

**Proceedings
of the
U.S. Strategy Conference
on**

**Tropical
Deforestation**

Sponsored by

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PREFACE

The "U.S. Strategy Conference on Tropical Deforestation" was convened by the U.S. Department of State and the U.S. Agency for International Development in Washington, D.C., June 12-14, 1978. Principal objectives included: expanding the level of awareness and dialogue within the U.S. about tropical forest management problems and needs, particularly as they exist in the developing nations; and helping define more responsive U.S. policies and programs for the near and long term.

This Proceedings presents the major conclusions, recommendations, points of view, and formal statements which emerged from the Conference. It is being distributed widely within and outside the United States to lend support to those who have been attempting to focus increased attention and effort on the rapid disappearance of forest and vegetative cover in tropical areas, and also to expose to review and debate the views, perspectives, and recommendations of a select group of leading U.S. government and non-governmental forestry and natural resource managers and scientists. The U.S. participants were assisted by representatives from the Food and Agriculture Organization, the World Bank, and the United Nations Environment Program. (See Chapter V for the Conference participants.)

The initial chapter presents an overview of the principal conclusions and recommendations. Readers are also referred to Chapter III, which contains the detailed recommendations developed by separate Conference workshops convened to address the unique deforestation problems of the *humid* tropics and the *semi-arid* regions. In addition, participants were invited to submit short statements conveying their personal perspectives and recommendations on the deforestation situation. Many chose to do so . . . and these per-

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sonal statements constitute a valuable resource. Although they are not included in these published Proceedings, they will be made available to interested parties on request.

The Conference organizers in the U.S. Department of State and the U.S. Agency for International Development bear sole responsibility for the selection and mode of presentation of the material contained herein. This is particularly true with respect to Chapter II, "Principal Conclusions and Recommendations," since time did not permit the conferees to seek unanimous agreement or a solid consensus on every point.

Special appreciation is extended to Mr. Douglas R. Shane, who served as principal editor; and to Associates for Renewal in Education, Inc. (Washington, D.C.), and especially to Ms. Lana D. Smith, of that organization, who coordinated the taping and transcribing of the Conference and the publishing of this document (under a U.S. Department of State/AID contract). The invaluable staff support, financial assistance, and general guidance provided by the Secretariat of the U.S. Man and the Biosphere Program is also gratefully acknowledged.

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U.S. STRATEGY CONFERENCE ON TROPICAL DEFORESTATION

I. INTRODUCTION

Prior to the Conference, all invitees were sent the following list of "Critical Issues" related to the future U.S. role in the area of tropical forest management, with a request that they be viewed as a backdrop and framework for the presentation of formal statements and for discussion in the plenary and workshop sessions.

- *How serious is the tropical deforestation situation? Can the level of international and national action currently being proposed realistically make more than a dent in the deforestation situation which involves national sovereignty considerations, deeply-rooted social and cultural constraints, strong short-term economic development incentives, and often the apparent absence of economic alternatives to the use of forest resources?*
- *What are the motives and proper rationale for addressing tropical deforestation . . . humanitarian? . . . need to protect past and future development investments? . . . desire to preserve sources of raw materials? . . . the perception that tropical forests are an "endangered species" and thereby the responsibility of all mankind? . . . concern about regional and global climate changes? What is the demand/opportunity for U.S. assistance in this field?*
- *What are the economic penalties to the U.S. and other forest product consumers from (a) short-term reduction in timber operations; and (b) disappearance of the tropical forests over the next several decades? What is the paper and lumber industry doing to sustain its resource base?*
- *Where do we stand with respect to our knowledge about and application of reforestation and agroforestry in the tropics, including state-of-the-art on use of faster growing tree species? Are there potential problems in introducing monoculture activities (i.e., *Leucaena*)? What about firewood alternatives?*
- *What priority should be attached to further investment in problem identification and improving the statistical knowledge of deforestation? Doesn't sufficient data already exist to indicate the scope and seriousness of the problem?*
- *What is the magnitude of U.S. capabilities in this field, and the extent and overall impact of our existing programs?*
- *What type of new U.S. and international efforts makes sense . . . training? . . . ecological research? . . . R & D on alternative sources of energy and building materials? . . . technical assistance in forest management or in*

legal-institutional mechanisms? . . . establishment of national or regional forestry institutions?

- *Can an overall U.S. strategy and a programmed division of labor be developed that will increase the effectiveness of the diversity of our current (seemingly uncoordinated and underfunded) activities?*
- *What domestic and international events (e.g., conferences, meetings) over next two-three years might the U.S. use to accelerate discussions/work on tropical forestry issues? What international and regional bodies should we look to and encourage to play lead roles?*

II. PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

This section presents the principal conclusions and recommendations which emerged from the U.S. Strategy Conference on Tropical Deforestation (as determined by its organizers and the editors of this Proceedings). *General* conclusions and recommendations are presented first, followed by those specifically focused on the appropriate U.S. role and response. The order of presentation does not reflect any assignment of priority.

The inclusion of a particular item should not imply its endorsement by all Conference participants: some differences of opinion did exist. However, the following compilation does indicate where the predominance of concern and discussion was focused. It identifies specific issues, problems, and possible next steps that deserve serious consideration by countries which are suffering from or are threatened by deforestation problems, as well as by international organizations and other nations seeking to provide assistance.

The reader is also referred to Chapter IV, *Workshops: Discussions and Recommendations*, in which specific recommendations developed in each of two workshops are reported.

Although the participants sometimes differed with respect to perceptions of specific problem priorities and possible solutions, the Conference was united on the following which might be viewed as the major conclusion and recommendations which emerged from the meeting:

The world is being confronted by an extremely serious problem with immediate and long-range socio-economic and ecological consequences as the result of the accelerating loss of forest and vegetative cover in the humid and semi-arid lands within or near the tropical latitudes. Further, the community of nations must quickly launch an accelerated and coordinated attack on the problem if these greatly undervalued and probably irreplaceable resources are to be protected from virtual destruction by the early part of the next century.

Principal Conclusions

1. Throughout most areas near to and within tropical latitudes, forests are disappearing at a rapid and alarming rate. Efforts to justify and mobilize preventative and remedial actions are to a significant degree being stifled by the present *lack of information* about: deforestation rates and trends; the nature and impact of forest removals at the local, regional, and global levels; the character and value of the species of trees, wildlife, and other genetic materials being lost; and whether and how tropical forests can be effectively and economically sustained. Continuing devastation of the forest resource in the face of such serious deficiencies in our knowledge of its long-term economic, ecological, and environmental importance is short-sighted and potentially tragic.

