	225,597
Latin America	84,754	27,230	110,333	222,317
Total	202,816	86,850	331,000	620,665

Source: Grainger (1990a)

4.2 Lack of Reliable Data

The first and major shortcoming is a severe lack of data on global resource distribution, even though satellite remote sensing technology has been available for almost twenty years. Estimates of tropical forest areas and deforestation rates, for example, are still very inaccurate and while some disaggregation is possible, e.g. to separate the areas of tropical moist and dry closed forests, the accuracy of the estimates is not very great (Grainger, 1984a). There are no estimates for the area of degraded lands in the humid tropics except for secondary forest regenerating after clearance for shifting cultivation (forest fallow) or logging for timber (see below). Since there are no separate data on the areas of montane closed forests the estimate of the area of deforested watersheds in Table 5 required a subjective assessment by this author. Estimates of the areas of open woodlands in the dry tropics are even less reliable than for tropical closed forests (Grainger, 1990e). Although dry areas have received most attention in studies of land degradation, estimates of the extent and rate of increase of desertification are mainly based on subjective expert assessments rather than remote sensing measurements (Dregne, 1983; Mabbutt, 1984). Monitoring deforestation in the dry tropics is much more difficult than in the humid tropics, even with medium resolution satellite imagery (e.g. Landsat MSS), and the problems in monitoring desertification are even greater (Grainger, 1990e).

4.3 Measures of Degradation

The lack of practical measures of the degree of resource degradation reflects general data limitations. Indeed, researchers are often forced to frame estimates of gross areas of degraded lands in terms of the classification schemes used for their source data. Thus, the only indication of the area of degraded lands in the humid tropics is given by FAO/UNEP statistics on the area of logged forests and forest fallow (Lanly, 1981). Logged forests were excluded from the above estimate since the focus was on the potential for increasing tree cover: most logged forest usually just requires protection to allow natural regeneration, and while heavily logged forest may need line planting or other silvicultural measures, there is no way, using present data, to distinguish using present data the different degrees of logging and the extent of overlogging. Forest fallow is degraded relative to mature or primary forest and has a theoretical potential for plantation establishment, but much of it is still actively used for shifting cultivation, and this would have to be displaced if plantations were established. Some forest fallow is more open and degraded than others and in its extreme form may comprise only weedy grassland, but the size of this area, and its suitability for reforestation, is unknown. We badly need an improved measure of land (i.e. vegetation and soil) degradation in the humid tropics suited to monitoring by remote sensing. Devising one for our present purposes will not be easy, for although it is possible to distinguish short-rotation forest fallows from mature forest on Landsat MSS imagery and logged forest from unlogged forest on higher resolution imagery, these broad classes alone are insufficient. We need to assess the degree of degradation in more detail and estimate the extent of low density forest fallow (i.e. with a high grassland component) and heavily logged forest.

In dry areas the problems are even greater. There is still no agreement even on how to define the degree of desertification in terms of measurable parameters: it should be remembered that desert is only the most extreme form of this phenomenon (Grainger, 1990e, 1991). Lightly desertified land may still be used by farmers and herders, while severely desertified land may only be restored at high cost and over considerable time. Most moderately desertified land could in theory be afforested but estimates of the suitable area would need to take into account mean annual rainfall and other site factors, and not all of the land would be available in practice. In devising a practical set of desertification indicators it would be desirable to specify parameters measurable by remote sensing techniques supplemented by limited ground measurements (Mabbutt, 1986). But interference between the reflectance of soil and sparse vegetation, and both seasonal and multi-year variations in vegetation cover, present substantial problems when trying to assess long-term trends in soil and vegetation degradation and separate degraded areas from those still actively used for cropping and/or grazing (Tueller, 1987; Prince et al, 1990).

Economic as well as physical measures of degradation are needed. Large areas of degraded land undoubtedly exist but a substantial proportion has not been abandoned and is still in some form of productive use. Indeed it could be argued that land which has been abandoned is probably so degraded that it would be difficult to revegetate. Degraded land still in agricultural use can be classed as economically underproductive in comparison with potential yields obtainable from the most productive possible agricultural land use. It will also probably be physically underproductive, with the difference from the net primary productivity of the climax ecosystem for the area showing the potential for increasing the carbon sequestration rate.

4.4 The Need for Spatial Data

Spatial data are crucial when making accurate estimates of land suitability. For even if data on degraded forest fallows, heavily logged forests, moderately and severely desertified drylands and deforested catchments were available as national totals, without spatial data in the form of vegetation and land use maps it would be impossible to link these to climatic and other environmental factors which influence suitability. As we still lack global maps derived from remote sensing measurements for even the main types of tropical closed forests (i.e. tropical rain forest, tropical moist deciduous forest and tropical dry deciduous forest), the gap in our knowledge is tremendous. This is unlikely to be filled before 1992 at the earliest when the first results of the FAO/UNEP 1990 Tropical Forest Resource Assessment are to be published, and it will probably take some years more before the kind of data we need will be available.

Some scientists have tried to compensate for the lack of global forest resource data obtained from medium (MSS) and high resolution (TM) satellite imagery by using low resolution AVHRR imagery (Tucker and Choudhury, 1987). But the low resolution (1-4 km compared to 30 m and 79 m for Landsat TM and MSS) limits the accuracy of estimates of forest areas and makes estimates of deforestation rates of doubtful value because large areas of small clearances are missed. The utility of AVHRR for assessing degraded areas must therefore be questionable. Monitoring by medium to high resolution satellite imagery appears essential for this purpose.

4.5 The Area of Land Suitable for Afforestation

Current estimates of the total extent of land suitable for afforestation may be too high. Large areas of degraded drylands are of questionable suitability for tree plantations. Degradation also occurs in more humid areas, but here definitions of physical degradation of ecosystems relative to the climax type may also give misleading estimates of areas available for planting or in need of further treatment. For example, in the humid tropics forest fallow vegetation consists of low bushy woodlands far inferior to mature tropical rain forest and therefore relatively degraded, but they usually form part of a shifting cultivation rotation which is, if not sustainable, at least capable of becoming such. Removing most of the forest fallow area, for example, would cut the total area of suitable land from 621 million hectares to 420-450 million hectares.

This section has argued that to obtain more accurate estimates requires: (a) better spatial data on basic resource distribution; (b) techniques to distinguish areas by degree of land degradation or underproductivity. To achieve the first of these aims, a more rigorous global monitoring programme is needed, with the specific aim of estimating suitability for combating climate change rather than other purposes. The UN Conference on Environment and Development in 1992 should therefore give top priority to ensuring that a continuous global monitoring programme for the tropical forests (called for in Resolution 25 of the UN Conference on the Human Environment in 1972) is finally established, and to extending it to monitor desertification (Grainger, 1984a, 1990f). If a large scale afforestation programme is launched to mitigate climate change this will also require continuous monitoring.

Research to develop techniques to classify large area land suitability should begin now, and not wait for better global data to become available. Improved measures of soil and vegetation degradation should be devised for both the dry and humid tropics (FAO/UNEP, 1984; Grainger, 1990e, in preparation; Morgan, 1986). It would also be possible to undertake case studies of small areas for which sufficient data on basic resource distribution and degradation are either available now or could easily be obtained. Using geographic information system (GIS) techniques land areas could then be classified by degree of degradation and underproductivity, climate, soil type and terrain in order to obtain a better estimate of physical suitability.

Economic data are needed too, particularly for afforestation costs. Currently we use rough estimates of planting costs (e.g. a mean of $500 per hectare), but they range from below $200 to more than $1,000 per hectare, depending on differences in site quality, in costs of labour, land, capital, transport, raw materials etc., and in the species and planting system used (e.g. plantations, agroforestry systems etc.) (Troensegaard, 1989). More extensive sampling of planting, maintenance and harvesting costs on an international basis should enable a database to be assembled so that maps of the distribution of physical land suitability can be converted into distributions of economic suitability according to the cost of afforestation. Having on a GIS global maps of the distribution of tropical lands by suitability for afforestation, growth rate and cost of afforestation would allow modelling of forest response strategies which maximized the carbon sequestration rate but minimized planting and other costs.

4.6 The Area of Land Available for Afforestation

Much supposedly 'degraded' land is suitable for afforestation but may not actually be available for it. A variety of different uses normally compete for each area of land, and although the focus on degraded land is intended to assume that this is not the case, much degraded land may still be used for some form of agriculture. Even if environmental quality and economic productivity are both low, those who use the land - who might simply be nomadic pastoralists whose herds graze it occasionally - may be unwilling to convert it to forest or allow it to be fenced off to facilitate natural regeneration of vegetation. They may also not wish to forsake a traditional land use - however unattractive - for one of higher productivity which is less familiar and therefore more risky. Usually the people most able to invest in new land use practices and risk failure are the richer farmers who own the best land. The poorest and most unproductive lands tend to be owned or managed by the poorest members of the community who are least able to invest or take risks. Converting estimated areas of suitable land into areas of available land is therefore not straightforward. The simplest approach might be to categorize land as being: (a) economically available, i.e. the present owners would sell it to the government for afforestation; (b) managerially available, i.e. under certain circumstances the owners would change its use, e.g. from grazing to forest, or from pure cropland to cropland with a higher tree cover; (c) available by government order only, with governments forcibly resettling into villages people such as shifting cultivators from tropical rain forests and nomadic pastoralists from arid rangelands, but even if this were politically possible it could be organizationally difficult.

A more complicated but ultimately more reliable approach would be to assess land availability as a function of price using standard economic supply/demand relations. Thus the area of economically available land would be expected to be a function of the price per hectare which the government would be prepared to pay for land it wished to afforest. The area of managerially available land would be a function of the price for which the goods produced by the new land use could be sold. The latter price would vary from one land use to another - with separate supply/demand curves for plantations of different timber species, agroforestry systems etc. (see below) - and also with distance from the nearest market and the associated transport costs. The whole question of what determines farmers' choice between different land use options in this regard is a highly fertile area for research, as is the related issue of the link between local, national and world timber prices and land availability for afforestation.

5 SOCIAL, ECONOMIC AND ORGANIZATIONAL CONSTRAINTS ON INCREASING AFFORESTATION RATES

Even if a sufficient area of suitable land were available for afforestation there would still remain the problem of planting trees on it quickly enough to have a significant mitigating effect on climate change. It is easy for modellers to propose target rates of afforestation to combat climate change, based on such criteria as the need for no net annual increase in atmospheric carbon dioxide concentration due to either all emissions or those from the tropics alone. But local social, economic, political and environmental factors can make such target rates impractical or reduce the speed at which present rates can be increased. So it is important that target rates be distinguished from the rate which can actually be achieved at a given time and modelling techniques be improved to take account of likely delays caused by these constraints.

5.1 Social Constraints

Disregarding for the moment how the output from the new plantations will be utilized, we can separate social constraints on the size of the target planting rate from organizational constraints on how fast this target rate can be achieved. People are needed to plant trees, but trained personnel are in short supply. In the dry tropics, governments are trying to overcome shortages of trained foresters by turning to social forestry programmes which have varying degrees of participation by local people and include a greater mix of tree species and outputs (Grainger, 1990e). Gaining this participation takes time but is rewarded by higher tree survival rates as people are less likely to cut down trees a few years after the project has ended. Social forestry is still in the early stages of development and there is a great need for research into the factors which contribute to its successful implementation (Fox, 1989; Romm, 1982, 1989).

5.2 Organizational Constraints

All afforestation programmes, whether implemented in government forest reserves or under social forestry conditions, require considerable organization, especially if carried out on a geographically dispersed national scale. Poor organization, particularly the wrong choice of sites and species or an inability to supply the necessary inputs - such as seeds and other materials - to tree nurseries, often causes programmes to fail (Grainger, 1990e). Any programme seeking to dramatically increase planting rates will be delayed as current organizational practices and structures are modified to cope with the new level of activity. Retraining of existing staff and training of new personnel will impose a 'learning curve' for both government forestry departments and non-governmental organizations. It also takes time to carry out the species trials needed in each area, and then to import seeds in bulk and establish nurseries. Careless site and species selection in an attempt to meet unrealistic externally set planting targets is a recipe for disaster. Social forestry programmes incur additional delays due to the time which must be spent in educating, motivating and consulting local people before the project begins . Some of the most successful programmes start small and rely on the power of demonstration and word of mouth to increase the number of participating people or groups. The rate of dissemination can be slow at first but then rises quite rapidly (Grainger, 1990e).

5.3 Economic Constraints

A further constraint is lack of investment capital. Money is always scarce and tree planting is expensive, involving mean initial costs of $500 per hectare and subsequent maintenance costs of up to five times that figure. So far, how the costs of establishing a massive carbonforest are to be met has not been addressed. It is widely assumed that the funds would come from developed countries rather than the tropical countries themselves. But the sums involved are huge: 600 million hectare would cost $300 billion (thousand million) in planting costs alone, and even spread over 50 years (using the 12 million hectares per annum scenario) and neglecting interest charges the cost would be $6 billion per annum. Even the 3 million hectares per annum scenario would cost $1.5 billion annually. Those responsible for planning a carbonforest programme should identify soon the approximate level of funding available for it, otherwise a great deal of time could be wasted in evaluating scenarios which are mathematically feasible but politically unrealistic. It is also important to convert national estimates of areas of physically suitable and available land into areas available for planting at a given cost, so that the total cost of the programme can be minimized.

5.4 Constraints Imposed by the World Wood Market

The socio-economic constraints on tree planting discussed above assumed a fully subsidized carbonforest programme. But wood is a marketable resource, valuable as timber, pulp, and fuelwood, and the carbonforest programme cannot be considered in isolation from the world wood market. Indeed, selling wood for industrial purposes (e.g. conversion into sawnwood, plywood etc.) is vital, for if the carbon sequestration capacity of world forests is to be maximized, trees must be harvested when mature and not left to become overmature, die and decay. On the one hand, income from the sale of wood produced by the new plantations will offset planting and maintenance costs, and the price of timber will be one of the factors determining the availability of land for afforestation. On the other hand, the timber price depends upon the supply/demand balance, and here the market could impose constraints on the scope of the carbonforest. Too large a carbonforest would produce a volume of wood far greater than present or even anticipated future world demand and cause prices to fall dramatically. Thus, a 600 million hectare carbonforest would have a sustained yield of 7,000 million cubic metres of industrial wood per annum: over two and a half times projected world demand in 2030 (table 6) (Dykstra and Kallio, 1987). Even if half of the carbonforest output were used for fuelwood, substituting for non-renewable fossil fuels (the Mixed Scenario in table 6), industrial wood production would still be higher than anticipated future world demand in the High planting scenario and about half the present level of consumption in the Low scenario (Grainger, 1990a).

Table 6 Industrial Wood Production Scenarios

CO_2 Increase	Planting Rate Over 50 years (million ha per annum)	Sustained Yield (million cubic metres per annum)	
		Industrial Scenario	Mixed Scenario
100	12	6,975	3,488
50	6	3,488	1,744
25	3	1,744	872
10	1	698	349

Source: Grainger (1990a)

It is also important to consider what will happen to existing sources of wood. If half of the carbonforest output were used for fuelwood then its industrial wood production would be of the same order of magnitude as current consumption but would swamp the world wood market, depressing prices and possibly forcing present forest owners to clear forests for more profitable uses, so defeating the entire purpose of the carbonforest. It might be argued that when the carbonforest has been established there should be a total ban on all logging in tropical rain forests, with tropical hardwood from plantations being used instead. But regardless of the quality of the wood produced, and even with half of the output burnt as fuel, the Low planting scenario would lead to an annual harvest more than six times current tropical hardwood production. So even if the governments of the developed countries were to pay for the entire 600 million ha carbonforest, the realities of the world wood market (and therefore world politics) would probably result in a planting rate far lower than 12 million hectares per annum. Data on expected planting costs should therefore be combined with projected timber prices to estimate likely net discounted revenues if a proper assessment of the various tree planting and wood production scenarios outlined is to be made.

5.5 Incorporating Constraints in Forest Response Assessment Models

The next generation of forest response assessment models should not assume constant tree planting rates but take account of delays imposed by social, economic, organizational and political constraints as research data become available. Most constraints are internal to each country, but some are determined largely exogenously, e.g. average world industrial timber prices, and modelling these constraints will be slightly more complicated.

6 ALTERNATIVES TO AFFORESTATION

6.1 Vegetation Enhancement

It is usually assumed that the carbonforest will consist entirely of forest plantations, but since any tree planting programme in the tropics is likely to have a large social forestry component, for the reasons stated earlier, the actual carbonforest will be much more heterogeneous. Pure plantations on communal land and farmland will tend to be small in size with a mixed species content, particularly multi-purpose species which can produce food, fodder, fuelwood and other products besides timber. But plantations by themselves are not inevitable, and it is possible that also established will be a wide range of agroforestry systems involving mixtures of trees, crop cultivation and livestock raising, e.g. windbreaks around fields, intercropping with field and other tree crops, and the planting of timber and other tree crops in pastures (Grainger, 1980, 1990e; Nair, 1989).

In view of this, and the increased carbon sequestration rate which would result simply from raising present agricultural productivity and sustainability (e.g. by using planted tree fallows in short-rotation shifting cultivation), it is probably better to refer to vegetation enhancement than to afforestation. The rise in the annual net carbon sequestration rate due to agroforestry and other social forestry planting may well be less than if the carbonforest were to consist solely of pure plantations, but the chances of achieving target planting rates are probably greater since this strategy will correspond more closely to local people's needs. However there are problems for planners with this more heterogeneous approach since it will be more difficult to assess overall suitable and available areas and the costs involved. The mitigating effect of various types of vegetation enhancement may also need to be expressed in terms of forest plantation equivalents (just as the warming effect of a rise in total greenhouse gas concentration is commonly expressed in terms of the equivalent rise in carbon dioxide concentration).

6.2 Forest Conservation and Protection

A large amount of carbon is currently being taken out of the atmosphere by regenerating secondary forests. Just how much is unknown, and this represents a major source of error in global carbon budget calculations. Extending the area of tropical closed forest within national parks and other protected areas, and expanding the area of commercial timber production forests protected from illegal clearance or logging will maintain and even increase this uptake rate. The amount of tropical moist forest within protected areas has risen steadily over the last two decades, prompted by national concerns, the IUCN World Conservation Strategy, and more recently innovative debt-for-nature swaps (Grainger, in preparation). These efforts should be given an additional impetus by being included within climate change mitigation programmes. In recent years there have been increasing calls for more sustainable management of tropical moist forests. This can be achieved by improving current logging systems, ensuring that logging activities conform to present government regulations, protecting both logged and unlogged forest from illegal clearance and logging, and developing and introducing new silvicultural systems. Of these approaches improved forest protection could be implemented relatively quickly - it is not necessary to establish formal forest reserves immediately - and lead to a significant reduction in net carbon dioxide emissions, for not only will deforestation be reduced but logged forest will be free to regenerate (and hence take up more carbon) undisturbed.

7 CLIMATE CHANGE MITIGATION AND FOREST POLICY

7.1 International Forest Policies

Until now discussions of forest response options to mitigate global climate change have been somewhat detached from the ongoing debate on international forest policy, especially policy on tropical forests. Clearly this cannot and should not continue for much longer, for two reasons. First, international policy on tropical forests, however inadequate it may still be, has nevertheless evolved by consensus between the developed and developing countries as a result of lessons learnt from past successes and failures. Climate change mitigation programmes should take advantage of this evolutionary background to avoid repeating past mistakes. Second, since forest responses to climate change must take place within the structure of regular forestry activities it is essential that as far as possible they fit within the current policy framework, although they may be a welcome catalyst for further policy evolution. This is particularly important given the current reconsideration of the Tropical Forestry Action Programme (TFAP), and the need for complementarity between the principles of the Global Climate Convention and proposed Global Forest Convention, which are now under preparation.

One of the most important lessons learned by foresters in the past twenty years has been the need to move from a technocratic forestry approach to a more people-oriented one. This led to major shifts in forest policy by FAO, the World Bank and other agencies in the late 1970s. Extensive industrial plantations in tropical countries are these days regarded with more scepticism than previously, the emphasis being on small social forestry schemes. These are generally more effective than large plantations in the long term, but are more difficult to plan and implement and involve both government and non-governmental organizations (NGOs), with a lot of 'bottom-up' rather than 'top-down' planning. If such an approach is to be successful it is vital for NGOs to be closely involved with international and national planning of carbonforest programmes coordinated by governments and UN and other international agencies. They also need better technical support than has been the case until now (Grainger, 1984b, 1990).

Another lesson which has still to be widely accepted and included in international forest policies is the need for a multi-sectoral approach. The TFAP was intended initially to control deforestation (World Resources Institute et al, 1985; FAO, 1985) but failed to fulfil its aims. This may be explained in part by the very restricted scope of conventional tropical forest policy analysis, with policymakers being unable to recognize all the factors affecting changes in tropical land use and forest cover (Ross and Donovan, 1986). So the TFAP promoted afforestation and other forestry-related projects but largely ignored the role of agriculture, NGOs, indigenous peoples and other key factors. Lack of comprehensiveness is also a threat to the success of a future carbonforest programme, and if planners ignore these factors or the link with the world wood market, the programme is liable to be ineffective or fail completely.

7.2 National Forest Policies

If a carbonforest programme is established there will be changes in international forest policies but it is possible that the only substantive change in national forest policies will involve a dramatic increase in all forms of activity, e.g. rates of afforestation, investment in forest management, etc. The most important modification to international policy as far as the tropical countries are concerned will relate to how these new initiatives are justified. Taking the attitude that tropical countries should engage in largescale afforestation so that developed countries can continue to burn fossil fuels at present rates will be unacceptable, and so will equating the rate of carbon uptake by tree planting with the net annual carbon dioxide increment from all sources. It would be far more equitable for tropical afforestation to be seen as offsetting greenhouse gas emissions from tropical countries only, and this would also lead to more feasible target planting rates.

Seen in this light, efforts to strengthen current forestry programmes in tropical countries should generally be welcomed, but both donor and recipient countries would be wise to only allocate funds which can be spent on implementable projects (another lesson learned by hard experience). New projects should therefore be designed according to four basic principles:

1 Concern about global climate change should be used to increase each participating tropical country's ability to satisfy local social, economic and environmental needs, by strengthening existing programmes and policies rather than creating new ones, enhancing rather than displacing existing land uses, and creating new employment rather than unemployment.

2 Targets for planting rates should take into account present and potential demand for the goods and services likely to be produced by the new forests and the effect of this production on the local economy.

3 Afforestation programmes must be carried out in environmentally sensitive ways, and be biased, wherever possible, towards activities which restore degraded environments.

4 Targets for planting rates should be feasible in terms of present knowledge about the limitations on afforestation activities.

8 RESEARCH PRIORITIES TO OVERCOME CONSTRAINTS ON ASSESSMENTS

Many of the questions raised when considering forest response options to mitigate global climate change cannot be answered at present. This is not surprising bearing in mind the lack of data on forest resources, rates of deforestation and desertification, and the early stage to which modelling techniques for forest response assessment have so far progressed. Research is required to overcome these limitations as soon as possible. The recommendations made in this paper may be summarized as seven main research priorities:

1 More accurate data on the extent, distribution and rate of change of forests, vegetation cover and land quality in the tropics is urgently needed. The data should be obtained from medium to high resolution satellite imagery in a format suited to transfer to a geographic information system (GIS) for further analysis in connection with climate change mitigation research.

2 Research is needed to define new measures of tropical vegetation and soil degradation that can be monitored efficiently by satellites with the minimum possible need for collection of ground data. This research, which should be based on detailed regional case studies of degradation taking place in the field, will allow more discriminating evaluation of tropical degraded lands as more global data become available.

3 New techniques should be developed to assess land suitability on a large scale, involving spatial comparison of degraded land areas with climate and other site factors on a GIS, and also including data on economic aspects of land suitability. The latter will require extensive data collection to provide more accurate estimates of planting and other costs by region, country and site type to enable better costing of the various planting scenarios.

4 New techniques for land availability assessment are also required, together with basic supportive research on economic and other factors which determine whether a farmer will choose to adopt an alternative land use and if so which one. Another challenge for largescale modelling involves linking tree planting scenarios more explicitly to world wood demand scenarios through supply/demand functions.

5 If feasible tree planting scenarios are to be formulated, then some fundamental studies of industrial and especially social forestry programmes are needed to investigate the organizational factors which could delay the increase in afforestation rates.

9 CONCLUSIONS

Recognition of the constraints on increasing global forest area to mitigate climate change will lead to the formulation of more realistic afforestation scenarios and to improved information inputs to policymakers. But this will not happen overnight, because of the need for improved resource data, enhanced modelling techniques and fundamental research on various aspects of land management. Policy should also be an input to modelling, and the realism of future forest response assessments will depend on the results of parallel research to improve tropical forest policy analysis. When more realistic scenarios have been produced, effective implementation of forest response strategies will be determined by the extent to which they are coordinated with national and international forest policies.

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ABSTRACT

The main findings and recommendations of the conference were:

- although the problem of greenhouse gas emissions is essentially a fossil fuel problem and must be addressed as such, forestry response options can assist in mitigation of atmospheric greenhouse gas build-up. Forestry response options to climatic change can provide relatively low cost, short term policy responses to sequester carbon in forests and soils, and to avoid additional releases of greenhouse gases via deforestation, using techniques and delivery systems already available. Forestry response options should be justifiable for sustainable development to meet basic needs. Prevention of deforestation is seen as a higher priority than reforestation in the tropics, as a response to climate change; it also offers greater greenhouse gas reduction benefits;
- participants supported the development of a World Forest Conservation Protocol for all global forests in the context of a climate change convention process that also addresses energy supply and use.

The conference concluded that "no agreement on forests and global climatic change will be reached without commitments by developed countries on greenhouse gas emissions, and that while the conservation of tropical forests is of crucial importance for global climatic stability, it is of more crucial importance for national economic and social development, for the conservation of biodiversity and for local and regional climate and environmental reasons." They further concurred "that the specific elements of such a protocol are a matter for international negotiations, but that they may include fundamental research, tropical forest planning, measures to use, protect and reforest, international trade, financial assistance, and the advantages and disadvantages of national and international targets."

Other recommendations included:

- that countries should formulate or refine and implement national forest management plans after assessing links between forestry, agriculture, transportation, and energy sectors, whilst considering the implications of relevant social and economic issues like landlessness and poverty;
- slash-and-burn being considered a major cause of tropical deforestation - creating employment outside the agricultural sector, and intensifying and sustaining agriculture on non-forest land is recommended, particularly involving 'high knowledge, low input' agricultural systems such as agroforestry. Increasing the value received for crops on the international market would increase farmers' ability to buy inputs;
- transport systems such as railways, pipelines and the navigation of waterways, which have comparatively little impact on forests, should be encouraged over roads. Access to logging roads should be controlled;
- there is need to develop criteria to value forests for their raw materials and the value of their public works functions (hydropower potential, erosion control, etc.). The importance of forests should be fully recognised in national development planning and national income accounting, with deforestation considered a form of disinvestment, and production of forest resources a way of maintaining the capital base of the country;
- developed countries' practices with respect to their own forests will be widely interpreted as signalling their level of commitment to forest conservation in general;
- forest management practices could be improved by defining areas for guaranteed long term harvesting and forest product extraction. Basing timber harvest on detailed forest inventory and exactly specified plans could minimise damage and maximise natural regeneration. Forest product use could be diversified and, as in Brazil, legislation encouraged to require large commercial fuelwood users to replant to the level of their wood consumption;
- countries should promote reforestation and tree planting on bare land to sequester carbon as well as for other environmental benefits such as soil and watershed conservation. This may be as agroforestry,

plantations, or the natural regeneration of degraded forest;

- the international community should work to develop and apply effective codes of conduct for the sustainable exploitation of the forest. Support should be given to initiatives by the International Tropical Timber Organisation to provide guidelines for sustainable forest management, labelling of timber produced by sustainable methods, increased international timber prices, combined with extra revenues being reinvested in sustainable forestry management, and imported requirements for sustainably produced timber;
- the international community could use the process of correcting current imbalances in the international economic system to alleviate pressures for the tropical countries to resort to unsustainable use of natural resources and to create incentives for conservation and sustainable use (such as debt for nature swaps, structural adjustment measures);
- climate change concerns could be incorporated into the mandates and programmes for research, development, lending, and structural adjustment of institutions and frameworks, including multilateral and bilateral donors and international organisations such as TFAP and IUCN;
- improvements are needed in estimates of current forestry emissions as well as emissions benefits of forestry response options.

The Potential Contribution of Forestry in Tropical Countries to Decrease Atmospheric Carbon Content

T Bekkering and C de Pater (presented by A Schotveld)[1]

ABSTRACT

Forestry interventions in tropical countries could, at maximum, contribute to an approximately 15% lower atmospheric carbon content by 2100 compared to a scenario where deforestation would continue at present rate and no reforestation would be carried out.

Forest conservation is more effective in limiting climatic changes than reforestation. A worldwide policy for preserving the forests' carbon pool should concentrate on the following countries: Cameroon, Congo, Zaire, Argentina, Bolivia, Brazil, Colombia, Peru, Uruguay, and Venezuela, Malaysia, Indonesia, and India.

When reforestation is considered, and national food production policies are assumed to aim at self-sufficiency, the following countries still have significant areas (more than 10 million ha) available: Central African Republic, Madagascar, Mexico, Argentina, Bolivia, Brazil, Chile, Colombia, Peru, Uruguay, and Venezuela. Total area thus theoretically available does not exceed 385 million ha.

The feasibility of a large-scale conservation and reforestation effort will depend very much on developments on both agricultural and silvicultural sectors. The forestry sector should also be structurally and economically upgraded, and develop diversified approaches, including or combining conservation strategies, sustained yield and management, large-scale plantations, community forestry, farm forestry, and agro-forestry systems.

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Current Land Use in the Tropics and Its Potential For Sequestering Carbon

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ABSTRACT

Three categories of land where trees may be grown are identified:

- disturbed or secondary forests: if protected from further logging, fuelwood harvest, or other encroachment, such forests can be expected to accumulate carbon until they return to their original biomass;
- severely degraded lands that formerly supported forests: such lands might return to forest if protected or left alone, but the category is distinguished from the first because degraded lands might require varying amounts of input (soil preparation, planting, water, nutrients, and so on) for recovery or growth;
- agricultural or settled land for agroforestry: lands under intensive agriculture are unlikely to be turned over to reforestation projects. On the other hand, the growth of crops can sometimes be enhanced by interplanting with woody species that would also accumulate carbon.

The approach used to estimate where carbon might be accumulated in trees was to compare a map of current land use with a map of vegetation prior to human disturbance. The rationale was that lands formerly forested (prior to human disturbance), but not currently forested, provide the greatest potential for re-establishment of trees.

The analysis was based on digital satellite imagery, using NOAA vegetation index imagery. The resulting data were classified and incorporated in a Geographic Information System (GIS) for each of the three major tropical regions: Latin America, Africa, and South and Southeast Asia. Similar studies are appropriate for countries in the temperate and boreal zones. Other GIS layers included topography, Matthews' global map of pre-disturbance vegetation, and Holdridge Life Zones, as well as regional vegetation maps.

The results of the analysis indicate that, for the tropics as a whole, there may be as many as 579×10^6 hectares of degraded land, formerly covered with forests or woodlands, available to be planted to, and managed as, plantations, and another 858×10^6 hectares of secondary grasslands and secondary forests that, if protected from further use, could be expected to accumulate carbon in woody vegetation and, perhaps, soils. In addition to these areas with potential for increasing the number and mass of trees, there may be as many as 500×10^6 hectares of agricultural lands with potential for sequestering carbon through some form of agroforestry.

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Estimating Tropical Biomass Futures: A Tentative Scenario

Mark C Trexler[1]

ABSTRACT

This report describes a study, currently being undertaken by the Climate, Energy and Pollution Program of the World Resources Institute, to systematically incorporate social and economic variables into estimating the overall potential for tropical forestry to help slow global warming. Other studies have considered the theoretical availability of land on the basis of largely physical parameters, or have made assumptions about the extent to which deforestation can be slowed and how existing forestry programmes can be converted into carbon. Such studies have paid little attention to the many social, political and infrastructural variables that influence the potential for slowing deforestation and encouraging reforestation in a country.

The WRI study includes the compilation of country-specific assessments of the role tropical forestry could play in slowing the accumulation of carbon dioxide in the atmosphere. Profiles for more than 50 countries were built up using literature reviews, interviews and questionnaires, and estimates of land availability and implementation rates were derived. The rates at which forestry efforts could be implemented in each country up to the year 2050 are also being estimated. Thus the potential reduction in carbon emissions through lowered deforestation rates, and the potential removal of carbon from the atmosphere through reforestation, are estimated. This study essentially considers land availability (for reforestation) that might be reasonable for a country, not what is physically possible. Tentative conclusions include the following:

- deforestation can be significantly slowed in many countries, but it will take decades to achieve the full benefit of such efforts. In the short term, reducing deforestation rates appears to be more effective in storing carbon, but in the long term, reforestation is more effective;

- there is great potential for the implementation of forest regeneration and farm forestry options, and in many cases these are likely to be much more economic means of meeting local needs - as well as carbon storage objectives - than plantations could be. Of great importance in allowing forest regeneration is fire control, since fires currently maintain huge areas of land in a grassland climax;

- on a regional basis plantations do have an important role to play in long term carbon storage. Under the scenario, relatively little land is committed to plantations, but it appears that all the called-for plantations can be implemented over the coming decades;

- issues of land ownership are paramount;

- for at least a decade, social, political and infrastructural barriers will keep plausible reforestation rates very modest. Even then, realistic reforestation rates will not account for all the land theoretically available;

- a thorough understanding of local situations is required;

- global warming mitigation through forestry demands involvement of sectors such as land tenure and tax, agriculture, population, etc.

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Climate Change and Global Forests: Current Knowledege of Potential Effects, Adaptation and Mitigation

FAO[1]

ABSTRACT[2]

International political interest is beginning to focus on the need to identify policy response options to climate change in the forest sector. The final report of the forestry subgroup of the Intergovernmental Panel on Climate Change (IPCC) of UNEP and WHO, a science assessment and policy process begun in 1988, has recommended early negotiations on a Global Forestry Protocol to address climate change, along with a broader energy protocol (AFOS, 1990). Policy and programmatic responses to climate change are already underway by FAO and other local, national, and international development organisations.

The IPCC science assessment group concluded that the global mean surface air temperature has risen 0.3 to 0.6 °C since 1880, and that the five warmest years during that 100-year period were in the 1980s. Temperatures are predicted to rise about 0.3 °C per decade over the next 100 years, with a broad uncertainty range that could produce far lesser or greater changes, assuming no policy responses to global warming are introduced. The net result would be a global mean temperature about 1°C higher than at present by 2025, and 3°C higher 100 years from now. Temperature increases are predicted to be greater than this global average in southern Europe and central North America, with accompanying reduced summer precipitation and soil moisture, on average. Results for the tropics and southern hemisphere do not yet produce consistent predictions. Other IPCC scenarios assume widespread introduction of policies to slow gas emissions, and concomitantly show significantly slowed warming. Key uncertainties in this generation of computer models of climate fluctuations include a confident assessment of sources and sinks of greenhouse gases, and of the role of clouds, oceans, and polar ice sheets in influencing climate change.

Forestry options appear to offer only a temporary solution, which would last perhaps 30-100 years. When planted, conserved, or more intensively managed forests reach their natural biomass productivity equilibria, they are in balance in terms of gas fluxes, and theoretically serve neither as sinks nor sources of GHGs (Houghton, 1988; Marland, 1988). Few viable, global scale plans to slow forest loss in the tropics have been advanced; most are simply policy options. Slowing tropical deforestation, and expanding reforestation, may offer two of the most cost-effective policy responses to increasing CO_2 emissions. Only rudimentary estimates of the feasibility, costs, and consequences of large scale reforestation have been performed. Replacement of swidden agriculture with permanent low-input, sustainable agricultural systems may offer particular promise.

Obstacles to slowing deforestation and to planting and maintaining reforested lands in the tropics include degraded soils, limited research on appropriate species and systems, limitations in institutional capabilities, lack of government incentives, and soaring population growth rates. Economic and population pressures in many regions make net afforestation difficult to achieve. Cost estimates for plantation establishment in the tropics, of which 80% of the costs are for labour, range from about US$ 100-200/ha/yr for dry areas with less than 1100 mm of rainfall per year, to over US$ 1,000/ha/yr in wetter areas receiving over 1800 mm/yr.

1 Forestry Department, FAO, Rome, Italy.

2 Draft report.

Progress Reports on International Studies of Climate Change Impacts: Section Four: Global Forests[1]

T H Smith, H H Shugart and P N Halpin[2]

ABSTRACT

The project has two main objectives: to estimate the environmental impacts of climate change on boreal and tropical forested systems, and to identify and evaluate adaptive strategies for reducing the vulnerability of these systems to climate change. Scientists and institutions on five continents are collaborating on this project. It does not examine impacts on temperate forests.

The project is evaluating the response of forests at two scales: the global distribution of forest ecosystems and the regional composition and productivity of boreal and tropical forests. The global analysis provides an assessment of the transitions between major vegetation / biome types. The regional analysis allows for the evaluation of the transient dynamics associated with these transitions, as well as estimates of composition and productivity for the forests within these regions. The results of these analyses will be used to evaluate potential impacts and adaptive responses for timber and fuelwood production and for protection of natural areas.

The methodology involves the use of the 'Holdridge Life Zone Classification System', which provides a means for relating, on a global scale, the distribution of natural vegetation associations to climate indices of average annual precipitation, biotemperature, and a potential evapotranspiration ratio.

Preliminary results are available for the first year of the project. The distribution of Holdridge Life Zones under current climate, and four climate change scenarios are investigated. All climate change scenarios show a significant change in the distribution of climates suitable for the different life zones, and it is postulated that these climatic shifts could result in alteration of half the world's vegetation. All scenarios show a decrease in the areas of climate associated with tundra and desert, with corresponding increases in areas of climate suitable for grassland and forest. Although the total coverage of potentially forested areas increased in all cases, the scenarios differed in the extent to which this increase was attributable to moist and dry components. All four scenarios show an increase in the extent of dry forest; two scenarios show a decrease in the extent of moist forest.

Considering possible changes in the areal extent of climates associated with major forest types, boreal, warm and subtropical moist forests decline under all four scenarios. In contrast, other forest groups either remain stable or increase in their areal extent under the changed climate conditions. Although there is an increase in these forest types, their distributions undergo a significant geographical shift.

Future research will include the development and application of forest gap models to address the dynamics of tropical rainforests in response to environmental change. Projects have been initiated in Costa Rica, Venezuela and Malaysia. Research is also under way to develop a model that can address the important gradient of open woodland / savanna to forest in the semi-arid tropical regions. Impact assessment in the focal regions will be expanded, and the development of policy options to mitigate and respond to these potential impacts, will be undertaken by a network of collaborators.

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1 Draft Report to the United States Environmental Protection Agency of Policy Analysis.

2 Department of Environmental Sciences, University of Virginia, USA.

4 Economic and Cost Issues

Evaluating the Costs and Efficiency of Options to Manage Global Forests: A Cost Curve Approach[1]

K Andrasko[2], Kate Heaton[3] and S Winnett[2]

ABSTRACT

Slowing tropical deforestation, and rapidly expanding tropical and temperate reforestation, may offer two of the most cost-effective policy responses to curbing build-up of CO_2 emissions. Estimates of the feasibility, costs, and consequences of large-scale reforestation have been performed. They tend to be based on generalized estimates of land availability, growth rates and planting costs, so they are crude. The dynamics of competition among land uses have not been assessed. Analysts have generally not addressed the feasibility of proposed activities, nor the links to markets, supply and demand relationships, or global and national economies. Our goal should be to move toward least-cost forest and land use response assessment and planning, comparable with least-cost planning in the energy sector. Global and national scale estimates can be prepared through aggregating site-level data, however, new analyses of reforestation and forest management potential and costs will be needed at site. Farm-level estimates are needed to compliment large-scale, centralized, planning and management schemes that are currently being developed, such as Brazil's FLORAM analysis (see below).

The most urgently needed assessments are the identification of no-regrets options, with low relative costs, that make sense for economic, social, and ecological reasons independent of future changes in forest conversion rates or potential climate change. Integrated natural resource management and social forestry projects providing forest products, protection, economic opportunities, and cooperative management by local people and resource professionals, are likely to be the more successful in addressing global forest management goals than single-purpose projects, such as tree planting for carbon sinks.

Reforestation costs may range from US$230 to $3000 per hectare. Costs of carbon sequestration through forestry range from about $5 to $43 per ton. The tropics are generally thought to have higher potential for carbon sequestration at lower cost. Perhaps 621 to 865 million hectares (ha) of land in developing countries could support reforestation.

1 INTRODUCTION

Intensifying current levels of forest management to maintain high amounts of standing biomass on forested lands, to reduce tropical deforestation, and to aggressively reforest available agricultural or degraded lands, offers significant potential for maintaining -- or expanding -- the provision of a broad array of services provided by forests. These services include biodiversity, watershed protection, maintenance of regional and global hydrologic and carbon cycles, food and fiber, and economic development.

Slowing tropical deforestation, and rapidly expanding tropical and temperate reforestation, may offer two of the most cost-effective policy responses to increasing atmospheric concentrations of carbon dioxide. However, while detailed country forest plans have been prepared under the aegis of the Tropical Forestry Action Plan (TFAP) and economic development planning exercises, only simple estimates of the feasibility, costs, and consequences of large-scale reforestation have been made, using simple point estimates of land availability and planting costs.

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1 Presented by K Andrasko.

2 US Environmental Protection Agency, Office of Policy Analysis, Washington DC, USA.

3 Bruce Company, Washington DC, USA.

Table 1 Overview of Global Forest Services and Scales of Analysis.

Services		Scales of Analysis	
	Site	National	Global
Economic/Market	Building materials, employment	Timber, Fuelwood	Timber trade
Non-Economic	Water, food medicines, fuelwood	Water supply and quality	Regional hydrologic cycles, climate maintenance, biodiversity

1.1 Approach

In general, there is an inverse relationship between the geographic scale of analysis of forest management options, and the quality and availability of data needed to perform adequate economic analyses of these options. Thus first-generation cost estimates of global forest management options have necessarily relied on relatively simple data and assumptions about land availability, costs, and feasibility of the given option. However, more detailed cost benefit analyses have been done for individual options at the site level; some illustrative examples are provided.

Improved national-level cost estimates of forest response options can be generated by: a) identifying the costs and benefits of different forest management practices appropriate for specific country conditions, b) comparing these options in a common metric (e.g., tons of biomass or carbon stored), c) performing land availability analysis for forest and degraded lands potentially available for reforestation or another option, d) aggregating these options cost and land assessments into cost curves that display relative cost effectiveness, and e) assembling quantities of land within each option considered to feasible to reforest or manage into a set of national forest policy options, to assist policymakers in constructing policies and programs to implement forest responses.

1.2 Focus on Climate Change and Carbon Storage

Forest-sector response options to climate change are particularly important because they appear to be: a) capable of partially offsetting current fluxes of CO_2, b) modest in cost relative to other options, c) feasible with existing technologies and practices, if widely disseminated, and d) capable of providing a wide range of ancillary social benefits (e.g., fuelwood supply, reduced soil erosion, wildlife habitat) significant enough to justify forestry options even without the spectre of global warming.