2. The cumulative national and worldwide economic, social and environmental costs of the loss of tropical forests now are not well documented. However, they are already sizeable—and growing rapidly. Mankind's ability to meet basic human needs and quality of life objectives is critically dependent upon proper stewardship of tropical ecosystems. The loss of sources for wood products and fuelwood; the inability to maintain soil and water systems; the disappearance of plant and animal genes and species; and the forfeiture of aesthetic and cultural values are all consequences of forest mismanagement. Global climate changes associated with large-scale deforestation are postulated, although information on the role of forests in the carbon dioxide cycle is presently insufficient to permit a conclusive determination about climate implications. Our inability to identify and quantify these impacts, and the preoccupation of many governments with more immediate economic matters, are constraining efforts dealing effectively with the situation.
3. Without greater recognition of the value of the forest resource and much improved stewardship, large areas of the world's tropical forests will be lost by the end of the century. Tropical forests should be perceived and treated as being non-renewable in character in the absence of better information about their character and value to man, significantly upgraded management capabilities, and the will to maintain and protect them.
4. Exponential population growth, coupled with lack of alternative economic development opportunities, is the basic driving force in loss of tropical forest cover. This results in the clearing of forest land for small-scale extensive agriculture, large-scale intensive agriculture, cattle grazing and ranching, fuel and building materials, and human settlements. Of lesser magnitude are shifting cultivation and commercial forestry—the latter also involving road building that opens up the forests to colonization by the land-hungry poor.
5. Demand for wood by families in the semi-arid regions and by the charcoal industry has created critical economic and social problems for tens of millions of people, principally in Africa, Asia, and the Caribbean region.
6. Institutional capabilities for addressing and controlling deforestation need strengthening at all levels. In those countries most affected, forest management planners and practitioners must be trained and supported and international organizations and donor countries need to expand their expertise to help solve unique and often unfamiliar problems of tropical environments. Forestry in the tropics has, to date, been greatly neglected when compared with the collective level-of-effort the international community has mobilized in other natural resource areas.
7. There is little systematic monitoring of tropical forest areas in progress. Consequently, current estimates of the rate of deforestation are extremely variable in their accuracy. For some areas most subject to change, available "data" represent little more than guesses. These circumstances do not negate or diminish the general conclusion of the Conference that a serious problem exists, but they do point to serious gaps in our knowledge of the exact dimensions and potential consequences of the problem.

8. Because the deforestation situation requires urgent attention, remedial action will necessarily have to go forward on the basis of incomplete information and data. There is, however, enough knowledge of tropical forest management principles presently available to enable politically committed countries to make significant inroads on deforestation problems. It is essential that the available information and guidance be presented to decision-makers on a timely and meaningful basis.
9. Major scientific and technological challenges remain. These include:
 - Establishing and implementing deforestation monitoring and assessment systems at the global, regional, national, and local levels;
 - Identifying and quantifying the range of economic, social, and environmental costs associated with deforestation, including climate impacts; and also the benefits received from proper forest management, including the economic importance of drugs, genetic materials, and wildlife;
 - Improving the understanding of basic physical, chemical, biological, and ecological processes, particularly in rainforests, as a prerequisite to predicting the impact of large-scale clearing of vegetation and to making decisions on the best use of the land; and
 - Developing alternatives to the present use of forests (e.g., fuel substitutes, agroforestry, firewood lots), as well as improved techniques for reforestation and afforestation, including use of faster-growing species.
10. Responsibility for proper forest management, and the implementation of reforestation and other corrective measures, cannot be left solely to professional foresters, particularly since they are sometimes viewed as antagonists by rural people who feel unjustly prevented from utilizing an essential resource. Local citizenry must be intimately involved both in the planning and the implementation phases of forest and land management programs.
11. International organizations and governments have become increasingly aware of tropical forests as problems associated with forest disappearance are found more commonly to undercut and offset development gains sought through programs in other sectors. Examples include rapid siltation of reservoirs, reduction of water supply for human and agricultural use, decrease of electrical power-generating capacity, intensified flooding, loss of badly needed wood products and firewood, loss of valuable plants and animals, and intensification of basic social and economic problems in general. The World Bank released in February 1978 a Forestry Sector Policy Paper which stresses the need to give much higher priority to the protection, conservation, and wise use of forests on a long-term basis, and to consider forestry as an important component of integrated rural development programs. The International Union for the Conservation of Nature and Natural Resources (IUCN) is preparing a World Plan of Action on Conservation and Wildlife which includes both

tropical forest and semi-arid region ecosystems—and it should be of considerable assistance to governments, international organizations, and other institutions in raising awareness and in designing new programmatic responses. The Food and Agriculture Organization (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Environment Programme (UNEP), and the Organization of American States (OAS) have important tropical forestry activities; and Canada, Sweden, France, Norway, Australia, the Netherlands, and several other countries provide development assistance in this field. To date, however, the collective effort of these organizations and governments has been comparatively small and is clearly inadequate to meet rapidly expanding needs.

12. Many commercial forestry operations are devoting increased attention to protecting and sustaining the resource, in part because of enlightened self-interest and in part because of tighter government regulation. This is not uniformly true, however, either among companies or among countries. While logging does not directly cause deforestation, the trends toward indiscriminate colonization of “logged-out” areas could have serious consequences. Further, the introduction of monocultures has also raised important issues and other potential problems. However, forestry plantations and the introduction of new faster-growing species offer promising alternatives to the opening up of yet-untapped native forests.
13. Deforestation now occurring in the Panama Canal's upland watersheds, largely as the result of squatters, and the secondary impacts on water availability pose a special and serious challenge for the United States and Panama. Measures must be taken at once if undesirable, permanent changes in the Canal's water regime are to be avoided.
14. The United States, other donor nations and international organizations should recognize that their efforts are doomed to failure if the nations directly impacted by deforestation are unprepared or unwilling to give high priority to the problem, or if the local populace is unprepared to deal with it because of a lack of awareness or the absence of alternatives to traditional patterns of behavior that are destructive to the forest resource. To heighten national and local receptivity, forest protection and management projects should emphasize local benefits, such as their contribution to water availability, food supply, flood prevention, and income from marketing of products, and should be selected on the basis of a high probability of success.
15. Countries and institutions which seek to provide assistance and guidance with respect to the improved management of tropical forests must be sensitive to the fact that almost all such forests exist in developing nations which legitimately exercise sovereignty over the resource.
16. Consequently, U.S. motives for addressing problems of tropical forests should be clearly understood both within and outside the United States. They derive from: (a) our commitment to assist in raising the living standards of the

rural poor throughout the world; (b) the fact that deforestation may create environmental and ecological problems of a global nature which thus would directly impact on the United States; (c) a requirement that the U.S. exercise proper stewardship of its own limited humid tropical forests and larger arid and semi-arid regions; and (d) the desire and need we share with other nations to sustain world supplies of timber and other forest products over the long term.

Recommendations For Future Action

17. Improved forest land-use policies, strategies, and programs for the tropics (both humid and arid) should be designed, advocated and vigorously pursued by the United States, other nations, and international organizations to counter an emerging natural resource and environmental management problem of global importance.
18. Broad-based, integrated, and coordinated programs and approaches should be designed and implemented within an overall economic development context. Education and manpower training, scientific research, resource inventorying and assessment, technology demonstration and application, policy planning and implementation, and building local awareness and support all require attention. Integration of forest management and protection concerns into rural development programs should become routine, recognizing the importance of forest resources to meeting the basic human needs of poor people over the near and long terms.
19. Forestry should be elevated in importance within national economic development planning to place it on a par with agriculture, water resources, and mining.
20. Mechanisms need to be developed for coordinating and strengthening the variety of international efforts being planned to cope with the tropical deforestation problem.
21. Strong national population policies backed by effective programs should be designed and implemented as an imperative for finding long-term solutions to deforestation problems in most areas of the world.
22. Energy requirements and alternative energy sources should be carefully evaluated when new development programs and projects are conceived and implemented to assess their potential impact on the local and regional forest resource. This is particularly important in firewood-short areas.
23. High priority should be given by governments and international organizations to accelerating land-use survey, inventory, and classification activities, as well as land-use planning, at national and local levels. This is a prerequisite for enlightened decision-making on economic development activities which will, or may, impact on the forest resource. Development programs must be conceived and implemented on the basis of a broad look at the best possible

allocation and use of the land; in a fashion that considers and seeks to optimize the use of the totality of available natural resources over large areas; and so that important natural resources are not indiscriminately and unknowingly forfeited or lost.

24. Global, regional, and local monitoring and assessment systems and programs are needed to provide better information on the rate, trends, and impacts of both deforestation practices and forest management and protection efforts in the tropics. The expanded use of satellite imagery should be considered, and the feasibility examined of establishing coordinated global and regional monitoring programs within UNEP's Global Environmental Monitoring Program (GEMS).
25. Governments and the international scientific community should press for a better representation of tropical forest ecosystems in the Biosphere Reserve component of the UNESCO Man and the Biosphere Program (MAB), and attempt to increase support for MAB's research and training activities. Selection of tropical forest biosphere reserves should be based on thorough scientific studies aimed at identifying areas which encompass broad ranges of ecological values.
26. The concept of establishing regional Centers of Excellence for forestry research in the major forest zones of the world should be seriously examined.
27. Forest protection and management should be an integral part of general environmental education programs.
28. Training of forest managers is an important area for expanded development assistance where there is a commitment by governments to protect and properly manage forest lands and to provide the necessary counterpart institutional, legislative, scientific and technical support. Such training should be provided within the country seeking assistance to the greatest extent possible.
29. Improved techniques and systems for information exchange are urgently required to meet the needs of nations having a tropical forest resource. State-of-the-art publications on tropical silviculture and the management of tropical forests should receive high priority, along with compilations of "how to" success stories on various approaches to watershed and forest management. These should be designed for broad international distribution as a means of providing hope, guidance, and incentive to development planners and resource managers in affected countries as well as in international organizations and nations providing assistance.
30. The feasibility of a global conference on tropical forestry management, or a series of regional-level meetings, should be explored as one approach to raising the level of awareness of deforestation trends and implications, and to help mobilize a coordinated international response. Such events, if properly designed, can be quite effective for promoting information exchange,

cooperation and coordination among international organizations, technical experts, and politicians.

31. The United States should lead by example with respect to the protection and management of its own tropical forests, and also those of other countries in which United States' public and private institutions are carrying out activities which impinge on the indigenous forest resource. This includes, in particular, the Panama Canal Zone, Puerto Rico, and countries and regions in which AID and the Peace Corps are sponsoring programs.
32. United States commercial firms should take the lead in carrying out improved forest management and protection programs, including introduction of soundly conceived plantation forestry which has the potential for expanding yields from four to ten times without opening up new areas to commercial forestry. Such initiatives should help U.S. companies protect their investments over the long term without damaging their competitive positions. Because improved protection and maintenance of the resource base is also clearly in the interest of the host government, it seems reasonable that other foreign investors would be required to adopt similar successful approaches and patterns of behavior. Further, the U.S. Government should examine mechanisms to encourage and assist U.S. firms to carry out strengthened tropical forest conservation and management programs overseas.
33. A comprehensive U.S. policy and strategy on tropical forestry should be jointly developed by the Department of State, AID, the Department of Agriculture, the Department of the Interior, Peace Corps, National Science Foundation, the Council on Environmental Quality, and other appropriate public and private institutions. It should identify priority programs and activities for U.S. bilateral and multilateral support; outline fields in which the U.S. has special competence; define the types of potentially destructive actions which should be avoided or modified in tropical forest ecosystems; address the matter of responsibilities of United States firms, agencies, and institutions operating abroad; and enunciate research, development, demonstration, and training needs. The policy and strategy should be developed in consultation with other nations and appropriate international organizations to ensure that it complements the experience and activities of others.
34. A new U.S. interagency committee on international forestry should be established for purposes of information exchange, consultation, cooperative program planning, coordination and review, and recommendation of U.S. policies, strategies, and activities. This is particularly important given the U.S. Forest Service's new mandate in the international forestry area. Such a body could begin its work by reviewing in depth the Conference recommendations and suggestions.
35. AID should develop an operational policy paper on forestry along the lines of the World Bank sector paper; and also increase significantly its staff capabili-

ty and programming in the areas of forestry, watershed management and land-use classification and planning.

36. AID, other donors, and host governments should routinely plan for and include reforestation, revegetation, and anti-deforestation activities within their rural development programs. Existing rural development and other appropriate programs should be reviewed to determine whether they are compatible with sound forest management objectives, and whether stronger or new forestry components should be added.
37. AID, other donors, and governments should routinely address forest management considerations within the framework of their environmental assessment policies, procedures, and reviews. A wide range of well-intentioned development programs, including beef export promotion, veterinary medicine, population resettlement, and the extension and upgrading of rural roads, can place great pressures on the forest.
38. Given the close interaction between the drive for expanded agricultural production and deforestation, AID and other donors should increase their support for programs designed to advance the state-of-the-art and application of agroforestry. The new International Center for Research in Agroforestry offers promise in this regard, and should be given encouragement and support by the United States.
39. The United States, other nations, and international organizations should expand their support for:
 - Biological and ecological research on tropical forest ecosystems, including ecological succession, genetics, silviculture, mineral cycling, and wildlife ecology;
 - Environmental research on the impact of deforestation on global climate, local and regional weather, soil and water regimes, the stability and vigor of reforested lands, and the capacity of deforested areas to sustain various development patterns and practices;
 - Socio-economic research to determine: patterns of land ownership and use, attitudinal factors which can have negative or positive effects on deforestation practices and reforestation efforts, and the most effective method of justifying and implementing expanded anti-deforestation and forest management programs in the face of traditional social and economic constraints; and
 - Research and development to find sound alternatives to traditional practices, including firewood substitutes, more efficient use of wood as a fuel and of wood residues from industrial processes, best utilization of secondary forests, improved varieties of quick-growing species for reforestation and afforestation, and ways to improve existing rangelands and agricultural areas to take the pressure off forest lands.

40. There is an array of international and national institutions with experience, capabilities, and expanding programs in tropical forestry management. The U.S. therefore should design and provide its assistance with a clear recognition of how it can support the existing framework of institutions. Areas in which the U.S. has special competence include: monitoring and assessment; integrated natural resources planning and environmental management; forest and arid lands management; industrial forest technology; and basic scientific and technological research.
41. The use and implications of clearcutting in tropical forests require research and analysis on an urgent basis—particularly in view of the expansion of interest in, and technology for, forest plantations and the economic use of naturally regenerated secondary species. In general, clearcutting should be applied only within the framework of a broad and sound strategy for long-term use and management of a forested area, or where the land is clearly suited to a higher economic or social use such as food production.

III. PRESENTATIONS

The Conference was structured around a series of invited presentations under the following headings (which also reflects the formal agenda of the meeting).

Because the speakers were not asked to provide formal papers, the following highlights of the presentations represent excerpts, by the editors, of transcriptions from audio tapes of the Conference sessions.

- **Welcome and Introduction**
- **The Nature of the Deforestation Problem—Trends and Policy Implications**
- **Response to Date—Institutions**
 - International Overview
 - World Bank
 - UN Food and Agriculture Organization
- **Response to Date—Scientific and Technological State-of-the-Art**
 - CO₂—Deforestation Relationships
 - Biological Research
 - Monitoring and Assessment
 - Commercial Forestry
 - Agroforestry
 - Energy Alternatives
 - Revegetation Using Selected Species
- **Perspectives on Future Needs and Opportunities**
 - Industry
 - Scientific Community
 - Environmental Community

Immediately following a number of the statements in this chapter are views, suggestions, and questions which emerged during the discussion sessions.