Three major strategies utilizing policy or field practice options to improve forest management will be considered here:

Strategy 1: Maintain Forest Area
1. Protection of Forest Reserves
2. Extractive Reserves

Strategy 2: Reduce Loss of Forests
3. Natural Forest Management
4. Sustainable Agriculture and Agroforestry
5. Increased Use of Pastures

Strategy 3: Expand Forest Area
6. Reforestation, Plantations
7. Restoration of Degraded Lands

Three major scales of forest management options are considered in the paper: global or regional assessments of the potential for introducing forest management options, site-level examples of detailed cost or economic analyses of specific management practices, and national-level analyses of response options.

The paper focuses on potential responses to climate change in particular, and attempts to compare widely different analyses of responses by using the common metric of tons of carbon sequestered by a given practice, in order to allow direct comparison. Evaluation of a fuller set of services provided by forests is needed, but was not possible at this time.

1.3 Qualitative Summary of Efficiency of Options

Table 2 summarizes reforestation options for climate change as determined by a workshop of foresters at the IPCC conference on tropical forests, Brazil, 1990. The table effectively sums the group's judgment of relative effectiveness of options from a perspective of costs, potential contribution to reducing atmospheric CO_2, and a range of carbon benefits (AFOS, 1990).

Table 2 Qualitative Comparison of Reforestation Options to Slow Atmospheric CO^2 Accumulation, by IPCC Tropical Forest Response Options Workshop

Notes: 1. Workshop held by IBAMA (Brazil) and USEPA (US) under auspices of Agriculture, Forestry and Other Subgroup (AFOS), IPCC Response Strategies Work Group (III), January 9-11, 1990, at University of Sao Paulo, Brazil.
2. Assessment of effects is relative contribution of options to slow atmospheric accumluation of CO_2, from 1) small expected contribution, to 3) large
3. FF = potential for fossil fuel replacement by bioenergy plantations
4. HA^{-1} = potential of option to reforest large number of hectares within 10 or 75 years
Source: AFOS, 1990

Two general types of forest were assessed: 1) Protection forests (for watershed protection/erosion control; ecosystem restoration; preservation; carbon stock); and 2) Production forests (biofuel plantations; industrial timber; agroforestry; community woodlots; carbon sequestration). The Sao Paulo workshop members concluded that local fuelwood and shelterbelt options may be cost effective, but may lack potential for a major global impact. Agroforestry was believed to have both low costs and substantial global potential. Biofuel and industrial options were believed to have higher costs, but large global potential.

2 AN OVERVIEW OF COST ANALYSES OF OPTIONS TO PROTECT OR EXPAND FORESTS

A number of different site-level, national and global analyses of options to protect or expand forests have been done. Some include cost data, but in general economic studies are limited by insufficient data. Large forest-sector loans by the World Bank and other multilaterals are the general exception. Few true economic analyses of forest response options have been done at the national or global scale. Such analyses should incorporate direct and indirect costs and benefits, including capital and labor costs, revenues, the value of ecological and non-market benefits, and a comparison of the net-present-values of different forest management alternatives.

Currently, a concerted effort is being made to extend the knowledge of valuation of non-market forest goods. A number of international fora have recognized that this should be given utmost priority. Efforts should also be directed to valuing the full benefits of forestation and conservation. For example, afforestation offers a stream of ecological and economic benefits worthwhile on their own merits (forest products to meet rising demand, forest products industry jobs, fuelwood, maintenance of biodiversity, watershed protection, nonpoint source water pollution reduction, recreation). The stream of direct and indirect benefits that accrue from reforestation, afforestation, and forest maintenance tend to reduce costs.

Site specific studies (described in sections below) have been done in which the effects of introducing technologies and land management practices at the site level are analyzed, (e.g., Trexler, et. al., 1989).

At the national level, TFAP and forest sector review country exercises generally include detailed cost estimates. A few regional/national-scale studies have developed sophisticated estimates of growth and carbon fixation rates based on field data extrapolated to a range of actual land capability classes for a region or country (e.g., Moulton and Richards, 1990).

At the global level, there are numerous over-simplified global-level analyses of costs to fix all the CO_2 emitted by a country or globally by all sources. They are based on generalized assumptions about land availability, growth rates and planting costs, e.g. Marland, 1988; Sedjo and Solomon, 1989; Meyers, 1989. The models of forestry response strategies to limit greenhouse gas emissions have limited assessment of economics (e.g., Grainger, 1989, 1990; and Houghton, 1988, in Lashof and Tirpak, 1989).

A range of computer simulation analyses exists at the forest, national, and global level. Several large, interactive, computer models exist which can simulate the macro-economic effects on the global forest sector of changes in timber supply demand and prices given a number of assumptions about global forest trade. A number of simulations by the CINTRAFOR model (Cardellechio et al; 1989) indicate that it may be possible to use these models to investigate the effect of changes in national-level forest policies on the global forest sector, and vice versa.

3 DEVELOPING A NEW GENERATION OF COST ESTIMATES

Two major types of cost estimates of large-scale forestry options are needed by policymakers to supplement existing global estimates. Deductive scenarios envisioning forest responses of a relatively centralized, government- or commercial-sponsored nature (e.g., massive afforestation programs on degraded lands in the tropics, or surplus croplands in temperate countries), which build on detailed land availability databases, need to be fabricated at the national and global scales. More inductive farm forestry scenarios, built on assumptions of increased tree planting or woodlot management, and protection by small farmers and landowners, are especially required to complement the existing centralized approaches.

Cost estimates for these scenarios will most likely be useful if they address the following considerations:

1 Costs need to include both short-term expenditures, such as seedling stock or establishment costs, and long-term expenditures such as those investments in capital or infrastructure (e.g. processing and transportation facilities).

2 The stream of market and non-market benefits need to be quantified wherever possible. Ideally, both costs and benefits should be distributed differentially across the proposed activities on a prorated basis (e.g., if a project provides fuelwood and carbon storage to slow climate change, the costs and benefits should be proportionally distributed to each service).

3 The costs and benefits need to be levelled for comparison across different time frames, on an annual basis, and in common units, where possible. This type of analysis should permit identification of the greatest stream or mix of benefits (be it biodiversity, local health or climate related) for the least cost.

4 The potential activities should be linked to market-driven economic models of the forest sector and country economies, in separate analyses if necessary.

5 A set of cost curves of various options needs to be developed, which will allow evaluation of the specific mix of activities which, for different places, provides the lowest cost opportunity.

Such analyses will help us complete cost/benefit comparisons across options, ecoregions, and time frames.

3.1 Estimating the Efficiency of Potential Forest Management Options

A major goal of this suggested analytic approach is to move toward least-cost forest and land use response assessment and planning, comparable with least-cost planning in the energy sector. The policy-relevant goal is to identify which mix of options at a given site is likely to best achieve the stated forestry goal (e.g. a carbon offset of x million tons) at least cost and with the highest probability of success. To slow deforestation in a region of Central Africa, for example, the options mix may include sustainable agriculture, forest protection, changes in logging practices, and switching fuels to bioenergy and gas.

3.2 Incorporating the human dimension into large-scale reforestation

While reforestation activities are necessary to reverse degradation of global forests and as a response option to climate change, tree planting should not interfere with higher priority uses of land to meet basic human needs. Consideration should be given to opportunity cost associated with converting land to tree cover. Land suitable for reforestation may appear idle, when in fact local populations, as well as plants and animals, depend on it, and its non-forest attributes, for survival.

Tree planting, however, need not interfere with use of land for subsistence needs. It can help provide for basic human needs through integration of trees into the agricultural landscape to provide for fuel, fodder, crops, and soil maintenance and fertility. If tree planting programs are to be widespread and ultimately successful, priority should be given to planning programs that benefit local populations by taking into consideration land use needs, local customs and land tenure patterns. Priority ought to be given to designing programs that will also offset pressure on standing forests by providing forest resources or sustainable systems of agriculture (e.g. agroforestry) to replace those that exhaust soil fertility, thus necessitating forest clearing for new land. Consequently, new analyses of reforestation and forest management potential and costs are needed at the farm level, e.g. 100 farmers plant and manage 50 trees per year for 5 years. These farm-level estimates are needed to compliment large-scale, centralized, planning and management schemes that are currently being developed, e.g. Brazil's FLORAM analysis described below.

4 GLOBAL ESTIMATES OF LAND AVAILABLE FOR AND COSTS OF REFORESTATION

Notwithstanding the many practical limitations to massive reforestation efforts, gross analyses exist of the amount of land that could theoretically be available for reforestation, and the potential costs and carbon benefits. These estimates suffer from their application of high growth rates and generalized cost estimates to vast tracts of highly differentiated, deforested tropical lands. The lands have been identified through FAO data and satellite imagery and may not actually be available for reforestation when social, political and economic constraints are considered. EPA-funded studies are attempting to assess what land is actually available for reforestation, using remote sensing estimates of land and experts' assessments of social, political and economic feasibility. (See Trexler and Dixon et.al., these proceedings).

4.1 Land Availability

Two major global estimates of land in developing countries available for forestation are widely reported. According to Grainger (1989b, in IPCC, 1990), a total of 621 million ha may be available for forestation in the tropics. Of this total, 418 million ha are in the dry and montane regions and 203 million ha are forest fallow in the humid areas. According to Houghton (1990a, in IPCC, 1990), up to 865 million ha in the tropics are available for forestation. Of this total, there may be about 500 million ha of abandoned lands that previously supported forest in Latin America (100 mill ha), Asia (100 mill ha), and Africa (300 mill ha). The additional 365 million ha could be available only if increases in agricultural productivity allowed this land to be removed from production.

4.2 Carbon benefits and costs

1) If the upper estimate of 865 million ha of potentially available land were reforested, a total of 150 billion tons C could be removed from the atmosphere after forest maturation (Houghton, 1990, in IPCC, 1990).

2) Sedjo and Solomon (1989) have proposed that the current annual net increase in atmospheric carbon (approximately 2.9 billion tons C) could be sequestered for about 30 years in approximately 465 million hectares of plantation forests, at an initial establishment cost possibly as low as $186 billion in the tropics or $372 billion in the temperate zone, a large but not inconceivable sum. This area would also produce as much as 4.7 billion cubic meters of industrial wood annually, three times the current annual harvest.

3) Three scenarios of replanting evaluated by Grainger (1989b) include planting 6 million ha/year over 10 years, 8 million ha/year over 20 years, or 10 million ha/year over 30 years to offset 5%, 13% or 26% of the 5.5 billion tons C currently released from burning fossil fuels annually (Table 3). The 13% reduction scenario achieved over 20 years would lead to an annual harvest of 2,600 cubic meters, the size of the anticipated demand for wood in 2030 (Grainger, 1989b in IPCC, 1990).

Table 3 Afforestation Strategies to Achieve a Range of Reductions in Annual Fossil Fuel CO_2 Emissions (5.5 billion tons)

%CO^2 reduction	Total area planted (million ha)	Planting rates/yr (million ha)			
		10	20	30	50
26%	300	30	15	10	6
13%	150	15	8	5	3
5%	60	6	3	2	1

NOTE: Assumes average growth rate of 15 cubic meters3/yr
Source: Grainger, 1989b, in IPCC, 1990.

Assuming an average planting cost of $400 per ha, the estimated cost of the above three scenarios is $2.4, $3.0 or $4.0 billion per year, respectively. Options trading-off time and money to reach specific planting targets are presented in Table 4. The shorter the time-frame to reach a given level of planting and carbon uptake, the higher the annual cost of planting.

Table 4 Costs of Planting Scenarios to Achieve a Range of Reductions in Annual Carbon Dioxide Emissions from Fossil Fuels

%CO^2 reduction	Total area planted (million ha)	Total Cost	Costs (US$ billion)/year over planting period			
			10	20	30	
26%	300	120	12.0	6.0	4.0	2.4
13%	150	60	6.0	3.0	2.0	1.2
5%	60	24	2.4	1.2	0.8	0.5

Source: Grainger, 1989b in IPCC 1990.

4) Additional estimates of the areas, carbon sequestration rates and reforestation costs to achieve various carbon dioxide emission offset goals in both temperate and tropical environments are listed in Appendix 1.

4.3 Tropical vs. temperate zone planting

A wide variety of forestation options could be pursued on a global basis. The costs and effectiveness of reforestation will, in fact, vary according to location. According to the cost of carbon sequestration ranges from $5 to $30 per ton of carbon. The annual cost per ton of carbon sequestered is generally lower in the tropical than temperate zone, both due to higher growth rates and biomass accumulation potentials per unit area, and to lower land and labor costs. Given these factors and the greater availabilty of land for reforestation in the tropics, the overall potential to increase terrestrial carbon storage is generally considered to be greatest in the tropics.

4.4 Restoration of Degraded Lands

Enhancing natural regeneration could be a more cost effective means than afforestation and reforestation to restore and increase carbon fixation on vast areas of formerly forested lands that have been degraded by anthropogenic practices. The main techniques of restoration are controlling frequent fires that suppress vegetation and providing sources of seeds for tree and shrub species. About 1 billion hectares of forest fallow from swidden agriculture exist, much of which has low standing biomass that could benefit from enhanced regeneration. Large areas of previously forested savanna and grassland exist in Africa and else where, the natural regeneration of which is suppressed by frequent fires. Desertification has moderately or severely affected 1.98 billion ha globally, especially in the African Sahel, Southern Africa, Southern Asia, and China and Mongolia (WRI, 1987; OTA, 1984).

5 NATIONAL-LEVEL COST ANALYSES OF FOREST MANAGEMENT PROGRAMS

Recent concerns about deforestation and climate change have prompted many nations to develop forest management plans and reforestation plans. The most notable forest management planning exercise to date is the Tropical Forestry Action Plan (TFAP), which has 80 participating developing countries and has resulted in many detailed national forest inventories and management plans. Several nations, mainly in the temperate region, have assessed the potential carbon-storage rewards associated with major tree-planting initiatives, largely in response to concerns about global warming. The focus here is on cost estimates of such forest management and reforestation efforts.

5.1 United States

5.1.1 Analysis of Reforestation Potential

The US has about 100 million hectares of cropland and pasture that are environmentally sensitive or economically marginal and, therefore, potentially suitable for tree planting (USFS, 1991). The geographic distribution of marginal land is mainly in the Southeast, Appalachia and Gulf states (Moulton and Richards, 1990). There are also approximately 300 million hectares of private and public forests, some of which could benefit from timber stand improvement to increase productivity (USFS, 1991; USFS/EPA, 1989).

Moulton and Richards (1990) have done an analysis of the potential to offset different percentages of the United States' annual emissions of from fossil fuels through tree planting on cropland and pasture, plus improvement of existing forest stands. The costs of sequestering a ton of carbon range from $5.26 to $43.33 per ton. Table 9 presents estimates of total, marginal and average yearly costs for programs to offset 5%, 10%, 20%, 30% and 56% of the US emissions of 1.4 billion tons annually.

Table 4 Annual Costs of Offsetting Carbon Through Tree Planting

Offset	Total Cost (Mill $US)	Marginal Cost ($US/ton C)	Average Cost ($US/ton C)	Acres (Millions)
5%	700	N/A	9.72	36.9
10%	1700	16.9	12.00	70.9
20%	4500	20.9	15.73	138.4
30%	7700	23.6	17.91	197.6
56%	19500	43.3	N/A	350.0

Source: Moulton and Richards (1990)

Trexler (1990) identifies the theoretical and practical carbon benefits (Table 5) that could be obtained through 7 different land management options, such as conversion of private lands to forest, foregoing old-growth timber harvest, and biomass energy production. The greatest carbon benefits are anticipated in reforestation, forest management and biomass energy. All options cost below $100/ton of carbon sequestered.

5.1.2 Current and Proposed US Programs

Conservation Reserve Program
Current US tree planting programs planted 1.2 million ha between 1985-1989 with existing financial and programmatic incentives geared to replacement levels of planting. For example, the Conservation Reserve

Table 5 US Biotic Policy Opportunities and Costs

Option	Theoretical Carbon Benefit[a] (millions of tons/yr)	Practical Benefit to2030	
		(millions of tons/yr)	($/ton)
Urban Forestry	15	3-5	$0-25
Private Land Conversions	400-900[b]	50-150	$0-50
Public Land Conversions	(not known)	(not known)	(not known)
Forestry Management	100-400	35-75	$0-100
Forgoing Old-Growth Harvests	10-20	5-10	$0-100
Biomass Energy Production	400-1,000[b]	20-150	$20-75
Increase Wood Use	(not known)	(not known)	(not known)
Soil Carbon Buildup	50-100	10-25	$0-10

a. The carbon benefit figure estimates carbon storage in biomass and in soils as well as fossil fuel carbon displaced through implementation of the biotic options. Figures represent as average annual carbon benefit and thus overstate the carbon benefits in the early years of a policy option's implementation.
b. These entries cannot be summed because they involve use of overlapping land bases.

Program (CRP) of US Department of Agriculture, whose goal is to retire highly erodible cropland and pasture from production, paid an average of $219/ha (average rental payment of $125/ha tree and establishment costs at an average of $94/ha), to plant 850,000 ha of trees from 1986 to mid-1988. Additional subsidies of about $220-345/ha would probably stimulate additional tree planting on hundreds of thousands of hectares of economically and environmentally marginal crop and pasture land.

America the Beautiful
"America the Beautiful" (ATB), is the new national reforestation program announced by President Bush in January, 1990. The original ATB plan called for a combined rural and urban program of planting, maintaining and improving 1 billion trees per year for 20 years via a 50/50 federal/private cost-share arrangement. It called for planting 970,000 trees per year on 600,000 hectares (1.5 million acres) of rural land and 30 million trees per year in communities, and improving stocking rates and health on 73,000 hectares per year of private forest land through Timber Stand Improvement (TSI). The "America the Beautiful" Plan would theoretically offset 2 to 5% of 1989-level US carbon dioxide emissions for the period of the program (USFS, 1991; USFS/EPA, 1989;) .

The U.S. Congress passed legislation to begin funding the program in October, 1990, although at half the originally proposed $175 million level and through a USFS program that may emphasize TSI and forest management for multiple benefits over tree planting. Increased funding is proposed for 1992.

5.2 Europe

Van der Meiden, (1990) has done an analysis of the availability of land for reforestation, and the potential for carbon sequestration for various countries within and outside of Europe and the European Community (EC). He examined afforestation scenarios that assumed the availability of certain percentages of agricultural or forest lands.

The studies indicate that the greatest potential for reforestation exist outside of Europe (i.e., in USSR, USA, Canada, China and Australia, among other countries). A small opportunity for reforestation exists in the EC. Since Northern Europe already maintains substantial forest, the main opportunities in Northern Europe are in enhancing the management of existing forests, as described below under Finland.

5.3 Germany

The Federal Republic of Germany has produced the "Assessment of the Potential, Feasibility, and Costs of Forestry Options in the Temperate and Boreal Zones" (FRG, 1991). It also includes estimates for afforestation options in Germany. One set of estimates identifies a total land availability of 700,000 hectares for afforestation, with an average potential for carbon sequestration of 108 tons of carbon per hectare. The assessment assumes roughly 10,000 ha/yr would be planted by 2050, at an average cost of $3000/ha for direct establishment costs. The total sixty-year program would cost $2.1 billion and sequester 76 million tons of carbon at an average cost of $28 per ton. The cost and benefits of other components of the program have not yet been determined.

5.4 Finland

A silvicultural management case study at the country-level for Finland (Kellomaki et al., 1988, reported in AFOS, 1989) examines the effects of intensifying management practices on harvest and carbon yields. Results reveal that Finnish forests could store 273 million tons of additional carbon in above-ground biomass by altering management regimes. This is figure is equal to total Finnish emissions of carbon from fossil fuels during the next 39 years, assuming the annual carbon emissions remain constant at 7 million tons. Changes in management practice include increasing planting density, higher allowable basal areas, lighter thinnings, and delays in the timing of thinnings and final harvest.

Cost savings are expected to result from the changes in management. Decreasing the percent basal area removed in thinnings reduces labor time spent in thinning operations. The act of discounting income and cost streams over time has the effect of lowering the magnitude of those streams that accrue farther in the future. Thus, delaying expenditures on thinning and harvesting for as much as 10 years lowers costs the more years they are delayed and the higher the discount rate used in the analysis. In the Finnish example, intensifying management practice as described reduces costs by 43% when discounted at 4%, and by 48% at a 5% discount rate.

5.5 Australia

Australia (with both subtropical and temperate forests) commenced its One Billion Trees plan in 1989, to restore degraded forests, offset climate change, and conserve biodiversity. The plan entails planting 1 billion trees on 1 million ha by 2000, including 400 million in community planting, and 600 million in natural regeneration of degraded sites and direct seeding, plus a small National Afforestation Program to establish hardwood plantations. Establishment costs are estimated at $230-1560/ha, with a total of $250 million over 10 years (no maintenance costs are available). Carbon benefits are expected to be 6-10 mill. t C/y, and 300-500 mill t C over the 50-year life of the program (Eckersley, 1989; Hawke, 1989).

5.6 Brazil

Brazil, which has had one of the highest afforestation rates in the tropics over the past 30 years, has done an assessment of the potential for large-scale reforestation in the country. The assessment, called the FLORAM project analysis, was completed in December, 1989 by researchers at the University of Sao Paulo, but is not currently expected to be implemented. The analysis (Ab'Saber et al., 1989) concluded that Brazil has the potential to sequester a total of 5 billion tons of carbon over a 30-year period through a combination of reforestation and restoration, and associated soil and below-ground carbon accumulation.

Twenty-seven regions were reviewed for the study. Amazonas, the Pantanal wetlands, and the dry northeast are the main regions in which no activity is assumed. The suitable lands within 23 regions were divided into five productivity classes, with potentials for sequestering carbon ranging from 1.3 to 13.1 tons of carbon/hectare. Half of the land has an intermediate productivity of 7.3 tons of carbon/hectare.

Twenty-two regions were identified as having 20.1 million hectares of land suitable for large-scale reforestation, covering 2.4% of Brazil. This reforestation might sequester 2.418 billion tons of carbon over 30 years. Three types of large-scale reforestation activities and their relative proportions were identified: Industrial plantation (72%); Ecologically corrective restoration of degraded sites (14%); Mixed industrial/ecological (14%).

The plantation establishment costs are not estimated, but are indicated to range between $400-$1000 per hectare. Another $100-200/ha may be needed for some maintenance, e.g., fertilization and replacement planting upon tree mortality. If plantation establishment costs an average of $700/ha, the direct costs (only) of large-scale reforestation on 20.1 million hectares would be about $14 billion over the 30-year life of the program, or about $17 billion if maintenance costs are included. Table 11 identifies the areas, carbon benefits, and average costs per hectare associated with each type of reforestation.

The savannas of the northeast and the southern periphery of Amazonia were identified as having an additional 45 million hectares suitable for special ecologically corrective activities (e.g., planting nuclei of adapted species, creating forested buffer zones for the Amazon, and restoring river corridors). Since the productivity of this vast area is very low, only 920 million additional tons of carbon sequestration are expected over 30 years.

Above-ground biomass in the reforestation and restoration projects is expected to fix a total of 3.3 billion tons of carbon. Considering that above-ground biomass may represent only 2/3 of the total carbon that is expected to be fixed, an additional 1.7 billion tons of carbon is expected to be stored in the below-ground biomass and soils. This brings total carbon sequestration potential to 5 billion tons in 30 years, which represents about 4.3% of the excess carbon dioxide accumulated in the atmosphere since the industrial revolution, or about one third of Brazil's current annual rate of CO_2 emissions from deforestation.

Table 11 Brazil's FLORAM Reforestation Potential Analysis: Area, Carbon Fixation, and Cost per ton of Carbon.

TOTALS	TOTAL AREA (10^6ha)	TOTAL CARBON FIXED		COST OF TON OF CARBON $/tC @ different costs ($x/ha)		
		IN 30 YRS (10^6tC)	tC/ha	at $400/ha	at $700/ha	at $1000/ha
Industrial Reforestation	14,467	1691	117	3.42	5.99	8.55
Corrective Reforestation	2,890	363	126	3.18	5.57	7.95
Mixed Reforestation	2,791	364	130	3.07	5.36	7.66
TOTALS	20,148	2418	120			
AVG				3.22	5.64	8.06

6 CONCLUDING REMARKS

6.1 Social Dimensions to Forestation

Establishing trees is not just a question of money and techniques. No matter how much money is made available for reforestation, there are very real limits to the institutional capacity of many tropical countries to plant, maintain and manage large areas of planted forests. Furthermore, local land tenure, land use customs and laws, cultural characteristics and taboos, and perceived self-interest will affect willingness of local populations to participate in activities necessary to establish and maintain trees. Establishing stands of trees may have higher initial costs than scattering trees throughout the landscape by individual farmers, but the effort and costs of maintaining scattered trees may be greater, since they must be protected from fire and livestock (Weber, 1991).

Economic and population pressures in many regions make net afforestation difficult to achieve. A workshop was held in Guatemala in 1990 to examine the potential for reforestation and restoration in Central America. It concluded that while suitable land is available, socio-economic and institutional capacity barriers currently limit reforestation efforts in the region (WRI, 1991).

6.2 Economic Issues Related to Large-Scale Reforestation

Economic obstacles to widespread reforestation center on the high costs of site preparation, planting, forest management, and financial incentives to private landowners, and alternative land or forest product uses. China, for example, is experiencing rapid economic development that has led to housing construction that consumed 195 million cubic meters of wood (0.05 billion tons C) from 1981-85, equivalent to the total annual growth of all China's forests (Brown et al., 1988a).

Financial incentives to private landowners are generally necessary for reforestation, especially in temperate regions. U.S. state foresters maintain that financial incentives on the order of \$125-250/ha (\$50-100/ac) may be sufficient to bolster reforestation of harvested woodland and surplus croplands in most states in the U.S.

National and global scale reforestation scenario building is currently limited by incomplete and not widely representative tree growth rates, forest standing biomass, land availability, socio-economic feasibility, and establishment and management cost data. Present estimates may be high or low by a factor of 3-10, especially if economies of scale are realized. For example, recent cost estimates in the U.S. for a 20-million-ha federal planting program have declined by about 40 percent during program analysis and design as better data and more thorough analyses became available.

Improved national level cost estimates of forest response options can be generated by: a) identifying the costs and benefits of different forest management practices appropriate for specific country conditions, b) comparing these options in a common metric (e.g., tons of biomass or carbon stored), c) performing land availability analysis for forest and degraded lands potentially available for reforestation or another option, d) aggregating these options cost and land assessments into cost curves that display relative cost effectiveness, and e) assembling quantities of land within each option considered to feasible to reforest or manage into a set of national forest policy options, to assist policymakers in constructing policies and programs to implement forest responses.

Two major types of cost estimates of large-scale forestry options are needed by policymakers to supplement existing global estimates. Deductive scenarios envisioning forest responses of a relatively centralized, government- or commercial-sponsored nature (e.g., massive afforestation programs on degraded lands in the tropics, or surplus croplands in temperate countries), building on detailed land availability databases, need to be fabricated at the national and global scales. More inductive, farm forestry scenarios built on assumptions of increased tree planting or woodlot management and protection by small farmers and landowners are especially required as complements to the existing centralized approaches.

However, analysts currently know enough about reforestation and land restoration benefits and costs to have convinced policymakers in several countries to launch major forestry initiatives to expand forest area and increase carbon storage in forests. The national programs begun in 1989-91 in Australia, U.S., Germany, Canada, and the Netherlands, in addition to existing national reforestation programs or policy goals (e.g., Thailand's Royal Forest Department goal of achieving 40 per cent forest cover) convincingly demonstrate this conclusion.

6.3 Net-Gas Balance Analyses Are Needed

True net GHG balance analyses of the benefits of any response option in forestry to potential climate change, incorporating all fluxes of multiple gases associated with all phases of growth, harvest, and final disposition of biomass and carbon have not been completed as yet. Net balance analyses of different forest practices are needed, to accurately determine the relative benefits of competing response options, and need to include releases of GHGs from disturbance of soils, during manufacturing and transport of fertilizer, use of fossil fuels during harvest and transport, etc.

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APPENDIX 1

SITE-LEVEL ANALYSES

A. Strategy 1: Measures to Maintain Existing Forests

Option 1: Conserve Standing Primary, Old-Growth Forests as Stocks of Biomass Offering a Stream of Economic Benefits

Specific cost estimates for conservation are limited, although Swisher's (1991) analysis of Costa Rica's Tropical Forestry Action Plan (described below under national-level analyses) shows forest conservation to be the least expensive of 6 forestry options per ton of carbon. Conservation costs $1.50 per ton of carbon storage, compared to $15 per ton for timber plantations, one of the most expensive options.

According to one study, the lifetime direct cost of forest protection ranges from $25 to $115/ha, when discounted at a rate of 10%. These costs, however, only reflect direct protection and management costs and do not account for the types of programs needed to address the causes of deforestation, e.g. encroachment by cultivators practicing unsustainable systems of agriculture (Graham et al., 1990).

Option 2: Conserve standing forest in extractive reserves

Extractive reserves are a newly evolved example of natural forest management in which economic products like nuts and rubber are sustainably extracted from forests. Recent research has shown that perpetual, sustainable fruit and latex (rubber) harvest offers far larger economic returns than timber felling, plantation planting, or cattle grazing on the same plot. The net present value of future yields of a hectare of species-rich Amazonian forest in Peru was calculated by Peters et al. (1989). Potential values are $6330 per hectare if fruits and latex are sustainably harvested, and an additional $490, totaling $6820 if periodic selective timber cutting occurs as well. This compares to $3184 if the hectare of forest is converted to a plantation of Gmelina arborea managed for timber and pulpwood, $2960 if converted to cattle pasture, and $1000 if all merchantable trees were harvested at once.

B. Strategy 2: Measures to Reduce Loss of Forests

Option 3: Sustainable Natural Forest Timber Management Systems

Instead of traditional clear-cuts of large tracts, natural forest timber management (NFM) systems involve a smaller and sustainable harvest from forests, with less damage. An example of NFM is the Palcazu Development Project system in Peru. Thin strips of forest 20-50 meters wide are harvested on 30-40 year rotations. These strips mimic natural forest gaps. They regenerate naturally as they are reseeded and encroached upon by the surrounding forest. Economic analysis of the project indicates a net return of $3500/ha harvested and processed on the project's portable sawmill and charcoal kiln. Once the diversification and expansion of the processing center is completed, net returns should increase to $27,000/ha harvested (Hartshorn et. al, 1987).

Option 4: Substitute Sustainable Agriculture and Agroforestry for Swidden Forest Practices

Implementation of sustainable agricultural practices may prove to be one of the most effective and inexpensive means of maintaining site productivity thus reducing forest loss and securing carbon storage. For every hectare farmers put into sustainable agricultural and soil management systems, 5-12 hectares of tropical rainforest could be potentially saved from loss, based on an 18-year field project in Yurimaguas, Amazonian Peru (Sanchez, 1988; and Sanchez and Benities, 1987).

A range of actual costs and revenues for three sustainable agricultural systems in Latin America (extensive agroforestry, intensive agroforestry and low-input cropping) are outlined in Table 1A below. The figures in Table 5 include labor and material costs only. Although not reported in the table, a full accounting of the costs of such systems would ultimately need to include land costs, loan finance charges, and transport to market as well. Indicators of these costs appear in the note at the bottom of the table.

Table 1A **Actual Costs and Revenues of 3 Sustainable Agriculture Systems in Latin America**

Sustainable Agriculture: Cost & Revenue Data	Extensive Agroforestry	Low input Cropping	Intensive Agroforestry
Costs[c](Labour, Materials)/ha/yr	\$47[a]	\$737[b]	\$767[a]
Gross Revenues/ha/yr	\$76[a]	\$2229[b]	\$1059[a]
Net Revenues/ha/yr	\$29[a]	\$1492[b]	\$292[a]

Note: Land purchase costs may be roughly the value of one year's crop under current practices (Antholt, C., personal communication 4/91; Sanchez, P., personal communication, 4/91). The value of a crop produced from one year's unstainable shifting cultivation in Peru is about \$260 per hectare. Loan finance charges were 30%, transport costs were 3%, and labour and materials were 60% of overall project costs for low input cropping in Peru (Sanchez and Benites, 1987).

[a]Anderson, et al. (in press)
[b]Sanchez and Benites (1987) Science vol 238, pp. 1521-7
[c]Costs exclude land, loan finance charges and transport to market

Table 2A lists the theoretical costs and benefits of the 3 sustainable agricultural systems. It includes estimates for the cost of agricultural extension and the benefits associated with avoiding deforestation and the subsequent need for reforestation. If a government launched a program to promote sustainable agriculture, depending on the type and extent of its involvement, its financial risks for the first year of a start-up program could range from as low as the \$5 per hectare for the extension costs alone, to as high as \$52 to \$772 per hectare, if governments guaranteed loans to farmers for labor and materials. Once established, however, the three sustainable agricultural systems should theoretically have negative costs (i.e. result in savings or profits), ranging from \$3529 to \$14,292 per hectare for net revenues plus reforestation costs avoided.

Table 2A Theoretical Costs and Benefits of 3 Sustainable Agriculture Systems in Latin America

General Assumptions	Extensive Agroforestry	Low Input Cropping	Intensive Agroforestry
Net Revenues/ha/yr	$29[a]	$1492[b]	$292[a]
Agricultural[c] Extension Costs ha/yr	$5	$5	$5
Hectares of Deforestation Avoided/year	5[d]	4.6[e]	20[d]
Reforestation Costs Avoided/year[f]	$3500	$3220	$14000
Tons of C Emission from Deforestation Avoided/year[g]	350 tons C	322 tons C	1400 tons C
Costs and Benefits	**Extensive Agroforestry**	**Low Input Cropping**	**Intensive Agroforestry Agroforestry**
Total Costs	$52	$742	$772
Total Benefits	$3,529	$4712	$14,292
	Riverbank Dwellers, Corbu Islands, Acara, Para, Brazil	Rice and cowpeas with fertilizer, Yurimaguas, Peru	Nipo Brazilian Farmers Tome-Acu, Para, Brazil

[a]Anderson, et al. (in press)
[b]Sanchez and Benites (1987) Science vol. 238, pp. 1521-7
[c]Antholt, Chuck, World Bank, personal communication, 4/91
[d]Sanchez, Pedro, personal communication, 4/91
[e]Sanchez, Pedro, (1988), "Deforestation Reduction Initiative: An Imperative for World Sustainability in the 21st Century", Bureau of Science Technology, USAID, Washington DC
[f]Assumes reforestation cost of $700/hectare. (mid-point of $400-$1000 reforestation cost from Ab'Saber, et al. (1989) FLORAM Reforestation Proposal, University of Sao Paulo, Advanced Studies Institute, Brazil)
[g]Assumes 70 tons Carbon/hectare = Average Carbon content in Latin American tropical forests (brown & Lugo, (1984) Science vol. 223, p. 1290-3

Option 5: Increase Intensity of Use of Pasture Converted From Forest, to Prevent Additional Forest Conversion

Serrao (1990) estimates forest loss to new pasture formation in Amazonia from 1970 to 1990 at 17.5 million hectares. This forest conversion emitted about 2.4 billion tons of carbon, after accounting for growth of new biomass in pastures. Response options to slow forest conversion for pasture reviewed by Serrao include: 1) intensifying cattle production on existing pasture, 2) using silvo-pastoral systems, 3) reclaiming degraded pasture, and 4) increasing use of existing natural grassland ecosystems. Economic analysis of one 15-year cycle of an alternative silvo-pastoral system estimates total costs at $1600/ha, and gross revenues from sales of corn, wood, and beef from the system at $6560/ha, with net returns of $4960/ha (see Table 3A), not to mention the benefits of reforestation costs avoided.

Table 3A **Projected Rough Economic Figures for a Silvo-Pastoral System in the Amazon (1989)**

Integrated System of Schizolobium amazonicum (540 trees/ha) with Brachiaria brizantha cv. Marandu pasture in 15-yr cycle.	
Costs of establishment/management	US$/ha
1st year (trees + crops)	400
2nd year (crops)	180
3rd year (crops + pasture)	220
4th year on (pasture and cattle management; wood management and harvest)	800
Total costs in the cycle	1,600
Gross returns	US$/ha
Corn sales (harvests 1st, 2nd, and 3rd years)	580
wood sales (harvests 5th, 10th and 15th years)	4,380
Beef sales (total of 11 years)	1,600
Total gross returns in the cycle	6,560

Source: Serrao, 1990

C. STRATEGY 3: Measures to Expand Forested Area and Provide Sinks of Greenhouse Gases

Option 6: Integrated Forestry Projects

Integrated natural resource management and social forestry projects providing forest products, protection, economic opportunities, and cooperative management by local people and resource professionals are likely to be the more successful in addressing global forest management goals than single-purpose projects (e.g., tree planting for carbon sinks or biodiversity reserves).

Three integrated social forestry projects in the tropics (Table 4A) were proposed to offset the lifetime CO_2 emissions of a 180 Megawatt coal-fired electric plant in the U.S. because planting and managing forests is less expensive in the tropics, where biomass growth rates are higher and planting/maintenance costs are lower. Note that the pre-project estimated cost per ton of carbon sequestered ranges from $0.82-$1.37 for these projects in the tropics, compared to estimates for afforestation in the U.S. of $5-43/ton of carbon.

The CARE/WRI proposal detailed in the table was funded to offset the power plant emissions. The project, which builds on an existing CARE social forestry project for community benefit in Guatemala, is described by Trexler, et al. (1989). Since it is in the early phases, its success cannot be fully evaluated yet. It is, however, one of the first forestry sector responses to global warming. It has spawned international interest in forestry offsets for fossil fuel emissions, and the potential for forging a mutually beneficial link between the international energy and forestry sectors. The Guanacaste project is described in the section on forest restoration.

Table 4A **Overview of Three Social Forestry Projects Proposed to Offset CO_2 Emissions of a 180-MW Electric Plant in Connecticut, U.S.**

Forest Attribute Guancaste/Costa Rica	CARE/WRI/Gu atemala	WWF/Costa Rica
Total area of project 70,400 ha	101,000 ha	122,000 ha
Protected in forest 70,400 ha	19,740 ha	72,000 ha
Logged or managed forests	38,000 ha	
Newly established woodlots (plantations)	13,140 ha	12,000 ha
Agroforestry lands	68,350 ha	
Carbon sequestered 40-year life of plant 8.6 Tg over c	18.1 Tg C	11.0 Tg C
Cost estimate $11.8 million (cash or in-kind)	$14 million	$9.6 million
Cost per ton C $1.37 sequestered	$0.82	$0.87

Note: Offset goal = 0.39 million tons C/yr x 40 yrs = 15.6 million tons C over life of project
Sources: Andrasko, 1990; Trexler et al., 1989 (Guatemala); WWF, 1988 (Costa Rica); Jansen, 1988c (Guanacaste).

Option 7: Increase Tree Planting Programs

Costs of establishing a forest plantation vary from US $230 to $3000 per hectare. Harvest cost per hectare may be US $6,750/ha (Sedjo and Solomon, 1988), but probably would be offset by revenues. Maintenance costs would be extra and land rental or purchase costs relatively low.

Estimates of costs for plantation establishment in the tropics (80% of which costs are for labor) range from about $100-200/ha/y for dry areas with less than 1100 mm of rainfall per year, to over $1000/ha/y in wetter areas receiving over 1800 mm/y (FAO Forest Resources Division, unpublished data, 1989). Dry sites may require little site preparation and wide spacing of seedlings, compared to wetter, closed-canopy forest sites, and hence tend to be relatively less expensive to plant.

Option 8: Restore Degraded Lands

Natural regeneration of forests on lands cleared for agriculture or pasture may offer a low-cost method of capturing carbon at a significant scale if protection from fire and grazing can be sustained. An ambitious plan to restore dry forest cleared for agriculture and cattle grazing in the Guanacaste National Park in Costa Rica has been organized by organized by Daniel Janzen and Costa Rican ecologists (Jansen, 1988a,b). A closed-canopy dry forest with significant representation of its previous flora and fauna is expected to evolve within 10-50 years. This natural regeneration may sequester an estimated 8.6 million tons of carbon at a rough cost of $11.8 million (mostly for land purchase), or $1.37/t carbon (Jansen, 1988c). The plan involves removing barriers to natural regeneration and conservation through 1) suppressing fires and cattle grazing; 2) assuring seed sources and dissemination; and 3) addressing needs of local villagers.

Forestation and Forest Management Options and their Costs at the Site Level

R K Dixon[1], J K Winjum[1] and O N Krankina[2]

ABSTRACT

Sustainable silvicultural practices are required to ensure an uninterrupted and affordable flow of goods and services from the Earth's 4,070 million hectares of forests. Demographic and environmental pressures have altered the status and development of boreal, temperate and tropical forest biomes. A relatively small proportion of primary or secondary forests are routinely managed on a sustainable basis. Forestation of harvested stands, degraded or abandoned lands, and other sites in boreal, temperate and tropical systems range from 10-15 million hectares, annually. The cost of natural and artificial forestation ranges from $30-2,500/hectare, depending on such factors as site condition, site preparation, size and quality of seeds, seedlings or advanced regeneration, and juvenile plantation protection requirements. Intermediate silvicultural practices such as thinning, fertilization, drainage or irrigation, range in cost from $5-500/hectare. Protection of forests from fire, insects and disease range from $<1-50/hectare. Financial analyses of silvicultural practices reveal that boreal, temperate and tropical forest systems can be managed profitably. Case studies of selected forest management investments in representative countries reveal an internal rate of return of 5-35%. However, financial return on investment is highly dependent on land rent/costs, initial forest establishment costs, and rotation length. Sustained management of global forests will probably not increase significantly without policy changes to stimulate positive national actions and create incentives for local populations.

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Costs of Sequestering Carbon Through Tree Planting and Forest Management in the United States[1]

R J Moulton and K R Richards[2]

ABSTRACT

One approach to limiting the buildup of carbon dioxide (CO_2) in the atmosphere is to sequester carbon in forests. Several reports have estimated the amount of tree planting and the associated costs that would be required to significantly affect the net release of CO_2, but they have been largely 'back of the envelope' calculations. This report employs detailed data on actual planting practices, amounts of marginal agricultural land, average merchantable timber yields, historic rental rates, and the ratio of total ecosystem carbon to timber carbon to calculate the incremental amount of carbon that could be sequestered by a rural tree planting and forest management programme in the United States. Marginal and total cost curves indicate the relation between costs and the extent of the sequestering programme.

The report includes the following findings:

- An extensive tree planting and forest management programme could sequester as much as 807 million short tons (56.4 percent of the current annual US CO_2 releases) at an annual cost of $19.5 billion;
- A programme to reduce US net emissions of CO_2 by 20 percent would involve 138.4 million acres and cost $4.5 billion per year, or an average of $15.73 per short ton;
- The costs of carbon sequestering range from $5.26 to $43.33 per ton;
- Some of the least costly opportunities for carbon sequestering are on forest land and marginal pasture land, although the largest portion of the carbon capture in a programme involving reductions of 10 percent or more must be on marginal cropland;
- The geographic distribution of marginal land indicates that such a planting programme would be largely concentrated in the Southeast, Appalachia, and the Gulf States.

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1 US Department of Agriculture Forest Service, General Technical Report WO-58. December 1990.

2 USDA Forest Service, and University of Pennsylvania, USA.

Cost and Performance of CO_2 Storage in Forestry Projects

Joel N Swisher[1]

ABSTRACT

The paper states that reversing the trend towards deforestation involves two general approaches: protection of remaining forested land; and reforestation using natural restoration, forest plantations, fuelwood farms or biomass energy plantations, and agroforestry.

A formula for analysing costs of establishing forestry projects is given, and the need to examine ongoing management and monitoring costs is discussed. Methods are drawn from the literature for measuring carbon storage, and an analysis of carbon storage in sample forest projects is given. National estimates of carbon storage potential are discussed, and the case of Costa Rica is examined in some detail. Particular attention is paid to the amount of carbon that might be stored, were all the projects within the TFAP for Costa Rica to be implemented.

The paper concludes that many countries are anxious to implement forestry projects and have substantial renewable energy potential, although they may be financially constrained. The key to success in establishing forestry projects is considered to be local socio-economic benefit, and with greater understanding of social and technical issues, the author considers it would be possible to lower the cost of CO_2 mitigation whilst assisting sustainable development programmes.

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Part B Additional and Extended Papers
1 Introduction

State of Forestry in the Asia-Pacific Region

Y.S.Rao[1]

1 STATE OF FOREST, FOREST PRODUCTS AND FOREST INDUSTRIES

1.1 Land Utilization

The Asia-Pacific region, hosting 2800 million people, is the home for half the world's population. The land area of the region, which is close to 3000 million hectares, comprises a mosaic of ecosystems ranging from the Himalayas which straddle the main land of Asia, to the flood plains washed by the river systems and the island ecosystems in the Indian Ocean and the South Pacific. Agricultural land accounts for about 500 million hectares which is 30 percent of the world's arable land. Permanent pastures occupy 963 million hectares of which 90 percent occur in three countries: Australia, China and Mongolia. Forests and woodland occur on some 650 million hectares and represent 16 per cent of the world's total in this category. Depletion of the thin mantle of fertile top soils occurring in fragile tropical forest ecosystems can quickly render these lands unproductive. The high ecological and social costs of land degradation and the need for restoring ecological stability have therefore become a major concern of several countries in the region.

1.2 Forest Resources and their Management

1.2.1 Forest resources

Out of an estimated area of 650 million hectares of forest and woodland in the region, about 445 million hectares occur in 16 tropical countries[2] of the region. Of these about 292 million hectares are closed broadleaved forests, the most valuable of forest formations in the region.

Indonesia, Malaysia, Myanmar and Papua New Guinea together account for 70% of the closed broadleaved forest areas of the region. More than three quarters of such forests in Indonesia are confined to Kalimantan, Sumatra, and Irian Jaya. The predominant broadleaved forest type is "tropical rain forest" where dipterocarps are the most important botanical family by number and commercial value. In Myanmar the closed forests have a predominance of teak. In Malaysia and the Philippines, mixed dipterocarp forests account for over 90% of the area. In Papua New Guinea the forests are essentially of non-dipterocarp nature. Productive broadleaved forests which have been logged over account for 85% of the closed forest area in Indonesia, Malaysia and the Philippines. They are part of the area under concessions which supply the bulk of tropical logs to international markets and for domestic processing.

Some 30 million hectares of open broadleaved forests occur in the region, predominantly in India, Laos, Kampuchea, Papua New Guinea and Thailand. Together these five countries account for more than 80% of the region's area under this classification. Only a quarter of these forests are considered productive; nearly all the productive forests are in continental southeast Asian countries. In Thailand, the dry dipterocarp forests in the northeast are included in this class.

Bamboo forest represent an important resource supplying rural needs for construction material, cottage industries and even raw material for pulp and paper industry. These forests extend over some 5 million hectares, predominatly in India, Laos, Myanmar, Thailand and Vietnam.

For ecological reasons, mangrove forests, which extend over 6.3 million hectares, are of special interest to the region. Important mangrove resources exist in Bangladesh, India, Indonesia, Malaysia, Myanmar, Pakistan, Papua New Guinea, Philippines and Vietnam. These resources are depleting at a rapid rate due to excessive use for fuelwood/charcoal and conversion into shrimp farms.

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2 Bangladesh, Bhutan, Brunei, Dem. Kampuchea, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand and Vietnam.

1.2.2 Changes in Forest Area

Deforestation continues to threaten and erode the area under forest cover in several countries of the region. A new FAO assessment of forest resources of the region under the global project: "Tropical Forest Resources, 1990" showed that compared with some 2 million hectares per year during the period 1976-80, the rate of annual deforestation in the Asia-Pacific region (15 countries) during 1981-90 was close to 4.7 million hectares per year. The following are the rates of deforestation by sub-region:

South Asia	1700	ha/yr
Continental South East Asia	1400	"
Insular South East Asia	1600	"
Total	4700	"

The countries where the increase is pronounced are: India, Indonesia, Myanmar, Philippines, Thailand and Vietnam.

1.2.3 Reforestation

A major effort to raise forest plantations and promote tree growing in rural areas was observed in almost every country. These efforts assumed four different forms: (i) block plantations funded and implemented by government agencies on forest land; (ii) reforestation of areas other than forest lands either by the government or through community efforts; (iii) plantations by private individuals and companies on land either owned by them or taken on lease or on communal lands; (iv) homesteads and family woodlots, scattered trees, and trees in combination with crops.

There has been a substantial and significant increase in the reforestation effort by the developing countries of this region in recent years. According to one estimate, current efforts exceed 3 million hectares per year[3] and the investment surpasses US dollars 1000 million a year. Clearly, in the recent past, the tide has turned in favour of reforestation and regreening. At no other time in the history of forestry development has there been such a surge of public interest and national and international effort directed towards rebuilding the forest and tree resources of the countries in this region.

The cumulative area under plantations up to 1990 in Bangladesh was 335,900 hectares. In recent years, plantation targets ranged between 10,000 to 20,000 hectares per year. In China, over the years, 31 million hectares of forest plantations have been established and forest cover increased from 8.6% of the land area in 1949 to 12.98% in 1990. During 1951 to 1991, India afforested close to 16 million hectares. In recent years, on average, 1.5 million hectares per year of plantations were established. In Indonesia, by 1988, 1.44 million hectares of timber plantations were established, 5.8 million hectares being "regreened" and 1.2 million hectares "reforested". In Peninsular Malaysia, by the end of 1988, approximately 38,000 hectares of plantations were established including tropical pines and fast-growing hardwood species. In Sabah, 41,000 hectares of plantations were raised. In Myanmar, from 1968 to 1990, about 330,900 hectares of plantations were established. The area under forest plantations in New Zealand in 1989 was 1.2 million hectares. The Republic of Korea reported that annual planting activities during 1986-88 amounted to about 48,000 hectares per year. In Sri Lanka the area planted by the forestry department until the end of 1988 was 170,000 hectares. The estimated annual planting area in the next 5 years is 5,000 hectares In Thailand, over the past 30 years, about half a million hectares of plantations have been raised. Out of this, 150,000 hectares were established by concessionaires on lands made available. Recently there has been a move to encourage private sector reforestation. An office of private reforestation has been established in the Royal Forestry Department to encourage private sector involvement in reforestation. On a selective basis, forest lands are being leased out for establishing plantations charging a nominal rent. The Board of Investment has given promotional privileges to six major private companies to set up eucalyptus plantations to produce chips for export. More recently, the leasing of forest lands to private entrepreneurs has become a controversial issue since in some cases where private companies have been granted such leases, local people have been moved out. The policy and the system of incentives for raising industrial plantations is currently under review by the government.

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3 Including linear and scattered tree growing under community forestry, where it is assumed that every 2000 trees equals 1 hectare of reforested area.

1.2.4 Forest Management

It is only in the latter half of the 20th century that a majority of the countries in the region emerged as independent nations. Since then, there has been a marked increase in forest land under the direct ownership, control and management of governments. Private ownership, ownership by corporations, communities, trusts, temples and other forms do exist, but do not account for any sizable area. In Burma, 14% of the total land area of the country is under reserved forests. In Thailand about 15 million hectares have been reserved. In Sabah 37% of total forest area is reserved; in Sarawak it is only 8%.

Either monocyclic or polycyclic systems of forest management are observed in the region. Monocyclic systems (better known as shelterwood systems) aim at obtaining a fairly uniform crop for subsequent harvest. Polycyclic systems - classical selection felling with or without improvement operations for the residual stand - are more common in high forest areas throughout the region.

1.2.5 Conservation and National Parks

In almost every country of the region, a growing awareness and interest in conservation of wildlife and protection of environment has lead to the creation of national parks, wildlife sanctuaries, biosphere reserves and other areas similarly protected under some kind of statutory provision. In the forests included in these reserves, in addition to strict protection from biotic interference, logging and even management intervention by forestry departments is kept to a minimum. On a rough estimate some 10% of total forest area in the region has been incorporated into these reserves and consist mostly of closed broadleaved forest. The areas constituted as national parks and equivalent reserves in selected countries are indicated below:

Bangladesh:	4 national parks.
Bhutan:	13 protected areas (978,200 ha.) including 1 national park; 3 wildlife sanctuaries; 3 wildlife reserves; and 6 reserved forests.
China:	383 forest/wildlife reserves and 27 forest parks.
India:	69 national parks (3 million ha.); 410 wildlife sanctuaries (10 million ha.); 11 "project tiger" areas.
Nepal:	7 national parks (864,000 ha.); 4 wildlife sanctuaries (97,000 ha.); 1 conservation area (266,000 ha.).
Pakistan:	10 national parks (968,000 ha.); 84 game reserves; and 83 wildlife sanctuaries (2.75 million ha.).
Sri Lanka:	11 national parks (460,000 ha.); 5 nature reserves (64,000 ha.) and 50 sanctuaries (256,000 ha.).
Myanmar:	15 wildlife sanctuaries (472,800 ha.).
Thailand:	63 national parks (3.34 million ha.); 32 wildlife sanctuaries (2.95 million ha.).
Indonesia:	352 conservation areas (14.8 million ha.) whose break-up is 184 nature reserves (8.1 million ha.); 73 wildlife reserves (5.8 million ha.); 61 recreation forests (0.26 million ha.); 13 game parks (0.37 million ha.); 14 grand forest parks (0.16 million ha.) and 7 marine parks (0.08 million ha.). There are 24 national parks covering 6.7 million ha., but these are functional management units comprising one or more reserves.
Malaysia:	8 national parks; 6 wildlife sanctuaries; 11 wildlife reserves; 9 bird sanctuaries; 2 marine parks; 6 state parks; 27 communal forests and 74 virgin jungle reserves.
Philippines:	68 national parks (447,000 ha.); 2 marine parks (340,000 ha.) and 8 wildlife sanctuaries (960,000 ha.).
Vietnam:	87 nature reserves (1.1 million ha.) including 7 national parks, 49 nature reserves and 31 cultural and scenic sites.
Papua New Guinea:	3 national parks (55,000 ha.); wildlife management areas and sanctuaries (560,900 ha.).

1.3 Forest Products

Developing countries of the Asia-Pacific region produced about 1,000 million m^3 of roundwood during 1988, which is 29 percent of the world total. Roundwood production registered an average annual rise close to 2% which is about the same as the world average. In terms of quantity, fuelwood and wood for charcoal constitute the bulk (77%) of the removals. Sawn logs and veneer logs constitute only 16% of total roundwood production. Log production rose from 134 million m^3 in 1978 to 163 million m^3 in 1988 at an average annual rate of 2%, which is higher than the world average of 1.5%. During the same period the proportion of log exports in relation to total log production declined. The pattern of production and exports in the different countries of the region has also undergone substantial alteration in the decade 1978 to 1988.

Major changes in the pattern of log production and exports during 1978-1988 are summarized below:

- Export of logs from Indonesia was banned, which meant that from a peak log export figure of 19.2 million m^3 in 1978, Indonesia saw a complete stoppage of all log exports in 1987. Export of logs earned for Indonesia about US$ 1,550 million in 1979 (a peak year), but by 1988 this earning was reduced to a mere US$ 278,000. There was increased domestic processing - especially wood-based panels - as evidenced by a rise in production from 425,000 m^3 in 1978 to 6.6 million m^3 in 1988. A feature of the 80's was the emergence of Indonesia as the most important exporter of processed wood products in the region. Indonesian export of wood-based panels grew from 70,000 m^3 in 1978 to 6.4 million m^3 in 1988. Export earnings from panels grew from US$ 18 million in 1978 to US dollars 2,135 million in 1988.

- Export of logs (including teak) from Myanmar increased from 77,000 m^3 in 1978 to 208,000 m^3 in 1988. In terms of export earning, the rise is from US$ 35 million in 1978 to US$ 73 million in 1988.

- In the Philippines, hardwood log production during 1978-1988 decreased significantly from 7.2 million to 3.2 million m^3. There was a corresponding decline in log exports from 2.2 million to 176,000 m^3. The growth in export earnings from sawnwood and panels during the period was from US$ 164 million to US$ 255 million.

- In Malaysia log production continued to rise, from 29 to 35 million m^3 in a decade. This increase was mainly attributable to production in Sabah and Sarawak. There is also an increase in the quantity of logs exported, from 18 million m^3 in 1978 to 21 million m^3 in 1988.

- A notable feature in the region was the growing dependence of Thailand on imports of logs in recent years. From a net exporter, Thailand has emerged as a net importer during 1978-88. Sizable imports of logs first started in 1977 (61,000 m^3) and gradually increased to around 500,000 m^3 by 1988. The importation is mainly from Malaysia.

1.4 Forest Industries

Increasingly scarce supplies of industrial raw materials have constrained the optimum operation and further development of wood-based industries in many countries of the region. This is particularly so in the countries of South Asia where very little growth in the establishment of new wood-based industries is observed and existing industries are facing raw material shortages and installed capacities are under-utilized. Contrary to the situation in South Asia, forest industries in South East Asia, particularly in Indonesia, are expanding in a significant way. For example, Indonesia's forest industry profile in 1989 shows:

- 3,500 sawmills with an installed annual capacity of 19 million m^3 of sawn timber;

- 111 veneer/plywood mills with an installed capacity of 7.1 million m^3 per year;

- 54 block board mills with 735,000 m^3 annual capacity;

- 7 particle board mills with an annual capacity of 755,000 m^3; and

- 38 pulp and paper mills and 82 paper machines with a pulp capacity of 192,000 air dry tonnes per annum (ADT).

The pulp and paper industry in Indonesia is experiencing unprecedented growth: by the year 2000 it is expected that the pulp capacity will reach 2.7 million ADT and paper capacity 3 million ADT. Plans to realize the great potential of the sector (based on fast growing plantations) as an export industry are under implementation.

1.5 Forest Products other than wood

More commonly known in several developing countries of this region as Minor Forest Products, non-wood forest products (NWFP) provide considerable opportunities in the developing countries of the region for augmenting local employment and incomes. Local communities collect, process and market bamboo, rattan, beedi leaves (Diospyros melanoxylon) resins, gums, lac, oil seeds, essential oils, medicinal herbs, tannin materials, etc. Rural people also draw upon the forest for food such as honey, mushrooms, a wide variety of tubers, fruits and leaves and bush meat. The forests of the region, in view of their heterogeneity and numerous multi-purpose species, can be considered as a veritable land bank for NWFP. Increasing the potential contribution of these products to domestic economies and world trade poses a challenge, and is a legitimate area of concentration in the future.

Among the important NWFP extracted from the forests of Bangladesh are Golpatta (leaves of Nypa fruticans), honey, wax, cane and bamboo. In Bhutan, collection and processing of resin and turpentine and distillation of lemon grass provide an additional source of income to the rural people. NWFP in China fall into seven categories: (i) edible oils (olive, Thea oleoss etc): (ii) industrial oil (tung oil, jojoba, etc): (iii) edible fruits (chestnut, walnut, etc): (iv) spices/flavouring agents (pepper, cinnamon, etc): (v) medicinal herbs and (vi) industrial NWFP (resins, lac, etc), and (vii) wildlife products and raw silk. In India several states have established co-operatives to organize NWFP by the tribal population. The range and quantities of NWFP collected in India is vast. Some 90 types of NWFP are extracted from Indonesia's forest, the most prominent of which are rattan, resin, damar, copal (agathis), kayuput oils and tangkawang nuts. In the Republic of Korea, NWFP statistics are collected on a systematic basis for 10 product groups which include a variety of products such as bamboo, mushrooms, resin, tannin, medicinal plants and fruits/nuts. The NWFP of Malaysia include rattan for furniture and basket-making, bamboo for panelling, baskets and handicrafts, damar, resins and gums from several tree species for the manufacture of varnish and finishes. The forests of Myanmar are capable of yielding a very wide range of useful NWFP. There are approximately 30 different products, the important ones being: bamboo, canes and cutch. In Nepal, resin, turpentine, katha and cutch are the most important among the NWFP. In Pakistan, rosin and turpentine are important industries. In Papua New Guinea, the most important NWFP are resins, copal, rattan, Mentha arvensis (mint), Calophyllum nuts and cinnamon oil. Wildlife is very important as food for the rural people. Two crocodile species (Crocodylus porosus and C. novaeguineae) form the main cashcrop for many villages. In the Philippines, rattan and bamboo cottage industries are playing a significant role in maintaining the local economies. A number of NWFP are collected in Thailand. More important ones are: bamboo, canes, resin, honey, camphor, etc. In Vietnam in addition to bamboo, rattan, resins and lac, benzoin (Styrax spp.) is an important NWFP.

2 PRESENT STATE OF FORESTRY TRENDS AND SHORT-TERM PROSPECTS

2.1 Forest Policies, Legislation and Development Planning

Except in a few countries significant changes in forest policy in recent years have not been reported. But development plans reflect the countries' concerns about the rapid rate of resource depletion and the need for intensified efforts into reforestation, particularly through involvement of people and private enterprise.

In Bangladesh, the forestry policy of the country was reviewed for the last time in 1979. It was accepted that careful scientific management and qualitative improvement of existing forests shall be an important national goal. Among the strategies pursued during the last few years were the replanting of the hill forest areas, promotion of homestead forestry, reforestation of coastal areas, and planting and protection of the mangrove forest areas. Bangladesh has also opted for extensive community forest projects where the strategy is to promote people-oriented forestry at the Upazila level.

In China, the Ministry of Forestry prioritized six main tasks during 1987. Among these are the formulation of a comprehensive reforestation plan, law enforcement in forest management, a sound system to fight forest fires, practice of forest management through a system of strict implementation of allowable annual cut, perfecting the contract responsibility system and making greater efforts to manage the state forests. During the 1980's, flexible forestry policies were adopted and the agricultural contract responsibility system gained ground and gave scope for increased reforestation efforts by individuals as well as co-operatives. Some 20 million hectares of barren hills had been offered to 50 million peasant households as allotments to set up small family forest farms and orchards. About 175,000 co-operative forest farms were set up throughout the country.

In Fiji, forestry policy aims at establishing an efficient forest industry producing more value-added forestry products from plantation forests. Roundwood production for industrial use is targeted to be fives times the present level of production.

A noteworthy development in India is the adoption of the National Forest Policy, 1988. The revised Forest Policy seeks, primarily, to ensure environmental stability and states unequivocally that derivation of direct economic benefits must be subordinate to the principal aim of maintaining ecological balance. No forest should be clear-felled, nor should exotic species be introduced, through public or private sources, except after long-term scientific trials undertaken by specialists in ecology and forestry. As far as possible, a forest-based industry should establish a direct relationship between the factory and the individuals/entities who can supply them the raw material and even support them with inputs including credit, technical advice, and market support.

Following the log export ban in 1985, Indonesia promulgated several policy measures to stimulate domestic processing resulting in the establishment of a growing wood-based panel industry. The role of the state-owned forestry corporations increased and a new corporation (Marunda Terminal Wood Centre) was established. Indonesia allocates 70% of government revenue for forestry development in the provinces. The 5-year development plan of Indonesia (1989/90-1993/94) targets the creation of 113 million hectares of permanent forests, consisting of 64 million hectares of production forests, 30 million hectares of protection and 19 million hectares for conservation forests. It was also projected that 1.5 million hectares of timber estates will be developed during the plan period.

Myanmar's forest policy remained essentially unchanged since 1963 when the role of private entrepreneurs was ended, all forest activities were nationalized and forest enterprises guided and controlled by the state became operational. Development strategies and planning in the years that followed 1963 centred around the role that forestry can play in rural development. Forest villages in the reserved forest were awarded limited rights of usage of forest products.

The Industrial Master Plan (1986-1995) of Peninsular Malaysia identified wood-based industries as a priority sector. The development planning effort in Malaysia is spearheaded by a consideration to maintain sufficient areas of productive, protective and amenity forests while at the same time, recognising that sustained efforts to promote economic activities through processing, trading and marketing are vital for the development of the country. Among the objectives of the 5-year plan (1986-1990) were: consolidation of permanent forestry estate, application of selective management systems, modernization of the forest industries, expansion of reforestation efforts, integration of forestry with agriculture, and the development of a forest information and monitoring system.

Nepal is struggling with enormous deforestation and land degradation problems. The main efforts in the near future will be aimed at forest cover rehabilitation. The recently prepared forestry sector master plan will form the basis for future development.

The major economic and forestry policies of the government of New Zealand ensure that forestry investment decisions are determined by their real profitability rather than by tax advantages, subsidies, special grants, etc. In order to implement their forest policy, the Ministry of Forestry was radically reorganized. Whereas the Ministry of Forestry provides policy advice, the New Zealand Forestry Corporation was charged with the responsibility of business in forestry. The Department of Conservation was created to pursue the objective of conserving the natural historic heritage of the country.

In Papua New Guinea a new Forest Policy was approved by the government in May 1990. New forest legislation is in the offing which may include such major initiatives as: amalgamation of the existing Acts into a single Forestry Act, banning of certain high quality species from log export, establishment of a Forest Industry Office and increased penalties for breaches of the law.

Following the change of the government in the Philippines in 1986, drastic structural changes in forest and natural resource administration were implemented resulting in substantive delegation of authority to the field officers. The export of logs and lumber were banned with effect from August 21, 1986 and July 1, 1989 respectively.

In the Republic of Korea, the objectives of the long-term national forest master plan are to carry forward the reforestation phase which ended in 1987 to what is termed as the "development foundations phase" during 1988-1998. Thereafter, the country intends to implement an enlarged development phase to foster self-regulation and sustained yield.

Sri Lanka continues to follow the forest policy of 1980, which is essentially oriented towards conserving the existing forest resources and increasing the area under community forestry. A major feature of Sri Lanka's development is the incorporation of sizeable and significant components of forestry within the rural development programmes.

In Thailand, the National Forest Policy formulated in 1985 stipulated that 40% of the land should be kept under forest cover and all land above 35% slope should be dedicated to forestry. The policy also stated that 25% of the forest land should be managed for production purposes. In 1989, the government imposed a total nationwide ban on logging and liberalized the policy on import of logs.

2.2 Forestry Institutions

Several countries have restructured their forestry departments and administrative procedures. Among the major trends are assigning administrative and developmental responsibility to district level bodies and involving local communities and NGOs in forest management and reforestation. The demand for trained personnel is growing but several forest departments still remain understaffed and unable to cope with increased national and international investment into forestry.

2.2.1 Forestry Education

Approximately 120 forestry schools in 17 countries of the Asia-Pacific region offer professional level forestry education. The countries with more than 20 institutions each are China, India, Japan and the Philippines. Several agricultural universities offer forestry degrees which are included among the institutions mentioned. The annual intake of students in the universities is the highest in China, where more than 500 students enter the forestry professional degree courses every year in the Beijing Forestry University. The student intake in most of the institutions in the other countries is between 50 and 100.

Among the issues requiring urgent attention is the updating of curricula for training forestry professionals, technicians and field level workers. The Regional Community Forestry Training Centre in Thailand caters to the training needs in community forestry to some extent. The Asian Forestry Education Network (AFEN) currently being serviced by the FAO Regional Office (RAPA), is proving to be a useful vehicle for disseminating information to forestry education institutions.

2.2.2 Forestry Research

Among the more recent initiatives on forestry research is the consultation held at RAPA during August 1988. The consultation reviewed the status, problems and prospects for forestry research in individual countries as well as in the region. It suggested ways to reorient and upgrade national research efforts. The consultation established: an Informal Network of Forestry Research Managers (INFORM), with its first rotating secretariat provided by the Forest Research Institute of Malaysia for 1990-91. The consultation also formulated a regional programme, Forestry Research Support Programme for the Asia-Pacific Region (FORSPA) and was promised funding support from the Asian Development Bank and UNDP. The establishment of INFORM and FORSPA are important steps to strengthen national forestry research capabilities in the region.

3 IMPLEMENTATION OF THE TROPICAL FORESTRY ACTION PROGRAMME (TFAP)

Since it was launched in 1985, the TFAP has gained momentum and to date 17 countries in the region have undertaken TFAP or Master Plan exercises. The status of implementation, by country (in summary) follows:

in Bangladesh the Master Plan exercise is being coordinated by the Asian Development Bank and a draft project document was written by a preparatory mission in July 1989 with ADB, FAO and national participation; in Bhutan the base survey of the Master Plan exercise is expected to be completed by the end of February 1991; in Fiji an International Round Table type III is tentatively planned for April 1991; in India the government is initiating a TFAP exercise with UNDP/FAO support which will result in a national plan with action programmes aimed at the national and state levels; in Indonesia the five-year plan for the forestry sector, together with reports prepared by an ongoing FAO/World Bank project for forestry studies, were the basis of the National Forestry Action Programme; in Laos the government recently approved the final TFAP document; in Malaysia the finalisation of the draft final report is expected by December 1990; in Myanmar the government has expresseds interest in a TFAP exercise and requested an in-country information meeting; in Nepal the Master Plan was prepared with the support of ADB and was endorsed at a donor's meeting in 1988 and 1989, where some 66 percent of the external assistance requirements (estimated at US$ 170 million for 1990-95) was pledged; in Pakistan the ADB reached a broad agreement with the government and UNDP on the terms of reference and modalities of the Master Plan exercise, in which FAO is involved as associated agency responsible for studies on upland degraded watersheds and institutional aspects; in Papua New Guinea the national forestry action plan, prepared with support from the World Bank, was endorsed at an International Round Table type III held in Port Moresby in April 1990; in the Philippines a donors' meeting on the Master Plan for Forestry Development, prepared with support from ADB and co-financed by FINNIDA, was held in Manila in October 1990; in Solomon Islands an official request for assistance to initiate a TFAP exercise was received by FAO in September 1990; in Sri Lanka based on a FAO/Investment Centre mission report, FINNIDA and the World Bank assisted the government in preparing a Master Plan; in Thailand an agreement has been signed between the government, UNDP and FINNIDA to prepare a forestry sector Master Plan, which was officially inaugurated on 3 January 1991; in Vanuatu the government requested support for a TFAP exercise in April 1990; and in Vietnam the sector review studies were completed by the end of 1990 and a draft final report prepared in January 1991.

4 REFERENCES

National Report on forestry received by FAO Regional Office from the countries of the region (October to December 1990)

National Progress Reports presented at the 14th Session of the Asia-Pacific Forestry Commission (April 1990)

Country papers presented at the following regional technical meetings held during 1990 at the FAO Regional Office for Asia and the Pacific, Bangkok: Agroforestry (15-18 May 1990); Forestry Education (26-29 June 1990); Tree Breeding and Propagation (10-13 July; 1990); Forestry Statistics (29 Oct-2 Nov 1990); Agroforestry and Animal Husbandry (12-15 Nov 1990); Management of Protected. Areas (10-14 Dec 1990).

Intervention Notes

H.E. Ting Wen Lian[1]

The statements we have just heard, especially from Your Excellency, are indeed very inspiring and serve as an excellent guide for the discussions of this workshop. Your statements also play a very important part in the international consciousness-level raising process on forests. My delegation wishes to express warm appreciation to the sponsors for their support of this workshop and the continuation of our discussions on forests.

Indeed, my delegation notes that this workshop comes at a most opportune time, so soon after the conclusion of the second UNCED Preparatory Committee early this month in Geneva. It is a good sign that we have not allowed the dust to settle before we pick up again the lively threads of deliberations in Geneva. We understand that this "Technical Workshop" is designed to provide additional information for future UNCED meetings and wider discussions on forestry issues. In view of this, my delegation considers that the relevant point of departure for this workshop, would be the report of the second UNCED Preparatory Committee and specifically the section dealing with forests.

Delegations here are no doubt already familiar with the deliberations at Geneva. However, my delegation wishes only to recapitulate some of the more significant trends. Firstly, it was the general recognition that before the international community could decide on the form of a global consensus on forests, an enormous amount of data had to be in place. Malaysia identified these missing links and my delegation would be pleased to list them out later. Secondly, there was also at Geneva, the general view that the consideration of a non-legally binding global consensus on forests might be achieved, or possibly some formula less ambitious could be incorporated in the Earth Charter. There was certainly concern all round that with the time constraint and with Rio a year away, that progress on the other two ongoing conventions on climate change and biological diversity, should not be adversely affected.

Therefore, it was evident to my delegation that the general mood of the second UNCED Preparatory Committee, ruled out the prospect of a legally-binding convention on forests for UNCED 1992. Indeed, Malaysia has made it clear at many fora that we do not support hasty initiatives which seek to conclude a legally-binding convention on forests. While we may not be totally averse to one in time, my delegation sees no merit in rushing headlong into a legal convention on a subject which has vast ramifications especially for developing countries, in terms of socio-economic implications. Putting the cart before the horse should be avoided - and an empty cart at that, because most of the required information, as I mentioned, is still not available.

My delegation, therefore, does not see this workshop as providing another forum to advance the proposal of a forest convention. Neither is this a forum to coax or jolt the political will to agree on a forest convention. At this point, my delegation notes that the recently concluded Preparatory Committee in Geneva and "affirmed that the UNCED process is the most appropriate forum for conclusive decisions pertaining to a global consensus on forests". So we do not expect this workshop to examine the merits or the preferred form of an eventual global consensus, and it is our hope that this workshop will resist the temptation of becoming another forum for the furtherance of those objectives. And I appreciate, Mr Chairman, your statement which has been very reassuring on this point.

While we are on this point, my delegation must confess that it has become increasingly perplexed since September last year as to why technical fora and especially important international technical agencies like FAO are being utilised to promote the hasty agenda of some countries to formulate a forest convention. I say this from firsthand experience as I am also permanent representative of Malaysia to FAO. My delegation can appreciate the concern for the environment, and in fact Malaysia has played an active role in activities relating to the environment, and in the formulation of the Langkawi Declaration on the Environment endorsed by developed and developing countries in the Commonwealth; but we are beginning

1 Malaysian Ambassador to Italy

to sense that there may be something more ominous in the almost missionary zeal shown by certain countries in their pursuit of a convention on forests, and it is our hope that it has nothing to do with the fact that these same countries happen to be leading exporters of temperate timber.

My delegation wishes to affirm, however, that our sense of disquiet does not shake our resolve to identify the most efficient and realistic ways for the better management of forest resources. As a matter of fact, it is a reflection of our genuine concern for the maintenance of a wholesome environment, that Malaysia adopted a positive position vis-a-vis the present focus on forests. It has always been our contention that forests should be considered as a part of the whole environmental perspective which includes the phenomena of ozone depletion, climate change and pollution. We were astonished as to why tropical moist forests which cover only 7% of the earth's surface and responsible for 9% of the greenhouse effect gas emissions, have been singled out for special treatment. However, we set aside our initial reservations, because we decided it was necessary to study in depth each and every problem concerned, in order to assess the role it plays in the enhancement or degradation of the environment.

My delegation is convinced that much more can be gained in terms of creating an atmosphere of shared endeavour, especially when considering a subject like the environment which is man's common space and heritage. Therefore, it is the earnest hope of my delegation that those who have been in the fast lane for a forest convention, will get back into the mainstream and channel their boundless energy and reservoir of expertise in the directions indicated at the recent meeting of the UNCED Preparatory Committee. In this respect, my delegation considers the prospect of further pressure to elaborate a convention on forests in time for Rio 1992 as both impractical and counter-productive. Therefore, Mr. Chairman, in view of the observations we have made, my delegation recognises that this workshop has an important role to play in establishing a clear signal that those assembled here have common objectives would be to identify and collate the relevant substantive technical data required for a serious consideration of the need for some form of global consensus on forests. At Geneva, my delegation, identified the areas where information was lacking. At the risk of taxing the patience of those who were in Geneva, I would like to enumerate the items again as we feel this workshop should benefit from the presence of the technical experts. The missing information required is as follows:

1 Analysis of the historical loss of boreal, temperate, sub-tropical and tropical forests world-wide, and their respective contribution to global environmental degradation.

2 Review of the extent, quality and rates of depletion of forest cover due to deforestation, acid rain, air pollutants, fire and desertification, for the respective boreal, temperate, sub-tropical and tropical forests world-wide.

3 Analysis of the respective role of boreal, temperate, sub-tropical and tropical forests as carbon and heat sinks, and their contribution to global warming in relation to other sources of greenhouse gas emission;

4 Assessment of the respective role of boreal, temperate, sub-tropical and tropical forests in the conservation and rational utilisation of biological diversity and bio-productivity, at the species habitats and ecosystems levels respectively;

5 Analysis of the impact of deforestation on sustainable agricultural production, especially in developing countries;

6 Assessment of the respective ecological role of boreal, temperate, sub-tropical and tropical forests in soil and water conservation, and their respective socio-economic development role, in providing food security, the eradiation of poverty and raising standards of living and quality of life at the local and national levels;

7 Analysis of the current levels and structure of world trade and the characteristics of trade regime in temperate and tropical timber and timber products;

8 To prepare reports on:

A An appropriate level of minimum forest cover for all countries, particularly beginning with the developed countries which have converted large forest areas for seasonal field crops;

B The enhancement of existing institutions to provide data on existing expertise and technologies, in the field of sustainable forest management, conservation and development;

9 Quantification of the respective economic values of boreal, temperate, sub-tropical and tropical forests in terms of:

(a) Timber and forest products;

(b) Watershed protection,

(c) Flood mitigation,

(d) Soil protection and conservation,

(e) Sanctuary for wildlife,

(f) Recreation and ecotourism,

(g) Habitats for genetic resources,

(h) Carbon and heat sinks.

To elaborate on Ambassador Ulsten's list of some "components", my delegation would also like to state at this juncture our broad concerns pertaining to forestry within the context of environment. These concerns include the following:

1 To recognise that countries have permanent sovereignty over their forests within their territories and the right to develop them in accordance with their needs and level of socio-economic development;

2 To acknowledge the need for an agreed minimum level of forest cover for each country of the world as part of their global obligation to protect and conserve forest resources,

3 To call on all countries, particularly the developed countries that have undergone extensive deforestation to draw up national forestry action plans aimed at substantially increasing their current extent of forest cover through afforestation and reforestation, as the conservation and rational utilisation of forests is a common responsibility of all mankind. Indeed, this would constitute the beginning of the process of the greening of the world. In this regard, some of these countries should display transparency in matters pertaining to their forestry as well;

4 To remove tariff barriers and the provision of better market access for higher value-added timber and timber products and to provide a supportive international economic environment which promotes economic growth and development, as these would encourage and enable producer countries to better conserve and manage their renewable forest resources for long-term benefits and keeping with the needs of the environment;

5 To ensure that countries which allocate more than their fair share in forest land be compensated for their sacrifices made for the benefit of the world community;

6 To ensure that any losses incurred by traditional users in reserving certain forests or modifying existing forest land-use in meeting environmental need be compensated,

7 Importing countries should cease all forms of unilateral actions to restrict and/or ban the use of timber, especially tropical timber. These actions are arbitrary and against the spirit of free trade and are counter-productive in efforts to sustainably manage, conserve and develop the forest resources. As such there should be acceptable norms and a code of conduct to prevent such violations,

8 To recognise the need of developing countries with substantive forest resources to convert some of these forests for permanent non-forestry uses in their overall socio-economic development based on rational sound land use policy and strategies,

9 To recognise the multiple role of forests in timber production and other forest produce, preservation of biological diversity and climate stability, minimisation of damage to rivers and agricultural land by floods and erosion, safeguarding of water resources and their ethical, aesthetic and cultural values, and the need to manage them in the overall context of sustainable development,

10 To acknowledge that the practice of selective logging in tropical rain forests, in a controlled manner and which maintains the ecological character of the forests, is not deforestation and will not lead to loss or destruction of forests,

11 To acknowledge that the destruction of forests is closely interrelated with poverty and demographic pressure in developing countries and in this context it must be viewed as an integral part of the development process and cannot be considered in isolation from it,

12 To recognise and acknowledge the relationship between the external indebtedness of developing countries and the phenomenon of net transfer of resources from developing to developed countries and hence their inability to manage, conserve and protect their forest resources,

13 The technological needs and the need to strengthen effective international cooperation in areas of research, environmentally sound technologies to developing countries, at preferential and concessional terms to enable them to better manage, conserve and develop their forest resources. In this regard, the activities of ITTO and FAO's tropical forestry action plan should be supported,

14 The need for new and additional financial resources by developing countries to manage their forests sustainably and in increasing their forest cover. In this context appropriate mechanisms including the proposal from China should be welcomed,

15 To recognise the close linkages between forest conservation and forest development in contributing to sustainable socioeconomic development and in meeting the basic needs of mankind including food security and the alleviation of poverty,

16 To recognise the need of equitable sharing by the world community of the burden of forest conservation and development, including the application of financial compensation to offset opportunity cost foregone in forest conservation without commensurate use. Incidentally, our statement was distributed as a Working Group I document and the points I just listed out were incorporated in the Report of the Preparatory Committee.

It is the hope of my delegation that this workshop would firstly assist in ascertaining and assessing how the nine missing items of information could be obtained, and secondly, the workshop could consider the sixteen principal areas of broad concerns identified in our list. We believe that the acknowledgement and acceptance of those substantive concerns would bring us closer to the core principles which have to be addressed and to find expression in any global consensus on forests.

Finally, my delegation wishes to make comments on the statement or report which will emerge from this workshop. In the light of what we have said earlier on in this intervention, we are hopeful that the report of the workshop will serve as a significant technical input to the UNCED process. As such it would be entirely inappropriate to include recommendations citing preferred options viz forest convention, protocol etc. Such attempts would not be helpful as they prejudge the UNCED process and consequently may even jeopardise the positive contributions of the technical experts participating in this workshop.

At the end of the day when you stand with shovel in hand to dig a hole in the ground to plant a tree, it is your willingness and ability to do so that really matters, and not the way you are dressed-whether you are in a three-piece suit or in your blue overalls. In short, the preoccupation with the form of the global consensus on forests is not the priority. It is more pertinent, at this stage to collate and assemble the relevant data. A political decision can only be made on a thorough examination of the whole range of forestry issues, and the ability to address those issues adequately, will depend on the economic and development commitments of governments.

Statement

World Wildlife Fund

Need for a Global Convention

The escalating loss and impoverishment of the world's forests ranks among the most urgent of the environmental crises facing humanity. International response to date has led to the International Tropical Timber Agreement (ITTA) and the Tropical Forestry Action Plan (TFAP), initiatives limited in scope to tropical forests and with marginal prospects of slowing deforestation - the result of mandates that neither clearly set forest conservation as a central objective nor sought to address root causes of forest loss outside the forestry sector.

There remains, therefore, an urgent need to go beyond existing initiatives, ideally to launch a comprehensive instrument on forests that will state a clear set of objectives for protection and restoration of the global forest estate; that will lead to fair and consistent policies across boreal and temperate as well as tropical forests; and that will act as a catalyst for addressing underlying equitable issues of international debt, land tenure, and other macroeconomic reforms.

Potential Elements of a Forests Convention

WWF accordingly strongly supports proposals for a Global Forests Convention that will:

* Provide for nationally prepared forest land use plans that will define the forest estate and set production and conservation targets which can serve as a basis for needed development assistance and economic and policy reforms;

* Establish a centralised monitoring system for forests worldwide to provide agreed upon data including rates of loss;

* Require of developed countries forest conservation commitments and practices that previosuly have been asked only of developing countries with tropical forests;

* Adopt clear guidelines for sustainable forest management, similar to those promulgated by ITTO, but applicable also to temperate and boreal forests;

* Recognise the interests of forest-dwelling peoples and provide for direct local participation in decision-making processes;

* Request countries to designate Forest Areas of Special Importance for heightened protection and international recognition;

* Consider creation of an international programme for tracing and authenticating sustainably produced timber in domestic and international commerce.

Procedural Initiative at UNCED PrepCom II

Despite numerous calls for concerted international action on world forests - in particular for a comprehensive, freestanding Global Forests Convention - no intergovernmental process is yet established to begin work on an agreement. If an instrument on forests is to have any chance of being ready by 1992, decisive action must be taken promptly.

A key opportunity to get this process underway came at the second UNCED PrepCom meeting, in March 1991 in Geneva. WWF calls on governments attending the UNCED meeting to establish and fund a single intergovernmental negotiating process for a Global Forests Convention, linked to UNCED but conducted through an independent negotiating committee with an ad hoc secretariat housed at Geneva. To ensure sufficiently broad sectoral representation and technical expertise, the ad hoc secretariat would draw its staff from the various relevant UN agencies and, where appropriate, other intergovernmental and nongovernmental organisations.

This arrangement:

* Responds directly to UNCED's draft Interim Report on Forests and endorses both the need for an international legal instrument on forests and the timeliness of beginning discussions now leading to its development;

* Recognises that the breadth of issues to be addressed under a Global Forests Convention places the endeavour beyond the competence of any single UN body, and requires inclusion of agencies and organisations having expertise in, inter alia, development, environment, and human welfare;

* Follows recent precedent arising in the climate change context, where an ad hoc secretariat was established at Geneva, consisting mainly of UNEP and WMO staff but remaining independent of their respective agencies. The negotiations on forests likewise should be aimed at completing an agreement by 1992;

* Enables the Forests Secretariat, by virtue of its Geneva location, to work closely with the UNCED Secretariat and with the Climate Secretariat, a necessity in the latter instance given the overlap of climate and forestry issues, the prospect of a forest protocol to a climate convention, and the need to ensure consistent policies and efficient allocation of effort;

* Could be accomplished at the UNCED PrepCom meeting, without need for further action by the UN General Assembly, by governments acting on their own initiative to establish a negotiating secretariat, as was done with CITES, the London Dumping Convention, and the Ramsar Convention on Wetlands.

CAN Statement on Forests[1]

K Snyder[2]

Nongovernmental environmental organization representatives attended the Intergovernmental Negotiations Committee on a Framework Convention on Climate Change held in Chantilly, Virginia, 1991. They discussed the possible adverse social and environmental effects of linking forests issues to the carbon sink potential of trees. A subgroup on forests was organized and met several times, separately and with the larger group of Climate Action Network representatives, to draft a statement on forests. Discussions on this statement will be continued for the months to come.

Three primary concerns emerged:

1) The inclusion of carbon sink components into a climate agreement should under no circumstances distract from the preeminent need for industrialized countries to reduce their emission of greenhouse gases. While this point is made clear in the forest statement, many people emphasized the need for a comprehensive NGO statement on energy and greenhouse gas emissions to balance the message on forests coming from the environmental community. Dan Lashof (NRDC) and T.J. Glauthier (WWF) head a group set up to compile an energy and targets paper which should be ready in a few weeks.

2) A second concern, not confined to issues around forests, was that the poor and unrepresented people of the world, particularly women, would most likely be the greatest victims of climate change and future policies and programs set up to address it. When discussions are focussed on targets and scientific data, it is often not clear how the interests of local and indigenous peoples will be protected. People and the conservation of nature must be kept in perspective. Part of the responsibility lies with the nongovernmental community to show how people, the environment and development are complimentary and how safeguards can be incorporated into climate strategies to protect local people and the ecological sustainability of specific areas. Language for such safeguards is within the targets section and the section on accountability and monitoring.