Welcome and Introduction

AMBASSADOR ROBERT C. BREWSTER, Acting Assistant Secretary for Oceans and International Environmental and Scientific Affairs, U.S. Department of State, Washington, D.C.

I am pleased to extend to you a warm welcome on behalf of the Department of State to this "U.S. Strategy Conference on Tropical Deforestation."

We have been encouraged and, frankly, surprised by the very high degree of interest and support this meeting on tropical deforestation has attracted. One reflection of that interest is the fact that so many leading U.S. experts have been able to come here to help us assess what the U.S. policy, strategies and programs should be in the months and years ahead.

The Department of State's sponsoring of this Conference results from two converging requirements. The accelerating disappearance of forest cover in the humid tropics and the loss of wood for fuel and other uses in the sub-humid tropics have been identified as extremely serious problems at a number of recent international conferences. These problems are also attracting increased attention in scientific literature and the popular press. Development planners, scientists, resource

managers, and the general public are all urging that something be done. Concurrently, there has been a rapid increase in the number of new proposals for deforestation policies, programs, and projects being generated by both national institutions and international organizations.

The Department of State is concerned about tropical deforestation because of the important international, social, economic and resource management issues which attend it. The United States is being called upon to take positions on, and support, a variety of activities being proposed by others. We hope to come away from this meeting with new insights into the most critical, unmet international needs in this area and with a clearer view of the types of U.S. and international programs now being pursued and proposed which deserve highest priority. We are also interested in identifying new opportunities which the United States might pursue domestically and through bilateral and multilateral channels in the years immediately ahead.

MR. ROBERT H. NOOTER, Deputy Administrator, U.S. Agency for International Development, Washington, D.C.

We in AID are delighted to have all of you here to help us work with the problems we are now groping with on how to become effective in dealing with the deforestation problems that face many of the countries where we work around the world. Most of the countries of the developing world are in the area of concern of this Conference—that is, the tropical or semi-arid areas of the world. Many of them have problems of the kinds you will be discussing during the Conference.

Starting with the 1977 fiscal year, we have had specific legislation attached to the

Foreign Assistance Act giving us responsibilities regarding the care of environment and natural resources in the developing world. This is a responsibility we are taking very seriously. We've done several things in the last couple of years in this connection. In the energy area we have established a new office working on renewable and unconventional energy sources, knowing—or anticipating—that the developing world is going to have to seek reliance on other than the conventional sources that the developed world has used in the past. We've also sponsored a number of National Academy of Sciences studies and

other research projects trying to get a more statistical way of dealing with or understanding the deforestation problems of the world. We're working with a number of other government agencies, including the Environmental Protection Agency, the Department of the Interior, and the Department of Agriculture as well as the United Nations in a joint program on this subject, and we have some \$25 million in our fiscal year 1979 budget dealing with either research or specific country programs having to do with the preservation or use of forests.

There are two things that we hope will come from this Conference. First, we want to get a clearer idea and develop a clearer public conception of the nature of the problem. Deforestation is one of those slow motion problems which is difficult to perceive on a year-to-year basis and yet has a profound effect over a longer period of time. I am reminded of the world population problem in this regard. I remember hearing about population problems in the fifties, a time when most people weren't taking the warnings seriously. On a yearly basis population growth was something that didn't get much attention, but after a number of years of dedicated work by people analyzing and making available longer range projections, we began to recognize the problem as very real and very urgent.

The deforestation problem is similar but 10 years behind in terms of public awareness.

We have to be careful, however, that we make our case with some precision. In the last several years, people have become more environment conscious and are more ready to accept the fact that these are issues that have to be dealt with. There is also a secondary trend, however, that involves a growing skepticism about wild claims concerning the world coming to an end for this or that reason. The deforestation problem should be laid out in such a way that it is clear that it belongs in the former category if we are to obtain real support in dealing with it.

The second thing I hope the Conference can produce is some additional guidance and help to us on what kinds of programs we should be engaging in and what sorts of programs will be effective.

I don't think we need be discouraged that we have an insoluble problem, but that doesn't mean that it will be easy to solve. Land management and reclamation weren't soluble in the United States until they became perceived as a problem. If we can bring a comparable level of public awareness to the deforestation problem, we will have made a valuable contribution toward its solution.

The Nature of the Deforestation Problem—Trends and Policy Implications

DR. GERALD BARNEY, Staff Director, "Global 2000" Study, President's Council on Environmental Quality, Washington, D.C.

Tropical deforestation is a very serious problem already and one which is growing more serious as time goes by. I have been asked to present a global overview to introduce this session, which is the sort of thing that we're trying to do with the "Global 2000" study that President Carter has asked us to undertake. President

Carter, in his Environmental Message to U.S. Congress, directed that the Department of State, the Council on Environmental Quality, and some 13 other appropriate agencies work together to develop a study of foreseeable trends in population, resources, and environment for the entire world up to the year 2000. The general plan

for the study is to work with the tools, the people, and the data that are available within the government in order to make some sense of what trends are likely to take place by the year 2000. The process begins with projections of the gross national product and population and uses that information as input to make resource projections of food, minerals, (fuel, and non-fuel) in forestry, and finally attempts some sort of environmental analysis of the overall trends. What I'm talking about today is what we've done in the area of forestry.

The first thing that we discovered in looking at the forestry question on a global basis is that the available data are quite limited. I initially had the impression that satellites would provide good information about forest cover throughout the world. Unfortunately, that is not the case. As we made inquiry, we found that the technology is available, that the satellites could provide very good information about forest cover throughout the world, but that as yet, no one has recognized this as being sufficiently important to either encourage that all of the data now available on tape from satellites be analyzed or that the satellites be passed over areas where the data are now inadequate. So neither have we sufficient basic data nor has that available data been analyzed. But we have been working with the information that is available, which, in some ways, is more limited than we would like.

Referring to the "Estimates of World Forest Resources, 1978 and 2000" [see Figure 1], note that for the developed countries—the Soviet Union, Europe, North America, Japan, Australia, and New Zealand—the subtotal for 1978 is approximately 1,464 millions of hectares of closed forest land. Note also that the figure does not change significantly by the year 2000. In other words, while there is a major cutting projected in the developed countries, there is a corresponding program of reforestation which projected out to the year 2000 suggests that the amount of closed forest will remain much what it is today. There is a change in the nature of

the forest, however, which is seen in the subtotal line in the growing stock area. There is an immeasurable decrease in the growing stock because the closed forest will be of younger growth. It's also important to recognize that the diversity in the forest will be decreasing because the reforestation is done largely with the most rapidly growing species.

In the developing regions of Latin America, Africa, Asia, and the Pacific, there is a closed forest area of something in excess of one thousand million hectares at present, but by the year 2000 there will be a significant decline in the forested area—down to 660 million hectares. The growing stock for the developing countries (LDCs) in 1978 is somewhat in excess of the growing stock in the developed world—171 billion cubic meters as compared with 156 billion for the developed countries. This is due in large part to the fact that it is largely old growth. It is climax forest in most cases that is the basis of the forest wealth of the developing countries, and as those are cut and used, the growing stock will decrease significantly down to 104 billion cubic meters by the year 2000. During this same period from 1978 to 2000, the world population will be growing from about 4.3 billion to about 6.4 billion. Thus, while the world stock of wood will be decreasing, the world population will be increasing, leading to a substantial decrease in the amount of wood per capita, going from 76 to 40 billion cubic meters available.