3) Finally, carbon sink strategies must place priority on the conservation of primary forests and provide safeguards for the protection of biodiversity, ecosystem services and cultural diversity. This is the main thrust of the statement and reflects on past discussions held on the forest agreement. A carbon sink strategy must not translate into a massive eucalyptus planting initiative. The incorporation of forest issues into climate has several advantages in that it provides a balance between North-South interests and has the potential to make available substantial funding for conservation.

The statement is currently in draft and is not therefore reproduced in these proceedings.

1 Update: February 21, 1991 climate/forest working group of the Climate Action Network

2 Washington DC, USA.

Part B Additional Papers for National Forest Options

Indonesian Forest Resources and Management Policy

Edy Brotoisworo[1 2]

1 INTRODUCTION

Tropical forest is one of the most important components of the world ecosystem, because of its role as a life support system. If the forest is utilized wisely, without neglecting its regeneration, it may be sustainably used as a renewable resource. The wise utilization of tropical forest has become a major topic of discussion as the development process in many developing countries has caused a substantial decline of the tropical forest.

Tropical forest is a potential source of foreign currency that can be used to finance development. Unwise utilization of forest resources, however, has caused various ecological problems which not only affect the countries themselves, but also the global environment. Therefore, international concern about tropical forests is currently increasing.

Indonesia, having the second largest tropical forest after Brazil, is currently trying to improve forest management by balancing production and exploitation with environmental conservation. This paper will briefly review the country's forestry sector policy. Data cited are from Situation and Outlook of the Forestry Sector in Indonesia, published by the Ministry of Forestry of the Government of Indonesia and FAO in 1990, unless stated otherwise.

2 INDONESIAN FOREST RESOURCES

2.1 The Country and the Population

Indonesia is a large archipelago, consisting of more than 14,000 islands, spread over an area of about 5,100 kilometers along the equator. The land mass is about 190.8 million hectares (RePPProt, 1989) or about 30% of the total area of the country, the remainder consisting of marine environment. The climate varies from perhumid to semi-arid, with annual rainfall ranging from 700 to 4000 mm. The mean daily temperature is 32°C while daily average humidity is 90%. There are five major islands, i.e. Kalimantan, Irian Jaya, Sumatera, Sulawesi and Java, the first two of which are shared with Malaysia (Borneo) and Papua New Guinea respectively.

The country is one of the most diverse in the world in terms of biology, ecology, demography, and culture. Situated between the Asian and Australian continents, it has two major regions. The Oriental region in the West, including Sumatera, Java, Bali, and Kalimantan, faunistically resembles the Asian continent, whereas the Australian region in the East, including Irian Jaya and the surrounding islands, faunistically resembles the Australian continent. In between these two regions, there is a transition zone called Wallacea which includes Sulawesi, the Moluccas, and the Lesser Sunda Islands. The fauna of this region constitutes an intermediate between the two continents, and is characterised by a higher degree of endemism compared to the other regions, particularly for birds and mammals species (FAO, 1982). These unique biogeographical characteristics have given rise to highly diverse ecosystems, in particular forest ecosystems, which need special conservation efforts.

In 1990, the total population was about 179 million, distributed very unequally over the country (Table 1). Most people live on Java, where 7 % of the total land area supports 60% of the country's population. The other islands, particularly Kalimantan and Irian Jaya, are relatively scarcely populated.

1 Institute of Ecology, Padjadjaran University, Bandung, Indonesia.

2 Edited by S Rietbergen, International Institute for Environment and Development, London, United Kingdom.

2.2 The Forest

In 1980, Indonesia adopted a forest land use plan based on a consensus among all relevant Ministries. Hence, it is called Forest Landuse by Consensus (Tata Guna Hutan Kesepakatan or TGHK). Five categories of forest totalling 144 million hectares or about 74 percent of the total land area, were identified.

Table 1 Population distribution in Indonesia, 1990.

	Land Area (x 1,000 ha)	Population	Density (people/km^2)
Sumatera	47,482	36,420,486	76
Java	13,257	107,517,963	811
Bali and Nusa Tenggara	8,642	10,161,531	117
Kalimantan	53,628	9,102,906	17
Sulawesi	18,612	12,511,163	67
Maluku	7,804	1,851,087	24
Irian Jaya	41,406	1,629,087	4
Indonesia	190,828	179,194,223	84

Compiled from: Indonesian Statistical Bureau, 1991.

Forest land as defined in TGHK is not necessarily covered in forest, but refers to all land administered by the Ministry of Forestry, roughly equivalent to the land which was under forest cover in the recent past. A more detailed and systematic study by the Regional Physical Planning Programme for Transmigration (RePPProT) estimated that the land under natural forest was 119 million hectares (RePPProt, 1989). A recent study carried out by the Ministry of Forestry of the Government of Indonesia and FAO (1990) estimated that the forested area was 108.6 million hectares. Table 2 shows the classification of forest land according to TGHK and the estimated forested land 1990. Comparing forest land according to TGHK with the forested area in 1990, a substantial decline of the forested area, mainly due to conversion to non-forest uses during the last few decades, is apparent.

Table 2 Forest in Indonesia, comparing classification according to TGHK and estimated forested area in 1990 according to the forestry study undertaken by Ministry of Forestry and FAO (1990)

Categories	Extent of Forest (million ha)			
	TGHK		1990	
	area	%	area	%
Conservation forest	18.8	13.1	14.6	13.5
Protection forest	30.3	21.0	25.2	23.2
Production forest*	64.4	44.7	46.1	42.4
Conversion forest	30.5**	21.2	18.7	17.2
Unclassed forest	-	-	4.0	3.7
Total	144.0	100.0	108.6	100.0

* - Production forest consists of limited and regular production forest
** - Includes some unclassed forest

RePPProt (1989) identified 12 forest types, which were further grouped into six categories for forest management purposes, i.e. a) mixed hill forest, b) submontane, montane, and alpine forests, c) savannah, bamboo, deciduous, mountain and monsoon forests, d) peat-swamp forest, e) fresh water swamp forest, f)tidal forest. The extent of forest considered to have management potential is 62.2 million hectares, consisting of 40.8 million hectares of mixed hardwood production forest, 2.1 million hectares of tidal forests and 19.3 million hectares of conversion and unclassed forest (some 30.4 million hectares of which have not yet been logged).

Forest resources have provided a significant contribution to the national economy. When the Indonesian tropical mixed hardwood forests were opened up for timber harvesting in 1966, many timber concessions were set up in the most forested areas of the country. There was a significant increase in log production from 1.4 million cubic meters in 1960 to 24.6 million cubic meters in 1978 and to over 32 million cubic meters in 1988. The increasing world market demand for logs stimulated the timber concessionaires to speed up log production from 1966 to 1980, when most of the logs produced were exported. After 1980, the government progressively introduced a log export ban, culminating in a complete ban in 1985. Since then, the production of roundwood has been absorbed by forest-based industries, which expanded dramatically, particularly the plywood industry. Production of plywood increased from 19,000 cubic meters in 1973 to over 8 million cubic meters in 1989, making Indonesia into a major world producer and exporter of wood products. This increase in forestry activities has created substantial employment, directly as well as indirectly. In 1987, forestry-related employment accounted for 5.4 percent of the country's total labour force.

Uncontrolled growth of industries depending on the forest resources, however, may adversely affect resource sustainability. Therefore, the government has determined the annual allowable cut for various forest areas on the basis of growing stock, a measure which will subsequently limit the number of forest-based industries depending on logs from these areas.

2.3 The Problems

There have been various problems in the Indonesian forestry sector during the last decades, but decline of forest cover has been the major one. A reduction in forest cover resulting from planned and unplanned deforestation is unavoidable for most developing countries having forest resources. Unplanned deforestation was mainly due to the conversion of forest to agricultural land, resulting from population pressure, shifting agriculture, and spontaneous migration. Forest fires have also contributed to deforestation. Planned deforestation was mainly due to transmigration, conversion to plantation estate, and other types of development projects. Table 3 shows the annual deforestation rate.

Table 3 Annual deforestation rate (hectares/year)

Source of deforestation	Best estimate	Range
Smallholder conversion	500,000	350,000 - 650,000
Development projects	250,000	200,000 - 300,000
Logging	80,000	80,000 - 150,000
Fire loss	70,000	70,000 - 100,000
Total	900,000	700,000 - 1,200,000

Source: World Bank (1990)

Smallholder conversion is dominated by shifting cultivation, one of the major threats to the forest resource. Expansion of shifting cultivation has been accelerated by the establishment of logging roads within concession areas and by road construction connecting areas to each other. In some cases, construction of base camps of timber concessions was followed by the establishment of shifting cultivator settlements (Anonymous, 1982), particularly in areas where control was inadequate. Recent data show that shifting cultivation covers an area of about 11 million hectares, and is practiced by some 1.2 million households or about 6 million people. Most of this area is in Sumatera and Kalimantan, which contain about 75% of all shifting cultivation areas.

Logging has also caused deforestation, as a result of overcutting, relogging, inefficient logging practices, inadequate enrichment planting and tending of residual stands among others.

Existing figures on deforestation rates should be critically examined, however, because of probable miscalculation of areas deforested. For instance, double counting may occur when deforestation due to logging is followed by shifting cultivation or when logged-over conversion forests are used for development projects.

3 THE BASIC FORESTRY SECTOR POLICY

Forests not only constitute a resource and habitat, they have also had an essential role in supporting human life from times immemorial. Therefore, there should be a balance between utilization for economic benefit, set-aside for conservation of ecological functions and use for social purposes.

The Basic Forestry Law No. 5 of 1967 stipulates that the management of forest shall be in accordance with the principles of multiple use and sustained yield. Several management systems have been designed in order to fulfil the following conditions for ensuring the sustainable development of the forestry sector:

- efficient utilization of site productivity,
- conservation of genetic resources,
- maintenance of environmental stability and quality,
- sustainable utilization of forest (wood and non-wood) products,
- retention of a viable residual stand after logging.

Management systems have to consider protection, production, and the views of people affected by the forestry activities.

The policy derives from the National Development Guidelines (Garis-Garis Besar Haluan Negara or GBHN) which clearly indicates that the forest resources should be utilized in a rational manner, in due consideration of their environmental role and the needs of the future generations. The national forestry sector policy is expressed further in the goals of Indonesian Tropical Forestry Action Plan. The plan seeks to gain economic benefit and to distribute the benefit equally among the population, while setting aside representative ecosystems as conservation areas. The main elements of the action plan are the following:

- to develop the Outer Islands (islands other than Java and Bali) and relieve population pressure on Java and Bali;

- sustainably utilize the mixed tropical hardwood forests and the man-made forests for national development;

- develop more productive man-made forests, and convert bare and unproductive lands into productive areas, in order to produce more wood for industrial processing and for energy, as well as to restore their environmental integrity;

- generate livelihood opportunities for forest communities and the rural population through the establishment of multiple use forest;

- conserve natural resources for the benefit of present and future generations of Indonesians.

4 FOREST RESOURCE MANAGEMENT POLICY

Based on the preceeding policy imperatives, Indonesia has outlined the forest resource management policy needed to achieve sustainable forestry development. The underlying principle of this policy is that each forest area should be allocated to a specific land use category within the overall national land use system. Each of the categories should be well defined in terms of their objectives, and management systems and plans. Land use categories, also called forest allocations, their main purpose and status with regard to exploitation are presented in Table 4.

Forests can be managed for various products in various ways. As a consequence, forest resource management can be conceived to consist of:

- Natural forest management

- Forest plantations
- Non-timber forest products
- Forest-based processing industries

Table 4 Land use categories, main purpose and their status with regard to exploitation

Categories	Main Purpose	Permitted Exploitation
Conservation	Nature reserves and genetic resource conservation, research, recreation.	None
Protection	Water conservation and soil protection.	None
Limited Production	Timber production and prevention of soil erosion.	Selective felling
Regular Production	Timber plantation.	Selection or clear felling
Conversion	Conversion to agriculture use.	Clear felling

4.1 Natural Forest Management

There are several forest management systems in Indonesia. The first government regulation for natural forest management was issued in 1966. The regulation stipulates that logging shall be done by selective cutting on a 60 year rotation. In 1967, the Basic Forestry Law was issued, covering Forest Concession Rights as well as logging regulations. A more detailed regulation was issued in 1972 (Decree No. 35/1972) by the Director General of Forestry. It stipulates that natural forest shall be managed under the following systems:

- Indonesian Selective Cutting System (Tebang Pilih Indonesia or TPI)
- Clear cutting with natural regeneration (Tebang Habis dengan Permudaan Alam or THPA)
- Selective cutting with artificial regeneration (Tebang Habis dengan Permudaan Buatan or THPB)

In practice, only the TPI has been applied.

4.1.1 Indonesian Selective Cutting System

This TPI system has been the main (if not the only) forest management system applied. The main features of TPI are a minimum exploitable diameter of 50 cm dbh, a cutting rotation of 35 years, and refining and subsequently tending of an adequately stocked residual stand.

Until March 1990, the number of timber concessions in Indonesia was 574, covering an area of about 58.8 million hectares (Saleh et al 1990). The size of the concessions ranges from about 15,000 to over 500,000 hectares, with the average being between 150,000 and 250,000 hectares. Many problems were encountered with the implementation of the system since 1966, for instance:

- pre-felling inventories of the growing stock were often inadequate
- Forest Landuse by Consensus, which was only approved in 1980, has interfered with the existing timber concessions, as some parts of the concession areas have been allocated to protection or conversion forest, causing overlap with other development plans such as mining, transmigration, etc.
- The government policy of completely banning log exports in 1985 has caused small timber concessionaires to sell their concession rights to the bigger ones, instead of merging. This has caused difficulties in determining who is responsible for the operations, a situation that has improved now the government has asked the buyers of concessions to take appropriate measures.
- Inefficient logging practices have resulted in a relatively high logging waste, i.e. 35-40% (25% according to MOF & FAO, 1990). On the other hand, stimulation of the development of forest-based industries has increased utilization of lesser known species and residual wood as industrial raw materials.
- Low skill of the logging workers has caused much damage to the forest in the past. Training may significantly reduce such damage. For instance, Simarta & Sinaga (1982) have compared wood waste from logging operations before and after training of workers, and found a decrease of waste from 16.69% to 5.78%.

- Concession rights are only valid for 20 years, while the cutting cycle stipulated by the law is 35 years. The resulting lack of interest on behalf of the concessionaires has led to overcutting and relogging, aggravated by a lack of knowledge about enrichment planting and tending of residual stands, etc.

In view of these problems, the Ministry of Forestry has recently taken serious measures including cancellation of concession rights, and fines for non-compliance with regulations. Furthermore, the 1972 decree has been replaced by decree no. 564 (1989) of the Director General of Forest Utilization, the implications of which will be discussed below.

4.1.2 Indonesian Selective Cutting and Planting System (Tebang Pilih Tanam Indonesia or TPTI)

Considering the problems encountered with the TPI system, the serious depletion of forest resources and reduction of timber supplies, the Ministry of Forestry issued Decree No. 564/1989 which stipulated the use of three above-mentioned cutting systems, but replacing the Indonesian Selective Cutting (TPI) system by the Indonesian Selective Cutting and Planting System (TPTI).

The new TPTI system stresses the obligations of the concessionaires to carefully consider and carry out natural regeneration and enrichment planting operations within their concession area, and specifies penalties for their non-observance. Pre-felling inventories have to be undertaken to assess whether residual stands contain an adequate stocking of at least 25 undamaged trees per hectare, of desired species of 20 cm dbh and larger, which can be harvested economically within 35 years. If this is not the case, enrichment planting has to be undertaken.

Beside the TPTI, the other two management systems (THPA and THPB) should also be considered. Which system will be applied depends on the results of a pre-felling inventory assessing the stand characteristics of each cutting block. The cutting cycle would be longer for these system, i.e. 70 years. The implementation of THPA and THPB strongly related to the newly introduced sylvicultural system, i.e. Industrial Timber Estate.

4.2 Industrial Timber Estate (Hutan Tanaman Industri or HTI)

In order to supplement timber supplies deriving from the exploitation of natural tropical forest hardwood, the government has designed a policy to stimulate the plantation of hardwood timber species. One of the reasons for promoting HTI is the experience gained with the implementation of TPI. Though the TPI system stipulated that replanting should be done after cutting, the concessionaires did not comply with this regulation in general. Because of this, the government established a Reforestation Guarantee Deposit Fund in 1980, requiring the concessionaires to pay fees to be used for forest regeneration. The concessionaires who engaged in reforestation would be refunded the deposit. Since this scheme did not work either, the government established the Industrial Timber Estate Development Programme using the reforestation fees collected.

HTI was introduced by means of Decree (Ministry of Forestry) No. 142/1984 on the Development of Industrial Timber Plantation, which was followed by Decree No. 162/1984, also issued by the Ministry of Forestry, dealing with the procedures. HTI is established on forested land following a clear felling or by afforesting barelands, and other degraded lands. The primary aim of the HTI is to produce wood to supply the future needs of timber for industrial purposes. Besides, it may also function as a tool for land rehabilitation, enhancing hydrological functions and reducing erosion. Environmental aspects should be taken into consideration in the design of a large scale forest plantation, as a consequence.

Indonesia has ambitious plans for plantation development. The target for the total area under plantation by the year 2000 is 25 million hectares, 6 million hectares of which should be timber plantations. The national target for the Industrial Timber Estate is to establish 4.4 million hectares during Five Year Development Plan (Repelita) IV (1984/85 to 1988/89), V and VI (1994/95 to 1998/99). It seems the target is unlikely to be achieved since the achievement under Repelita IV was very low. During the fiscal year 1984/1985, 24,000 hectares of HTI were established.

4.3 Non-Timber Forest Products

Most of the non-timber forest products (NTFP) have been exploited by local people since time immemorial. Many of these products have played an important role in the local economy, providing food security, employment and welfare to the local communities. The products which have high economic value at present are rattan, pine resin, and sandalwood.

Rattan is the most important NTFP in Indonesia. The rattan industry is located in rural areas, is labour intensive and has the highest economic value of all NTFP. For instance, the percentage export value of NTFP in 1988 was 7.2%, with 6.5% coming from rattan and rattan furniture. In order to make rattan contribute more substantially to local and national socio-economic development, several policies covering a wide range of aspects, from resource management in the field to development of processing and marketing have been introduced. The government banned export of raw rattan in 1979 and of semi-finished rattan in 1988, in order to increase the value-added.

Because of the rapid growth of rattan industries requiring large amounts of raw material, the government encouraged the establishment of rattan plantations either by private companies or by government corporation, thus anticipating the possibility of diminishing supplies of rattan from natural forest. The Philippines, Malaysia and Thailand are facing declining supplies of rattan, and the Philippines has even begun to import rattan for their well-developed rattan industry.

Besides rattan, a large number of other products can be extracted from the forest, e.g. gums, oil, fruits, nuts, medicinal plants, animal products such as meat, eggs, honey, etc. If NTFPs can be managed professionally and intensively, they can give substantial economic return, diversifying forest produce, and supporting forest-based industries and small-scale home industries. An additional benefit is that NTFP harvesting, unlike timber exploitation, causes less environmental degradation. However, if market demand is too high, increasing pressure may lead to depletion of NTFP resources.

Efforts to increase the role of NTFP other than rattan - particularly products which have good market prospects - have also received attention, in line with the Government policy to diversify forest production and to promote NTFP in the Repelita V (1989/90 - 1993/94).

4.4 Forest-Based Processing Industries

Indonesia has banned both the export of logs and of raw and semi-finished rattan. The objective of these measures is to develop incountry forest-based processing industries. The existence of such industries may encourage utilization of available resources, to enhance value added, to create more employment and to increase the contribution of forestry to the national income.

Beside promoting better utilisation of forest resources, forest-based processing industries may also create and stimulate the growth of related activities and development of social infrastructure, to support the existence of the industries, particularly in rural areas (multiplier effect). Forest-based industries can thus promote regional and rural development, and fulfil important social and economic roles.

The wood industry is the most important forestry development activity in Indonesia. Included are large industries (such as sawmilling, plymilling, and pulp and paper manufacturing) as well as smaller ones (such as chopsticks, safety matches, toothpicks, toys, pencils, wooden boards, agricultural implements, etc).

Sawmilling is the largest primary industry with 2,700 sawmills distributed across the country, amounting to a total installed output capacity of between 16 to 20 million cubic meters.

Wood-based panel industries have grown dramatically since the phasing out of log exports in the last decade. Export of wood-based panels reached a volume of over 8.0 million cubic meters in 1989, making Indonesia the second plywood producer in the world after the USA and the first plywood exporter, holding 40 percent of the global plywood export trade. Besides plywood, wood-based panels produced in Indonesia also include blackboard, with an estimated production of 483,000 cubic meters in 1988, and particle board, with a production capacity of 343,000 cubic meters per year.

In 1989 there were 32 pulp and paper mills in Java, 5 in Sumatera, and 1 in Sulawesi, producing 750,000 tonnes of pulp and 1,417,000 tonnes of paper per year. By mid 1990, the number of paper mills had increased to 40 units with an installed capacity of about 1.5 million tonnes per year.

5 CONSERVATION OF FOREST ECOSYSTEM

Forests, apart from their direct economic value, also have essential ecological and environmental significance, functioning as life support systems, and as habitat for flora and fauna.

The importance for forest ecosystem conservation is huge, as Indonesia has very high species diversity. The country, which occupies only 1.3 percent of the earth's land surface, holds about 10 percent of the world's plant species, 12 percent of the world's mammal species, 16 percent of the world's reptile and amphibian species, and 17 percent of the world's bird species, many of which are endemic. Therefore, Indonesia is classified as one of the world's mega-diversity countries (Anonymous, 1990). The reduction in forest cover has threatened many animal species with extinction, including 126 bird species, 63 mammal species, and 21 reptile species. As Indonesia feels obliged to conserve the wealth of natural resources and has committed itself to do so, national nature conservation policy states that all forms of life and examples of all ecosystems in Indonesia must be protected for the benefit of present and future generations. Air, water, soil, plants and animals upon which people depend must be protected, in particular.

Therefore, forest resources have to be developed in such a way as to conserve the long-term productivity as well as to maintain environmental quality. Up to the present time, Indonesia has declared the protection of 521 animal species, including 92 species of mammals, 372 species of birds, 28 species of reptiles, 6 species of fish and 20 species of insects.

To ensure the conservation of representative ecosystems and the associated flora and fauna, the Government of Indonesia has established several types of conservation area: nature reserves (including strict nature reserves and wildlife sanctuaries), hunting parks, natural recreation parks, high forest parks, and marine parks/reserves. As of August 1990, gazetted conservation areas were reported to number 366 units covering an area of 16.02 million hectares (Table 5).

Table 5 The gazetted conservation areas in Indonesia, 1990.

Type of Conservation Area	Number	Area (million ha)
Nature reserve (Cagar Alam)	187	8.40
Wildlife Sanctuary (Suaka Margasatwa)	73	5.80
Natural Recreation Parks (Taman Wisata Alam)	61	0.26
Hunting Parks (Taman Buru)	13	0.37
High Forest Parks (Taman Hutan Raya)	14	0.16
Marine Parks/Reserves (Taman Laut/Cagar Alam Laut)	18	1.03
Total	366	16.02

Furthermore, there are 24 national parks covering 6.7 million hectares. The area of the national parks typically ranges from about 500 to 7,000 square kilometers, but they are functional management units consisting of one or more existing reserves.

These are the efforts undertaken by the Indonesian Government to strike a balance between development and conservation, so that the needs of future generations are not sacrified for the needs of the present. As might be expected in a large country like Indonesia, however, control has become a major issue. One of the problems is that of human encroachment for settlement and shifting cultivation, which occurs in many of the conservation areas. Another problem is that of development projects being carried out in some conservation areas. Therefore, more attention should be given to ecosystem conservation.

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Convert All Forest Users into Managers of Forest Lands

Rauno Laitalainen and Manuel Boita[1]

1 Introduction

In Thailand, as in many other developing tropical countries, local people are at odds with forest administration over the use of government-owned forest lands. Government forestry staff, used to the classical practice of forestry, are learning that the local people, too, are forest users and managers of forest resources in their own way.

Classical forestry practice has centered on large tracts of government forests put under concession, controlled either by a private company or a state enterprise who pay nominal forest charges on the harvested timber. Timber, mostly large-sized, is harvested through capital-and technology-intensive techniques. Only commercial species ar eharvested, but others are ususally left injured during logging. The harvesting system employed is supposed to account for renewal of the forest crop. In practice, local people who could not be hired as company labourers and have no othermeans of livelihood but agriculture, follow after logging and convert forests to farms. Others have lived in the forest long before the logger came, and are often driven deeper into the jungle. Where concessions have been canceled, or logging banned, logging has persisted, albeit illegally since demand ofr timber continues and law enforcement is weak. Logging practices are as before, motivated by the extraction of commercial timber, but uncontrolled and untaxed.

Forest land, denuded in the above process but abandoned after its fertility has gone, is put back into trees through mono-culture. Some lands are not completely devoid of trees and could grow back into a forest, but are converted to mono-cultures anyway. Timber remains the over-riding consideration. Labour is hired locally, but people are barred from alternative uses of the land, such as for pasture or agroforestry.

Local people see that classical forestry practice, which results eventually in mono-culture crops, impacts negatively on the environemnt, drives them away from their source of livelihood, and supports fewer people than their way of using the land. Their practice, now labelled by academics as social forestry, involves the use of the forest for a mix of products, such as fuel, fodder, organic fertilizer, food, medicinal plants, resin, and also timber for housing and for cash. Timber extraction is small-scale and labour-intensive, and allows for crop renewal. Trees planted are of different species to produce a mix of needed commodities.

Another way indigenous people use the forest land is for agriculture. Where the soil is deep and located in flat to moderate slopes, farming can be sustained indefinitely with little infrastructural modification. In places where soil nutrients are depleted, the land is allowed to fallow and forest to grow back, so the crop-fallow cycle can be repeated over and over. Whatever way they use the forest, the local people contest the right to use the land. Legal land ownership is a moot issue, although they would prefer to have the paper to back their claims, especially when land values increase. Having been using the land for years before anybody else, they say that they have more rights over the land than industrialists who come in to convert it to mono-cultures. They fight development that takes their land and makes their lvies even more vulnerable than they already are.

2 Involve all potential forest managers

Resolution of the land use conflict is not easy. The problem has been around and all over the world, although in different places and times. The situation can be improved by recognising all possible uses of land and hence all possible types of managers. Forest users, who have less of information, money, and power, must be protected from being exploited if social justice is to prevail. If conditions are created so that managing the forest contributes more to their basic needs than forest exploitation, they can turn from encroachers to managers in due time.

1 Royal Forest Department, Thailand.

All parties interested in the use of land need to be vigilant of their rights, but do not have to be antagonistic towards each other. Landless farmers should be allowed to lease government land for forestry, and landowners encouraged to grow trees in areas not suited for cultivation. Local communities should be encouraged to organise into legal entities for forest management. Lower priority should be given to leasing forest land to large companies, where lcoal people will be displaced; nevertheless, where enough land is available such large leases may be possible and fair. When managing forest resources, state enterprises should operate under the same rules as the private sector. Forest administration should concentrate on regulating forest land use by the various parties mentioned, but it should continue to manage areas where there are no other interested parties, such as wilderness areas and reserves. The primary role of forest administration should not be to manage all the country's forests, but to translate forest policy into action.

3 Allow various management objectives for various beneficiaries

Figure 1 shows a matrix of forest managers and possible management objectives in the Thai context. Forests may be managed for products, services, and amenities. Products may be wood and non-wood, the latter including fodder, food, resin, gum, medicine, vines, and many others, which may be for indigenous consumption or sold to local and ex;ort markets. Soil and water conservation serves both upstream and downstream beneficiaries. Various amenities serve both local and global interests. A forest manager may have a main objective in mind, for example, growing wood for the local market. At the same time, however, he would be satisfying other objectives such as growing fodder and mushroom, or conserving the soil. The matrix shows what the main or alternate objectives could be in the Thai context.

4 Allocating forest lands to various forms of forestry

Salwasser (1990) suggests three basic models, adopted here as tree crop forestry, multi-purpose forestry, and preservation forestry. The names attributed to these models speak for themselves on what kind of forestry practices are involved in each of these models. In practice, of course, there are grey areas across these basic models particularly in the tropics where the forest yields a mix of products and services.

Present Thai forest policy recognises two types of forestry, namely: production forestry and conservation forestry. Logging is banned in all natural forests; consequently, all natural forests are for conservation pruposes. Production forestry can only be practiced in plantations established for the purpose. However, all three models can be applicable in the Thai context. Communities should be able to manage judiciously a forest for production of wood and non-wood products, without impairing the conservation function of the forest. Strict banning of timber harvesting should be limited to national parks, wildlife reserves, biodiversity reserves, and other preservation forestry areas.

The logging ban issue is not totally conservation-motivated; it is also politically motivated. But the logging ban is justified because none of the officially accepted managing entities had proven sincerity and capability to manage the forest on sustainable basis, and the issue of equitable access to forest rsources remained unresolved. This does not mean, however, that these issues will never get resolved and that the logging ban should forever remain. A more reasonable assumption is that, within a reasonable planning horizon, Thailand will be able to develop an equitable mix of managers who can manage the forest sustainably and following a total ecosystem management approach. It is on the basis that planning for this eventuality should proceed, while in the meantime the logging ban should stay. Following from this assumption, the matrix shown in Figure 2 is forwarded as a possibility for application in Thailand. Matrix 2 has been derived from matrix 1 with the addition of the classes of landholding and the forestry models.

In allocating forest land for the control of various managers, the issue of equity is a foremost consideration. For example, the interest of an industrialist must not come first before the interest of many local people who can just as well manage a forest property given proper government support. If economy of scale is a problem, small landholding can be consolidated and managed by a community of individual operators. But for this laternative to work, cultural or sociological bias must be overcome. Otherwise, each operator would work independently at less than optimum scale.

5 Concluding remarks

This paper has espoused the concept that classical forestry and social forestry can co-exist; if not, classical forestry should give way to social forestry. A proviso is that the issue of equity must have been resolved.

This should be done by putting equity before economy. In other words, the issue of "favouring many before one" should come first before the issue of "economy of scale" or "financial capability". Once society's value system accepts this, policy decisions can be made and planning and institution building can proceed from these considerations.

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Figure 1 Matrix of Potential Forest Managers and their Management Objectives

For what?	Products						Service and Amenities									
	Wood Products[1]			Non-wood products[2]			Soil conserv-ation	Water conservation			Biodiversity conservation		Recreation		Climatic Influences	
Consumers/ beneficaries?	Indigenous household	Local market	Export market	Indigenous household	Local Market	Export Market	Farmer/ land user	Farmers	Villages	Indus-tries	Local	Global	Local tourists	Foreign tourists	Local	Global
By whom?																
Landless farmers	M	a	a	M	a	a		a								
Landowners	M	M	a	M	M	a	a	M			a					
Local communities	M	M	a	M	M	a	M	M	M		a		a		a	
Private companies		M	M		M	M				a	a					
Industrial lessees		M	M		M	M	a			a	a					
State enterprise	a	M	M	a	M	M	a			a	a					
Forest administration							M	M	M	M	M	M	M	M	M	M

Figure 2 Matrix of Potential Forest Managers, their land holdings and forestry models and management objectives

Forestry models		Tree crop forestry		Multi-purpose forestry (conservation)			Preservation forestry	
Management Objectives		Products		Services and amenities				
		Wood Products[1]	Non-wood products[2]	Soil conservation	Water conservation	Biodiversity conservation	Recreation	Climatic influences
Potential managers	Land Holdings							
Landless farmers	Tree farms on leased land	M	M		a			
Landowners	Tree farms on own land	M	M	a	M	a		
Local communities	Community forests	M	M	M	M	a	a	a
Private companies	Forest plantations on own land	M	M		a	a		
Industrial lessees	Forest plantations on concession	M	M	a	a	a		
State enterprise	Forest plantations on concession	M	M	a	a	a		
Forest administration	Natural forests			M	M	M	M	M

1 - fuelwood, charcoal, poles, pulpwood, timber

2 - fodder, rattan, fruit, food, resin, gum, medicine etc.
Legend: M - may be the main objective, a - may be another objective, blank - may not be an objective at all

Pakistan National Policy for Forests, Wildlife, Watersheds and Rangelands, 1991

1 INTRODUCTION

At the time of independence (1947), forest area in Pakistan comprised 2 percent of the total land area. Later, however, due to afforestation efforts and restructuring of certain administrative boundaries, the percentage of forest area grew to 5.4 percent. Realising the growing economic importance of forests, the government enunciated three national forest policies in 1955, 1962 and 1980. Despite efforts made over the years, the forest resource underwent considerable depletion, attributable to population pressure, lack of policy initiatives and insufficient input, including reforestation programmes. Hence the need to review the National Forest Policy.

2 BASIC OBJECTIVES

The basic objectives of Pakistan Forest Policy are the following:

a. to meet the country's requirements for timber, fuelwood, fodder and other forest products, and other environmental needs by raising afforested areas from 5.4 percent to 10 percent of total land area during the next ten years;

b. to conserve the existing forest, watershed, range land and wildlife resources by sustainable utilisation and development, to meet the ever-increasing demands;

c. to promote social forestry programmes;

d. to encourage planting of fast-growing multipurpose tree species in irrigated plantations, riverine forests and private farmlands, to meet industrial and domestic demands;

e. to conserve biological diversity and maintain ecological balance through conservation of natural forests and other habitats, reforestation and wildlife habitat improvement programmes;

f. to contain environmental degradation in the catchment areas of rivers to check soil erosion, accretion of silt in reservoirs, and to regulate water supply for increasing the life span of multipurpose dams and regulating floods;

g. to take anti-desertification measures and rehabilitate waterlogged, saline and degraded lands through vegetation treatment;

h. to generate opportunities for income and self-employment for the rural populace;

i. to promote non-governmental and voluntary organisations to educate the masses and create public awareness of the need for environmental improvement.

3 PLAN OF ACTION

3.1 Management of Hill Forests

The existing pattern of forest management in the hills is traditional. Until recently, fellings mostly conformed to single tree selection systems with entire dependence being on natural regeneration which is neither adequate, nor uniform, nor certain for the complete re-establishment of these forests. It is therefore necessary that:

a. forests are managed intensively and the pilot projects, started in Kaghan Valley in Hazara and Kalam Valley in Malakand Civil Divisions, are replicated at other suitable locations;

b. extraction of conifers from forests must be limited to public sector only. Timber exploitation from forests has already been departmentalised. Departmental harvesting will also be extended to the northern areas;

c. reliance is also placed on artificial restocking of cut-over areas and for that purpose, central nurseries are raised from known seed sources of good quality;

d. the existing working plans are revised to ensure multiple and integrated use of the forest resource, in conformity with wildlife conservation and other environmental needs;

e. the existing road density of 2 metres per hectare be improved to at least 10 metres per hectare to facilitate timber extraction in log form;

f. forest operations be mechanised by installation of aerial rope-ways and skyline cranes, in particular for sites where road construction is undesirable, difficult or costly;

g. the jurisdictional charges of forest personnel are rationalised to make them more manageable.

3.2 Watershed Management

a. All watershed projects being a common source denominator would be planned and co-ordinated by the Federal Government, but implemented through Provincial Forest Departments in their respective areas.

b. Fodder production in the northern areas would be included as multiple use input in forest management. This would add substantially to the area available for extension of forests in this region.

c. Steps would be taken to prepare and classify an inventory of denuded watersheds on the basis of their susceptibility to erosion and landslides. A reforestation programme for such watershed areas would be implemented.

d. Grazing rights in reforested areas would be controlled until the newly-raised plants are fully established.

e. Incentives would be provided to land owners to establish tree and horticultural crops on lands exceeding 30 percent gradient. This will reduce the incidence of soil erosion.

4 MANAGEMENT OF IRRIGATED PLANTATIONS

a. The irrigation system in forest plantations is very old but is no longer effective and economical in its use of water. The full potential of such plantations is not being utilised. Water channels need remodelling due to a rise in the level of plantation beds and channels on account of siltation. Accordingly, water supplies to these plantations will be increased, management improved, inputs assured and the full potential of such plantations realised.

b. Additionally the possiblity of leasing such plantations for use and management by industrial users will be considered.

c. In view of the tremendous pressure on conversion of irrigated plantations, a ban would be placed on the change in land use of plantations.

4.1 Strengthen and Expand Social Forestry:

a. Vast public and private degraded, waterlogged and marginal farmlands are available in all the provinces and federal territories, with potential for development for tree culture and fodder production. By developing water resources or through water conservation measures, selected public lands will be leased out to forest industries and other interest groups for growing of trees or range management.

b. Additionally, the government will undertake to arrange adequate and effective distribution of saplings and seeds at nominal cost, promote the use of village shamlats for social forestry, encourage rehabilitation of degraded forest lands, consider the introduction of a forestry grant scheme and rationalise the price structure and marketing of wood produced on marginal and waste lands.

4.2 Management of Rangelands

In conjunction with tree culture, range management is an important land use by itself. Unfortunately, adequate attention has not been given to this sector in the past. In order to overcome this lag an appropriate development programme will be undertaken with emphasis on:

a. development of fodder tree planting programmes to increase availability of green fodder;

b. creation of grazing allotments, on an experimental basis, to induce private investment by livestock owners in rangeland management;

c. reseeding of depleted rangelands with nutritious and high yielding grasses;

d. encouragement of production of fodder for stall feeding to reduce pressure on rangelands;

e. promotion of livestock feeds from agro-industrial wastes and by-products;

f. encouragement of programmes which shift the emphasis from open grazing to stall feeding;

g. introduction of legislation to support range management agencies and their programmes;

h. integration of the management of range, crop and forest lands to ensure year-long optimum provision of forage and fodder to livestock;

i. encouragement and support for range research and its utilisation through extension services.

5 MANAGEMENT OF WILDLIFE HABITATS

Pakistan has a rich and varied flora and fauna. Plants and animals, both wild and domesticated, are the living entities of the ecosystem. Their co-existence contributes immensely towards the welfare of human beings since they provide the material basis for life: food, clothing and fuel for nutrition, warmth and maintenance of health and genetic knowledge, thus avoiding widespread regression to more primitive conditions. They are also a source of man's enjoyment of his environment. Wildlife habitats, i.e. forests, rangelands and wetlands, have been disturbed over the years as a result of population pressure and the development of agriculture and industry and other essential human needs. Activity in this field will aim to:

a. conserve all nationally endangered and endemic species of wild fauna and flora, in particular by ensuring the survival of the critical ecosystems that support such wildlife;

b. arrange periodic surveys of the country's wildlife and its habitats to monitor ecological changes;

c. develop habitat management plans, species recovery plans and habitat improvement programmes for the conservation of species of wild animals and plants;

d. increase investment in the wildlife sector and strengthen provincial and local wildlife and conservation areas, the infrastructure for managing species and habitats. Strengthen federal infrastructure responsible for policy, management planning and implementation of international conservation conventions;

e. expand the existing conservation education programmes of government organisations and NGOs and create public awareness to gain support for wildlife conservation;

f. enlist local participation in the management of species and habitats by sharing revenues from trophy hunting with the rural populace and by promoting private game reserves;

g. provide federal assistance for national parks and nationally important but endangered species of wild plants and animals.

5.1 Forest Extension

Pakistan has a meagre forestry resource, whereas demand for wood and its products is mounting because of population growth. Due to the arid climate, water constraint and financial limitations, additional areas cannot be taken up for forestry in the public sector. It is therefore imperative to grow the maximum number of trees on farmlands under social forestry to overcome the gap between supply and demand for wood, for which effective outreach/extension work is the key to success. The forest extension work shall endeavour to:

a. set up outreach/extension programmes featuring social forestry concepts, ideas and opportunities aimed for the relevant audiences;

b. train staff, motivators, NGOs and PVOs in outreach and extension techniques and methods;

c. develop a system for monitoring and evaluation of the outreach programmes;

d. provide a feedback mechanism in which researchers interact with both professionals and practitioners of farm forestry so that future research efforts can be tailored to solve real constraints;

e. establish demonstration areas serving as visiting points for farmers' tours/workshops and on-farm research trials in collaboration with research institutions to attract active participation of the farmer community.

It may be noted that in general the Action Programme for agricultural extension workers, with some variations, also applies to forestry extension.

6 FORESTRY RESEARCH AND EDUCATION

Trained manpower is an essential prerequisite for sound and effective management of national forests. Upgrading of forestry education to produce a corps of specialists in forestry-related disciplines will also encourage research for sustainable development.

a. Upgrade training facilities to expand and improve forestry education to cater for the future requirements of trained personnel in the following specialised fields:

   i) commercial forest management
   ii) urban forestry
   iii) social/farm forestry
   iv) watershed management and erosion control
   v) wildlife, parks and conservation areas management
   vi) forest products and logging engineering
   vii) range management techniques and practices
   viii) forest economics and resource analyses
   ix) minor forest produce

b. Integrate forestry education in the Pakistan Forest Institute with the university system.

c. Encourage the induction of women in to the forestry profession through training programmes.

d. Revise and upgrade inservice training for the forest service in line with modern trends of emphasis on social aspects of forestry.

e. Develop and strengthen research programmes which provide technologies on the social and scientific management of forest and rangeland resources.

f. Establish regional research stations to conduct research on specific local problems.

g. Involve and encourage the Provincial Forest Department and industries to finance research on problems relating to forestry and forest products.

h. Evolve an effective mechanism for the co-ordination of research on forestry and forest products by

Federal and Provincial Institutions and universities.

7 RESOURCE SURVEYS

To provide a sound planning base for the forestry, watershed and rangeland subsectors, the following will be undertaken:

a. periodic physical/mapping surveys of forests, watersheds, rangelands and wildlife areas;

b. implementation of a programme for the improvement of statistics relating to forests and wildlife which includes remote a sensing laboratory and Geographical Information System (GIS).

The RPA Assessment and Program: Forest Planning in the USA

Fred Kaiser[1]

Forestlands in the US are the source of much of the building materials used to house our Nation's people. They are also the source of most of the fibre for manufacture of paper and paperboard. Forestlands produce most of the high quality water in the US, provide opportunities for many forms of tourism and recreation, provide habitat for fish and wildlife, and are important insuring biodiversity and carbon sequestering.

Yet many of the political leaders in the US know little of the contributions or the important role that the US forestlands play. Attention of our political leaders often focussed from crisis to crisis and when they were forced to address a forest issue, they had to work with information that was developed on an ad hoc basis. Because of this short term focus, there were no long-term goals for the US forestlands and even if such goals could be identified, no mechanism existed of achieving them in the context of the Federal government's annual budget process.

Resources Planning Act

To overcome this lack of an informational and planning framework, the Forest and Rangeland Renewable Resource Planning Act (RPA) was passed by the US Congress. This Act requires the US Forest Service every five years to conduct an "Assessment" of the condition and use of the nation's forestlands and prepare a long-term "Program" in response to the "Assessment." The objectives are:

- GATHER and assess facts to determine the conditions on forestlands.
- SET goals for the use of the lands which would be consistent with investments made in the resources but satisfy society's anticipated needs.
- KEEP long-term needs in focus and not allow their circumvention by short-term objectives.
- REVISE plan regularly to refine estimates of supplies of, and demands for, resources and improve performance.
- COMMIT sufficient funds to these programs to make the plans become reality.

The RPA Act calls for an overall planning system including assessment and resource management plans for the national forests, research plans for the nine Forest Service research stations, and direction for Forest Service assistance to State forestry agencies and small private woodland owners. Regional guides for each of the nine Forest Service administrative regions provide an interface between the national RPA planning and the more geographically specific plans. This RPA Program incorporates information from all of these plans, as well as from the comprehensive forest resources plans prepared by States and the National Strategic Plan for Research. The various parts of this planning concerning forestlands in the US is a difficult challenge. Forestlands occupy approximately one-third (295 million hectares) of the area in the US. Ownership is a mixture of private and public. Market place transactions, however, dominate timber supplies with 70% of forestlands in private ownerships. There are few federal controls on private land timber harvesting in the US though there is a growing concern for environmental values. Forests in the US also vary tremendously, from sparse scrub forests of the arid interior west, to the highly productive forests of the Pacific Coast and the south, and from pure hardwood forests to multispecies mixtures, and coniferous forest.

In this paper, I would like to concentrate on the national planning efforts. Prepared every 5 years, the national Assessment and Program helps chart the long-term course of Forest Service management of the national forests, assistance to State and private forest landowners, and research. The program's focus is on Forest Service activities, though it must consider the activities of other forest and rangeland owners to help the Forest Service determine appropriate federal government roles.

1 USDA Forest Service, Washington DC, USA

Assessment

The Assessment is primarily concerned with prospective trends in supply and demand of renewable resources. It evaluates the economic, social and environmental implications of these trends, describes the condition and evolution of the resource base and identifies ways to manage forestlands to enhance the quality of life of present and future generations. Although many renewable natural resources are considered in the Assessment, the discussion centres around outdoor recreation and wilderness, wildlife and fish, range, timber, and water.

The Assessment of forestlands in the US revealed that forestland area has remained fairly stable over the last decade. Although there has been about one percent decrease in forestland due to urban and other development pressures, clearing of bottomland forests for agriculture has slowed in recent years.

Based on a permanent plot forest inventory system, forestlands in the US have proven to be resilient to use and often responsive to management. Currently timber growth in the US exceeds harvest even though about 14 percent of the world output of industrial roundwood is produced. This occurred even though timber harvesting is prohibited on 14 million hectares of public forestlands.

The Assessment revealed that demands for most renewable natural are expected to increase in the future, so the condition of this resource on a finite land base is a matter of national concern. Although the forest resource situation has improved over the last several decades, the future is uncertain or possibly deteriorating unless positive actions are taken. For example, current trends suggest that consumers may have to pay higher prices for timber. Projections regarding water resources indicate that water quality may decrease because of changing land use. The growing demand for recreation could lead to more user fees or to lower quality recreation experiences. Although there are many opportunities to increase resource supplies to meet increasing demands, conflicts among uses are likely, and some resource conditions may suffer.

The Assessment also points out that there are a number of forestland situations requiring immediate attention, either because they clearly present potential problems, because managers do not know how to deal with them, or because the consequences of the situation are uncertain. These include:

- THREATENED AND ENDANGERED SPECIES - The official list of plant and animal species categorised as threatened or endangered continues to grow. This is occurring because we are learning more about species and because some species populations are declining to dangerously low levels. Critically small populations result in restrictive management policies. Continuation of the decline of species will reduce benefits derived from wild species, greatly increase costs of management, require significant measures to maintain species and unique ecological conditions, and reduce human access where human activities are inconsistent with recovery.

- BIOLOGICAL DIVERSITY - As land use intensifies, natural diversity is reduced and ecosystems are simplified. The effects of such declines are uncertain. Potential impacts include reductions in the long-term productivity of ecosystems, reductions in the ability of biological communities to adapt to change, and forgone options for the future.

- GLOBAL CLIMATE CHANGE - Although considerable uncertainty exists, the impacts of global warming on natural ecosystems could be dramatic, depending on the magnitude of the temperature increase. Extensive global warming could cause major shifts in the processes, structure, and composition of ecological systems, and cause widespread economic dislocations and changes in land use.

- COMPATIBILITY AND CONFLICT OF MULTIPLE RESOURCE USES - Private lands, some 72 percent of the US forestlands, must provide a relatively greater share of future natural resource outputs if demands are to be met. However, there is not enough information about resource interactions on private lands to evaluate the feasibility of increasing total outputs from these lands. This situation could lead to misjudgments about the Nation's output capabilities, stifle increases in resource outputs that could be developed with more information, and misdirect public and private programs targeted at just one renewable resource.

Program Development

To develop a Program responsive to the Assessment, a number of steps were required. The first was to review the current direction that was contained in the existing plans. It became clear, based on this review and the Assessment findings, that new policy and budget direction was needed concerning the management of the National Forest System, assisting State and private landowners, and developing scientific information.

The second step therefore sought to answer three basic questions:

1 What is the most appropriate role for the Federal government regarding the current and projected natural resource situation?

2 What are some principle natural resource issues of public concern today, and how should the Federal government respond to these issues today and in the future?

3 What long-term strategy of management programs should guide Federal government actions from now through 2040?

To determine the adequacy of the answer to these questions a Draft Program was developed. With Assessment information as a backdrop, public comments on the roles, issues, and alternative strategies in the Draft Program were sought and taken into account during formulation of the final Program. A concerted effort was made to gain input from individuals who had a broad array of interests and who represented organisations with different goals. A separate effort was made to obtain comments from Forest Service employees. Comments were summarised such that preferences and concerns as well as reasons for opinions were reflected.

Based on the information received from the Draft Program and policy, a budget direction from policy officials, the Program was developed composed of three components: roles, responses to contemporary issues, and the long-term strategy:

- ROLES - Because any long-term strategic plan requires a philosophical foundation, the RPA Program includes role statements to express and clarify the Forest Service philosophy. That philosophy of where Forest Service programs are today and where they are headed in the future directly influences the Forest Service position on contemporary issues and in turn guides the formulation of the long-term program strategy. Indeed, how the findings of the RPA Assessment affect the agency's response is determined by the roles selected for the Forest Service.

- CONTEMPORARY ISSUES - A contemporary issue is any natural resource-oriented topic perceived to be a matter of nationwide public debate or concern. These issues, which can include key RPA Assessment findings that need public policy or management attention, overlap with Forest Service roles and responsibilities. Unlike roles, contemporary issues deal with specific natural resource conflicts at a given time and sometimes in specific geographic areas.

- LONG TERM STRATEGY - The long-term strategy is program of management actions from now through 2040 for the National Forest Systems, State and Private Forestry, and Research portions of the Forest Service. The resource outputs and resource conditions that result from these management actions, or the scientific information that would be produced in the case of the Research program, are central to the strategy, as are the costs of undertaking the necessary management actions.

Program

The program developed renewed the commitment to multiple-use management, increased preservation efforts and greater commitment to the development of new management procedures. This means that Forest Service programs and budgets needed to be implemented with greater environmental sensitivity. For the most part, RPA Program guidance describes movement toward a desired future level of resource outputs and resource condition and the needed budget adjustments. Four high-priority themes were developed: 1) enhancing recreation, wildlife, and fisheries resources, 2) ensuring that commodity production is environmentally acceptable, 3) improving scientific knowledge about natural resources and 4) responding to global resource issues.

To demonstrate how these themes were developed, a more detailed examination will be made of "Ensuring that commodity production is environmentally acceptable". Under this theme the Forest Service will increase the environmental sensitivity of commodity production on National Forest System lands. The level of commodity production will be adjusted downward where commodity production cannot be accomplished in an environmentally acceptable manner. The Forest Service will emphasise this sensitivity when providing technical assistance to State and private landowners. Development of a better understanding of basic ecology and methods of management that reduce environmental impacts will be a major objective of the Research program. Improved resource inventory data will be collected. More specifically:

- The nationwide total timber harvest level on national forests will be adjusted downward to provide for habitat needs of threatened, endangered, and sensitive species; special environmental values; reduced below-cost timber sales; and more ecologically sensitive management.

- Partial cutting will increase, and clearcutting will be used less.

- Water quality will be protected and deteriorated watersheds improved through implementation and monitoring of best management practices.

- Riparian areas will be maintained or brought up to acceptable conditions.

- Increased technical and financial assistance through the State and Private Forestry program for timber production on nonindustrial private forest lands will emphasise multi-resource planning and stewardship of all resources.

- Forest Service Research will focus on developing more environmentally sensitive techniques for commodity production.

Conclusion

Although it has been the tradition of the government to help meet the needs of present and future generations, new management challenges have emerged. Just as forests grow and change over time, so do people's attitudes and expectations. Caring for forestlands is a continuing, evolving process - one that needs to be attuned both to the long-term rhythms of nature and to the shifting needs and desires of people. Managing forestlands that are subject to increasing and competing demands is a complex and challenging task - one that requires a comprehensive and dynamic planning system. The RPA Program is an important linchpin in this system. It is a strategic process for developed policies and managing the activities.

The RPA Assessment and Program show that the US forestlands contain a wealth of resources that are available for a wide array of purposes. Significant improvements in many natural resource conditions have occurred since the "dust bowl" days of the 1930's in the US. These improvements demonstrate that our resources are resilient and responsive to thoughtful natural resource policies and careful management. The most important lesson from history is the need for continued vigilance and consistent resource management.

With the growing pressures of population, economic growth, and intensifying public debate on management of renewable resources, the Resources Planning Act was a step forward in the US and worthy of consideration elsewhere. The Assessment contains a good body of facts and is becoming more sophisticated as time goes on. The Program provides a long term option for forestland programs. Information from the Assessment and Program can be used to discuss emerging policy issues and help evaluate possible policy options. There is a better understanding of the forestland resource and the important contributions that it makes to the US. This helps raise the intellectual stature of discussions about forest policies and helps develop improved policy formation and legislative processes. It also helps demonstrate that actions taken by our citizens and resource managers make a difference.

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Part B 3 International and Global Issues
3.1 Options

Towards an International Instrument on Forests

J.S. Maini[1] [2]

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1 BACKGROUND

Forests are nature's most bountiful and versatile renewable resource. They cover a substantial part of the earth's surface, are indispensable to the survival of humanity and meet a wide range of economic, environmental, cultural and spiritual needs.

The use of forests by inhabitants in developed countries has shifted with changing socio-economic needs and evolving technological capacities. In pre-agricultural societies forests served as a major source of food, fibre and shelter. Subsequently, large tracts of forestland were harvested and cleared to meet the need for economic development and capital generation, and to create arable agricultural land to produce additional food for an expanding population. This same sequence of events is being repeated in many developing countries, perhaps at a considerably faster pace and with increasingly powerful technologies. At the same time, the importance of tropical, boreal and temperate forests to the environment is receiving worldwide attention, particularly in developed countries.

There is now increased recognition of a need to shift our approach to forestry from "sustained yield" aimed at maintaining an annual flow of wood, to "sustainable development" which takes into account both economic (wood) and environmental (wildlife habitat, soil and water conservation) outputs. Attaining this shift in output and values involves an associated shift from "forest management" to "forest ecosystem management".

During the past two decades, the scale, scope and complexity of environmental issues have been increasing from local and national to regional and global levels. Within this broad context, forest-related economic and environmental issues have recently emerged as a priority on the agenda of world leaders. This is because of the concern for and the need to:

1 satisfy the anticipated increase in demand for forest products from a rapidly growing world population and for other forest-based economic, environmental, social, cultural and spiritual values in a sustainable manner while recognizing the roles and rights of those who depend on forests;

2 facilitate orderly and free international trade in forest products;

3 address the issue of constantly shrinking forest cover and the consequent soil erosion, and general environmental and watershed degradation;

4 protect and conserve forests for their biodiversity and heritage value;

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2 Originally prepared for Informal Intergovernmental Consultation, February 1991, Geneva, Switzerland.

5 protect forests worldwide because of their impact on the environment regarding global carbon, oxygen, nitrogen, hydrological and climatic cycles. Tropical and sub-tropical forests have received particular attention in this context;

6 expand the global forest cover and forest biomass to increase the terrestrial carbon reservoir (by sequestering atmospheric carbon dioxide) and to decrease the concentration of atmospheric greenhouse gases. Forest harvesting and deforestation are neither the main cause of the anticipated global warming, nor are reforestation and afforestation the principal solutions. The role of boreal, temperate and tropical forests, in the global carbon cycle is now receiving special worldwide attention;

7 counteract forest soil acidification and forest decline associated with airborne pollutants, in most industrialized countries, particularly in Europe;

8 protect forests from the negative impacts of the anticipated global warming.

It is important to note that the right of sovereign nations to conserve, manage and utilize forest resources within their jurisdiction is unquestioned. However, with the recognition of sovereignty follows responsibility to consult and co-operate with other nations, to maintain and develop the productive capacity and ecological diversity of land to be inherited by future generations. In an increasingly interconnected and interdependent world, the transboundary and global environmental consequences of forest-related activities in individual countries have evoked interest and concern. Consequently, through mutual agreement, financial and technical assistance, investment and trade arrangements, nations, both individually and collectively, are searching for an appropriate framework to co-operate and assist in the conservation, management, development and utilization of forests at national, regional and global levels.

The forestry community[3] around the world now faces the challenge to meet the anticipated increase in demand for forest products, while responding to the need to maintain other values associated with the forest, including those related to the environment. Sustainable development and conservation of forests that harmonizes both the economic and environmental benefits is the most pressing challenge facing forest managers and forest policy makers at national and international levels.

2 EXISTING INTERNATIONAL FOREST-RELATED INSTRUMENTS DEALING WITH GLOBAL ENVIRONMENTAL CONCERNS

Several international legal instruments which relate to forests are presently in force. These international instruments (Annex I) can be divided into three categories:

i) instruments dealing exclusively with forests;

ii) instruments dealing with forests within the context of natural resources conservation and management including wildlife and wildlife habitat; and

iii) instruments dealing with pollution control which impact on forests.

These conventions and agreements focus on specific aspects of forests such as trade in tropical timber, forestry research, the protection of endangered species, and the protection of certain types of forest environment such as wetlands. Others are regional in scope and attempt to set general guidelines for forest development and conservation within the overall framework for the conservation of nature and natural resources. The lack of a framework at the global level to deal with all types of forests and all aspects of forest management, and the absence of an international consensus on policies and targets to be applied in forest development and conservation, has resulted in increased pressure on the world's forest resources.

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3 * Forestry community includes professional foresters, forest scientists, forest policy makers and all those engaged in the protection, management and utilization of forests.

3 PROPOSED INTERNATIONAL FOREST-RELATED INITIATIVES

A number of international initiatives are being prepared for the UN Conference on Environment and Development (UNCED) to be held in Brazil in 1992 ("Brazil '92"), which may have a significant impact on the conservation, management, utilization and development of forests. Those initiatives of particular interest include:

i) A possible protocol for forests in the proposed framework International Convention on Climate Change (ICCC). This would deal with the need to increase the role of global forests as a carbon reservoir;

ii) A possible protocol on forests in the proposed International Convention on Biodiversity (ICB). This would deal with the need to protect forests around the world as a rich source of genetic material and as wildlife habitat;

iii) An International Instrument on Forests - IIF - ("Instrument" covers a wide range of forms including: Declaration; Charter; Agreement; Framework Convention; Convention) which is expected to promote sustainable development and conservation of forests and to provide a comprehensive framework to formulate mutually supportive, current and future, forest-related international initiatives.

Whilst work on the Climate Change and Biodiversity Conventions has been in progress since 1988, the IIF has emerged on the scene rather recently. A forest convention was proposed in the June 1990 Report prepared by the Independent Review Committee on the Tropical Forestry Action Plan (TFAP). The idea received significant political support in the Houston Declaration, signed in 1990 by the G-7 leaders and by the President of the European Commission. Also, the Houston Declaration expanded the initial focus on tropical forests to include temperate and boreal forests. Thus, global forests emerged prominently on the international political agenda. Although there is a varying degree of support for the proposed IIF, the initiative has received attention in many international forums, including the following:

- The European Council, at its meeting in Dublin in June 1990, requested the European Commission to formulate proposals to deal with the threat to the tropical forests, in consultation with the concerned countries.

- The first Preparatory Committee meeting for "Brazil '92", held in Nairobi in August 1990, requested the UNCED Secretariat to provide further information and analysis on a wide range of forest-related issues. This initiative will be reviewed at the Second Preparatory Committee meeting to be held in Geneva during 18 March to 5 April, 1991;

- The Japanese Government, at the first Preparatory Committee Meeting of the UNCED in August 1990, proposed an international Charter for World's Forests;

- In October 1990, the ASEAN Ministers of Agriculture and Forestry agreed to contribute towards the preparation of a comprehensive report on forestry as requested by the first Preparatory Committee Meeting of the UNCED.

- Both the Forestry Task Force Report and the "Conference Statement" at the Second World Climate Conference, held in Geneva during 29 October to 4 November, 1990, recognized the need for an IIF. The Ministerial Declaration following the Second World Climate Conference recommended that "the protection and management of boreal, temperate and sub-tropical forest ecosystems must be well co-ordinated";

- The FAO became the first UN Agency to endorse the concept of an international instrument on the conservation and development of forests in Council in November 1990. Council agreed that FAO would make substantial contributions to the elaboration of such an instrument.

4 TOWARDS AN INTERNATIONAL INSTRUMENT ON FORESTS

4.1 Need

Forest-related issues are being addressed in a fractionated, piecemeal manner. In view of the overwhelming economic, environmental and social significance of forests at local, national, regional and global levels, forest-related issues need to be treated within a cohesive and comprehensive forests framework which accommodates economic, environmental, social and cultural dimensions.

In view of the anticipated investments in the protection, management and development of the world's forests, more effective disbursement of larger international forestry assistance funds, technologies and knowledge, various forest policy objectives must be harmonized and mutually supported through international or multinational consensus, collaboration and co-operation. Addressing forest-related issues in a fractionated manner is inefficient, not cost effective and undesirable. Furthermore, it is imperative and technically possible to harmonize social, economic and environmental dimensions of forests. An International Instrument on Forests promoting the sustainable development and conservation of forests would provide the necessary policy and institutional framework to guide international collaboration and collective action to accomplish this.

4.2 Scope

Conservation and sustainable development of forests worldwide, i.e., the harmonization of economic and environmental objectives, is at the heart of an International Instrument on Forests. Such an IIF will provide a necessary policy as well as institutional framework for international consensus and collaboration. There are several possible approaches to address the issues and opportunities related to the sustainable development and conservation of forests around the world. A conceptual framework based on a "geographical approach" is elaborated below.

Forest-related issues and opportunities can be dealt with on at least three geographic scales; (i) national, (ii) regional and (iii) global, that require response at the corresponding (i) national, (ii) multinational and (iii) international levels, respectively. This geographic approach with a few examples is described below:

i National Issues and Opportunities

Socio-economic: balancing of macro-economic and trade issues with micro-economic and subsistence considerations to assure local benefits, involvement and support.

Policy and information: formulation, implementation, assessment and revision of national forest and related policies within the framework of national economic, environmental, social and cultural objectives, incorporating national equity and participatory approaches.

Environment: ensuring a cross-sectoral approach on environmental issues that would on the one side allow for nature conservation and on the other side for sustainable utilization of forests for traditional wood products as well as non-wood products.

ii Regional and Transboundary Issues and Opportunities

Socio-economic: collaborative management of wide-spread outbreaks of insects, diseases and fires in contiguous countries, by sharing expensive suppression technologies; developing regional monitoring and early warning systems, and optimizing resource production and its rational use, including industrial utilization, in recognizing the biological and industrial capabilities of contiguous nations.

Policy and information: formulation of complementary policies for mutual benefit; provision of timely and credible information on forests and forest-related issues; sharing of technologies, knowledge and monitoring systems.

Environmental: the management of forests in the conservation of international watersheds as well as of wildlife habitat, particularly of species that migrate across national boundaries; prevention of transboundary air-borne pollutants that cause soil acidification and forest decline; collaboration for the protection of biodiversity in contiguous states.

iii Global Issues and Opportunities

Socio-economic: provide the basis to facilitate international trade in forest products, particularly from forests managed under internationally recognized forestry norms. These norms would have to be formulated by international consensus. Forest management guidelines developed by ITTO could be used as a starting point.

Policy and information: provision of credible and timely information on the state of the world's forests to permit: sustainable forestry practices; harmonization of policies; priority setting; transfer of funds and technologies; and sharing of knowledge.

Environmental: research on global environmental issues associated with the role of forests in global carbon, oxygen, nitrogen, hydrological and climatic cycles; conservation of biodiversity; formulation of strategies to respond to global warming.

4.3 Benefits and Activities

Depending on the consensus among the participating countries on the scope, an IIF could provide a policy and institutional framework to accomplish a wide range of benefits and activities, including:

- sustainably develop and conserve the world's forests (perhaps through a statement of guiding principles); improve forest management; strengthen relevant forestry agencies to promote sustainable development; derive multiple benefits from various forest-related activities on the three geographic scales referred to above; establish priorities at the national, and through consensus, at the multinational and international levels;

- establish institutional arrangements to foster action at national, multinational and global levels; permit transfer of financial and technical assistance; exchange knowledge and expertise; and collaborate on research and development;

- establish through consensus, internationally accepted norms of sound forestry practices;

- facilitate the flow of forest products in international trade particularly those that come from forests managed in accordance with internationally accepted norms;

- undertake informed priority setting and co-operative activities such as participating countries by monitoring, assessing and generating credible and timely information on the state of the world's forests;

- ensure coherence and complementarity with existing and planned legal and other initiatives such as climate change and biodiversity.

4.4 Legal Form

The international momentum behind an IIF is growing. What needs to be explored is the range of options available so that consensus can be sought on the form most acceptable. Choices could include a Declaration, Charter, Agreement, Framework Convention or Convention. Two basic alternatives may be considered:

1) The first would be a formal legal convention which would impose legally binding commitments on contracting parties. These commitments could be general and hortatory (i.e. make best efforts to...) as in the 1985 Vienna Ozone Convention, or they could be specific targets and schedules (i.e. reduce by X percent by Y date) as in the 1987 Montreal Ozone Protocol. Like the two ozone instruments, a legally binding forest convention could be drafted with general commitments which would then permit the negotiation of more specific protocols at a later date.

2) The second would be a political charter or declaration of principles agreed to by all the members

of the international body that negotiated the text. Such a charter would then provide guidelines for conduct. Countries that participated in promulgating the charter would be morally or politically obliged to follow its guidelines, but legal obligations would not be established between the contracting parties. The UN's 1982 World Charter for Nature or UNEP's 1985 Montreal Guidelines on Land Based Sources of Marine Pollution are two examples of this approach.

The above can be described as the "hard law" and the "soft law" options. The hard law option clearly registers a greater degree of commitment on the part of governments and makes clear which states consider themselves bound by its provisions and which do not.

A third approach could be considered ranging between a full international treaty and a simple charter or declaration of principles. The form of a legally binding convention, which would be maintained, requiring state ratification and formal membership. However a high level of voluntarism could be introduced into the convention; signatory stakes could be allowed to set their own targets. This would facilitate negotiating its provisions and permit a smaller number of ratifications before it comes into force.

4.5 Process

One can formulate elegant conceptualization and visionary objectives that would lead to the conservation and sustainable development of world's forests. The real challenge, however, lies in developing a common understanding of the issues and opportunities and in developing concepts, guiding principles and a vision which are shared by most participants. This shared vision has to be developed by consensus and not by coercion; the collective action has to be undertaken firstly and mainly through incentives and benefits and not through punitive actions, and by co-operation and not confrontation. The consensus building process is a valuable product by itself.

4.6 Funding of Negotiations

Consideration should be given to securing adequate funds to support a convention secretariat and the participation of representatives from the developing countries. Two drafting sessions involving about 10 participants from developing countries would require about US$ 75,000 each. Four negotiation sessions including costs for about 100 participants from the developing countries would require about US$ 500,000 for each session. The total cost is estimated to be about US$ 2.2 million. Holding negotiation sessions outside the "UN Capitals" would involve additional costs, approximately US$ 200,000 each session.

5 CROSS-LINKAGES BETWEEN THE PROPOSED CLIMATE CHANGE, BIODIVERSITY AND FORESTS CONVENTIONS

At least three aspects of cross linkages, namely biological, process and legal, between the three proposed initiatives need to be considered. From a biological perspective, forests are seen as a source of economic development and an important terrestrial carbon reservoir, as well as a rich source of biodiversity. Depending on the objectives and the creative choice of sites and species, it is possible to attain multiple economic, environmental, social and cultural benefits from the anticipated investments in forestry. Focusing narrowly on an initiative having only a single purpose would preclude deriving many potential benefits. Given appropriate policies and institutional framework at national and international levels, professional and technical forestry experts can deliver multiple services from forest ecosystems. It is therefore crucial that the forestry community be actively engaged in initiatives to help formulate and manage the international forest's agenda.

There is a need to formulate the co-ordination mechanisms that would ensure that the process of negotiation and the content of the three conventions is mutually supportive. Also, there is a need to determine legal cross-connections between the three initiatives. For example, is it feasible to formulate forest's protocols under the Climate Change and Biodiversity Conventions that are also included in the International Instrument on Forests?

Last, but not least, if the reason that the forest disappeared in the first place, is not removed, any plantation effort will have little or no long term effect. Since subsistence necessities are a common, if not prevailing reason, the local population must at least perceive that the benefits of the plantation are going to be equitably distributed and that their customary rights are not infringed. Any protocol that does not incorporate these fundamental developmental and social dimensions would be inefficient and most likely unsuccessful.

6 WILL THE INTERNATIONAL INSTRUMENT OF FORESTS IMPEDE PROGRESS ON THE BIODIVERSITY AND CLIMATE CHANGE CONVENTIONS?

The current work on the drafting and negotiation of the Biodiversity and Climate conventions proceed without interruption. What is urgently needed is to set up a formal institutional mechanism and a process to start formal intergovernmental consultations on an International Instrument on Forests. The first priority for an interngovernmental working group would be to formulate a set of guiding principles and general objectives that accommodate both the economic and environmental dimensions in a mutually supportive manner. These economic and environmental dimensions would be reinforced by specific actions and guidelines when dealing with more specific objectives such as carbon sequestering and conservation of biodiversity. An International Instrument on Forests should provide the necessary linkage between biodiversity, carbon sequestering and the sustainable development and conservation of forests.

7 CONCLUSION

UNCED '92 has provided a unique opportunity to expedite work on the sustainable development and conservation of world forests, the improvement of forest management worldwide, and the strengthening of forestry agencies. An IIF would provide the necessary policy and institutional framework and the technical basis for unimpaired international trade in forest products; collaborative international action; international transfer of funds and technologies; and sharing of knowledge and expertise. There is an urgent need to establish a formal intergovernmental process to attain these objectives. Close involvement of the forestry community in every aspect of this initiative is crucial to its success.

ANNEX I: List of Existing International Instruments Related to Forests[4]

Forest Instruments

The only forest instrument operating on a global level is the International Tropical Timber Agreement (Geneva 1983). This agreement provides a framework for co-operation and consultation between tropical timber producing and consuming members, promotion of tropical timber trade, support to research and development and encouragement of reforestation, forest management and wood utilization. The agreement is administered by the International Tropical Timber Organization (ITTO).

Natural Resources Instruments

Natural resources instruments operating on a global level are: the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar 1971); the Convention for the Protection of the World Cultural and Natural Heritage (Paris 1972); and the Convention on International Trade in Endangered Species of Wild Flora and Fauna "CITES" (Washington 1973). The first and second of these conventions apply primarily to areas, and the third to species, identified in each case according to certain criteria and designated for inclusion in lists that afford them special protection. All provide for contributions from the parties.

Natural resources instruments operating at regional level are: the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (Washington 1940); the African Convention for the Conservation of Nature and Natural Resources (Algiers 1968); the Treaty for Amazonian Co-operation (Brasilia 1987); the Convention on European Wildlife and Natural Resources (Bern 1979); and the ASEAN Agreement on the Conservation of Nature and Natural Resources (Kuala Lumpur 1985). With differences attributable to their adoption dates, these legal instruments aim at the conservation, utilization and development of soil, water, flora and fauna resources from an economic, educational, cultural and aesthetic point of view. The modernity of the ASEAN Agreement is reflected in its close attunement to the principles of the World Conservation Strategy. The Treaty for Amazonian Co-operation, inspired as it is by the aim of promoting the harmonious development of the Amazonian region, goes beyond conservation to such topics as co-ordination of health services or freedom of commercial navigation.

Pollution Control Instruments

A pollution control instrument operating on a global level is the Convention on Long-Range Transboundary Air Pollution (Vienna 1985), aimed at promoting observation, research and information exchange in order to counter the adverse effects of modifications in the ozone layer caused by man. "Adverse effects" are defined as changes in the physical environment of biodata, including changes in climate which have significant deleterious effects on human health or on the composition, resilience and productivity of natural and managed ecosystems, or on materials useful to mankind. The Protocol on Substances that Deplete the Ozone Layer (Montreal 1987) provides a regulatory framework for reducing emissions of CFCs and halons.

A pollution control instrument operating on a regional level is the Convention on Long-Range Transboundary Air Pollution (Geneva 1979) aimed at limiting and, wherever possible, preventing air pollution and at protecting both man and his environment against it by co-operating in the conduct of research and the development of appropriate measures.

4 Source: FAO 1990 - COFO 90/3(a).

Biomass Energy Conservation Options for Forest Conservation

N H Ravindranath[1]

1 INTRODUCTION

Biomass resources, particularly fuelwood, have played and are playing a significant role in the energy mix of developing countries, accounting for about 40 per cent of their total energy consumption[1]. Nearly half of the world's population cooks with biofuels. Cooking, heating bath water and production of bricks, tiles, pots etc are the dominant activities using firewood, especially cooking. In countries like India the gap between the demand and supply of firewood is very large[2] and it is growing. According to the State of Forest Report[3], this imbalance between demand and supply of firewood has led to continuous depletion of forests. Thus strategies for meeting the energy needs of cooking are necessary for conserving forest and village tree resources. In this report it is proposed to consider the biomass conservation potential through efficient use of biomass and through alternate fuels like biogas. The possible impact on forest and village tree resources is highlighted. These issues are analyzed taking India as a case study.

2 CONSUMPTION OF BIOMASS FUELS IN INDIA

The consumption of fuelwood, agricultural waste and animal dung in India is given in Table 1. It can be seen that fuelwood is the dominant type of biomass used as fuel. According to State of Forest Report[4] the firewood consumption in 1987 was estimated to be 157 million tonnes. Biomass fuels are consumed in rural as well as urban areas. According to figures quoted in Report of Advisory Board on Energy[5] (ABE) 94.5% of rural households and 58.1% of urban households use biomass fuels for cooking alone.

It can also be seen from Table 1 that biomass use is growing due to population growth. The projection of firewood requirement for the year 2004 made by the Advisory Board of Energy[5] is given in Table 2.

Table 1 Consumption of Non-Commercial Energy 1953-54 to 1975-76 (million tonnes)

Year	Fuelwood	Agricultural Waste	Animal Dung
1953-54	86.3	26.4	46.4
1960-61	99.6	30.6	54.6
1965-66	109.3	33.6	59.9
1970-71	117.9	36.3	64.6
1975-76	133.1	41.0	73.0

Source: Ministry of Environment and Forests (1986).

The firewood requirement is estimated to increase to 314 million tonnes and, in addition, 200 million tonnes of dung is projected to be used as fuel (ABE Report does not distinguish between crop residue and wood). Such a large demand would put tremendous pressure on all biomass resources, especially forests and village trees.

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Table 2 Estimates of biomass fuel requirement for cooking in 2004 (million tonnes)

	Firewood	Dung
Rural	247	-
Urban	67	-
Total	314	200

Source: Advisory Board on Energy (1985).

3 OPTIONS FOR COOKING ENERGY

In India only 19.5% of the geographic area is under forest and, further, only 10.99% of this has a crown density of 40% and over[6]. Micro level studies[7] have shown that even village tree resource is being depleted to meet the fuel and timber needs of nearby urban areas. Rural use of firewood is not likely to lead to significant deforestation, as the urban requirement, but would contribute to some degree of degradation though no estimates are available. Thus to conserve the tree resources both in the forests as well as village ecosystems there is an urgent need to search for alternatives. In addition an improved cooking system would also promote the quality of life of women.

A number of options are available:

1 Growing wood to meet the growing needs;

2 Conservation of wood fuel through efficient use;

3 The introduction of alternative sources of energy like biogas, electricity and solar energy;

What is required is a combination of all the three, such that an equitable and sustainable improved cooking system could be provided. Options based on commercial sources of energy like electricity, LPG and Kerosene are not feasible, as India is faced with severe scarcity of these. There is difficulty even in meeting the current needs of only 42% of urban and 5.5% of rural households.[5]

Thus the immediately feasible options are fuel efficient stoves and biogas. The potential of these in conserving firewood is considered here, although it is recognised that other options do exist.

4 BIOMASS CONSERVATION POTENTIAL

Biogas: Many countries like India and China have large biogas programmes. In India biogas is an important component of integrated rural development due to the following:

1 It is a renewable resource and does not cause pollution;

2 It totally eliminates the use of firewood;

3 It is a convenient fuel: easy to light and switch off, to control temperature, and smokeless. Thus it improves the quality of life of women, and

4 The slurry or processed output is a high quality manure for crop production.

Biogas production and firewood conservation potential are shown in Table 3. The firewood consumption of between 18.6% and 38.9% of population could be eliminated. Thus about 46 million tonnes of firewood could be saved (Table 4).

Table 3 Biogas potential and firewood conservation

Livestock population (cattle + buffaloes)	259 x 10^6	
Human population (1981 census)	683 x 10^6	
	peak season (5 months per year)	lean season (7 months per year)
Dung yield/animal/day (conservative yield)	7.35 kg	3.52 kg
Dung production at all India level per day	1.903 x 10^6t	0.911 x 10^6t
Biogas production potential per day at 35 liters/kg of fresh dung	66.6 x 10^6m^3	31.8 x 10^6m^3
Population - whose cooking energy needs could be met at 250 liters/capita/day (% of population)	266 x 10^6 (38.9%)	127 x 10^6 (18.6%)

Table 4 Biomass conservation potential in India (million tonnes)

Biogas: Assuming 127 million in rural areas shift to biogas (Table 3)	46
Fuel efficient stoves:	
Urban population (if all households use efficient stoves)	9
Rural population (if all households not covered by biogas programmes)	43
Total biomass conservation potential	98

Note: Population 1981 census: Urban - 160 million, Rural - 525 million
- Firewood use for cooking: approximated to 0.8 kg/capita/day
- 94.5% of rural and 58.1% of urban household use biomass for cooking (Reference 5)
- Saving considered 33% (Reference 8)

5 FUEL CONSERVING STOVE

Traditional cook stoves have low thermal efficiency, for example traditional stoves in South India have a utilization of 15%[8]. This offers a large potential to increase the efficiency and to reduce wood consumption, and further reduce pressure on village trees and forests. For example in the south Indian state of Karnataka, a fuel efficient smokeless three pan mud stove called ASTRA-stove has been developed with a utilization efficiency of 45% in the laboratory, and 34.7% in the field[8].

India launched a large improved stove programme in 1983, and since then about 10 million stoves have been built. Evaluation studies[9] have highlighted the shortcomings in design and dissemination. The potential for conservation has been shown in the field, and shortcomings could be overcome through appropriate design, dissemination, and education strategies.

6 BIOMASS CONSERVATION POTENTIAL

Assuming all the biogas potential is going to be tapped and all the remaining biomass using households are provided with fuel efficient stoves, the biomass (mainly wood) conservation potential is given in Table 4. The saving in biomass due to shifts to biogas would be 46 million tonnes. Further, if the remaining rural and urban biomass using households shift to efficient stoves, the saving in biomass would be 52 million tonnes. Thus a total 98 million tonnes of biomass could be saved.

The present case study has demonstrated the potential for significant reduction in wood use as fuel through biogas and fuel efficient wood stove programmes. Implementation of a fuelwood conservation programme would reduce the pressure on trees in forests as well as in village ecosystems. Research and development efforts are required to develop appropriate designs of biogas plants and wood stoves. This should be backed by a dissemination strategy that would include involvement of women at all stages. Finally adequate funds have to be provided. Meeting the biomass needs of local communities must be an integral part of any forest management option.

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Part B 3 International and Global Issues
3.2 Climate Change

The Potential Contribution of Forestry in Tropical Countries to Decrease Atmospheric Carbon Content

A Schotveld[1]

1 INTRODUCTION

Climate change and forestry have recently received increasing attention from scientists, policy makers, and the public. This attention was reflected in the recommendation of the Noordwijk Ministerial Conference on Pollution and Climatic Change (1989): "... to pursue a global balance between deforestation on the one hand and sound forest management on the other, whereby a world net growth of 12 million ha/year as from 2000 onwards should be considered as a provisional aim."

The subsequent questions arose: "Is this target realistic? If not, what target would be realistic instead, and how could it be achieved?" And also: "Is the tropical forestry sector adequately structured and equipped to achieve a substantial share of these targets?" and: "What has the sector already done in this respect?"

These questions have inspired to the commitment of a study which was carried out during late 1990 to analyse the potential contribution of forestry in tropical countries to decrease global atmospheric carbon content. The study was financed by the Directorate General for International Cooperation (DGIS) of the Ministry of Foreign Affairs of the Netherlands, carried out by DHV Consultants, and supervised by a working group of representatives from the Ministry of Housing, Physical Planning and Environment (VROM), the Agricultural University Wageningen, and the Department for Forestry and Landscaping of the Ministry of Agriculture, Nature Management and Fisheries (BLB). The present paper[2] is a summary of this study. The government has not yet taken a position on the consequence of the results of the study.

2 APPROACH

In order to answer the central question mentioned in the title, the following issues were studied:

1. the possible effects of global forestry activities in tropical areas with respect to the fixation of atmospheric carbon dioxide (based on available research results);
2. the problems of establishment, management, and conservation of tropical forests including the possibilities and constraints for sustainable management and expansion of forests (a systematic overview);
3. the National Forestry Action Plans of selected tropical countries in order to assess their possible impact on carbon fluxes;
4. the feasibilities of the target of a world-wide annual net forest expansion of 12,000,000 ha by the beginning of the next century.

3 THE POSSIBLE ROLE OF TROPICAL FORESTS IN GLOBAL CARBON FIXATION

Forests fix carbon. Young plantations and secondary forests fix more carbon than they release, whereas mature forests are approximately at equilibrium. The magnitude of the role of forests in the global carbon cycle is illustrated by the fact that forests are a reservoir for 75% of the world's carbon stored in vegetation, and forests soils store about 55% of all soil carbon (Wiersum and Ketner, 1989). It has, therefore, been argued that forestry could play a role in stabilizing carbon fluxes.

Deforestation leads to a release of carbon dioxide into the atmosphere both from vegetation and forest soil and destroys a carbon reservoir. Also the use of forest products has consequences for CO2 fluxes. To mention the extremes: burning fuelwood immediately releases CO2 into the atmosphere whereas in construction timber carbon will remain fixed for several decades. Wiersum en Ketner (1989) mention the

1 Ministry of Agriculture, Nature Management and Fisheries, Netherlands.

2 Prepared by Titus Bekkering (DHV) and Cathrien de Pater (BLB).

following strategies which the forestry sector could follow in order to control atmospheric carbon concentration:

- prevent deforestation and forest degradation;
- plant forests for long term carbon fixation;
- plant forests to produce wood as a substitute for fossil fuel.

For several reasons, the first two strategies are more advantageous in tropical areas than in temperate areas. These are:

- higher potential growth rates;
- easier to obtain funding (including foreign aid, debt-for-nature swaps, volunteer services, etc.)
- cheaper to establish and manage;
- greater need for forestry services and greater ancillary benefits (fuelwood, timber, fruits, fodder, soil conservation, etc.)

On the other hand there are a number of factors which make it uncertain that investments in tropical forestry will indeed result in forests being established. These are elaborated in par. 4.
Furthermore, the argument is often heard that the western world should not burden the third world with solving the problems caused by the west. If, however, forestry activities are undertaken in the tropics with other primary objectives - e.g., production or conservation - , and at the same time serve the objective of carbon fixation, the western world would perhaps be increasingly willing to contribute to such effort.

The following four scenarios were extracted from literature to predict the effect of forestry interventions on global carbon fluxes:

A. "Nothing changed": emission from fossil fuel and deforestation continue at present rates;
B. "Stop deforestation": Emission from fossil fuel continues but emission from deforestation is stopped;
C. Reforestation according to a proposal by Wiersum and Ketner (1989) whereby 14.8 Gt of carbon would be fixed between 1990 and 2100, with continuing emission from fossil fuel and a stop on deforestation;
D. Reforestation according to a proposal by Houghton (1990), whereby 152 Gt of carbon would be fixed between 1990 and 2100, with continuing emission from fossil fuel and a stop on deforestation.

It was concluded that forestry interventions in tropical countries could at maximum, contribute to a 15% lower atmospheric carbon content by 2100 compared to Scenario A.
However, precise quantification remains difficult and forestry interventions for carbon fixation may only be effective in combination with other measures that reduce atmospheric carbon content. Meanwhile, a "no regrets" policy was considered an attractive political option because forestry interventions serve many other politically desirable objectives.

4 ISSUES IN TROPICAL FORESTRY

Annual deforestation in the tropics amounts to approximately 17 million ha/year (FAO, unpublished, 1990). Annual reforestation is only one tenth of this. There are a number of complex factors which cause this unfavourable situation, and which are difficult to remedy and often involve other sectors outside forestry. They are:

- Underlying problems: Increasing population, rural poverty, weak local and central government structures, unfavourable international international political/economic relations leading to prices for exported raw materials, and unfavourable local and national power relations leading to displacement of small farmers into forest areas;
- Unsustainable exploitation of forest and other natural resources;
- Unfavourable agricultural sector developments, notably expansion of settled and migratory agriculture into forest areas;

To counter the above mentioned negative effects, several strategies have been developed over the years. Since mankind started rational exploitation of forest resources, arrangements for their management have been made. Being no longer adequate in many cases, they have been replaced by government-imposed management arrangements. Initially, they often contributed to forest degradation as they were mainly focused on short-term (logging, agricultural production) instead of long-term (environmental, genetic, non-timber) benefits. Later, however, growing awareness and concern among governments and other interest groups slowly led to changes of approach. The following four strategies have emerged by now:

Forest Conservation: Establishment of a (network of) national parks and other reserved areas. A distinction should be made between nature conservation excluding any use of forest resources, and forest conservation which allows for disciplined utilization under sustainable forest management guaranteeing protection and regeneration. The merits of this strategy for carbon fixation are high, but it is difficult to be put into practice since it does not yield immediate large economic benefits by which it may gain priority with decision-makers. Sustainable forest management is still being developed and has only been implemented on a limited scale. The interests of the indigenous population are slowly being taken into account in the management of reserves, through the development of buffer zones and sustainable economic alternatives.

Plantations: Mostly large-scale government or private enterprises. Areas have almost tripled between 1965 and 1980. Plantations are economically attractive and thus appeal to decision-makers. However, problems are often posed by 1) the reliance on a small number of species which are mostly planted in monocultures entailing, consequently, diseases and or environmental degradation; 2) the allocation of land which is disputed by local populations whose needs and interests tend to be poorly identified or disregarded by decision-makers. Experience has learned that plantations do offer perspectives as long as they do not replace natural forests on poor soils, do not clash local interests, and are economically profitable.