On a global basis the data on forest cover that are available [see Figure 2] indicate that in 1950 the earth's total forest area approached five billion hectares. Information from 1973 suggests that the total forest area then was about 2.6 billion hectares. If those data are correct, it implies a loss rate during the period from 1950 to 1975 of about 95 million hectares per year. If we take the 1973 number of 2.6 billion hectares and ask what is the present loss rate and obtain that information, we arrive at a number of about 20 million hectares per year. It is this much lower figure of 20 million hectares per year loss on which our

projections are based—not on the 95 million hectares per year. Perhaps the reason that the loss rate seems to be so much higher in the past is that the 1950 data may actually be higher than was actually the case and more recent data may be more accurate. Thus, there may not have been a loss rate as high as 95 million hectares per year in the past. The period from the year 1975 to 2000 has been divided into two large groups—the forest in the LDCs and the forest in the industrialized countries. The forests in the industrialized countries are projected to remain essentially of the same magnitude up to the year 2000, while in the LDCs the accessible forest declines rapidly during this period so that by the year 2000 most of the forests left available are those that are inaccessible.

The implications of the high rate of deforestation are many. One is that the countries that are most in need of maintaining a strong biological strength for their development—the less developed countries—will be depleting their stock of forest resources at a very rapid rate. While there is some talk of reforestation, the reforestation rate will not be adequate to keep up with the depletion that is projected. Furthermore, the projected reforestation will lead to a great deal of simplification, with only a few tree species, such as eucalyptus, being used for reforestation. Another major implication relates to climate. There is growing evidence that the deforestation that will take place up to the year 2000 and beyond will be of such magnitude that it may have implications for the global climate, both through the changes of the earth's albedo and for adding carbon dioxide to the atmosphere.

Perhaps one of the most significant implications of massive deforestation will be the loss of species. What is a reasonable estimate of global extinctions by the year 2000? Given the amount of original tropical forest already lost and the estimate of an additional two-thirds loss of the remainder by 2000, it seems that tropical forest diversity and the number of species in the *remaining tropical forests* will have been reduced by one half. It has been estimated

that 10 percent of the world's biota is dependent on virgin Amazonia forest, five percent on the less diverse and less widespread African forest and 10 percent on Southeast Asian forest, thus the diversity loss *worldwide* from removal of two-thirds of the tropical forests (alone) would amount to one-eighth of the planet's biota.

What exactly will happen as a result of the loss of species is not entirely clear. It is clear that much of our current agricultural system depends on there being a genetic stock from which hybrids and very fast growing crops can be produced and from which we can extract genetic material to improve disease resistance. It is also clear that we don't even know what the species are that in many cases would be lost—or how they would be a potential help to mankind in the future. That is a very hard thing to estimate.

It is clear, however, that there would be tremendous problems associated with water resources due to deforestation. Perhaps a quarter of the human population in Southeast Asia now depends upon the continued operation of a single watershed. As the forests are removed, the implications for what will happen to water management problems is almost beyond imagination. Tremendous problems already exist, and they are rapidly getting worse. As the water problems worsen there will be severe implications for agriculture. The water will not be available when it is needed in dry periods, and, without the forest to help retard the sudden run-off, flooding will take soil away and cause erosion, further aggravating problems of agricultural development. I have to say that we see tremendous problems in this area and that perhaps the most difficult ones to cope with are going to be those associated with reforestation in heavily populated areas. In those areas the dependence is not so much on forestry-related wood products and lumber but for firewood for domestic sources of energy and heat. It seems that efforts at reforestation in populated areas are running into difficulty because people need to cut very young trees for fuel wood before they've had a chance to grow significantly.

Discussion

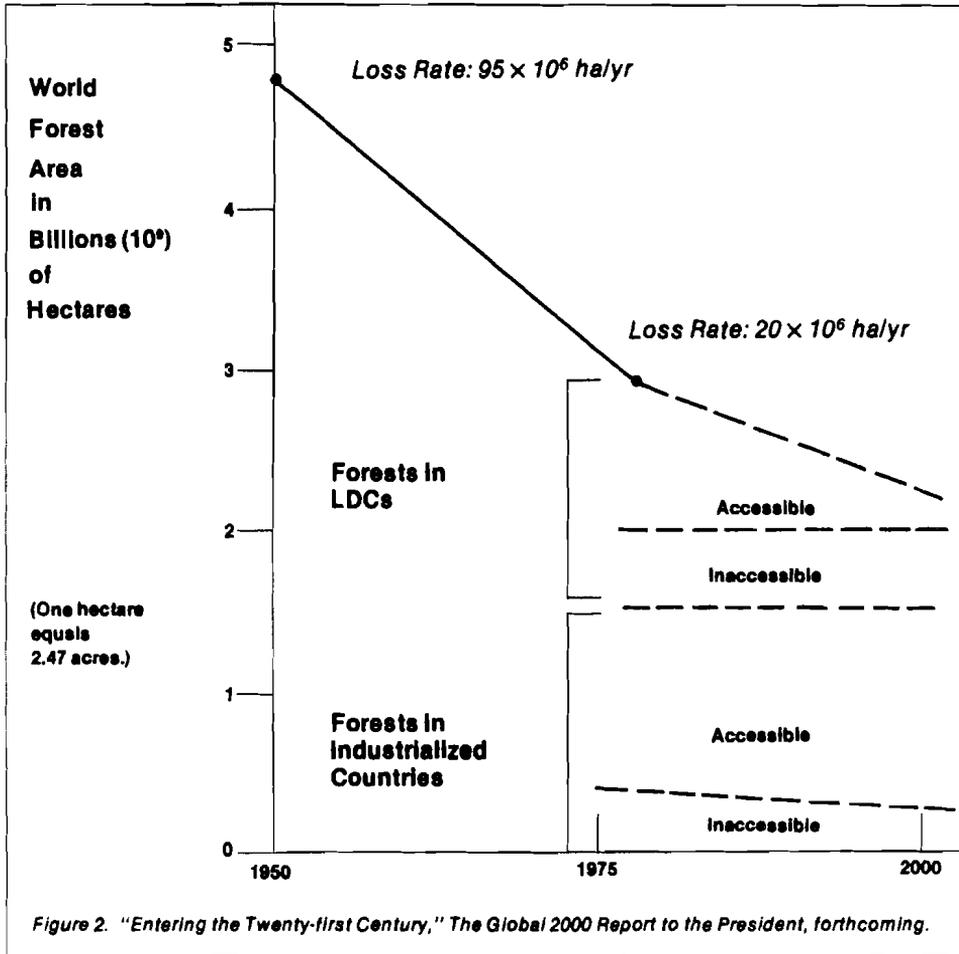
Some Conference participants expressed the view that **Dr. Barney's** figure of 20 million hectares per year of tropical forest lost to deforestation activities was too high. It was suggested that a more realistic figure would be 2.5 to 3 million hectares of closed and open tropical woodlands deforested annually.

Questions were raised as to whether Dr. Barney's estimates included not only closed forest areas, but also open woodlands. Dr. Barney responded that the figures on deforestation applied to closed forests while those pertaining to growing stock included both closed forests and open woodlands.

	CLOSED FOREST (MILLIONS OF HECTARES)		GROWING STOCK* (BILLIONS OF CU M OVERBARK)	
	1978	2000	1978	2000
	U.S.S.R.	785	775	79
Europe	140	150	15	13
North America	470	464	58	55
Japan, Australia, New Zealand	69	68	4	4
<i>Subtotal</i>	1,464	1,457	156	149
Latin America	550	329	94	54
Africa	188	150	39	31
Asian and Pacific LDCs	361	181	38	19
<i>Subtotals (LDCs)</i>	1,099	660	171	104
<i>Total (World)</i>	2,563	2,117	327	253
World Population (Billions)			4.3	6.4
Wood Per Capita (CU M Per Capita)			76	40

**Commercial sized wood in closed forests and open woodlands.*

Figure 1. "Entering the Twenty-first Century," The Global 2000 Report to the President, forthcoming.