Community forestry: Aims at encouraging large numbers of local people to plant trees on public or common lands to satisfy local needs for forest products and increase benefits for lower social strata. The approach is decentralised and diversified, and tree densities are often lower than in large-scale plantations.
Three factors are important for success: 1) security of the target group over land and tree tenure; 2) participation of the target group in design and management of interventions; 3) establishment of rules and regulations accepted by and controlled by the target group.

Farm Forestry: Integration of tree planting into the agricultural farming system of the individual farmer (boundary planting, individual woodlots, and agro-forestry techniques). The system has traditionally been applied in many different forms in many areas, but attention to it in development projects is of a recent date. Security of land and tree tenure is a prerequisite to success. The accuracy of technical and social design of the intervention is also of paramount importance. Since farm forestry requires target families who can spare some land, it is not always compatible with the development objective of helping the poorest, often landless people.

5 IMPLICATIONS OF SOME SELECTED NATIONAL FORESTRY ACTION PLANS FOR CARBON FIXATION

The Tropical Forestry Action Plan was initiated in 1986 to come to better management of the world's forests through comprehensive National Forestry Action Plans. These would lead the way to increased investments in the forestry sector and better donor coordination. Being the only global framework for tropical forestry available, the TFAP should also serve as a framework for tropical forestry activities with the objective of preserving carbon pools and actively fixing atmospheric carbon. Strengthening of TFAP and national forestry institutions will be indispensable in meeting the objective of carbon fixation.

Analysis of selected countries where a commitment to improving the forestry sector has been shown and where National Forestry Action Plans (NFAP's) have been drafted reveal that the "carbon relevance"of planned forestry activities is very limited. Although efforts for reforestation in the selected countries have been stepped-up considerably (approximately three times the present reforested area per year) the total area is small (approximately 2.3 million hectares) compared to the area projected as be necessary for a global impact.

It is therefore, surprising that the impact on carbon fluxes is negligible, particularly if deforestation in these countries continues. This will be the case for most countries studied despite the implementation of NFAP's. If, however, deforestation is brought to an end, unlikely as it may be, the impact on carbon fluxes would be substantial.

6 THEORETICAL SCOPE FOR GLOBAL FORESTRY INTERVENTIONS

The extent to which it will be feasible for a country to preserve its forests or achieve a net expansion of forest area will largely depend on land requirements in the future for agricultural subsistence and basic food production. A calculation of carrying capacity for future generations can be used as a method for ruling out countries with little potential for forest conservation or reforestation and for selecting those with such potential. The following approach was used: The calculations on forest conservation were focused on tropical countries with major forest areas (over 15 million ha in the moist tropics or over 15 million ha and with an average biomass of over 35 m^3/ha in the dry tropics). Preservation of these forests depends among others, on the future need for agricultural lands (including infrastructure, etc.). If these requirements surpass the present cultivated area, forest will presumably be taken into agricultural production, which will render preservation of present forest area extremely difficult.
As for forest expansion by plantations, countries were selected that may have a surplus of land after feeding their population (in 2025, at present input levels without victimizing their present forest areas). From this surplus the present forest areas as well as the area under major industrial and export crops were subtracted as being unavailable for reforestation/afforestation. However, since no scenarios were developed addressing agricultural production above subsistence level or for export, it should be considered as a first, approximation only, and detailed country studies will have to reveal whether the theoretical potential can be put into practice.

Forest conservation for carbon fixation should be given priority in countries located in the humid tropics which have major forest areas and where, in theory, no conflict between land use for agricultural production and forestry has been predicted for the future. These countries are: Cameroon, Congo, Gabon, Zaire, Bolivia, Brazil, Colombia, Guyana, Peru, Venezuela, Malaysia and Indonesia. In the drier tropics, Mexico, Argentina and India deserve attention because of the relatively high biomass in their forests. The total forest cover in these countries exceed 15 million ha/country and adds up to over 86% of all moist tropical forests. The fact that future food production is not the only threat to the existence of the forest area, is illustrated by the fact that at present deforestation in these 15 countries amounts to 11.7 million hectares annually. The complexity of the problem, the substantial economic interest and the enormous number of people and communities to be reached imply that large scale deforestation will continue, unless action is taken. Such action cannot become successful overnight and even if an ambitious effort would aim at completely stopping deforestation by the year 2000, an additional 117 million hectares of forest would still be lost in these countries.

There seems to be land available to extend the forest area. Based on future land requirements for agricultural subsistence production, the following countries, theoretically, have land available: Central African Republic (CAR), Madagascar, Mexico, Argentina, Bolivia, Brazil, Chile, Colombia, Peru, Uruguay and Venezuela. The total amount of land available does not exceed 385 million hectares and will probably be much lower. If it as also assumed that fallow land is available for reforestation, the maximum available area would be 553 million hectares. In land use statistics, many of these (outside the forest fallow areas) are classified as permanent grazing lands. This implies that forestry activities in these areas would, in many cases, have to compete with livestock production. In such regions sufficient incentives will have to be offered to change land use to forestry.

Extending forest will only have a limited effect on atmospheric carbon content (even if the largest possible areas and carbon fixation rates are used). Therefore, it is felt strongly that forestry interventions should not be executed with carbon sequestration as a primary objective. Rather carbon sequestration should be seen as a positive side effect of relevant forestry activities.

It is noted that there is a large discrepancy between the desired annual forest establishment of more than 12 million hectares as laid down in the "Noordwijk" conference (more than 12 million hectares because deforestation is supposed to continue), and the currently planned plantings in the TFAP countries of 2.3 million ha/year. The latter figure should be considered a realistic maximum of what the 15 countries can do under the present circumstances. It is difficult to estimate what areas will be available for planting when more countries still have to draft their National Forestry Actions Plans and the efforts of all countries will increase further. It seems unlikely, however, that a tropics-wide planting programme will ever amount to more than a fourfold increase of the present tropics-wide planting, and the 15 countries studied are planning a threefold increase) unless institutional capacity is structurally increased. This would imply that in order to reach the "Noordwijk" objective, the remaining 6 million or more hectares (depending on the rate of deforestation) would have to be planted annually in temperate zones. Such an increase might, however, have a negative impact on marketing possibilities for tropical wood and thus have a bearing on the possibilities of extending the plantation areas in the tropics.

Under the assumption that the recipient countries would have a strongly increased absorptive capacity, the global objective of a net increase of tropical forest cover of 12 million ha/year, would require an investment of some US$ 19,000 million/year. Given the present level of ODA funds allocated to forestry this would represent an almost twenty-fold increase and would call for a substantial increase in ODA assistance and investments form the private sector.

Reforestation would only include trees planted on forest lands. Trees on agricultural fields (agro-forestry), along roads, home gardens, plantations of rubber, oil palm etc. have not been included although they are important for carbon fixation. Quantification of these aspects would require further study.

It is noted that, to date, international assistance in the forestry sector has paid relatively little attention to Latin America. Since the potential for forest conservation and reforestation are greatest in this continent, it is suggested that this should change.

7 POSSIBILITIES AND CONSTRAINTS OF INTERVENTIONS

Arresting deforestation and forest degradation demands measures in several fields. As far as the problems relate to forest degradation as a result of agricultural expansion and logging by companies working on a large-scale it might include:

- assistance at the policy level (improve legal systems and law enforcement to safeguard conservation) and institutional development in order to strengthen conservation through government policies;
- assistance to private or public logging companies prepared to adopt sustained yield management practices in tropical rain forests and a wood buying boycott of those who are not. Assistance in the form of subsidy or tax incentives because they employ less profitable but ecologically more acceptable practices might be considered. It should be noted that strict monitoring mechanisms should be applied by the donors;
- technology development for sustainable use of tropical rain forest.

Quantitatively, the main cause of deforestation is not the use of tropical wood but land use pressure from small and landless farmers. Forest degradation caused by these people should be addressed through

A. the development of appropriate and ecologically sound agricultural systems (including agro-forestry systems); to achieve settlement of shifting cultivators and colonizers. FAO studies have shown that in many parts of the world agricultural output could rise significantly if management levels were raised and it is heavily stressed here that part of the solution to deforestation lies in improved agriculture. If shifting cultivation could be arrested in this way, the regeneration of fallow lands would contribute significantly to the fixation of carbon. Agricultural development to reach this objective would have to include research, implementation, and the management of extension.

B. a strictly controlled system of sustained yield would production forests and conservation forests.

It is not realistic to expect the 15 prime, tropical forest countries to set aside almost 1000 million hectares of natural forest land without making any use of them. An effective forest conservation system must be based on a mixed consumptive and non-consumptive use strategy in which consumption use should include all products, including wood. Stopping the devastating effects of the industrial cutting of tropical wood should be carried out through economic incentives encouraging sustained yield practices, rather than by a total consumption ban on tropical (hard)wood. Therefore, an indiscriminate ban on tropical wood must be regarded as being counter productive, but a ban on wood from companies not operating on a sustained yield bases could be a useful instrument.

As for expansion of forest areas, if global effects on results in terms of carbon fixation are to be achieved, a diversified approach should be followed using a combination of the three strategies mentioned in earlier paragraphs., which best fit local conditions and objectives. Of these strategies, the commercial large and medium size plantations offer an attractive option to fix the largest possible amounts of carbon per hectare in sparsely populated areas. This would call for major investments and assistance in the field of developing credit and incentive programmes to stimulate the establishment of new plantations. It should be noted that the system should be designed in such a way that private companies will not only be motivated by the incentives offered, which might in fact lead to below standard forests being established. Strict systems of legal checks and balances should promote the advantages of scale, but at the same time prevent potential disadvantages in the field of socio-economy and ecology. Strict monitoring and control remain necessary.

At the small farmer's level, planting trees on communal lands and private farms, will be particulary suitable for extending forest cover in more densely populated areas. Attention should be paid to technology development but probably more to extension management and community organization. The amount of carbon fixed per hectare will be smaller than from the large scale plantations, but the ancillary benefits of soil conservation, providing for fuel, timber and fodder demands might be higher. The number of people to be reached and relatively long lead periods before benefits come about foreshadow high investment costs. The involvement of the local population in the development of tree planting, management schemes, and technology compatible with their farming systems is essential. Strength here lies in the combined effect of many small, individual contributions and actions.

Current Land Use in the Tropics and its Potential for Sequestering Carbon

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1 INTRODUCTION

If global rates of deforestation and fossil fuel use continue to increase in the future as they have in recent decades the increased concentrations of greenhouse gases in the atmosphere are expected to warm the earth by about 0.3°C per decade over the next century (range of uncertainty 0.2° to 0.5°C per decade) (Intergovernmental Panel on Climatic Change (IPCC), Houghton et al. 1990). If no steps are taken to reduce emissions of CO_2, CH_4, or N_2O, the mean surface temperature of the earth is predicted to be about 3°C warmer before the end of next century and will continue increasing until such steps are taken.

Global warming will not be stopped until the concentrations of greenhouse gases in the atmosphere are stabilised. This stabilisation, in turn, requires large reductions (>60%) in emissions of greenhouse gases, particularly those with long residence times in the atmosphere. According to the business-as-usual scenario of the IPCC (Houghton et al. 1990), CO_2 will account for about 60% of the enhanced warming over the next 100 years, four times more than the next most important heat-trapping gas, CH_4.

The steps required to reduce emissions of CO_2 include a reduction in the use of fossil fuels and a reduction in rates of deforestation. Combustion of fossil fuels accounts for the largest emissions of CO_2, about 5.5 Pg carbon in 1987, or 75% of the total global emissions. Deforestation is estimated to have released between 1.5 and 3.0 Pg carbon in the late 1980's (Houghton 1991b), or about 25% (20-35%) of the global emissions of CO_2. Deforestation and subsequent land use are also responsible for emissions of CH_4 and N_2O, such that about 25% of the total global warming potential from all greenhouse gases is from land use (Houghton 1990b).

The long residence times of most of the greenhouse gases in the atmosphere means that gases emitted this year will trap heat not only this year, but for centuries to come. The oceans will eventually remove the excess carbon from the atmosphere, but they cannot do so for centuries. In contrast to the oceans, growing forests can accumulate carbon rapidly and could be used to shortcut the natural carbon cycle and reduce atmospheric concentrations of CO_2 more rapidly than would otherwise be the case.

The work reported here is part of an effort to estimate how much carbon might be removed from the atmosphere through reforestation, and how rapidly such a removal might occur. One of the first steps in providing these estimates is to determine the area of land available for sequestering carbon. This study considered the availability of land in the three major tropical regions: Latin America, Africa, and South and Southeast Asia. Similar studies are appropriate for countries in the temperate and boreal zones.

2 APPROACH

2.1 General

Carbon is stored on land in soils and trees. Because the rate of accumulation of carbon is higher for trees than for soils, the question of where to accumulate carbon becomes: where can additional trees be added? or where can existing trees be grown larger? In general, there are three categories of land where more trees or larger trees might be grown:

- Disturbed or Secondary Forests.
  If protected from further logging, fuelwood harvest, or other encroachment, such forests can be expected to accumulate carbon until they return to their original biomass.

1 The Woods Hole Research Center, USA.

- Severely Degraded Lands that formerly supported forests.
  Such lands might return to forest if protected or left alone, but the category is distinguished from the one above because degraded lands might require varying amounts of input (soil preparation, planting, water, nutrients, and so on) for recovery or regrowth.

- Agricultural or Settled Land suitable for Agroforestry.
  Lands under intensive agriculture are unlikely to be turned over to reforestation projects. On the other hand, the growth of crops can sometimes be enhanced by interplanting with woody species that would also accumulate carbon.

The approach used here to estimate where carbon might be accumulated in trees was to compare a map of current land use with a map of vegetation prior to human disturbance. The rationale was that lands formerly forested (prior to human disturbance), but not currently forested, provide the greatest potential for re-establishment of trees. In some places the potential cannot be achieved because the land is currently intensively used for food production. Such agricultural areas might, nevertheless, be managed, for example through agroforestry, so as to sequester carbon. The point of this analysis was to determine where lands might be managed to accumulate woody biomass.

The approach we have used also allows for analysis of alternative management options. Options vary, for example, depending on the amount of resources available for management. Eventually, the approach will be used to incorporate biomass and rates of carbon accumulation in the analysis. The different kinds of information will be combined to produce a more concrete estimate of the potential for reforestation to remove carbon from the atmosphere.

2.2 Current Land Use

The following is a description of the methodology used to obtain a preliminary estimate of reforestation potential in three major regions of the tropics: Latin America, Africa, and Tropical Asia. Additional methods are being developed to refine these estimates, but will require more time to pursue.

Our analysis of current land cover was based on digital satellite imagery. Data from satellite imagery at resolutions of less than 100 meters have been widely used to produce maps of land cover as well as qualitative evaluations of vegetative growth. On a continental scale, however, the effects of cloud cover, seasonality of the vegetation, year-to-year variability, and the enormous expense of processing make using data of such high resolution impractical. Coarse resolution imagery offers an alternative to acquire and process information on such large areas. The NOAA global vegetation index is an example of imagery with such coarse resolution, 15 km X 15 km. It also has the additional advantage of high (weekly) temporal resolution. This multi-temporal coverage provides information on vegetation phenology that is extremely useful for identifying land-cover/land-use classes.

2.3 Image Processing

In all three regions studied, we began with regional sub-images taken from a set of three years of weekly global NOAA vegetation index imagery. This vegetation index was, in turn, obtained from the NOAA Advanced Very High Resolution Radiometer (AVHRR) series of satellites. The normalized difference vegetation index (NDVI) is computed from digital image data acquired from a variety of multispectral satellite and airborne sensors, and is strongly related to vegetative parameters such as greenleaf biomass and leaf area index. The NDVI is calculated by subtracting the red light reflectance from near infrared (NIR) reflectance, and normalized by dividing by their sum. Clouds, water, and bare ground result in very low NDVI values, while vegetation produces a range of values related to the density and vigor of the vegetation. Weekly images of global vegetation activity are produced by combining daily passes from the AVHRR satellites and taking the maximum value from all passes, thereby minimizing cloud cover and maximizing the vegetation signal. Resampling is conducted to reduce the resolution from 1 km to 15 km at the equator, producing a manageable global dataset. The weekly data for each year were aggregated into months - some months had 4 weeks, some had 5, determined from the julian dates from the weekly data header files. The monthly datasets were created by selecting the maximum pixel value from the incorporated weekly data, thereby further minimizing the effects of cloud cover in the output dataset. The three years of 12-month data (12 bands) were then aggregated by averaging the months, to provide a single twelve-month dataset which represents the average vegetation activity for the years 1986, 1987, and 1988.

2.4 Unsupervised Classification

The original twelve month, twelve-channel NDVI image file contains more data on temporal and spatial variations in vegetation cover than can be easily managed. Thus, we simplified the data to a single layer with a limited number of distinct classes. Unsupervised classification was chosen for this task, as it relies solely upon the data to define the composition of classes. This method is commonly used when little is known about the data before classification, and allows the computer to assign land-cover classes based on the overall variability which exists in the regions of interest. Our PC-based image processing and geographic information system is limited to processing 7 channels of satellite data with the unsupervised classification algorithm. We therefore performed data compression by processing the NDVI 12-channel file using principal components analysis to produce 7 principal components channels for clustering. The number of classes in the final classification for each region was determined by running several clustering iterations of 20, 25, 30, 35 classes, etc. and choosing the output classification that seemed to best capture the variability of each region without the unnecessary extra detail that would compromise the accuracy of the class labelling process. The number of classes chosen to represent each region varied according to the land-cover diversity of the region being considered.

The resulting classified images were incorporated into a Geographic Information System (GIS) for each region. Other GIS layers included topography, the twelve average monthly NDVI image layers, Matthews' global map of pre-disturbance vegetation, Holdridge Life Zones, as well as regional vegetation maps such as White's vegetation map for Africa.

For each regional classified image, the monthly NDVI values were extracted by class from the GIS, and graphed to facilitate labelling and analysis of the classified image. Two values were extracted: the mean and the standard deviation for each class. These values were imported into a data tabulation software package, and graphed with time (months) on the x-axis, and NDVI value on the Y-axis to produce 'phenology curves'. The mean value and two standard deviations from the mean were graphed for each class.[2]

2.5 Cluster Labelling

Classes from the clustering operation were labelled using three sources of information. Literature sources were used for the majority of classes, and maps were used when studies from the literature were not available. In a few cases, only the phenology curves were available for inferring what the characteristics of a particular class might be. In such cases these curves were compared with curves from labelled classes. The studies selected from the literature met two criteria: they had to be ground studies covering very large land areas that could be located on the image, and they had to contain a description of land use as well as the natural vegetation type. Wherever possible, and especially for large classes, several studies were used, and an attempt was made to represent the spatial range of the class by locating a literature study within each major region of the class. This was important for classes which were present in different climatic and/or latitudinal zones. Other GIS layers were considered in assigning class labels, and were helpful in accurately locating the literature study sites on the image. For example, many literature studies made reference to altitudinal zones, which were easily found using the topographic GIS layer. Once references and labels had been assigned, there were as many as 5 class labels for some classes, and the dominant label or combination of labels was chosen to represent the class in the final legend and report.

2.6 Comparison of current and pre-disturbance land cover

Once the final map of current land cover had been produced and labelled, it was compared it with a 'pre-disturbance' map in order to determine the potential for restoring the landscape to its maximum carbon storage capacity. The map of predisturbance vegetation we chose to use was Matthews' (1983) map of global vegetation, although the 1-degree (110 km) resolution is much more coarse than the 15-km data from satellite. The Matthews map and the map based on classification of the imagery were compared using a matrix operation to assign distinct class numbers to all possible combinations of predisturance and current land cover (Tables 1, 2, 3). Prior to this operation, all similar classes in each classified image were combined to facilitate the interpretation of the matrix operations. Matthews' vegetation classes were simplified into 6

2 Editor's note: Examples of these graphs were given in the original manuscript; due to production difficulties it was not possible to include them. Readers are refered to the authors of this paper if they wish to obtain copies of these.

major groups: Forest, Woodland, Grassland with 0%, <10%, and 10-40% Woody Cover, and Desert. The 27-35 classes of current land use/land cover, obtained through satellite imagery, were grouped into forest, woodland, and grassland, each of which had three or four potentials for reforestation.

2.7 Management options for reforestation

All of the steps described so far have attempted to define reforestation potential by the intersection of current land cover and predisturbance vegetation. The potential for sequestration of carbon depends, however, not only on the extent to which current land cover (and carbon stocks) differs from predisturbance vegetation (biophysical constraints), but also on the resources available for different management options (social and economic constraints). For the analyses that follow, we assigned each current land cover a reforestation potential. These potentials are listed, below, in order of increasing cost (and increasing carbon sequestering potential):

- 'Leave Alone' was assigned when a minimum potential for sequestering carbon exists, and/or when a minimum effort would be required/afforded.

- 'Agroforestry' was applied in instances where there is evidence of agricultural use of the land, but a use not so intensive as to preclude the addition of some woody vegetation on the landscape.

- 'Protection' allows a land cover to regrow to its natural (predisturbance) type, accumulating carbon in biomass and soils as it does. This potential is most applicable in disturbed or secondary forests, where simply protecting the forest from continued disturbance or current land use will result in an increase in carbon storage. Protection requires prohibition of further use of the forest.

- 'Plantation' is used in severely degraded situations where natural regrowth to maximum potential carbon would occur only with significant assistance, thus requiring large inputs. To be successful in sequestering carbon, plantations require protection and the costs involved.

These four reforestation options range in effort from no action ('Leave Alone'), to light investment ('Agroforestry'), to heavy investment (prohibiting further encroachment, shifting cultivation, logging, and so on), to intensive replanting and subsequent protection ('Plantation'). They also range from low to high potential for storage of carbon. The range can, thus, be thought of as extending from pessimistic (little resources available or little potential for sequestering of carbon) to optimistic (costly options, but with a large potential for sequestering of carbon).

This qualitative scale of optimism and pessimism is useful for describing management options because many land covers can be managed in more than one way. In the analyses that follow, we assigned each land cover an optimistic and a pessimistic reforestation potential. For example, land determined, from satellite imagery, to be Deciduous Scrub/Shrubland and determined, from Matthews' predisturbance map, to have been formerly forested could either be left alone (pessimistic) or used for the establishment of plantations (optimistic). This example is the first entry in Table 1a (top left). The second entry, Savanna/Pasture/Shrubland currently, forest previously, was assumed to be suitable either for plantations (optimistic) or for agroforestry (pessimistic, because agroforestry requires less resources and stores less carbon). Each of the 105 possible combinations of current land cover (27 categories) and predisturbance vegetation (7 categories) were assigned a most pessimistic and a most optimistic management option. These options were then summed to define the limits of areas available for sequestration of carbon.

Tables 1a, 2a, and 3a give the tabular data for the matrix operations for Latin America, Africa, and Tropical Asia, respectively. The column headings are derived from Matthews'(1983) global map of pre-disturbance vegetation classes, which we assumed to represent potential vegetation. This map contains 30 vegetation classes, some portion of which are represented in each regional subset. We combined similar classes from these subsets into groups of major vegetation types, including forest, woodland, grasslands with various woody components, and desert. The columns of the matrices, thus, represent potential vegetation, or the vegetation that could be re-attained in the absence of human disturbance. The rows of the matrices of Tables 1a, 2a, and 3a are combined vegetation classes aggregated from the original unsupervised classifications of the regional satellite image datasets. The entries in the tables represent class numbers for reforestation options (leave alone, agroforestry, protection, plantation) outlined below.

Tables 1b, 2b, and 3b are identical and provide a key to the reforestation options displayed in Tables 1a, 2a, and 3a. 'Protection' means to protect an area so that it will sequester carbon by regrowth alone. This is most applicable in disturbed or secondary growth situations, where simply protecting from continued disturbance or current land use will result in an increase in carbon storage. 'Protection' is most often applied in 'Optimistic' scenarios. In contrast, 'Leave Alone' is often a pessimistic scenario which might be applied when a minimum potential for sequestering carbon exists, and/or minimum effort is to be applied. 'Plantation' is used in severely degraded situations where natural regrowth to maximum potential carbon would only occur with significant assistance. 'Agroforestry' is applied in instances where there is evidence of agricultural use of the land, but not so intensively as to preclude the addition of some woody vegetation on the landscape.

In addition to the four management options described above, two more options are listed under the column labelled 'Other'. Some areas were designated as having 'No Potential'(class 12) either because they already contain the maximum amount of carbon possible, as in undisturbed forest, or because human occupation of the land is so intense and permanent as to eliminate the possibility that the landscape will be allowed to revert to its potential maximum carbon content. This would be the case for irrigated agriculture, or urban areas. Other classes of land which might be deemed to have 'No Potential' are deserts and dry grasslands with no woody component, where allowing the land to revert to its maximum potential would not provide any carbon gain.

Lastly, areas labelled 'Discrepancy' (class 13) are those where the satellite-derived land-cover classification showed a land-cover class already higher in carbon storage than possible under potential land cover (as defined by Matthews). These discrepancies may result from errors in classification (either or both maps) or a real change in carbon content, as for example a human- or climate-caused encroachment of grassland with woody vegetation. Such discrepancies were ignored in this analysis. No management options were considered.

Examples of the final map outputs of both optimistic and pessimistic recoding strategies reflected in the matrices can be obtaind from the authors[3].

2.8 Optimistic and Pessimistic assignments

Table 1a: row 6 - 'Cropland', is used here as an example of how the optimistic and pessimistic class assignments were made. If the predisturbance vegetation of cropland was forest, an optimistic decision (which maximizes carbon gain with low cost) would be to apply agroforestry (class 4), as this would allow the intensive human use of the land to continue while increasing the carbon storage. The only other option under present land use is class 12, 'No Potential'. This choice was the pessimistic decision. It would be impractical to assign croplands to 'Protection' due to the intensity and permanence of human presence on the landscape. This same logic applies across the row, except that woodland agroforestry (class 8) was applied in areas of woodland potential, and grassland agroforestry (class 11) was applied in all other cases where current land use is cropland. Several combinations of potential and current vegetation did not occur in row 6 of this matrix, and are labelled 'N/A'. If an intersection between cropland and desert did occur, however, it would be labelled as class 12, 'No Potential' in both optimistic and pessimistic scenarios, as the highest carbon storage potential of the land would probably not be significantly different from current use.

Table 1a: row 22, 'Dry woodland/shrubland', presents a different combination of options, as there is no indication that it is currently under human occupation or utilization. If the potential vegetation is forest, an optimistic decision would be plantation (class 3), as this landscape would obviously require assistance to recover to its potential. A pessimistic decision would be to leave the land alone, to allow it to recover at natural rates to whatever natural state could be attained, and would require the minimum effort in terms of management. If potential vegetation is woodland, the same decisions of plantation or leave alone are made, only under woodland rather than forest categories (classes 7 and 6, respectively). Under the vegetation potential of shrubland and all forms of grassland with woody components, optimistic decision rules assume that the present land cover is optimal as it is, and the best thing to do is leave it alone (class 10). A pessimistic view might assign class 12, 'No Potential', as no improvement could be made. Protection would not be necessary, as protecting the land would require effort and would not increase the potential carbon storage. Lastly, under a potential vegetation of grassland with no woody component, both optimistic and

3 Editor's note: These maps accompained the original manuscript but have not been included due to production difficulties.

pessimistic classifications were assigned a class of 13, for a discrepancy exists where current land cover exceeds the potential (Matthews) in terms of carbon storage.

Optimistic and pessimistic options were chosen to describe the maximum and minimum effort which could be implemented. Carbon gain was assumed to be related to the amount of effort (resources) available for management, given the potential and present use. It was not the purpose of this study to determine what would be the optimum policy choice for a given landscape, but merely to attempt to specify the range of options available. The choice of what option to use must be based on other variables as well, such as the social and land-use characteristics of the country, and the amount of financial aid available. If these social and policy constraints on reforestation effort are known in a spatial dimension so that they can be incorporated into the geographic information system, the range between optimistic and pessimistic options could be narrowed.

2.9 Country Summaries

Once these classes had been determined, and both an optimistic and pessimistic map produced, preliminary country estimates of potential reforestation area were computed from the GIS. A political boundary overlay map was used to tally the total number of pixels of all classes within each country's boundaries. Area under each class was determined for a country in the following manner: total area for the country, in hectares, was obtained from the FAO Production Yearbook (FAO 1987); the ratio of pixels in the class to total number of pixels within the country was calculated, and this ratio multiplied by the FAO total area. By using this method, we avoided any issues related to varying pixel size at the continental level.

3 RESULTS

For the tropics as a whole, there may be as many as 579×10^6 hectares of degraded land, formerly covered with forests or woodlands, available to be planted, and managed as, plantations, and another 858×10^6 hectares of secondary grasslands and secondary forests that, if protected from further use, could be expected to accumulate carbon in woody vegetation and, perhaps, soils. In addition to these areas with potential for increasing the number and mass of trees, there may be as many as 500×10^6 hectares of agricultural lands with potential for sequestering carbon through some form of agroforestry.

The tropical lands with potential for sequestering carbon are not evenly distributed among regions (Table 4). The largest area with potential is in Latin America; the smallest area is in Asia. Under optimistic conditions, about 40% of area of Latin America and about 39% of Sub-Saharan Africa could be expected to accumulate carbon through some sort of management. In tropical Asia, only about 18% of the land is available for increased storage. These estimates are probably somewhat low, however, because of systematic errors in the analyses.

There are at least two sources of error. First, areas that appear to be holding more carbon currently than they did prior to disturbance (Discrepancy, class 13) may be misclassified. Properly classified, these areas would increase the areas with potential to sequester carbon. Over the entire tropics, the area assigned to this discrepancy category amounted to about 15% of the total area, and about 35% of the land with some potential for storing additional carbon. On the other hand, this discrepancy could be real. Most of the discrepancy appears in grasslands that now contain some woody cover, but that were apparently without woody cover prior to disturbance. It may be that these disturbed grasslands may hold more carbon than undisturbed lands. When grazed, for example, some grasslands accumulate woody plants. The change in carbon below ground, however, may reverse the above-ground trend, if a continuous mat of grass roots is replaced with clumps of woody species with barren soil between. Too little is known about this topic to determine here whether some forms of human disturbance have increased, rather than decreased, the storage of carbon on land.

A second, smaller, error arises from the resolution of land/water boundaries. Border pixels that contain both water (either inland waters or ocean) and land could not be properly classified and, hence, were left unclassified. The area known to be in inland waters (FAO 1987) was subtracted from the total number of unclassified pixels to determine the size of this 'edge effect' (Table 4). In general, unclassified areas were responsible for underestimating the areas with potential to accumulate carbon. But in Africa the area in inland waters was larger than the total area unclassified, suggesting that small bodies of water were not "seen" by the satellite imagery and were classified as land cover. In this case, the area available for carbon storage was slightly overestimated. The number of edge pixels was about 10% of the total area potentially reforestable. Thus, the limits imposed by resolution and by uncertainty of classification were responsible for an underestimate of potential areas by, at most 45% (35% from discrepancy and 10% from land-water boundaries). The underestimate was probably considerably less than 45%, but its magnitude cannot be estimated at this time.

These estimates of land availability are optimistic in the sense that any management requires resources. On the other hand, the consequences of increasing the area of forests include many local and regional benefits in addition to the more global benefits of carbon accumulation. Forests provide timber and fuelwood and other renewable resources, restore productivity to degraded lands, stabilize soils and water budgets, and harbour a disproportionate number of the world's species.

4 COMPARISON OF RESULTS WITH OTHER ESTIMATES

4.1 Production Yearbooks of the FAO

The analysis presented here is a first attempt to use satellite data over the entire tropics to determine land cover. The resolution of the satellite imagery was 15 km, only 30-35 classes were determined for each continent, and only one or two literature studies were used as 'ground truth' for each of these classes. How good are the estimates? Before comparing the estimates of land availability with previous estimates, we ask how well the classification was in general. How do the satellite-derived estimates of forest area, for example, compare with other estimates of forest area? For a preliminary answer, we graphically compared the results of the satellite classification with estimates of land use provided by the Production Yearbook of the FAO (1987)[4]. The overall agreement is good, especially for forests, although outlying points indicate large discrepancies for individual countries. In a number of countries, pastures and, to a lesser extent, croplands, were not identified as such by the satellite-derived classification (see also Table 5c). These errors probably resulted from mosaics of pastures and woodlands, that were more often classified as woodlands than as pastures. With identification of a greater number of classes, and with a larger number of literature studies used as ground truth across an entire continent, the error from this mosaic problem can be reduced.

Comparisons between satellite classification and the Production Yearbooks within each of the three tropical regions showed better agreement for Latin America and Asia than for Africa, where the greatest areas of mosaics exist. Some of the discrepancies may have resulted from inaccuracies in land-use statistics.

4.2 Other Estimates of Land Available for Sequestering Carbon

Plantations: Other estimates of land available for carbon accumulation in the tropics are compared in Table 5. Table 5A shows degraded areas estimated to be available for plantations. The results presented here agree for the entire tropics with earlier estimates of Houghton (1990a), independently derived. However, individual regions vary by more than a factor of two, and the estimates cannot be said to agree. The work reported here, though still preliminary, is thought to be more accurate than the earlier work. Grainger's (1988) estimates of degraded lands are much larger for Africa and Asia than other estimates. His estimates were for desertified drylands, most of which he did not realistically expect to be reforested.

Our estimates of the area with potential for plantations corresponds with the 'industrial reforestation' strategy of Graham et al. (1990) for Sub-Saharan Africa. Only one of the three strategies of Graham et al., however, corresponds in methodology and concept with our estimate: their base-case model of land physically suitable for forest plantations (defined as land not presently in "forest" or "forest fallow" and land with a potential productivity of more than 6 tonnes C/ha/year). Graham et al. (1990) assumed that 1% of that land would be planted annually. "Suitability" was further divided into three categories; high, medium, and low. The three categories summed to a total of 191.3 million hectares, 50% lower than our optimistic estimate of 284 million hectares (our pessimistic estimate = 0).

Protection of secondary forests: Logged forests or fallow forests, if protected from further logging and from shifting cultivators, could be expected to accumulate carbon as they regrew to their original biomass.

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4 Editor's note: Due to production difficulities it was not possible to reproduce these graphs in these proceedings; interested readers are referred to the authors for copies.

According to the FAO/UNEP assessment of tropical forests (FAO/UNEP 1981), there was a total of about 600 x 10^6 hectares in logged and fallow forests in 1980 , (Lanly 1982, Table 5B). In comparison, our estimates yielded a total of 858 x 10^6 hectares, with most of the difference between our estimates and theirs in Africa. The higher estimate is probably a better estimate of the area of "disturbed" forests. In tropical Asia, most forests seem to be disturbed or degraded to some extent, even those classified by FAO/UNEP as undisturbed (Brown et al. 1991, Houghton 1991a). Few forests in the world today may qualify as undisturbed by human activity.

Our estimate of forest area with a potential to sequester carbon if protected cannot be compared with estimates of African land use by Graham et al. (1990). Their 'preservation' category includes areas of intact forest that might be preserved from further deforestation. Our 'protection' category, on the other hand, includes secondary forests and fallow forests that, if protected from further disturbance, might sequester carbon during regrowth. The rationale for 'preservation' and the rationale for 'protection' in these two studies are not comparable.

Finally, our estimate of areas with a potential for agroforestry is lower than estimates of agricultural area (croplands and pastures) reported in the Production Yearbook of the FAO (1987). As discussed above, our classification procedure often underestimated the area of pasture and cropland.

A comparison with the work of Graham et al. (1990) is difficult because our estimate is of total area available currently, while their estimate is an area that could be brought into agroforestry by some point in time, depending on its rate of application. By the year 2001, between 26 and 47 x 10^6 hectares might be in agroforestry, according to Graham et al. (1990), assuming growth rates of 2% or 4%, respectively. Our pessimistic estimate of 54 x 10^6 hectares for Africa is similar to their higher estimate; our optimistic estimate of 213 x 10^6 hectares is considerably larger than either of theirs. But Graham et al. (1990) do not provide an estimate of how much land could potentially support agroforestry if its application were allowed to continue beyond 2001.

5 CARBON

Preliminary estimates of the potential for plantations, protected secondary forests, and agroforestry to sequester carbon (tC/hectare) are given in Table 6. The amount of carbon/hectare sequestered was estimated as follows:

1) Carbon sequestered in converting degraded lands to plantations:
   delta $\text{carbon}_{\text{plantations}}$ = (carbon of undisturbed forests/2)

   Plantations were assumed to hold, on average, half as much carbon in vegetation as undisturbed forests (FAO/UNEP 1981); that is, an amount of carbon intermediate between zero (year after harvest) and maximum biomass (year before harvest).

2) Carbon sequestered in the protection of secondary/fallow forests:
   delta $\text{carbon}_{\text{protection}}$ = carbon in undisturbed forests - carbon in logged forests (averages for regions from Brown et al. 1989).

3) Carbon sequestered in agroforestry:
   delta $\text{carbon}_{\text{agroforestry}}$ = 60 tC/ha in American and Asian countries (Graham et al.,1990), = 25.6 tC/ha in African countries.

The total amount of carbon potentially sequestered (available area x C/hectare sequestered) as a result of these management options is given in Table 8.

6 COSTS

Preliminary estimates of the costs per hectare for the three management options were obtained here (Table 7) from a limited number of sources. The average cost per hectare to establish and maintain Plantations was US$200 for Tropical Asia, US$ 374 for Latin America, and US$611 for Africa. A number of sources mention the dominant role that labor plays in the establishment of both plantation and agroforestry, and the importance of logistics and infrastructure for plantation establishment (Leach and Mearns 1988; Boonkird et al. 1985; EPA 1990; Sanchez and Benites 1987). The average cost for protection of forests was assumed to be US$70 per hectare throughout the tropics. This estimate of cost does not include costs of policies to deal with relocation of displaced populations, development, or encroachment pressures. Under agroforestry, the average costs were US$627/hectare for tropical Asia and Latin America and US$ 400 for Africa. The total cost (total available area x cost/hectare) of sequestering carbon as a result of these management options is given in Table 8.

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Table 1a Details of relabelling method - Latin America

Row No. Aggregated Classes from 35-Class Classified Image	Forest Opt / Pess	Woodland Opt / Pess	Shrubland Opt / Pess	Grassland 0-10% Wood Opt / Pess	Grassland 10-40% Wood Opt / Pess	Grassland Opt / Pess	Desert Opt / Pess
1 Decid Scrub/Shrubland	3 2	7 6	10 10	10 10	10 10	10 10	13 13
2 Savanna/Pasture/Shrubland	3 4	7 8	11 10	11 10	11 9	11 10	13 13
3 Evergreen Forest w/Shift Cult	2 2	13 13	13 13	13 13	13 13	13 13	N/A
4 Pasture/Shrubland	3 4	7 8	11 10	11 10	11 10	11 10	13 13
5 Irrigated Agriculture	12 12	12 12	12 12	12 12	12 12	12 12	12 12
6 Cropland	4 12	8 12	11 12	N/A	11 12	11 12	N/A
7 Cactus/Bush Desert/Barren	3 12	7 12	9 12	N/A	9 10	10 12	12 12
8 Disturbed Forest/Shrub/Crop Mosaic	1 4	13 13	13 13	13 13	13 13	13 13	N/A
9 Matorral/Cultivated Mosaic	3 4	7 8	11 10	N/A	11 10	11 10	N/A
10 Degr Arid Woody Formations w/Crops	3 4	7 8	11 10	N/A	11 10	11 10	N/A
11 Forest	2 2	13 13	13 13	13 13	13 13	N/A	N/A
12 Thorn Forest/Pasture/Crops	3 4	13 13	13 13	13 13	13 13	13 13	13 13
13 Degr Forest/Thorn Forest	1 2	13 13	13 13	13 13	13 13	13 13	13 13
14 Degr Forest/Woodland/Pasture	3 4	5 8	13 13	13 13	13 13	13 13	N/A
15 Cropland/Perm Grazing	4 12	8 12	11 12	11 12	11 12	11 12	12 12
16 Degr Forest/Thorn Forest/Past/Crop	1 4	13 13	13 13	13 13	13 13	13 13	N/A
17 Dry Grassland/Cropland	3 4	7 8	N/A	11 10	11 10	11 10	N/A
18 Pantanal	1 2	5 6	9 10	10 10	10 10	10 10	13 13
19 Grassland/Grazing/Cropland	3 4	7 8	N/A	11 10	11 10	11 10	N/A
20 Degr Forest/Woodland/Cropland	3 4	5 8	N/A	N/A	13 13	13 13	N/A
21 Highly Seasonal Grassland/Cropland	3 4	7 8	11 10	11 10	11 10	11 10	N/A
22 Dry Woodland/Shrubland	3 2	7 6	10 12	10 12	10 12	13 13	N/A
23 Seasonal Grassland	3 12	7 12	10 12	N/A	N/A	10 12	N/A
24 SubAlp/Pol Woody Mosaic w/Crops	3 4	7 8	N/A	N/A	N/A	13 13	N/A
25 Cropland/Degraded Scrub Forest	3 4	7 8	13 13	N/A	N/A	13 13	N/A
26 Wetter SubAlp/Pol Woody Mosaic	3 2	7 6	13 13	N/A	N/A	13 13	N/A
27 Dry Shrub/Bunchgrass	3 12	N/A	N/A	N/A	N/A	10 12	N/A

Table 1b Key to classes: Policy Options to Sequester Carbon

Potential Vegetation Category:	Forest	Woodland	Grassland	Other
Class Numbers and Names:	1. Protection 2. Leave Alone 3. Plantation 4. Agroforestry	5. Protection 6. Leave Alone 7. Plantation 8. Agroforestry	9. Protection 10. Leave Alone 11. Agroforestry	12. No Potential 13. Discrepancy

Table 2 Details of relabelling method - Africa

Class No.	Aggregated Classes from 33-Class Classified Image	Forest Opt / Pess	Woodland Opt / Pess	Shrubland Opt / Pess	Grassland 0-10% Wood Opt / Pess	Grassland 10-40% Wood Opt / Pess	Grassland Opt / Pess	Desert Opt / Pess
1	Desert	3 12	7 12	9 12	9 10	9 10	9 12	12 12
2	Grass/Shrub, <10% Woody Cover	3 2	7 6	10 10	10 10	9 10	10 10	13 13
3	Sudan Savanna	3 2	7 6	10 10	10 10	9 10	13 13	13 13
4	Grassland/Sudanian Woodland	3 2	5 6	10 10	10 10	9 10	13 13	N/A
5	Forest	2 2	13 13	13 13	13 13	13 13	13 13	N/A
6	Edaphic Grass/Semiaquatic Veg	2 2	2 2	10 10	10 10	10 10	10 10	N/A
7	Pasture/Veld/Agriculture	3 4	7 8	11 10	11 10	11 10	11 10	12 12
8	Sudanian Woodland	3 2	7 6	10 12	10 12	10 12	13 13	N/A
9	Shrub/Bush/Rainfed Ag	3 4	7 8	11 10	11 10	11 10	11 10	N/A
10	Wooded/Bush/Grassland	3 2	7 6	10 12	10 12	10 12	10 12	N/A
11	Mos Forest/2nd Grassland	1 2	13 13	13 13	13 13	13 13	13 13	N/A
12	Miombo Woodland	3 2	5 6	13 13	13 13	13 13	13 13	N/A
13	Dwarf/Sparse Shrubland	3 2	7 6	10 12	10 12	10 12	10 12	13 13
14	Plantation/Dist.Forest/Ag	4 2	8 6	13 13	13 13	13 13	13 13	N/A
15	Secondary/Degraded Forest	1 2	13 13	13 13	13 13	13 13	13 13	N/A
16	Montane Vegetation	3 2	7 6	10 12	N/A	10 12	10 12	N/A
17	>75% Cultivated	4 12	8 12	11 12	11 12	11 12	11 12	N/A
18	Fynbos Shrubland	3 2	7 6	10 10	10 10	10 10	10 10	13 13
19	Eroded/Degraded	3 4	7 8	11 12	11 12	N/A	11 12	12 12
20	Cult w/Montane Forest Relicts	3 4	7 8	13 13	13 13	N/A	13 13	N/A
21	Upland Dry Forest	N/A	13 13	13 13	13 13	N/A	13 13	N/A
22	Lake Aquatic Vegetation	N/A	N/A	12 12	12 12	N/A	12 12	13 13
23	Hi-elev Scattered Woodl/Forest	3 2	N/A	13 13	13 13	N/A	13 13	N/A
24	Savanna/Wooded Steppe/Rainfed Ag	3 4	7 8	11 10	11 10	N/A	11 10	N/A

Table 2b Key to classes: Policy Options to Sequester Carbon

Potential Vegetation Category:	Forest	Woodland	Grassland	Other
Class Numbers and Names:	1. Protection 2. Leave Alone 3. Plantation 4. Agroforestry	5. Protection 6. Leave Alone 7. Plantation 8. Agroforestry	9. Protection 10. Leave Alone 11. Agroforestry	12. No Potential 13. Discrepancy

Table 3a Details of relabelling method - Tropical Asia

Class No.	Aggregated Classes from 26-Class Classified Image	Forest Opt / Pess	Woodland Opt / Pess	Shrubland Opt / Pess	Grassland 0-10% Wood Opt / Pess	Grassland 10-40% Wood Opt / Pess	Grassland Opt / Pess	Desert Opt / Pess
1	Desert	3 12	7 12	9 12	9 10	9 10	9 12	12 12
2	Tropical Lowland Evergreen Forest	2 2	13 13	13 13	13 13	13 13	13 13	N/A
3	Irrigated Agriculture	12 12	12 12	12 12	N/A	12 12	12 12	12 12
4	Open Forest/Shifting Cultivation	2 2	13 13	13 13	N/A	13 13	13 13	13 13
5	Deciduous Monsoon Forest	2 2	13 13	13 13	N/A	N/A	N/A	N/A
6	Semi-evergreen Moist 2ndary Forest	1 2	13 13	13 13	N/A	13 13	13 13	N/A
7	Other/Non-vegetated	3 2	7 6	10 10	10 10	N/A	10 10	12 12
8	Foothill Deciduous Forest	2 2	N/A	13 13	N/A	N/A	N/A	N/A
9	Dense Dipterocarp Forest	2 2	13 13	13 13	N/A	N/A	13 13	13 13
10	Logged Dipterocarp Forest	1 2	13 13	13 13	N/A	N/A	13 13	N/A
11	Submontane Tropical Forest	2 2	13 13	13 13	13 13	13 13	13 13	13 13
12	Dry Cult w/Scattered Trees/Shrubs	3 4	7 8	11 10	11 10	11 10	11 10	13 13
13	Shrub Savanna/Dry Agriculture	3 4	7 8	11 10	N/A	11 10	11 10	13 13
14	Disturbed Forest	1 2	13 13	13 13	N/A	13 13	13 13	N/A
15	Seasonally Flooded Agriculture	4 2	8 6	10 10	N/A	N/A	10 10	13 13

Table 3b: Key to classes: Policy Options to Sequester Carbon

Potential Vegetation Category:	Forest	Woodland	Grassland	Other
Class Numbers and Names:	1. Protection 2. Leave Alone 3. Plantation 4. Agroforestry	5. Protection 6. Leave Alone 7. Plantation 8. Agroforestry	9. Protection 10. Leave Alone 11. Agroforestry	12. No Potential 13. Discrepancy

Table 4 Optimistic and pessimistic estimates of the area of land (10^6 ha) available for sequestering carbon in the tropics. Areas with no potential for sequestering carbon (class 12) are included in the category 'leave alone'.