DR. NORMAN MYERS, Natural Resources Defense Council, Nairobi, Kenya

In discussing the global problem of tropical deforestation, it is important to consider what is happening in various regions and in individual countries because of the many policy implications. For example, what does the Department of State or AID do with regard to a country which might lose its remaining forests within the next five or 10 years as compared with a country which might still have considerable areas of undisturbed forest by the end of the century. There are two different categories of needs and op-

portunities which can be broken down into sub-categories. For example, the lowland rain forest of the Philippines and Peninsular Malaysia may well be logged over and grossly disrupted, if not eliminated, in wide areas as early as 1985. Similarly, a rapid process of deforestation is occurring in Ghana, Nigeria, and the Ivory Coast. In Central America the problem is urgent because in 10 years there won't be much tropical forest left, except in a grossly disrupted form.

Looking toward the end of the century, it appears that given present patterns of forest exploitation, a good deal of lowland forest in Indonesia will have been eliminated or fundamentally modified. This projection is based on present rates of exploitation, and it is quite likely that these rates will accelerate due to increased activity in commercial logging, various forms of shifting cultivation, and fuel wood collection. In the eastern sector of Brazil's Amazon Basin it is quite likely that there will be widespread deforestation, if not outright clearing. According to some authorities, however, the western sector of Brazil's part of Amazonia may undergo a great deal less disruption by the end of the century. So while it is useful to have global figures of how much forest is disappearing per year, how much is left now, and how much will be left in time, the problem should be broken down, as much as possible by region and country.

Let us consider why the United States is concerned about deforestation in the tropics. First of all, there is the climatic question [see Dr. George Woodwell's presentation, "CO₂—Deforestation Relationships"]. One area of concern is the albedo effect of deforestation, in which far more light and heat are reflected from deforested areas than from areas where there is a large mass of vegetation to absorb light coming from the sun. There is also the possibility of particulate matter in the atmosphere resulting from large-scale burning. These activities could possibly disrupt climatic patterns not only in the tropics, but also in the temperate zone of the planet. It has been suggested that as a result of massive deforestation in the tropics there could be a decline in precipitation in the grain growing belt of the United States. If this were to happen, possibly within two or three decades, the United States might find itself with too little rather than too much food in an increasingly hungry world. This would have far reaching implications for the United States in the areas of foreign policy and national security. I hesitate to put it in these terms, but I think that this is a dimension of the problem which is worth looking at.

Secondly, let us examine the problem of disappearing species. Dr. Gerald Barney has suggested that several hundred thousand species may be lost through the process of wide-scale deforestation in the tropics. The tropical forests, with their rich biotic diversity, contain more species than any other ecological zone on earth. Many of those species are more predisposed to endangerment, if not extinction, than those of the temperate zone. When the United States fundamentally modified its eastern deciduous forest over the past two hundred years, and especially since the Civil War, it lost the passenger pigeon and several other species. But the fallout was not very high. In the tropical rain forest the fallout is likely to be a great deal higher because the species are not nearly so adaptable. Many of them have highly localized distributions confined to as little as one hundred square kilometers. When small areas are deforested by commercial logging or by shifting cultivation, the species loses its total life support system and it disappears. If we consider that some half million species might disappear in the tropical moist forests by the end of the century, this works out to a rough average rate of around 100 species lost per day. Clearly, the process of destruction is going to gather momentum and will be much more acute in the 1990s than it is right now.

I suggest that species loss is important for pragmatic reasons because of the vital roles served by wild species of plants and animals as genetic resources. It has been noted that the United States is dependent on germ plasm from tropical moist forests to maintain the productivity of its food crops. It has also been stated that the American economy is more dependent on foreign sources of germ plasm to maintain its agricultural productivity than it is on foreign sources of oil. While that may be putting it in pretty extreme terms, I believe that there is a lot of substance in this argument, which has been carefully developed by Worldwatch Institute. This is one dimension of how important it is to this country to maintain genetic resources in the tropics.

For another example, when one goes to the local drug store with a doctor's prescription, there is one chance in two that the drugs one purchases will have been derived in some way from some wild plant or wild animal species, and there is a chance of one in five or possibly one in four that that species will have been derived from a tropical moist forest. I can't give an exact dollar figure for the value of these species in the pharmaceutical trade for 1978, but in the late 1960s the value for drugs developed from wild species was on the order of \$3 billion. The National Cancer Institute at Beltsville, Maryland, has stated that if tropical forests are widely eliminated within the foreseeable future, this would cause a major setback to the anti-cancer campaign because so many new drugs are being developed from plants of the tropical moist forests. Of some 1,500 plants from the tropical forests of Costa Rica studied, as many as 15 percent were found to have potential for the campaign against cancer. These are only representative examples of the genetic importance of tropical moist forests to the agriculture and health programs of not only the United States, but also the rest of the world.

Let us consider another possibility with regard to the importance of species. There is the possibility that developing countries could use their forests, and particularly some of the faster growing species within them, to engage in a process which is popularly known as growing gasoline. Fossil fuels, mainly petroleum, coal, and natural gas, are simply plant material which has been gestating through geological time. It now appears technologically possible through processes known as pyrolysis and hydrolysis to telescope that process in just a few hours by assembling sufficient plant bio-mass in one place and turning it into alcohol fuels which are suitable for powering cars. Brazil has already made a good deal of progress in this area. It is possible that developing countries could, within 20 years, develop quite large sources of petroleum from their tropical forest areas by establishing plantations of fast growing vegetation. This

depends in turn on whether a sufficient variety of tree species are left. One successful example is *Leucaena leucocephala*, which has been developed in the Philippines. This is quite an extraordinary tree that grows very fast and can be used for a wide variety of purposes, not only having potential for growing gasoline, but also for use as wood for fuel and building materials. I believe that some parts can be eaten by humans for their high protein content while *Leucaena* foliage can be used for livestock. This is something of a miracle tree and a good deal of the development work with this species has been conducted in the Philippines by USAID.

I believe that the Department of State and AID should give more emphasis to tropical forestry because it has an important place in the new development campaign to meet basic human needs in the developing countries. I have often heard it said by government leaders, economic planners, and international assistance people that while forestry is important, it does not have as high a priority as growing food, health programs, or better water supplies. I believe this is a mistake in perception because although forestry is not competitive with these other economic sectors, it must be seen as complementary or supportive of them.

In the Philippines the Green Revolution is starting to dissipate because the three crops of rice which can be grown each year are dependent on regular supplies of water for irrigation throughout the year. As the Philippines lose their forests, especially on the hilltops, the regular supplies of water are declining, and Philippine agricultural productivity is beginning to run into trouble. The International Rice Research Institute, located in the Philippines, has developed the Green Revolution in Southeast Asia and has an annual budget of about \$8 million, supplied primarily by the Ford and Rockefeller foundations. In the same township where the Institute is based are several forestry research institutes whose total budgets, since they

were established several years ago, have not yet reached \$1 million. This is an example of the discrepancy in research funding. The Philippines are beginning to learn something from this lesson.

In Kenya, in the last few months, there have been unusually heavy rains and extensive floods. Roads have been washed away and the railway system has been disrupted. As a result, government agencies are now becoming aware of the vital role played by forests in controlling erosion.

In some countries hydroelectric schemes are being halted because of siltation in reservoirs. Engineers in some countries are now promoting forestry. In still other

developing nations, domestic water supplies to urban areas are both inadequate and unhealthy because of deforestation activities. Again, forestry can serve as an important support factor for development campaigns designed to meet basic human needs.

Any important U.S. strategy in the developing world should include the promotion of agroforestry. AID has already begun to undertake the establishment of community woodlots in order to relieve the pressure by fuel woodcutters on primary or little disturbed forests. But it has been estimated by the World Bank that in order to establish community woodlots of sufficient scope for the developing world, some \$2.5 billion would be required.

“DEFORESTATION—DEATH TO THE PANAMA CANAL”

DR. FRANK WADSWORTH, Director, Institute of Tropical Forestry, U.S. Department of Agriculture, Rio Peidras, Puerto Rico

The Panama Canal is probably the world's most important ship channel. Nearly 15,000 ships pass through it every year, and its width and depth dictate the design, dimensions, and cargo displacement of much of the world's fleet. The Canal reduces open ocean shipping by distances of up to 10,000 miles.

The recent Panama Canal Treaty, providing for relinquishment of the Canal by the year 2000, reflects no decline in U.S. interest in the Canal but rather, in line with Panama's request, that the Canal should be administered by that sovereign nation.

The capability of the fresh-water supply of the Canal to continue to meet growing demands has been taken for granted. About one-third of the water of Gatun Lake is used to generate hydroelectric power. Additional water from the lake and from the tributary reservoir, Lake Alajuela, serves urban needs in the Canal Zone and in the cities of Panama and Colon. The passage of each ship through the Canal releases 52 million gallons of stored fresh

water to the sea. This use disposes of more than half of the runoff from the Canal watershed. Nevertheless, a set of locks one-third larger is under consideration which would require an even greater amount of fresh water for each additional ship passage accommodated.

Land use within the tributary watersheds has also reflected confidence in the capabilities of the Canal watersheds to meet growing demands. Originally covered with dense rain forest and still 85 percent forested as recently as 1952, some 250,000 acres, or 35 percent, of the Canal watersheds have since been deforested—burned for cultivation or pastureland.

The boundaries of the Canal Zone have never included the headwaters that feed Gatun Lake. Not only these headwaters, but also parts of the Zone itself have, in recent years, been deforested. Apprehension of trespassers in the Zone by the United States is now complicated by criticism in the Panamanian press.

In May of 1977, the passage of an above average number of ships, an increased use of water for hydroelectric power and the domestic supplies of growing cities, and the production of timber, food, and forage crops within the Canal watershed, led to a dramatic demonstration of the limits of the capability of the water system. The surface of Gatun Lake dropped to 3.1 feet below the level required for full Canal use. Some ships sent part of their cargo across the Isthmus by land, reloading it at the other coast, and certain bulk cargo shippers even abandoned the Canal, sending very large cargo carriers around the Horn.

In 1977, this predicament coincided with a serious drought, and this was seen as a harbinger of what could soon take place every year. Water consumed for power and domestic needs drains the lake. Deforestation and cultivation in areas adjacent to headwaters accentuate both flood losses through the spillway and low flow in the dry season. Deforestation has caused sedimentation in Lake Alajuela to depths of 25 feet in some places, resulting in the lake's having already lost more than 5 percent of its active storage capacity. Current land use trends will, by the year 2000, result in the sedimentation of about 40 percent of the storage capacity of Lake Alajuela. This would mean further losses to shipping due to widely varying draft tolerances and drastic fluctuations in water availability for power and urban use.

Several solutions to these growing water problems have been considered. Removal of sediment from a reservoir the size of Lake Alajuela is not considered feasible. Raising Madden Dam by 10 feet is physically feasible, but at best would only delay the crisis. The five additional reservoir sites existing in the watershed could only replace the active storage capacity being lost at Lake Alajuela and would themselves eventually become sedimented. Channeling water from an adjacent watershed could increase the water supply, but would also increase sedimentation because adjacent watersheds are also being deforested. The pumping of sea water into Gatun Lake involves the risk of introducing organisms from the Atlantic into the Pacific.

None of these proposals is more than a stop-gap procedure because none offers more than a temporary reduction in the rate of deterioration. Only forests can restore and stabilize the capacity of the Canal. Even if Madden Dam were raised, the five additional dams built, fresh water tunneled from elsewhere, and power and urban water consumption discontinued completely, the effect of continued deforestation would be inexorable. Sooner or later it would mean death to the Canal as a reliable world trade route.

The most critical remaining area of primary forest in the Canal Zone covers some 225,000 acres in the rainy headwaters of the Chagres River and adjacent subwatersheds tributary to Lake Alajuela. This area provides about 40 percent of the water for the entire Canal watershed. It is now being invaded by shifting cultivators. This is of critical significance to the United States, and a major irreversible decline in the utility of the Canal can be expected to take place during the incumbency of the United States as operator of the waterway unless corrective action is taken immediately. But by the time the United States transfers the Canal to Panama, the Canal may have become a worthless ditch, a colossal monument to resource mismanagement. However fortuitous the timing, could the United States deny that it had foreseen the trouble and not forestalled it? Could the United States point to the fact that it does not control the critical headwaters outside the Canal Zone while the Zone is being continually deforested? Would the United States really have had no part in this obstacle? Clearly the diplomatic problems in this respect could transcend those which brought on the recent treaties.

The most urgent step necessary to save the Canal is the immediate halt of deforestation of the watershed, particularly in the valleys of the Chagres and Indio rivers. The capacity of these remaining rain forests to control soil and water movement is almost irreplaceable. Of nearly equal urgency is the discontinuation of cultivation and pasturing in the watershed and the reforestation of an additional 240,000 acres of steep land. A rational program of land use

will also require the more intensive use of some 150,000 acres suitable for agriculture, thereby providing employment for the 10,000 rural families living within the watershed. These watershed control practices are needed chiefly outside the Canal Zone. Leadership for this program must come from Panama since even the forest within the Canal Zone can no longer be protected without the support of Panamanian authorities. Since operation of the Canal in the immediate future is in jeopardy, it seems more than logical that the United States share with Panama the cost of needed conservation, watershed management, and rural development.

USAID has for some months been developing a five-year watershed management program with the government of Panama. The program is aimed at developing the Department of Renewable Natural Resources (RENARE), an agency within the Ministry of Agriculture, with emphasis on protection and development of the Canal watershed. An AID project may start a program to protect the Canal, but it could fall short in one critical aspect—continuity. A long-term assurance of adequate water for the Canal should not have to rely on extraordinary financial allotments made from time to time by the two governments. What is needed is an assured continuity which would sustain a cadre of well-trained, career-oriented personnel.

If the future of the Canal is at stake, should not management of the watershed be a proper and high priority use of Canal fees?

These fees, which are said to amount to \$300 million annually, are used in part for other types of Canal maintenance, such as dredging the channel. A flat percent of gross Canal fees would presumably rise with inflation and thus assure long-term support. Matching of fee allotments by the Panamanian government might be desirable, but if required, could introduce an element of uncertainty into the program which must be avoided. If the program were supported entirely from Canal fees before the year 2000, it would have no adverse financial impact on Panama thereafter.