	Latin America Opt.	Latin America Pess.	Africa Opt.	Africa Pess.	Asia Opt.	Asia Pess.	All Tropics Opt.	All Tropics Pess.
Plantations	240	0	284	0	55	0	579	0
Protection	295	15	456	0	107	0	858	15
Agroforestry	274	277	213	54	12	25	499	356
Leave alone	811	1328	987	1886	608	758	2406	3972
Discrepancy	331	331	430	430	55	55	816	816
Edge effect	44	44	-5	-5	62	62	111	111

Table 5 Estimates of tropical land areas (millions of ha) available for the sequestration of carbon.

	Latin America	Africa	Asia	All Tropics
A. Degraded lands with potential for plantations.				
Grainger* (1988)	162	741	748	1651
Houghton (1990a)	100	300	100	500
Graham et al. (1990)		191		
This study	240	284	55	579
B. Secondary and/or fallow forests suitable for protection.				
Lanly (1982) Fallow forests	179	178	78	435
Sc'ndry forests	67	41	60	168
Total	246	219	138	603
Houghton (1990a)**	150	150	65	365
This study	295	456	107	858
C. Agricultural areas with potential for agroforestry.				
FAO (1987) croplands	178	155	269	602
pasture	553	638	35	1226
total	731	793	304	1828
This study	274	213	12	499

* Desertified drylands. The total of 1651 X 10^6 ha includes 331 X 10^6 ha croplands.

** Estimates are 85% of Lanly's (1982) estimates of fallow; converting from shifting cultivation to low input permanent cultivation is estimated to require only 15% of the land now in shifting cultivation (Sanchez and Benites 1987).

Table 6 Average sequestration of carbon (tC/ha) for different management options in different regions.

	Latin America	Africa	Asia
Plantations			
Forest	44	68	56
Woodland	27	37	40
Protection			
Forest	27	32	78
Woodland	8	9	28
Grassland	3	4	11
Agroforestry	60	30	60

Table 7 Average costs (US$/ha) for different management options in different regions.

	Latin America	Africa	Asia
Plantations	374	611	200
Protection	70	70	70
Agroforestry	627	400	627

Table 8 Potential sequestration of carbon (PgC) and total cost (billions US$) by region for implementation of management options on all available areas.

	Latin America PgC/US$	Africa PgC/US$	Asia PgC/US$	All Tropics PgC/US$
Plantations	9/90	15/174	3/11	27/275
Protection	7/21	3/32	7/7	17/60
Agroforestry	16/172	6/85	1/8	23/265
Total	32/283	24/291	11/26	67/600

Estimating Tropical Biomass Futures: A Tentative Scenario

Mark C. Trexler[1]

1 THE POLICY PROBLEM

It is a well-known fact that human activities are rapidly changing the composition of the earth's atmosphere, and that additional warming of the atmosphere may be one result. The accumulation of CO_2 in the atmosphere, with global concentrations now 25% above where they were at the start of the industrial revolution, is projected to be responsible for about half of whatever global warming does occur. Close to six billion metric tons of carbon are released to the atmosphere annually through fossil fuel combustion; somewhere between one and two billion metric tons of carbon are believed to be released through land use change, mostly by deforestation in tropical regions.[2]

2 THE HYPOTHESIS

There is little doubt that responding to the threat of global warming will require major adjustments in global energy mix and consumption rates, starting with those of the developed nations. Considerable attention, however, is also being focused on forestry as a contributor to and possible mitigator of global warming. Slowing deforestation, for example, can reduce the amount of carbon being emitted to the atmosphere in the first place. Reforestation can actively remove CO_2 from the atmosphere, leading some observers to suggest that it would be possible to "offset" some quantity of fossil fuel emissions through large-scale tree planting.

The literature addressing global forestry's potential role in mitigating global warming is growing rapidly and is generally enthusiastic. Very large areas of previously forested land exist around the world that could in principle be reforested to draw carbon dioxide (CO_2) from the atmosphere. Politicians see forestry-based global warming mitigation strategies as being subject to few of the obvious political impediments facing efforts to modify energy consumption patterns. In addition, forestry-based policies are often characterized as inexpensive ways to slow the buildup of CO_2 in the atmosphere.

Because of perceptions regarding land availability and relative tree planting costs, it is often suggested that forestry as a mitigation strategy be pursued primarily in the tropics.[3] Indeed, it is commonly asserted that more than one billion hectares of previously forested but now degraded or abandoned tropical lands ought to be available for reforestation of some sort. Reforestation of this much land could in principle remove billions of tons of carbon from the atmosphere every year. This could be interpreted to suggest that the mitigation of global warming through forestry can significantly reduce the need to modify the patterns of energy use that now contribute so much carbon dioxide to the atmosphere from developed countries.

3 CONSIDERING THE TROPICAL FORESTRY OPTION

Conservation of tropical forests, and reforestation, is of course justified on various counts: for soil and water conservation, food production, biological diversity conservation, long-term national economic development, and sustainable rural development generally. So forestry motivated on global warming mitigation grounds can also be effectively translated into on-the-ground programmes already justified on other criteria.

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2 It is worth recalling two factors in assessing the sources of carbon dioxide. First, the temperate zones were the source of large carbon emissions through deforestation in prior centuries. Second, it is projected that fossil fuel emissions from developing countries will exceed those from developed nations in just a couple of decades. Given these two variables, all countries concerned about global warming have an interest in considering the full range of possible response options.

3 Recent analysis suggests that there is likely to be considerable potential for the implementation of forestry measures in temperate countries as well. Indeed, the availability of well-developed infrastructures and market mechanisms in many temperate-zone countries suggests that some types of forestry could be more reliably pursued in temperate rather than tropical zones. See: Trexler, M.C., 1991. Minding the Carbon Store: Weighing U.S. Forestry Strategies to Slow Global Warming, World Resources Institute. Moulton, R., and Richards, K., 1991. The Costs of Carbon Sequestration in U.S. Forests. U.S. Forest Service.

The prospect of engaging in tropical forestry efforts to mitigate global warming raises two fundamental questions:

- What forms might "global warming forestry" take, and would they be the appropriate ones?
- How much potential really exists to modify land use trends (and thus carbon emissions and storage trends) in tropical countries in light of population growth, land availability, infrastructural, technical and other constraints?

3.1 Approaches to Global Warming Forestry

At least four different types of forestry efforts can be considered of value to global warming mitigation:

1. Protecting or managing already existing forest that would otherwise be lost through deforestation in coming decades.
2. Allowing or actively promoting the recovery of degraded or secondary growth forests, as well as the regeneration of forest cover on suitable cleared lands.
3. Deploying farm and agroforestry techniques on existing agricultural lands to increase tree cover, provide for fuelwood and cash income needs, and reduce pressures on natural forests.
4. Deploying commercial plantations for timber, fuelwood, electricity, or other products.

These four approaches to global warming mitigation are all premised on the same basic principle. Slowing the leakage of biotic carbon to the atmosphere, or even reversing the direction of particular flows within the overall carbon cycle, will slow the accumulation of CO_2 in the atmosphere and thus mitigate global warming. On a ton-for-ton of carbon basis, global warming mitigation dictates no particular priority among these four options, and it makes no difference to global atmospheric CO_2 concentrations whether a ton of carbon is added to vegetation in a temperate or a tropical country.

The different options, however, are likely to vary widely in terms of their country-specific potential, carbon storage timeframes, cost-effectiveness, and the magnitude of secondary costs and benefits. Although under the right circumstances each of the four approaches has a role to play in meeting the needs of tropical countries, there is legitimate concern as to which approaches might be emphasized as part of a truly large scale intervention.

If the interest in mitigating global warming through forestry is to further the social and development goals in tropical countries, considerable country-specific attention must be directed to assessing what types of forestry interventions are most appropriate given local needs and conditions.

3.2 Approaches to estimating land availability

There is no obvious means by which to estimate how much land could actually be saved from deforestation, and how much land could be regenerated or reforested in one of the manners described. The literature has either limited itself to estimating essentially the theoretical availability of land on the basis largely of physical parameters (see prepared papers of Houghton et al, Grainger), has arbitrarily made assumptions about how fast deforestation can be slowed and what fraction of other "available" land areas could be converted to tree cover, or has attempted to convert existing forestry plans into carbon projections (see prepared papers of Swisher, Dutch government).

For all practical purposes, there has been little attention paid to the many social, political, and infrastructural variables that influence the potential for slowing deforestation and encouraging reforestation in a given country. Particularly little attention has been given to variables determining the likely rate at which forestry options might realistically be implemented. It is obvious that any effort to simultaneously launch major efforts to slow deforestation, promote forest regeneration, farm forestry, and plantations, will overwhelm institutional and technical capacities in the short term. Money is far from the only constraint facing such an effort.

Relevant variables to the determination of both land availability and plausible implementation rates include:

- land availability in light of population growth and agricultural needs;
- prevailing government policies as they encourage or discourage forestry;
- agricultural policies as they affect forest resources;
- land tenure systems as they affect land management incentives;
- government receptivity to policy changes in these sectors;
- government capabilities to implement and sustain forestry initiatives;
- a country's economic and political status and stability;
- non-governmental institutions and their ability to promote forestry;
- public perceptions of the local costs and benefits of forestry efforts;
- country experience with forestry initiatives in the past;
- long-term project sustainability in light of all of the above.

Each of these variables can vary dramatically from country to country, as can the type of forestry effort that might best be pursued there given both physical and social circumstances. Until country-specific analyses are performed taking these and other variables into account, global estimates of "available" land, as well as estimates of the carbon benefits of simply ending global deforestation, cannot credibly be used for purposes of estimating what can be accomplished through forestry, or for developing global warming mitigation policy.

3.3 A preliminary attempt to derive country-specific estimates

Beginning in the summer of 1990, the Climate, Energy, and Pollution Program of the World Resources Institute (WRI) with support from the United States Environmental Protection Agency, took the first step in compiling country-specific assessments of the role tropical forestry could play in slowing the accumulation of carbon dioxide in the atmosphere. The methodology of the research project was as follows:

- More than 50 countries were selected for study, excluding particularly small or arid countries. Whilst acknowledging that the large number of countries selected would keep the analysis relatively crude, it was thought important to perform at least a first-order assessment for the tropics as a whole.

- Standardized country "profiles" were established for each of the selected countries using Grandview, a computer software package particularly suited to the task.

- Country-by-country information was collected through extensive literature reviews, through more than 150 in-depth interviews with governmental and non-governmental experts on the selected countries, and through the circulation of a questionnaire to several hundred foresters around the world. Interviewees and respondents were specifically asked to estimate how much land they considered available for various types of forestry in a country, and the rate at which such efforts might be implemented. More than 150 questionnaires have thus far been returned, some with extensive and in some cases new information relating to the research questions posed.

- Based on information from the literature, interviews, and questionnaires, "best-estimates" of land availability and implementation rates are being derived. Specifically, the attempt is being made to project not only overall land availability, but also the rates at which forestry efforts could be implemented in each country to the year 2050. Specifically, the following numbers are being estimated:

    - current and projected deforestation rates;
    - potential for slowing deforestation rates;
    - area available for forest regeneration, and rates;
    - area available for agroforestry, and annual rates;
    - area available for plantations, and annual rates.

- The numerical estimates of land availability will be coupled in a spreadsheet with biomass density estimates for the different forestry approaches. The result will be estimates of 1) to what extent plausible changes in deforestation rates could slow the emission of carbon to the atmosphere in the first several decades of the next century, and 2) how much carbon could plausibly be removed from the atmosphere through increased reforestation, forest regeneration, and agroforestry early in the next century.

3.4 Land availability estimates

Although all the work just described has not yet been completed, land availability and implementation rates are now available for Africa and Asia. To summarize, Table 1 sums by continent the country-specific estimates for each evaluated land use. In interpreting the figures it is important to bear in mind that the estimates of land availability are intended to represent what might be reasonable for a country, not what is physically possible. Estimates of plantation land availability, for example, account not only for physical land availability, but also for the need believed to exist for additional plantation area. The estimate also takes into account the degree to which needs for fuel and timber might be met through regeneration and farm forestry if those are more cost-effective approaches to the production of the needed biomass. Estimates of what could be accomplished in each case by 2050 are intended to account for the current situation vis a vis country-specific policies and infrastructures, and for the ability to reduce the importance of these and other constraints over time. Although there is little doubt that these estimates are highly tentative and dependent on many variables that simply cannot be reliably predicted, they are intended to reflect a plausible and even optimistic scenario regarding abilities to change the devastating course of current land use trends.

Table 1 Land Availability and Adoption Rates (in millions of ha)

	Options - see key below								
	1	2	3	4	5	6	7	8	9
Africa	4.6	196	34.5	89.0	59.1	50.6	29.6	8.0	5.6
Asia	3.1	139	32.9	74.0	41.3	51.7	19.7	38.0	36.7
Total	7.7	335	67.4	163.0	100.4	102.3	49.6	46.0	42.3

Key for Table 1:

1 - Estimated current annual deforestation (closed and open)
2 - Projected deforestation to 2050, status quo
3 - Amount of deforestation that could be prevented through relatively aggressive policy efforts
4 - Amount of land available for regeneration
5 - Amount of land estimated regenerated by 2050
6 - Amount of land available for farm forestry
7 - Amount of land estimated in farm forestry by 2050
8 - Amount of land available for plantations
9 - Amount of land estimated in plantations by 2050

It is evident that the numbers just presented are dramatically below those cited in efforts to identify the amount of land theoretically as opposed to practically available for global warming forestry in any of its manifestations. Nevertheless, the figures as presented are by no means intended to provide a "worst case." Indeed, with the population and other pressures that are building in the studied countries, the scenarios presented here would represent dramatic increases in the effectiveness and magnitude of forestry programmes. For example, much of the land availability for Asia is estimated to be in India. Coincidentally, what is estimated to be feasible in India would come very close to meeting India's national goal of restoring tree cover to 1/3 of the national area. It is hard to imagine India achieving more than this, or wanting to achieve more than this, within the next 50 years.

3.5 Extrapolating to total carbon trends

Attempts to estimate the potential for carbon sequestration through forestry generally focus on efforts that involve the actual planting of trees, often one by one. In reality, of course, many things are occurring that will affect whether carbon is actually being stored or released on an overall basis. Some of these variables are as follows:

1 The replacement of natural forest cover with tree plantations is usually of no benefit from a carbon storage perspective. Unfortunately, many tropical plantations are in fact established on forest lands cleared specifically for the purpose. The plantation figures presented in Table 1 specifically assume the promulgation of plantations on lands not now under forest cover.

2 The net impacts of logging on carbon stores is difficult to assess. If being carried out on a sustainable basis, then logging can actually enhance total carbon storage (standing trees + long-term wood products). If being carried out unsustainably, logging can significantly affect carbon flows even if the statistics do not show up deforestation. It should be noted that global warming mitigation by no means necessarily calls for reductions in the use of wood products. Indeed, increased wood use can serve as an incentive to increase wood growth and overall carbon storage.

3 It appears that huge areas of closed forest around the world are not the climax forests they were believed to be, but instead are secondary forests that are still capable of accumulating carbon (Brown, pers. comm.). If the forests could be left to recover, even "mature" forests could accumulate a lot of additional carbon.

4 Ongoing land uses are often just as important to long-term carbon trends as large scale tree planting can be. Millions of hectares of plantations already exist in the tropics, although the data collected in this study suggest that many of them are far less productive than they could be. Millions of hectares are already in agroforestry uses, and these should be encouraged. Tropical agricultural lands could also store a lot more organic carbon than they currently do. Working within existing land uses to increase carbon storage should not be overlooked in the push to implement new land uses over large areas.

5 The economics of wood supply and demand are often ignored in estimating the potential for additional tree planting. There is little doubt that tree planting and management programmes of all sorts, ranging from natural forest management to farm forestry to plantations, will work best if they yield an economic return. Planting trees for their own sake, or just to soak up carbon, is a difficult concept to work with in the context of tropical forestry. Yet if everyone plants trees, the economic return may fall. This is particularly the case where countries wish to plant plantations or manage their forests for export purposes. If large scale tree planting around the world is undertaken, export markets will largely disappear since most countries are in fact capable of becoming self-sufficient in wood supply. Crediting new planted lands with carbon storage value must account for any lands taken out of tree cover because of perceptions that their value has now been lowered.

6 A major potential use of biomass not considered in this analysis was that of large scale energy production. If countries decided to utilize biomass to commercially produce electricity in modern power generation facilities, a huge demand for new biomass would be created. This could serve as an incentive to reforest very large areas of additional land in the tropics (or to deforest very large areas while "new" biomass is not yet available). There is considerable question, however, as to the economic competitiveness and sustainability of biomass as a fossil fuel substitute, and of the realism of putting the needed infrastructures into place in the foreseeable future.

There is obviously a need for comprehensive computer models with which to project the real carbon implications of the many activities affecting biotic carbon flows in one way or another. The actual carbon implications of some policy proposals may be quite different than a simple multiplication of hectares by carbon per hectare would suggest.

3.6 Preliminary policy conclusions

This study reflects the first attempt to systematically incorporate social and economic variables into estimating the overall potential for tropical forestry to help slow global warming. In addition, it is the first time the country-specific views of country experts have been sought out to this end, and additional insights are welcome. Some of the conclusions that can be tentatively reached from the analysis, as reflected in the figures in Table 1, are:

- Deforestation can be significantly slowed in many but not all countries, but it will take decades to achieve the full benefit of such efforts. From a carbon perspective, slowing deforestation rates can be much more immediately effective in storing carbon than reforestation programmes, although by 2050 this is probably no longer the case. This is because it will often be easier to replace carbon stores in one part of a country than it will be to rapidly reduce deforestation in another.

- There is dramatic potential for the implementation of forest regeneration and farm forestry options, and in many cases these are likely to be much more economic means of meeting local needs (as well as carbon storage objectives) than plantations could be. It is likely that we cannot come close to achieving the overall potential to regenerate unproductive imperata and other grasslands, as well as other degraded lands, by 2050. This is because the priority assigned to such efforts will remain low while other wood supplies are available, and regeneration can pose significant technical and economic problems. Nevertheless, the single most important intervention into human activities resulting in carbon emissions may be that of fire control. Uncontrolled fires now maintain huge areas of land in a grassland climax, actively impede nature's efforts to regenerate forest on such grasslands, and also pose major threats to other forestry efforts.

  It also appears unlikely that we can implement agroforestry practices on all available lands by 2050. The success of such efforts is highly dependent on extension and other services that are in critically short supply on a global basis.

- On a regional basis plantations do have an important role to play in long-term carbon storage. In many individual countries, however, plantations are far less important than other options. Because of the relatively limited amount of land committed to plantations under the scenario, and the infrastructures already available to plant such lands, it does appear that all the called for plantations can be implemented over the next several decades.

More general policy conclusions include:

- It is attractive to conclude that large areas of tropical land are degraded and abandoned and are therefore available for tree planting. Country-specific research suggests this is not the case, and that issues of land ownership will be important.

- Land availability per se is not the primary constraint to global warming forestry in the near to mid-term. Social, political, and infrastructural barriers will keep plausible reforestation rates very modest for at least a decade or so. Even then, the rate at which reforestation can realistically be accomplished is modest compared to the plausible availability of land in many countries of the tropics.

- It is important to recall that the success stories that do exist in the tropical forestry sector tend to be quite site specific. This suggests that achieving similar successes in other areas will be dependent on thorough understandings of the local situation. This will dramatically slow our ability to move directly to the large scale implementation of virtually any forestry management option.

- Global warming mitigation through forestry cannot be successfully tackled by the forestry community alone, yet many important sectors are not yet involved in the debate. The successful implementation of large-scale forestry management options will be dependent on large-scale policy reform in the land tenure and tax arena, on large-scale increase in agricultural productivity, and on long-term efforts to stabilize population and other pressures on the natural resource base. It is these linkages that raise questions about the ability of an international forestry instrument to successfully cope with the overall problem.

Because deforestation is high and will have to be slowed incrementally, and because reforestation programmes are still very small and will have to grow over time, it is likely to be several decades before tropical land use change can have the effect of turning the tropics into a net sink for carbon. This is far from a reason to abandon the effort, since tropical land use change may otherwise contribute very large quantities of carbon to the atmosphere. However, it does throw into serious question the prospect of using tropical forestry to offset fossil fuel emissions in the developed or developing worlds. Instead, aggressive efforts must proceed on both fronts.

Part B 4 Economic and Cost Issues

Afforestation and Forest Management Options and Their Costs at the Site Level

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1 INTRODUCTION

Boreal, temperate and tropical forests occupy over one third of the Earth's land surface area. Currently, a relatively small proportion of the world's forests are managed on a sustained basis (Allan and Lanly, 1991). Expansion or intensification of establishment and management practices can improve the continuous flow of goods and services from boreal, temperate and tropical forest systems. Within tropical latitudes, over 2.5 billion people live in or near forest ecosystems and are highly dependent on fuel, food and fibre produced by trees (Taylor and Medema, 1988). Forests play a significant role in political, social and economic stability in developed and developing countries (OTA, 1984).

The status and development of forests has been influenced by continuous demographic, land use and environmental pressures (Gregerson et al, 1989; Schneider, 1989). Interest in the forest sector and sustainable management options has increased in recent decades due to rapid global forestation, loss of biodiversity, energy and commodity scarcity, desertification, and accumulation of greenhouse gases in the atmosphere (Maini, 1991; NAS, 1991). Forestation and management of existing forests may offer relatively low-cost options to slow deforestation, protect soils and watersheds, provide a continuous source of fuel, food and fibre, and conserve or sequester carbon in the terrestrial biosphere (Allan and Lanly, 1991; IPPC, 1990). An essential pre-condition of effective forest measures, including a sustainable impact on the resource, is whether management options meet local social and economic objectives (Gregerson, et al, 1989).

A number of proposals have been made in the past year for an international convention, charter, protocol or other agreement to maintain, manage or protect boreal, temperate or tropical forests (MAINI, 1991). The 1985 Tropical Forest Action Plan and 1989 Noordwijk Conference recognized the role of forests in transnational environmental issues, including global climate change, and stimulated interest in accelerated forestation and sustainable ecosystem management options. Three primary science-policy forest management goals can be identified in these proposals for a global forest instrument:

1 Assess land availability and suitability in different regions/biomes to meet Noordwijk afforestation targets and proposed Global Forest Agreement goals.

2 Identify promising technologies and practices that could be utilized at different sites to establish and manage forests while meeting local and regional environmental, social and economic objectives.

3 Assess costs and benefits of various management options for sustainable forest development including implications for agriculture, forestry and economic development.

The objective of this paper presented under agenda 4.8 of the workshop is to: 1) review the overall scope of forest management and land availability in boreal, temperate and tropical forest biomes, 2) report a range of forest establishment, management and protection costs at the site level for representative countries, and 3) consider options and the cost of forest establishment and management technology in selected case studies of India, West Africa and Union of Soviet Socialist Republics (U.S.S.R.). Data presented in this paper was derived from literature reviews and case studies of management options in the forest sector. Economic assessments are presented in 1990 U.S. dollar cost estimates, are subject to currency fluctuations and should not be considered absolute. Interest rates for individual countries were based on consumer price indices compiled by the International Monetary Fund. Cost data is presented for the purpose of relative comparisons.

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A relatively small proportion, less than 10%, of the Earth's 4.07 million hectares of forests are managed. Forest management is the application of biological and/or economic principles to produce sustained forest-based goods or services (Davis and Johnson, 1987). Boreal and tropical systems constitute approximately 75% of world forests, yet less than 3% are managed. The relatively limited application of management options within tropical latitudes, coupled with lack of incentives and benefits for local populations, contribute to accelerated deforestation and land degradation (Shepherd, et al, 1991). Approximately 25% of temperate forests are actively managed. Long term assessments in Europe and North America suggest forest productivity and health can be improved through appropriate management (Allan and Lanly, 1991). Recent analyses suggest the area of the Earth's forests under sustained management will not increase without policy changes to stimulate action to strengthen forest management (Brown et al, 1989).

Globally, up to 17 million hectares of forests are degraded or harvested annually (WRI, 1990). The 1989 Noordwijk Conference, considered options to sequester carbon in forest ecosystems to mitigate global climate change, and identified a target of a global net increase in forest cover of 12 million hectares, annually, by the year 2000. It has been estimated that a rapidly growing forest area of 400-500 million hectares is required to sequester 3 Pg of atmospheric carbon dioxide (CO_2) (NAS, 1991). Estimates of global land available for forestation varies widely with method of estimation (Grainger, 1988). Edaphic and climate, as well as social, political and economic factors influence land available for expansion of forest area (Trexler, 1991). The opportunities and limitations posed by socio-economic and political issues have been fully considered by others and will not be reviewed in this paper (Maini, 1991).

Table 1 Estimating land availability by forestation class (plantation or agroforestry) world wide

	Latin America	Africa	Asia	North America
Logged forest				
Plantation	16	32	42	11
Agroforestry	37	11	18	1
Sub Total	53	43	60	12
Fallow Land				
Plantation	20	29	23	14
Agroforestry	46	30	34	3
Sub Total	66	59	57	17
Watersheds				
Plantation	3	1	17	11
Agroforestry	25	2	39	2
Sub Total	28	3	56	13
Arid Lands				
Plantation	175	160	33	6
Agroforestry	264	262	68	1
Sub Total	439	422	101	7
Total	586	527	274	49

Sources: Grainger 1988, FAO 1987, Houghton et al 1991

A review of recent literature suggests 0.5 to 1.5 billion hectares of land may be potentially available to establish or re-establish forest or agroforest systems (table 1). A significant proportion of this land occurs in Africa, Latin America and Southern Asia. Logged forests, fallow land, unprotected watersheds or semi-arid lands are four categories of land available for forestation. Country-level estimations of land available for forestation varies widely due to the matrix of biophysical, social, political and infrastructural variables influencing classification systems. A complete review of this topic is beyond the scope of this paper and is presented by Grainger (1988) and Trexler (these proceedings).

Forestation practices range widely and include, but are not limited to, natural or artificial seeding, planting of bare-root or containerized seedlings, or coppicing of cut-over stands (Anderson, 1987). Application of seedling establishment technology varies with forest sector infrastructure, site conditions, knowledge and finances (Trexler, 1991). Most countries with a sustained forest products industry have established a system for forestation (Allan and Lanly, 1991). However, the national breadth, intensity and success of these programmes varies significantly. In 1990, the cumulative global area of land artifically forested was 130 million hectares, of which 25-30 million hectares are within tropical latitudes.

Table 2 Forestation costs at site level for selected regions/countries

Region/country	Family/Genera	US$/ha	Management Level*
Africa			
Congo	Eucalyptus	1400	VI
Ghana	Eucalyptus	275	M
Senegal	Acacia	700	I
S.Africa	Pinus	600	I
Sudan	Acacia	30	M
Zaire	Eucalyptus	100	M
Asia			
China	Populus	375	I
India	Casuarina	200	M
Malaysia	Dipterocarp	150	M
Pakistan	Prosopis	250	I
Philippines	Leucaena	175	I
Thailand	Leucaena	250	I
Europe			
France	Quercus	700	M
United Kingdom	Picea	1100	VI
Germany	Quercus	1500	VI
USSR	Picea-Pinus	150-200	M
Latin America			
Brazil	Eucalyptus	800	VI
	Pinus	800	I
Ecuador	Ochroma	650	I
Colombia	Eucalyptus	150	M
Chile	Pinus	175	I
North America			
Canada (BC)	Picea	1000	I
United States			
South	Pinus	600	I
West	Pseudotsuga	1200	VI
Haiti	Eucalyptus	50	M
Oceania			
New Zealand	Pinus	300	I

Sources: Allan and Lanly 1991, Anderson 1987.

* Management levels: VI = very intensive, I = intensive, M = moderate

The cost of forestation at the site level ranges from $30-$2,500/hectare for the 26 countries surveyed (table 2). Cost estimates include site preparation, seedling establishment and early protection but not access to the land. Intensive management of temperate forests on high quality sites generally have the highest forestation costs (Moulton and Richard, 1990). Establishment of easily coppiced, multi-purpose tree species and agroforestry systems on low to moderate sites within tropical latitude is least expensive ($30-$150/hectare) (Houghton, et al, 1991). Forestation success generally varies with intensity of management. Boreal forest systems are relatively difficult to establish and the cost varies from $150-$1,000/hectare, depending on site conditions, species, accessibility and forest sector infrastructure (Pisarenko, 1989). Forestation will continue to make a major contribution in compensation for deforestation losses in boreal and tropical systems, if social and political needs can also be accommodated. For example, establishment of a one hectare agroforestry system to provide food, fuel and fibre can offset deforestation in Latin America by 5-20 hectares (Sanchez and Benites, 1987).

3 COSTS OF FOREST MANAGEMENT AND PROTECTION PRACTICES AT THE SITE LEVEL.

The growth, health and yield of boreal, temperate and tropical forests can be significantly improved through application of management and protection technologies (Allan and Lanly, 1991). Intermediate silvicultural practices such as thinning, weeding, fertilization with nutrients, irrigation or drainage have been applied to improve forest growth and yield (Shepherd, et al, 1991; Pisarenko, 1989; Burley and Stewart, 1985). Protection of trees from insects, disease, grazing animals, pollutants or fire is employed unevenly in boreal, temperate and tropical systems. For example, the 1980's have witnessed a dramatic increase in the occurrence of fire within tropical and boreal forest biomes (Houghton, 1990). The proportion of managed forest systems is relatively low and the application of silvicultural practices and protection technologies could be significantly expanded (Andrasko, et al, 1991).

The cost of intermediate silvicultural practices at the site level ranges from $3-$400/hectare for the countries surveyed (table 3). Thinning and fertilization of temperate forest stands are the most expensive of the silvicultural practices reviewed (Moulton and Richards, 1990). Mechanization, availability, cost of labour and technology, site conditions, rotation length and species influence these estimates (Burley and Stewart, 1985). Current trends in temperate forest management are clear, the area of productive closed forest (conifer and broadleaf) is relatively stable, and growing stock and annual biomass increments have significantly increased (Allan and Lanly, 1991). In contrast, within tropical latitudes, silvicultural practices are primarily employed in deciduous forests (e.g. Tectona and Shorea) or in plantations and agroforestry systems, where the original forest is depleted.

Forests are subject to periodic damage from a variety of biotic (pathogens, insects) and abiotic (fire, pollutants) agents, including edaphic and climatic stressors (FAO, 1987). Fire, snow, insect and pollution damage are particularly extensive in boreal and temperate forest systems (Allan and Lanly, 1991). Technologies are available to mitigate stress and damage agents but the extensive area and long term growth cycle of forests precludes sustained protection. Indeed, many forest management systems were developed to cope with chronic stresses and avoid catastrophic events (Davis and Johnson, 1987). Tropical forests are also subject to a variety of damage or stress agents, but anthropogenic exploitation and degradation continues to be a major concern (Houghton, 1990).

Protection of boreal, temperate and tropical forest systems is a continuous activity and the cost ranges from <$1-$8/hectare/year (table 4). Fire and pest protection is relatively extensive within temperate forests and the costs are among the highest for the countries surveyed (Moulton and Richards, 1990). Animal husbandry and cultural practices within tropical latitudes require investment in protection of forest from grazing animals, especially goats and cattle (Taylor and Medema, 1988). For example, forest guardians are a necessary forest protection mechanism in multiple use agroforestry systems throughout South Asia and Central Africa (MacDicken and Vergara, 1990). Forest degradation in India is partially ascribed to more than 800 million animals grazing the forest.

Table 3 Cost of silvicultural practices at site level for selected regions/countries

Region/country	Family/Genera	US$/ha	Practice
Africa			
Congo	Eucalyptus	50	thinning
Ghana	Eucalyptus	5	thinning
Senegal	Acacia	15	thinning
S.Africa	Pinus	60	fertilization
Sudan	Acacia	3	thinning
Zaire	Acacia/Prosopis	10	thinning
Asia			
China	Populus	30	thinning/weeding
India	Casuarina	10	thinning
Malaysia	Dipterocarp	30	thinning
Pakistan	Populus	20	irrigation
Philippines	Leucaena	15	thinning
Thailand	Leucaena	20	thinning
Europe			
France	Quercus	100	thinning
United Kingdom	Picea	150	thinning
USSR	Picea/Pinus	40-60	thinning
Latin America			
Brazil	Eucalyptus	20	fertilization
Ecuador	Ochroma	10	thinning
Colombia	Eucalyptus	40	thinning
Chile	Pinus	85	thinning
North America			
Canada (BC)	Picea	100	thinning
United States			
South	Pinus	70-125	fertilization
West	Pseudotsuga	400	thinning
Haiti	Acacia	10	weeding
Oceania			
Australia	Eucalyptus	125	thinning
New Zealand	Pinus	100	fertilization

4 CASE STUDIES: INDIA, WEST AFRICA AND U.S.S.R.

The previous section surveyed the recent cost estimates of forest establishment, management and protection for major forest regions of the world. Three more examples (India, West and Central Africa and U.S.S.R.) of forest establishment and management options and their costs and benefits at the site level will be reviewed.

4.1 India

The subcontinent of India once contained significantly more land area in temperate and tropical forest systems than today. A growing population, sporadic rainfall and unsustainable land use practices have resulted in over 43 million hectares of substandard or degraded soils (Sharma, et al, 1989). These

Table 4 Cost of forest protection practices at site level for selected regions/countries

Region/country	Family/Genera	US$/ha/yr	Practice
Africa			
Congo	Eucalyptus	2	fire control
Ghana	Eucalyptus	1	pest management
Senegal	Acacia	<1	animal management
S.Africa	Pinus	2	pest management
Sudan	Acacia	<1	fire control
Zaire	Acacia	<1	fire control
Asia			
China	Populus	1	pest management
India	Casuarina	2	animal management
Malaysia	Dipterocarp	2	pest management
Pakistan	Leucaena	<1	pest management
Philippines	Leucaena	2	pest management
Europe			
France	Quercus	3	fire control
United Kingdom	Picea	2	fire control
USSR	Pinus	<1	fire control
Latin America			
Brazil	Eucalyptus	<1	pest management
Ecuador	Ochroma	2	pest management
Colombia	Eucalyptus	1	fire control
Chile	Pinus	2	fire control
North America			
Canada (BC)	Picea	3	pest management
United States			
South	Pinus	5	fire management
West	Pseudotsuga	4-8	fire management
Haiti	Prosopis	1	fire & pest mgmt.
Oceania			
Australia	Eucalyptus	3	fire management
New Zealand	Pinus	3	fire management

degraded soils support sparse vegetation and have very poor biological, physical and chemical properties (e.g. infertile, highly impermeable and high salt content). Growing fuel, fodder and food deficits in over 500,000 villages prompted the Government of India to establish tree plantations and forest management programmes on these wastelands. The Ministry of Forests and Environment, National Wasteland Development Board, Department of Non-Conventional Energy Sources and other agencies have spearheaded a programme to establish over 5 million hectares of trees on degraded lands in the 1980s (Jain, et al, 1989).

The costs and benefits of forest establishment and management for representative sites in four locations in India are presented in table 5. Initial investment costs to establish plantations or agroforestry systems range from $30-$150/hectare. Intensive management of Populus plantations in the Punjab requires significant investment in site preparation and seedling costs. Establishment and management of multipurpose tree species in woodlots or agroforestry systems are less expensive, even on degraded soils (Taylor and Medema, 1988). The financial internal rate of return, to the farmer, ranges from 6-50%. The highest rate of financial return was associated with short term forest management options. Ancillary benefits of forest management practices include soil reclamation and sustained flow of food, fuel or fibre to resource-poor farmers (Shepherd, et al, 1991).

4.2 West and Central Africa

Dry tropical forests occupy large areas of West and Central Africa (WRI, 1990). A growing population and commensurate demand for food, fuel and fibre, animal grazing practices and unfavourable edaphic and climatic factors have contributed to a reduction in the size and condition of primary and secondary forests (Allan and Lanly, 1991). Sustainable forest and agricultural management options are required to provide goods and services to rapidly growing local populations. A long term tradition of farm forestry or agroforestry systems by local populations provide viable options to establish and manage trees (Shepherd, et al, 1991).

Table 5 Cost and financial rates of return for selected forest establishment and management options in India (Gregerson, et al, 1989; Sharma, et al, 1990).

State	Option	Initial Investment (US$/ha)	Rotation (years)	IRR (%)	Comments
Punjab	Eucalyptus/ Populus plantation	150	5-10	15-25	Intensive management
Tamil Nadu	Casurina fuelwood	30	4-6	30-50	Soil reclamation
Uttar Pradesh	Shorea plantation	60	30-50	6-10	Minimal management
Kerala	Leucaena Maize agroforestry	55	5-7	18-30	Adequate rainfall and nutrition

Establishment and management of multipurpose trees on small farms (15-30 hectares) in short rotation culture have a favourable financial return on investment because of multiple goods and services derived (e.g. food, fuel, fibre) (Table 6). Agroforestry systems, which produce an annual food crop, have the highest internal rate of return. The initial investment cost at the site level range from $20-$45/hectare. Farmers are willing to invest in agroforestry systems which minimize their risk and maximize income (MacDicken and Vergara, 1990).

4.3 U.S.S.R.

The Union of Soviet Socialist Republics (U.S.S.R.) covers one sixth of the world's land area and contains approximately 810 million hectares of forest (Anuchin, et al, 1986). Boreal forest systems occur primarily in the Russian Republic and they occupy 800 million hectares of the U.S.S.R. The extensive area of forests in the U.S.S.R. and their remote nature currently precludes wide application of intensive management options. Dominant forest genera include Larix, Pinus, Betula, Picea, and Populus. Biomass growth ranges from 0.5 to 20 m^3/hectare/year and is highly dependent on tree species and site conditions (Table 7).

Table 6 Costs and financial rates of return for small farm fuelwood and agroforestry systems in West and Central Africa (J.Francois, Chief Conservator of Forests, Department of Forestry, Ghana, personal communication; Gregerson, et al, 1989).

Country	Average farm size (ha)	Genera grown	Rotation (years)	End Product	Initial invest-ment (US$/ ha)	IRR to farmer
Ghana	15	Casuarina	7	fuel/ furniture	20	9-32
Malawi	15	Casuarina/M aize	8	poles/ grain	35	65
Nigeria	30	Eucalyptus	10	poles/ fuel	45	7.4 (16.9)*
Senegal	20	Acacia /millet	5	gum arabic/ grain	30	15

* IRR (internal rate of return) increases to 16.9 if soil conservation is considered in analysis.

Table 7 Areal distribution and productivity of forest ecosystems in the U.S.S.R. (Anuchin, et al, 1986)

Ecoregions	Area (million ha)	Genera mix	Biomass m^3/ha/yr
Europe/Ural	191	Pinus Picea	1.6
West Siberia	90	Pinus Larix	1.3
East Siberia	242	Larix Pinus	1.2
Far East	270	Larix Pinus	0.8
Central Asia	18	Populus Juniperus	1.5
Total	811		

Forest establishment and management technology are applied in some regions of the U.S.S.R., but a relatively small proportion of the total forest area is intensively managed (Table 8). Over two million hectares of cut-over forests are reforested annually at a cost of $50-$200/hectare. Thinning of densely stocked stands, drainage of wet forest soils and protection (eg, fire) of boreal forest systems cost $30-$60/hectare. A well developed system of roads and a centralized forest management infrastructure reduce the cost of afforestation, thinning and protection in the steppe region.

Table 8 Forest establishment, management and protection practices and the cost in the boreal and steppe regions (Pisarenko, 1989).

Ecoregion	Forest Technology	Land area (million ha)	cost/ha (US$)
Boreal	forestation	1.0 (artificial) 1.2 (natural)	150-200 50-70
	thinning	3.1	30-40
	fire control	200 (land) 400 (aerial)	2-10
	drainage	0.1	50-60
Steppe	forestation	0.3 (artificial)	60-80
	thinning	0.1	20-30
	protection	0.1	2-4

5 SUMMARY AND CONCLUSIONS

Interest in the forest sector, especially concerning opportunities to mitigate projected climate change, protect biodiversity and provide a sustained flow of goods and services, has focused attention to biologic and economic management options at the site level. However, a relatively small proportion of global forests are managed. Because of recent deforestation patterns and economic development needs, the Tropical Forest Action Plan (TFAP) was developed to support sustainable biologic, social and economic options for wet and dry tropical forest systems (FAO, 1985). An analysis of TFAP intensification of some forest management practices within tropical latitudes has been linked to an increase in deforestation, and alternative sustainable options are required. Anthropogenic degradation of temperate and boreal forest has also stimulated efforts to identify and implement silvicultural options sensitive to environmental and social needs.

Despite the growing interest in the forest sector, only a small proportion of boreal and tropical forests are sustainably managed. Past and current social, political and economic policies have not always encouraged sustainable management of forest or agroecosystems, particularly within tropical latitudes (OTA, 1984). A wide array of silvicultural practices and technologies, acceptable to local populations, presently exists to establish, manage and protect forests. Moreover, long term assessments suggest some of these practices are biologically sustainable and economically viable (Allan and Lanly, 1991). Despite long rotation lengths and initial investment costs, the financial rate of return from goods and services harvested from forests is comparable to other investment options. Forest provide income, employment and social stability throughout the nations of the world. Non-monetary benefits such as protection of biodiversity, conservation of terrestrial carbon and recreation/aesthetic value are not normally considered in the traditional economic analyses, but should be considered in future policy analysis and decisions.

A wide range of sustainable establishment and management options are available to provide a flow of goods and services from boreal, temperate and tropical forests. Many of these management options are sensitive to environmental, social and economic needs of developed and developing countries. Forest establishment and management are logical, regardless of climate change, biodiversity and deforestation issues. The Global Forest Instrument or Agreement should be designed to encourage sustainable forest establishment and management options which meet local, national and international needs.

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Cost and Performance of CO_2 Storage in Forestry Projects

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1 INTRODUCTION

As the major sources of anthropogenic carbon dioxide (CO_2) emissions are fossil fuel use and tropical deforestation, the principal opportunities for emission reductions are implementing alternative energy technology and reversing deforestation, especially in tropical countries. Tropical deforestation contributes approximately 20 percent of current global carbon emissions (Schneider, 1989). The rate of tropical deforestation in the early 1980's was estimated at 11 million hectares per year, contributing approximately 1600 million tons of carbon to the atmosphere each year (Lanly, 1983; Houghton, et al, 1987). Recent estimates of deforestation rates are even higher (Myers, 1989; WRI, 1990).

The tropical land area that can potentially be spared from deforestation or rejuvenated through reforestation is large, of the order of a billion hectares (Myers, 1989; Houghton, 1990). This represents a major sink for global carbon emissions, and potentially one of the least expensive measures available for slowing the rate of CO_2 accumulation. Because land and labour, the two principal inputs, are inexpensive in most tropical nations, and because biomass growth rates are high, this carbon storage "technology" can achieve relatively low costs. Thus, reversing the trend of tropical deforestation, and promoting reforestation worldwide, is considered part of a global strategy to reduce the net atmospheric accumulation of CO_2. In late 1989, the European Ministerial Conference on Atmospheric Pollution and Climate Change proposed an agreement to stabilize OECD carbon emissions by the year 2000 and to achieve a net annual reforestation rate of 12 million hectares (Noordwijk Declaration, 1989).

Although there are many potential opportunities for reducing net carbon emissions in developing countries, the necessary technology and financial resources are concentrated in the industrialized nations. Moreover, the dominant responsibility for the climate change problem is clearly with the industrialized nations, who have borrowed the assimilative capacity of the atmosphere in building their affluent economies (Smith, 1989). Even if these nations agree to their level of responsibility, or their share of the remaining assimilative resource, some industrialized nations will likely be physically or technically limited in their ability to reduce emissions to the necessary level. Thus, it appears that it will be less painful for nations to agree to an emission reduction goal and to accept their share of the responsibility for meeting the goal if they are able to capture some of the reduction opportunities in other countries.

A variety of world fund mechanisms and emission trading systems have been proposed to transfer resources, when necessary, from nations with unfulfilled responsibility to those with unexploited opportunities (WRI, 1989, Swisher and Masters, 1989; Grubb, 1989; Goldemberg, 1990). Under such systems, each hectare of forested land, or land that can potentially be reforested sustainably, could provide a valuable environmental service to investors worldwide. In order to include forestry projects as a way to reduce net CO_2 emissions, it is necessary to determine the rate of equivalency between tons-carbon (TC) of fossil fuel emissions and tons of carbon stored by trees. The relevant unit of measurement is the increment in CO_2 flux, expressed as tons of carbon-equivalent, out of the atmosphere, compared to existing conditions (in the case of carbon removal) or to a reference conditions (in the case of prevention).

2 CARBON-SAVING SERVICES

Sustainable forestry can be defined as forest sector practices that maintain or increase both the forest resource stock and the flow of forest products over time. There are different types of forestry projects, each with different costs and different carbon flows (Trexler, 1990; Gradwohl and Greenberg, 1988). Reversing the trend toward deforestation involves two general approaches, which comprise seven different forestry project classifications:

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- Protect remaining forested land in forest reserves or natural forest management programmes;
- Reforest land using natural restoration, forest plantations, fuelwood farms or biomass energy plantations, and agroforestry.

Of these project classifications, forest restoration is the least common. Its goal is to restore degraded land to forest cover with as much of the natural biological diversity as possible. The restoration process may imitate the natural succession process by starting with fast growing exotic species and fire control to improve soil productivity. Later the propagation of native species is encouraged, using protected natural forest remnants as seed sources (Janzen, 1986).

Forest reserves are a more familiar project classification, encompassing many projects in which existing forest land is protected and maintained in a natural state, with little commercial exploitation. Timber plantations are also common, especially in temperate latitudes. These are commercial projects in which fast growing trees are planted and harvested in a continuous rotation to yield timber, paper and other products.

Agroforestry is the cultivation of trees on the same land with agricultural crops and/or livestock, which benefit from the ecological interaction between the trees and other components, to produce multiple outputs including wood, fruit, animal feed and fertilizer (Nair, 1989). Types of agroforestry projects include shade trees with perennial crops (eg. coffee or cacao), agrosilviculture (trees with annual crops), alley cropping (alternative rows of trees and crops), silvopastoral systems (trees with livestock), live fences and windbreaks, mixed homegardens, shifting cultivation with managed forest fallow, and taungya (crops grown together with young trees in forest fallow) (Budowski, 1987). The variety of outputs produced and the perennial ecology of agroforestry systems promise both economic and social benefits, and this approach is being seen increasingly as a replacement of non-sustainable land use practices in tropical regions (Winterbottom and Hazelwood, 1983).

Fuelwood farms are similar to timber plantations, except that they are usually planted on a smaller scale and provide some or all of their harvest to meet local fuel needs. Like agroforestry systems, fuelwood farms can be designed to relieve local pressure to cut native forests, allowing the protection of some area of standing trees. Biomass energy plantations, on the other hand, are planted specifically to produce fuel for commercial energy production, such as electricity generation.

Natural forest management involves the use of standing natural forests to produce timber, fibres, rubber, fruits, nuts and other outputs on a sustainable basis. At the same time the ecological functions of the forest, including watershed protection and erosion control, can be preserved (Gradwohl and Greenberg, 1988). An example of natural forest management is in the dipterocarp forests of Malaysia, where natural forest is harvested and thinned in order to promote the regrowth of the desired species.

Forest restoration, timber and biomass energy plantations, and the reforestation aspects of agroforestry and fuelwood farms store carbon in biomass grown in the project, offsetting emissions elsewhere. This opportunity has already been explored by a U.S. electric power company that contributed $US 2 million to a project that will plant 52 million trees in Guatemala (New York Times, 1988; Trexler, et al, 1989). For such projects, the carbon storage measurement must be adjusted to account for differences in the eventual fate of the biomass (standing trees, lumber, fuelwood, etc).

Forest reserves, natural forest management, and the protection aspects of other projects store carbon and prevent new emissions to the atmosphere, provided they are legally protected with an endowed budget for operation and maintenance. If carbon storage credit is considered for replanting but not protection of existing natural forests, there would be a counter-productive incentive to remove the natural forest and then replant. Although this strategy is sometimes suggested as a way to increase the rate of CO_2 removal by trees, it would likely result in a net carbon flux into the atmosphere (Harmon, et al, 1990).

3 COSTS OF CARBON STORAGE

Of course, carbon saving services need not be forest projects. Other possibilities include energy efficiency projects and renewable energy projects, which produce no CO_2. Investments in these energy projects would reduce net carbon emissions in proportion to the carbon-equivalent of the energy saved or produced. In order to compare the costs of carbon storage in a forestry project with the costs of other carbon emission reduction measures, such as alternative energy projects, the cost should be expressed in terms of the tons-carbon (TC) stored by the project. The cost should account for the possibility of leveraging through debt-for-nature (DFN) exchanges or other mechanisms. The carbon storage estimate should account for the possibility that some part of the project either will not succeed, or would have been done away. In either case, the effective carbon stored would decrease, and the cost per ton would increase.

$$\text{Total unit cost} = C_{net}\, X_{net}/(R_{net}\, F_{net}) \qquad [1]$$

where: C_{net} = Net cost of the carbon storage project (\$/ha)
X_{net} = Net ratio of cost with leverage to cost without leverage
R_{net} = Net increase in carbon storage from the project (TC/ha)
F_{net} = Ratio of net carbon emission reduction to net carbon stored by the project.

In the following analysis, cost values that are originally in foreign currencies are converted to US dollars using the interbank free exchange rate prevailing at the time for which the cost values are expressed. The dollar costs are then converted to 1989 dollars using the GDP deflator.

The cost of the project itself, C_{net}, must include the total amount of money that would have to be provided to establish, maintain, manage and monitor the project, rather than carrying out the landuse that the project replaces. Thus, C_{net} must include the opportunity cost for the land on which the project is implemented.

$$C_{net} - C_{opp} + C_{est} + C_{mnt} + C_{mgm} + C_{mon} \qquad [2]$$

where: C_{opp} = Opportunity cost of the project
C_{est} = Cost of establishing the project
C_{mgm} = Cost of management and extension services
C_{mnt} = Cost of an endowment to maintain the project
C_{mon} = Cost of an endowment to monitor the project's performance

The opportunity cost is the difference between the value of the land without the project and its value with the project (excluding the value imparted by the project itself). In the simplest case, the opportunity cost is the land value (P_{land}). If the project allows production of some marketable outputs together with the carbon savings, the value of these commodities must be considered to reduce the opportunity cost. These values are calculated for each year beginning the first year that gross revenues are sufficient to cover costs. Costs incurred before that time are incuded in the cost of maintaining the project, as described below. Production costs include harvesting, maintenance and protection (Sedjo, 1983).

$$C_{opp} = \text{Maximum}\ (0, P_{land} - NPV_{prod}) \qquad [3]$$

$$\text{where: } NPV_{prod} = {}_t\Sigma(GR_t - PC_t)/(1+r)^{t-1} \qquad [4]$$

and: r = Discount rate
GR_t = Gross revenues from the land's output in year t
PC_t = Production costs of project inputs in year t

The cost of establishing a forestry project includes the costs of seeds or seedlings and other materials; labour costs for site preparation, planting, and building access roads; and materials and labour for replanting trees that do not survive the first year (Durst, 1987). These costs are highest for forest restoration projects and lowest for agroforestry programmes. Management costs include the cost of overall administration and technical supervision, and the costs of training, technical assistance and extension services to provide for a sufficient level of technical competence on the part of the participants (Canet, 1989). These costs tend to be substantially higher for projects that involve agroforestry or smallholder plantations.

Both the maintenance and monitoring costs are recurring costs over the life of the project. To see that these costs are covered, and to provide an ongoing incentive for participation in the project, these costs must be provided for in the project funding. They include the cost of an endowment to provide for ongoing monitoring and for maintenance until the project yields sufficient revenues to cover future costs. Maintenance costs include weeding and thinning, road maintenance, and fire protection (Sedjo, 1983). These costs tend to be higher for projects that involve long term protection of mature or growing forests.

Monitoring costs include updating of site surveys, before and after soil testing, and destructive tree measurements (CARE, 1989).

4 MEASURING CARBON STORAGE IN FORESTRY PROJECTS

The score keeping procedure for carbon storage in forestry projects must account for the variation in growth rates among different biological resources, the timing of carbon storage over the forest life cycle, and the different fates of wood, leaf and soil carbon under different types of land use. Although these differences can lead to a great deal of detail, the procedure must be simple enough to be compatible with information that would be available to development organisations, government departments and private companies. Thus the procedure should incorporate only the most important parameters, such as species, climate, soil type, planting density, and the land management type and rotation time (Lugo, et al, 1988).

Each of the project classifications is different in terms of their carbon storage potential. Some store carbon in standing natural forest, some accumulate carbon in new biomass grown in the project, some accumulate carbon in harvested products that enter long term storage, and biomass energy plantations prevent carbon emissions from fossil fuel use. For the purpose of this analysis, the dynamics of the carbon flows over time are not considered. Rather, only the long term (more than 20 years) average or steady state carbon storage density is analysed.

The basic form of the net carbon storage credit (R_{net}) for a particular project, compared to a reference land use, is given as (adapted from Hall, et al, 1985):

$$R_{net} = A\,(CV_p + CS_p - CV_r - CS_r) \qquad [5]$$

where: A = Area of project in hectares (ha)
CV_p = Carbon stored in vegetation by the project (TC/ha)
CS_p = Carbon stored in soil by the project (TC/ha)
CV_r = Carbon vegetation for the reference condition (TC/ha)
CS_r = Carbon stored in soil for the reference condition (TC/ha)

For a specific project or reference case, the vegetation carbon (CV) terms in this equation (CV_p and CV_r) can be elaborated, assuming that carbon stored in ground litter and other organisms is negligible, according to:

$$CV = CV_{nat} + CV_{av} + CV_h \qquad [6]$$

where: CV_{nat} = Carbon storage density in natural forest
CV_{av} = Average biomass carbon during the rotation of plantation
CV_h = Steady state carbon value of the harvested biomass

For each forestry project classification, we can now relate the terms in equation 6 to the different flows of carbon in a project. Each type of carbon flow (standing biomass, new biomass, harvested biomass) corresponds to one term (CV_{nat}, CV_{av}, CV_h). As shown in table 1, the different project classifications are distinguished by the carbon flow terms that are relevant, in which case they are represented by a "+" in table 1. Carbon flows that are not relevant for a given project classification are represented by a "0" in table 1.

The carbon storage density in natural tropical forests, as a function of climate, is given by (Brown and Lugo, 1982):

$$CV_{nat} = 298 + 239 \log Z - 112Z \qquad \text{(TC/ha)} \qquad [7]$$
$$CS_{nat} = 154 \exp(-0.45Z) \qquad \text{(TC/ha)} \qquad [8]$$

where Z = Average annual (temperature/rainfall) in °C-year/dl

In general, the reference condition will be assumed to be pasture or low intensity agriculture, for which (Whittaker and Likens, 1973):

CV_r = 5 T-C/ha

Table 1 Parameters for Calculation of Carbon Storage by Land Use Classification

Sustainable Forestry Projects	Carbon flow:	Standing Biomass	New Biomass	Harvested Biomass
	Variable:	CV_{nat}	CV_{av}	CV_h
Forest Restoration		0	+	0
Forest Reserves		+	0	0
Timber Plantations		0	+	+
Agroforestry		+	+	0
Fuelwood Farms		+	+	+
Biomass Energy Plantations		0	+	+*
Natural Forest Management		+	0	+

* the carbon content of fossil fuel replaced

For other forms of forest conversion (Houghton, et al, 1989):

$CV_r = 0.40\ CV_{nat}$ for mature forest fallow
$CV_r = 0.75\ CV_{nat}$ for land converted to logged secondary forest

For projects that accumulate new biomass, CV_{av} is the long term average biomass carbon over the period of rotation. For projects in which harvested biomass enters long term storage (as timber, not paper or fuelwood), CV_h is the steady-state value of stored biomass carbon net of decay.

Both CV_{av} and CV_h depend on CV_m, the carbon stored (in TC/ha) in vegetation planted by the project, upon maturity. The value for CV can be determined according to the mean annual biomass increment (MABI), a measure of forest stemwood-biomass growth, which varies with species and climate (Brown, et al, 1986; Lugo, et al, 1988). The MABI must be corrected for wood density and the ratio of total-to-stemwood biomass to determine carbon accumulation. A simple estimate of CV_m, based on growth in a young forest, at which time annual growth is 6 percent of CV_m, is (Brown, et al, 1986; Cooper, 1983).

$$CV_m = p_c\ MABI_{max}\ SWM/g \qquad [9]$$

where: p_c = carbon density of wood (typically 0.26 TC/m^3)
$MABI_{max}$ = maximum MABI for a young forest (m_3/yr)
SWM = stemwood multiplier to convert to total biomass (range from 1.6 to 2.5)
g = maximum growth rate (0.06 from Brown, et al, 1986)

The value for CV_{av}, the average biomass carbon density over the length of a rotation (t_h), is proportional to the average ratio of standing biomass to biomass (B_{av}/B_m) at maturity. This ratio depends on t_h and on the fraction of biomass remaining after harvest (B_0/B_m).

For forest restoration, this infinity, so $CV_{av} = CV_m$.

$$CV_{av} = CV_m\ (B_{av}/B_m) \qquad [10]$$

$$\text{where: } (B_{av}/B_m) = \left\{ \int_{t=0}^{t=t_h} (B_t/B_m)\, dt \right\} / t_h \qquad [11]$$

and (B_t/B_m) = Ratio of standing biomass at time t to biomass at maturity
t_h = Rotation time between harvests

$(B_t/B_m) = \{1 - \exp(-g\ t)\ [1-(B_0/B_m)^{-n}]\}^{-1/n}$ (from Cooper, 1983)

where: (B_0/B_m) = Ratio of biomass remaining after harvest to biomass at maturity
n = 0.17 for fast growing species (from Cooper, 1983)
g = Maximum growth rate (0.06 from Brown, et al, 1986)

For harvested plantations, CV_h is the carbon content of the steady state value of the harvested biomass. This value is proportional to the fraction of biomass harvested (B_h/B_m) and N_{lts}, the fraction that enters long term storage (Cooper, 1983); Hall, et al, 1985). CV_h is assumed to accumulate until balanced by decay at a constant annual rate.

$$CV_h = CV_m\ N_{lts}\ (B_h/B_m)\ [\exp(-d\ t_h)/\ (1- \exp\{-d\ t_h\})\ ] \qquad [13]$$

where: $(B_h/B_m) = (B_t/B_m)$ for $t=t_h$

and N_{lts} = Fraction of harvest that enters long term storage (timber, not pulp or fuel)
d = Annual decay rate of harvested timber (0.01 from Houghton, et al, 1987)
t_h = Rotation time between harvests

The values for the soil carbon (CS) terms (CS_r and CS_p) are most easily related to the soil carbon content of a natural forest in the same climate (Detweiler, et al, 1985; Houghton, et al, 1987; Anderson, 1987; Brown, et al, 1989):

$$CS = N_s\ CS_{nat} \qquad [14]$$

where: $CS_{nat} = 154 \exp(-0.45Z)$ (TC/ha)
N_s = 0.50 for steep and highly erodible areas
N_s = 0.75 for pasture, cropland and fallow woodland
N_s = 0.90 for logged secondary forest and timber or biomass energy plantations
N_s = 1.00 for natural forest management, forest restoration, fuelwood farms, and agroforestry

The carbon content of the fossil fuel replaced by a biomass energy project is that of the fossil fuel that would be consumed to produce the equivalent amount of commercial energy. Assuming equal efficiencies for biomass and fossil fuel combustion and a heating value of 19 GJ/ton-biomass, or 38 GJ/TC, and using the carbon content for the fuel replaced as that of oil at 20kg/GJ, the carbon saved is 0.76 TC per TC in the wood burned. This value should be corrected for differences in efficiencies for the two fuel sources.

5 ANALYSIS OF CARBON STORAGE IN SAMPLE FORESTRY PROJECTS

The specific forestry projects studied in this research are based for the most part on projects completed, underway or planned in the Central American nations of Costa Rica and Guatemala. These projects were chosen because they represent some of the only examples now available of 1) internationally funded projects conducted with carbon storage as a goal, and 2) innovative use of international financing mechanisms, particularly debt-for-nature (DFN) exchanges, to fund projects of mutual benefit locally and internationally. Where necessary, additional data from other nations are drawn from the literature to allow the calculation of quantities that have not been measured or reported for the sample projects.

One case, the agroforestry programme conducted in Guatemala by CARE, is the only project studied that was explicitly considered for its carbon storage potential. Other projects studied, representing different project classifications, are among those being implemented using funds from Costa Rica's DFN exchange mechanism. The carbon storage results for the different project classifications can also be used to estimate the national carbon storage potential for forestry ICEO's in four Central American countries, based on project proposals and cost estimates given in the Tropical Forest Action Programmes (TFAP's) of these countries.

The CARE project in Guatemala is an agroforestry and reforestation programme that has received partial financing from a US electricity company to compensate for the CO_2 emissions from a new power plant (New York Times, 1988; Trexler, et al, 1989). The trees are expected to absorb 40-200 percent as much CO_2 as the company's 180 megawatt power plant will produce in 40 years (see table 1). The project is part of

CARE's rural development programme begun in the Guatemalan highlands in 1975. The programme is very decentralised, reaching all but one of Guatemala's geographical districts, and emphasises rural extension work. The extension aspect is conducted by forestry "promotors", employed by the Guatemalan Forest Service (Direccion General de Bosques, DGB), with assistance in the field from US Peace Corp volunteers (Nations, et al, 1987). Because this project was partly financed as a voluntary carbon emission offset, carbon storage estimates were made by CARE and subsequently revised by the World Resources Institute (WRI) which served as an intermediary for the carbon offset transaction (CARE, 1988; Trexler, et al, 1989). Below, the results of these two analyses are compared to the results from this study, as an example of the carbon storage analysis methodology presented above.

Both the woodlots and agroforestry component store net carbon in new accumulated biomass and harvested biomass that enters long term storage. Additonal carbon is stored in the standing biomass of protected forest areas and through soil conservation. The rotation time is 35 years, with a CV_m of 93 TC/ha, based on a mean annual biomass increment (MABI) of $8.6m^3$ /ha-year. This value is much lower than the MABI value of 20 m^3/ha-year used by both CARE and WRI. It is based on MABI values from an analysis of the forestry component of the existing CARE project in the same areas of Guatemala (Burniske and Prewitt, 1987). The CARE analysis involved destructive testing of a representative subsample of the total population of forestry plots. Because much of wood output early in the programme was used for fuel, the rotation times varied from as short as three years to ten years, the longest any project had been active at the time of sampling. Positive values for wood volume were only assigned to trees with trunks wider than a minimum diameter, excluding many trees from the younger plots. Thus, the longer cycle samples are more indicative of the total tree growth. The area-weighted average of all the samples from 7 to 10 years old is 8.6 m^3/ha-year.

Assuming the biomass remaining at harvest is 15 percent of CV_m, B_{av}/B_m for a 35-year rotation is 0.53 and B_h/B_m is 0.82. Of the biomass harvested at a given time, 15 percent is estimated to enter long term storage, while the remainder may decay or be used for fuel (Detweiler, et al, 1985). These values give accumulated biomass carbon, above that of the reference, of 50 TC/ha for CV_{av} and 22 TC/ha for CV_h. For a low-mountain humid forest life-zone with a temperature-to-precipitation ratio (Z) of 1.4, CV_{nat} is 175 TC/ha and CS_{nat} is 81 TC/ha. For protected forest, the reference is pasture with 5TC/ha, which gives a carbon storage value of 170 TC/ha. For soil conservation on the steep, erosion-prone land, carbon accumulation is 50 percent of CS_{nat}, or 40 TC/ha. The success rate for the agroforestry component is estimated at 75 percent, while the woodlots are planted and replanted to a sufficiently excess density that they are all expected to reach maturity (CARE, 1988).

The total areas to be planted in woodlots and agroforestry are 12,700 hectares and 63,500 hectares, respectively (CARE, 1988). Because the agroforestry area is only about two thirds fully stocked with trees, the equivalent forest area can be considered to be 42,300 hectares, for a total of 55,000 hectares. In addition 9,600 hectares of existing forested land will be protected, and soil conservation will be implemented on 8,600 hectares. Thus, the total carbon storage is 12,700 (50+22) + 42,300 (50+22) 0.75 + 9600 (170) + 8600 (40) = 5.2 million TC, or 94 TC/ha planted. These results are compared to those of CARE and WRI in table 2.

Another project studied is the Forest Development Program for Small and Medium Farmers (Programa de Desarrollo Forestal para Medianos y Pequenos Agricultores, DECAFROR) in Costa Rica. This project, which has similar carbon storage values as the CARE project but significantly higher costs, is an effort by the Costa Rican Forest Service (Direccion General de Forestal, DGF), Department of Rural Forest Development (Desarrollo Campesino Forestal, DECAFOR) to empower private forestry organisations who currently lack the needed administrative and organisational skill to carry out forestry projects on a widespread basis.

The principal funding mechanism for this project is the Fondo para Desarrollo Forestal (FDF), which was endowed by the local currency proceeds of a DFN exchange from the Netherlands government. For four years beginning in 1989, the total amount of the FDF ($10 million), by decision of the Ministry of Natural Resources (Ministerio de Recursos Naturales, Energia y Minas, MIRENEM), will finance 12,000 hectares of forest plantations by small farmers' organisations and cooperatives, through an innovative revolving rural credit programme (Canet, 1989). Training and technical assistance is provided through a rural extension programme.

Table 2 Comparison of Carbon Storage Estimates for the CARE Agroforestry Project

	CARE	WRI		This Study	
Woodlots	6.67	4.45		0.92	
New Biomass			0.67		0.63
Harvested Wood			3.78		0.28
Agroforestry	17.0	11.30		2.29	
New Biomass			1.70		1.58
Harvested Wood			9.60		0.71
Protected Forest	3.46	0.58		1.64	
Soil conservation	0.35	0.35		0.35	
Total	27.5	15.7		5.2	

Sources: CARE, 1988; Trexler, et al, 1989; Swisher, 1991

6 NATIONAL ESTIMATES OF CARBON STORAGE POTENTIAL

The approximate costs of the projects studied in Costa Rica range from $4/ton-carbon for forest reserves to $12/ton for small-holder woodlots and $25/ton for restoration of degraded natural forest ecosystems. Approximate costs of reforestation in Guatemala range from $15/ton for timber plantations to as low as $3/ton for agroforestry programmes (Swisher, 1991). It would also be useful to have national estimates of carbon storage potential as a function of cost, but sufficient information is not available to accomplish such as analysis, for the world or even for one nation.

As a first step in this process, however, we can formulate estimates of the national ICEO supply for Costa Rica and other Central American nations, using the project proposals and the cost estimates given in the national Tropical Forestry Action Plans (TFAP's), together with the carbon storage analysis procedure developed above. The TFAP process has several steps, during which the national status of forests and forestry is assessed, and necessary policies and initiatives are identified (FAO, 1986). In the later stages of the process, specific projects and funding needs are developed in a formal working plan. A draft plan has now been developed for Costa Rica, as well as Panama and Honduras. The Guatemalan TFAP process is not as far along, although an issues paper has been done. The national TFAP is not meant to suggest the total potential for forestry investments in a country, nor does it specifically consider carbon storage. It does, however, provide a list of needed projects that could be carried if sufficient funding were available for the forestry sector. The TFAP project proposals can be used to construct a national level estimate of carbon storage potential and cost.

The TFAP for Costa Rica proposes 27 projects in the standard TFAP categories of Forestry in Land Use, Forest Industry, Fuelwood and Energy, Ecosystem Conservation, and Institutions. The total cost estimate is $276 million, of which about 80 percent is for projects that would be relevant for carbon storage credit (Salas and Bauer, 1990). Other projects in the areas of industrial rationalisation and institutional development would not contribute directly to carbon storage, so these national level costs are not included. It could be argued, however, that these projects are just as necessary to the success of carbon-storing plantations and protected areas as the establishment and maintenance of the forest areas themselves, and that these costs should thus be included. The various projects are categorised by their project classification in table 3. Additional costs for monitoring and, in some cases land, are added to the project costs given in the TFAP. Multiplying the project areas and costs per hectare by the carbon storage estimates gives the total carbon stored and the cost per ton-carbon for each project, as shown in table 3.

Additional national level carbon storage potential can be estimated based on the TFAP's and other data from Guatemala, Panama and Honduras. These estimates can be displayed as a set of marginal cost curves. The values for Guatemala are based on the nationwide projects studied with the addition of an estimate for carbon storage in protected forest reserves (SIMUFOR, 1989; Molinos, 1989). For the forest reserves, the cost is based on the area-weighted average of the cost of protected areas in the Costa Rican TFAP, and the area is the fraction of total area now legally protected, 14.5 percent, applied to the total remaining closed forest area. The values from Honduras are based on preliminary TFAP project proposals, with the addition of forest reserves, based on the Costa Rican TFAP costs (TFAP, 1989). The area estimate is the total protected area (WRI, 1990). The values from Panama are also from TFAP project proposals (INRENARE, 1988). All carbon storage estimates are based on the values estimated above for similar project classifications in Costa Rica, corrected for climate differences. For Panama, one project classification is included that was not in the Costa Rican TFAP, biomass energy plantations, for which the carbon estimates are based on information from a Philippine dendrothermal project, corrected for climate (Durst, 1987; Sathaye, 1987).

Table 3 Carbon Storage in Costa Rica Tropical Forest Action Plan Projects

	Project Area ('000s ha)	Project Cost	Carbon Stored (TC/ha)	Unit Cost ($/TC)	Total Carbon (MTC)
Forest Restoration					
Protected Plantations	8.7	793	64	12	0.6
Watershed Regeneration	7.25	155	43	4	0.3
Watershed Reforestation	13.0	132	57	2	0.7
Forest Reserves					
Talamanca Mountains	700.0	38	69	1	48.1
Osa Penisula	160.0	81	70	1	11.2
Tortuguero Lowlands	150.0	61	65	1	9.1
Central Volcanoes	140.0	44	70	1	10.5
Arenal Volcanoes	100.0	148	65	2	6.5
Rincon de la Vieja	100.0	56	60	1	6.1
Nicoya Peninsula	50.0	195	60	3	3.0
Timber Plantations	95.0	1104	72	15	6.8
Agroforestry					
Agroforestry	17.65	335	79	4	1.4
Silvoagroforestry	6.0	115	44	3	0.3
Soil Conservation	11.0	555	76	7	0.8
Windbreaks	13.0	125	57	2	0.7
Fuelwood Plantations	28.0	1104	87	13	2.5
Natural Forest Management	28.0	1195	73	16	2.0

Source: Salas and Bauer, 1990

The results show that the total carbon storage potential in Costa Rica, based on the TFAP project proposals, is about 100 million tons-carbon at a marginal cost below $8/TC. This total excludes reforestation on more expensive land than that considered in the TFAP project list. Including such land may increase the total carbon storage potential, but at significantly higher marginal cost. The additional carbon storage potential from plantations on high-cost land is estimated to be about 40 million tons, at a marginal cost of $25/TC (Swisher, 1991).

The carbon storage potential, based on the Panama TFAP, approaches that of Costa Rica's, near 100 million tons-carbon at a marginal cost below 12 $/TC. Carbon storage estimates from forest protection in both Guatemala and Honduras reach about 40 million tons-carbon each at a cost of only $2/TC, and the total for projects in Guatemala approaches 60 million tons-carbon at a marginal cost of $16/TC. The total carbon storage for the four nations, at a marginal cost below $16/TC, is about 300 million tons-carbon.

7 CONCLUSION

The projects studied in this research, and most of the TFAP proposals, are projects that the Central American governments are anxious to implement but unable to because of financial constraints such as the foreign debt burden and poor terms of trade with the industrialised world (Umana, 1989). This type of project has received a boost recently from the advent of DFN exchanges that meet the dual objectives of relieving the debt burden and funding needed natural resources programmes. The need for reforestation in developing nations, evidenced by the projects proposed under the TFAP, and the vast renewable energy potential of these nations, indicate the potential benefits of international trade in environmental services, provided that the demand for these services is mandated by treaties or legislation within the industrialised nations.

Moreover, properly implemented biomass energy, reforestation and agroforestry projects can have significant social and economic benefits in developing nations (Nations and Komer, 1983). The local socio-economic effect is the key to the success of tropical reforestation efforts, and to their prospect of providing long term carbon storage. Many tropical plantation efforts have failed in the past, sometimes due to poor technical design but more often due to inattention to the local social context. With a greater understanding of these issues, it appears possible to lower the cost of CO_2 mitigation and simultaneously help finance promising sustainable development programmes.

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Appendix I: Programme for Technical Workshop to Explore Options for Global Forest Management [1]

Wednesday, 24 April 1991

8.00-9.00 - Registration

9.00-10.00 - Opening Ceremony: Slide Show on Thai Forests
Opening Statement presided by H.E. Prof Sanga Sabhasri Minister of the Ministry of Science, Technology and Energy and session chair
Keynote Speeches by
- H.E. Ola Ullsten, Swedish Ambassador to Italy
(Former Prime Minster of Sweden and Swedish Ambassador to Canada)
- Dr Saburo Okita, Former Minister of the Ministry of Foreign Affairs, Japan

10.15-10.45 - Discussion

10.45-11.45 - Coffee Break

11.45-12.00 - Plenary Session
Item 1: Overview and Introduction to Global Forest Context (chaired by Prof S Sabhasri and Ms Cornelia Quennet)

Paper: Dr Francis Ng, FAO, Rome

12.00-14.00 - Lunch

14.00-14.30 - Discussion of FAO paper

14.30-15.30 - Item 1 (continued)
Status of international initiatives to improve forest management:

- Climate Change: IPCC, Noordwijk Declaration, and Climate Change Convention

- Biodiversity: UNEP and IUCN
Biodiversity Convention

- Global Forest Instrument: summary of UNCED proposals forestry report work

- Financial, technical cooperation for developing countries: Tropical Forest Action Plan, ITTO, and Global Environmental Facility of World Bank

Paper: J S Maini, Forestry Canada

15.30-15.45 - Coffee Break

15.45-17.00 - Discussion

17.00-17.30 - Coordination meeting of 3 track chairs, rapporteur, and paper authors

17.30 - Coordination among track chairs

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1 As circulated at meeting.

19.00-21.00 - Dinner
Hosted by: H.E. Prof Sanga Sabhasri, Minister of the Ministry of the Science, Technology and Energy
Venue: Vibhavadee Ballroom B

Thursday, 25 April 1 991

9.00-12.00 - Item 2: National Experiences in Managing Forest Resources: Representative Case Studies Illustrating Successes, Shortcomings, Promising Opportunities for National-Level Planning for Managing Forests (chaired by Chairman or Co-chairman)

Note: Format shifts to 3 parallel, concurrent tracks

12.00-14.00 - Lunch

14.17.00 - Continue discussion

TRACK 1: Tropical Moist Forest

Assessment of land availability, technologies and practices, costs, and options with high probability for improving management and condition of, and increasing forest area via:

- conservation of forests and biodiversity
- sustainable forest management, including assessment of ITTO guidelines at that stand level
- afforestation and reforestation
- agroforestry and links between forestry and agriculture
- bioenergy

Assessment of national forest management plans

Paper: Y P Tho (Malaysia)

Track chair: Lukito Daruadi (Indonesia), Jaime Munoz-Reyes (Bolivia)

Rapporteur: Bill Howard (UK)

TRACK 2: Tropical Dry and Subtropical Forest (repeat sub-headings as above)

Paper: co-Gill Shepherd (UK)

Track chair: C D Pandeya (India) and E M Mnzava (Tanzania)

Rapporteur: Robert Dixon (US)

TRACK 3: Temperate and Boreal Forests

A) Introduction: short overview on different types of forest options (sustainable forest management including exceeding of forest biomass, conservation of existing forests, afforestation, agroforestry, bioenergy, etc.)

B) Representative case studies: describing on a national basis:

- status of forests (area, biomass, changes/trends etc.)

- status of forest options (incl. impacts on CO_2-level)

- options: realistic view to possibilities and time targets

- cost estimates

(1) Temperature Zones: NL/FRG/US and others (as far as available)

(2) Boreal Zones: CDN/FIN?/USSR? and others (as far as available)

C) Assessment of forest options in boreal and temperate zones at a global scale

- status of forests and forest options (as above)

- options

- cost estimates

D) Conclusions

Paper: H Volz (Germany)

Co-chair: Xu Deying (China) and F Kaiser (US)

Rapporteur: Tim Boyle (Canada)

Friday, 26 April 1991

09.00-10.00 - Plenary Session

Item 3: Implementation of Options (chair: Dr Sanga, co-chair: Cornelia Quennet, Germany)

10.00-10.30 Social development issues and the forest sector

- Land availability, tenure, economic issues

- Paper: Jeff Romm, Univ. California at Berkeley (US)

10.00-10.30 - Discussion

10.30-10.45 - Coffee Break

10.45-11.30 - Assessment of international options for coordinating, exchanging information on and reinforcing national options (ie, summing up the national options identified above into internationally feasible totals), including:

- experience of TFAP as coordinating mechanism
- guidelines for sustainable and natural forest management, and prospects for implementation at national level
- financial and technical assistance needs of developing countries
- international forestry instrument
- trade issues for sustainable development
- attainment of Noordwijk targets
- reforestation and restoration of degraded lands
- natural forest management
- conservation, including fire management
- other options

- Paper: Caroline Sargent and Mark Lowcock, ODA (UK)

11.30-12.30 - Discussion

12.30-14.30	-	Lunch
14.30-15.15	-	Economic issues: overview of cost estimates, benefits, cost effectiveness of, and potential incentives for implementation options (above)
	-	Paper: Ken Andrasko, USEPA (US)
15.15-15.30	-	Coffee Break
15.30-17.00	-	Discussion

Saturday, 27 April 1991

7.00	-	Field trip to Khao Yai National Park forests (details provided)
21.00	-	Return to hotel

Sunday, 28 April 1991

9.00	-	Drafting of track summary documents (track co-chairs, rapporteurs, paper authors)
	-	Drafting of meeting summary (Steering Committee)
		Free day for others if desired

Monday, 29 April 1991

09.00-10.30	-	Plenary Session Chair: Dr Sanga
		: Findings, recommendations and analytic needs
		: Reports by rapporteurs of each of 3 track sessions
		: Comparison of cost/benefits of options
		: Feasibility of options
		: Research and analytic needs
10.30-10.45	-	Coffee Break
10.45-12.00	-	Continue presentations and discussion
12.00-14.00	-	Lunch
14.00-15.30	-	Review of draft Summary Statement Chair: Cornelia Quennet (Germany)
15.30-15.45	-	Coffee Break
15.45-17.30	-	Conclusions, recommendations and statement of the meeting (continued)
	-	Discussion on preparation of proceedings

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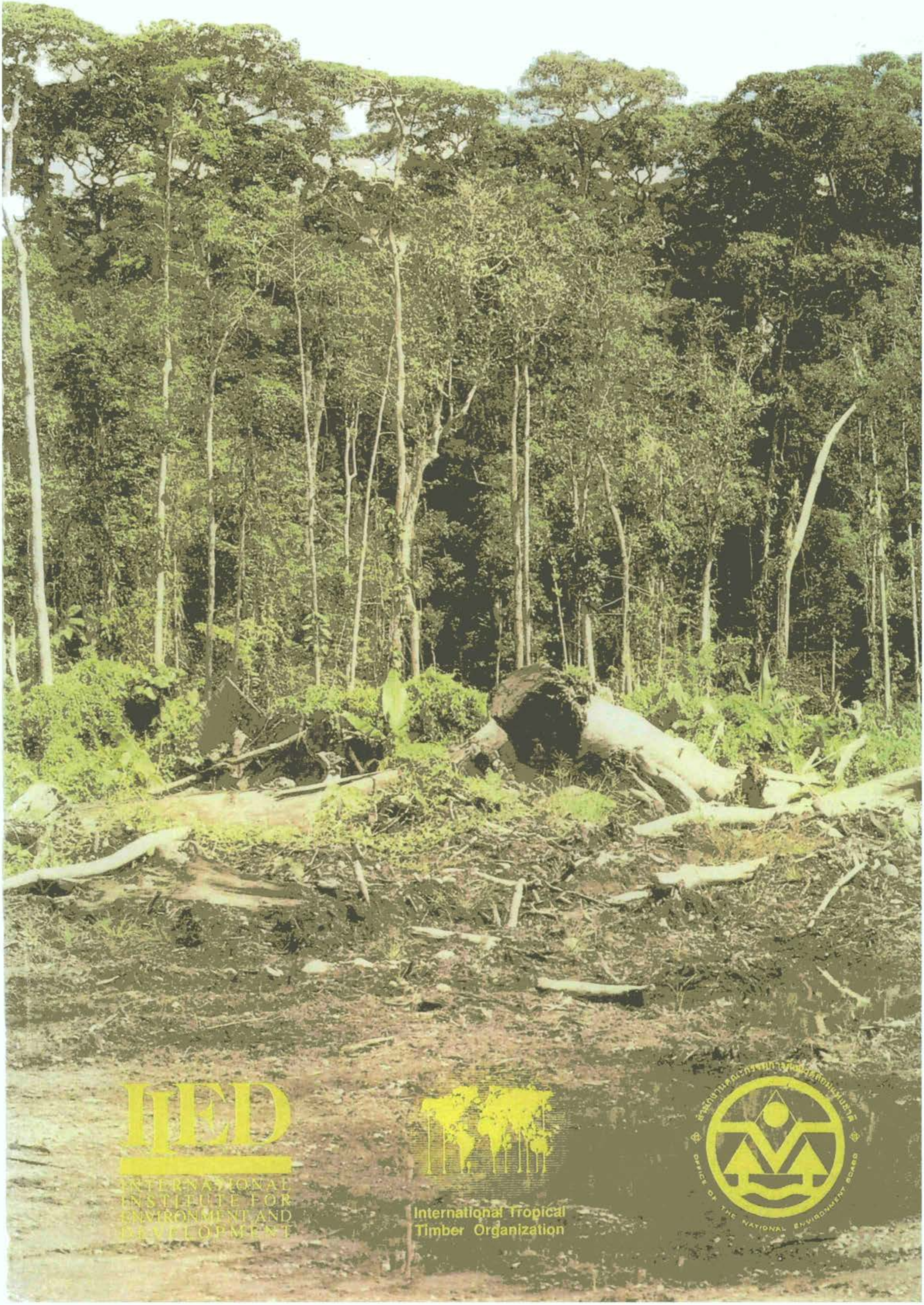
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