The recently signed Panama Canal Treaty provides in Article VI for a Joint Commission on the Environment, representing both governments, to oversee the watershed program between now and the year 2000. No treaty provision, however, appears to support or staff the commission. The channeling of funds from Canal fees for the operation of this commission and for the watershed management program of RENARE could provide continuity and involvement of both governments. The commission might utilize AID as a source of technical support. A continuing watershed protection management program, led from within the Panamanian government seems, under the critical circumstances that prevail, to be a minimum obligation of the United States. It could assure the preservation of the Canal as a world resource during the U.S. period of its operation and make possible its continued utility for an indefinite period thereafter.

Discussion

Among the views expressed in response to **Dr. Wadsworth's** presentation was the recommendation that the U.S. government should not provide funding for development projects abroad which would result in the destruction of tropical forest areas.

Another speaker noted that although conservation is often viewed as an impediment to progress, high economic costs are usually associated with projects that lack conservation practices.

Several speakers urged conference participants and government officials to view the problem of deforestation within the context of the overall problems confronting those developing countries with areas of tropical forests.

It was noted that because of the importance of the Panama Canal to world commerce, universal concern and action could result in saving the waterway, thus making the Canal a prototype for the application of necessary solutions.

Response to Date—Institutions

AMBASSADOR ROBERT O. BLAKE, International Institute for Environment and Development, Washington, D.C.

In discussing the environmental and the organizational thrust of what is happening regarding deforestation in the tropics, we have to go beyond the efforts of the United States. The problems are broader; the need for many organizations and many people to make their contributions is evident; and what we really need to do is know what each organization can do. Therefore, in addition to commenting on the work of AID and several other U.S. organizations, I will also talk about international financial institutions, the United Nations and its specialized agencies, and other bilateral agencies.

I would like to begin with one central—and I am afraid too evident—factor that must always be considered when one is looking at what the U.S. or any other organization can do to save the forests of the tropics: the principal agents for saving the forests are the government leaders of the countries where the tropical forests are located. It is their responsibility; they have the control; and they can say *yes* or *no* to what should be done in this day of national sovereignty. They have broad responsibilities to their countrymen, their neighbors, and to the citizens of the world regarding weather, climatic alteration, and the chemical composition of the atmosphere. Yet, short of a super crisis, it is very unlikely that the nations of the world

are effectively going to bear down on any other government to make them do something that they don't want to do.

Therefore, what we are talking about is, to a great extent, the persuasion and assistance to create within the governments of seven or eight principal countries the will and the capacity to do something about these problems. I will not try to analyze the reactions of the tropical forest countries. That is too complicated a problem and I am afraid it does not quite go to the center of what the U.S. is trying to do. But I will analyze what I believe to be the responsibilities of each nation involved, as well as the moral and practical responsibilities of other members of the world community. Admittedly, this is a very broad and very subjective type of thing, and although no one has enough knowledge to answer these questions with full confidence, I will make an effort to do so.

One basic premise that I would like to establish before going further is that the only realistic basis for getting tropical forest countries to undertake the fundamental and extremely difficult changes in their developmental policies is to help them realize that their self-interest lies in saving the forests. Unless they can be convinced that this is in their interest, the action that we are looking for will not happen.

Many of us accept the idea that preserving the gene pool and preserving representative ecosystems are of the utmost importance to the human race. But these are issues that have to be argued and they are not accepted in many of the countries about which we are talking. We also have to make a case for the broader problems concerning the impact of deforestation on the earth's atmosphere, climate, and weather. These are complex scientific problems about which there still is not a consensus, especially outside the scientific community, and the question of credibility arises here in a very real way.

There is a need in every one of these countries, with very few exceptions, for maintaining forests as sources of fuel wood and timber. It is politically naive to believe that these basic human needs do not generate political pressures on each nation's leaders. The leaders are first of all politicians or they wouldn't be in positions of power. It is also naive to believe that, at least in the immediate future, one will get from the developing countries a strong enough reaction against developmental exploitation to stop that exploitation. These countries need food; they need foreign exchange; and they need fuel, much of which must be imported.

As I examined the basic problems, what I found is that we are at the stage of recognizing the problems, but we have not yet arrived at the stage of having a really sophisticated strategy, either in the United States or in the world as a whole. This is one of the basic issues that we have to address immediately. This Conference is a sign of great hope and should be followed by other efforts. I believe the Department of State and AID should take the lead in trying to devise a strategy to deal with the tropical forests, considering not only State and AID and their actions, but also the private sector and their operations.

The U.S. government needs to examine problems of tropical forests more closely and to think in terms of human needs; to think in terms of the basic thrust of what AID policies are actually doing. We also

need to look at the extent to which we can control, possibly through public means or through the social audit functions of our environmental community, what is done by American companies operating in these countries. We need to examine scientific priorities. Someone needs to seize the initiative on these issues. I suggest that the logical bodies are the Department of State and AID.

Now I would like to discuss what is being done on the policy level, not only with AID, but with other agencies. I think that we have to ask whether these organizations promote environmentally sensitive policies and whether they are sensitive toward forestry in general and tropical forestry in particular. Do they have a defined doctrine and has it been agreed upon? Are these institutions exercising leadership in problem areas? If there is anything we need right now it is leadership. Neither AID nor State now has a definitive doctrine concerning tropical forests. Bits and pieces of policy exist in various papers, but they are not generally known or coordinated. And there are no sector papers which say what the United States should do about forestry, or more specifically, tropical forestry, or the multiple interconnections which I have been talking about. This seems to me to be an obvious need and one which should be corrected quickly. I can say that we all are proud of the leadership which is displayed in calling this Conference, but it needs to be consolidated. The problems and the inconsistencies of our policies need to be discussed and reconciled.

Good work in defining what needs to be done in tropical forestry development is being done elsewhere. The World Bank's Forestry Sector Policy Paper, which recently appeared after a long amount of work, is the best short document on forestry development and its relation to environmental practice that exists. Through the process of coming up with this paper, new viewpoints, policies, and funding criteria were adopted by the World Bank. The Bank is, I believe, headed in the right direction. The Bank has also started

something that is conceptually important: its definition of environmental forestry. While this is far from being fully defined in the paper, it is as good a start as has been made to date. The tropical forestry part of the paper is, in my view, quite good and needs to be looked at closely by those involved with the problem.

What is important is that the paper discusses the importance of land use planning, of knowing what is in the forest, the kinds of soil, weather factors, and other pertinent data which are needed in order to make judgments on how the forest can be used. The paper also does a very good job in enunciating the importance of the additional work, scientific and practical, necessary to find the means, through agroforestry, of the appropriate kinds of exploitation of the tropical forest. It is also quite daring politically in the way it discusses the importance of avoiding high grading in timber exploitation in a number of developing countries. It urges that timber exploitation be done directly by the countries involved and not by foreign multinational companies, thus ensuring that the financial gain goes to the country concerned. An important aspect which needs to be approached in a U.S. policy paper is the whole question of institution building in the forestry sector. In this area there is much to be learned from the World Bank's efforts.

The same thing cannot be said of the regional banks. The only one which has any kind of a real forestry policy paper is the Inter-American Development Bank (IDB), however, the paper is not of much importance because the IDB is not very involved with forestry. The other banks are doing very little. Also, there exist no well-defined policies among the regional banks concerning road building, colonization, or dams. Each of these problems has to be faced quickly if we are going to deal effectively with deforestation.

Some of the work which has been done by the FAO in such areas as agroforestry, parks, and reserves has been absolutely

essential in the development of current doctrine. It is not their principal function, however, which is rather to provide such things as technical assistance and surveys. Basic development has to be financed through national and international financial organizations.

I can't say too much about where the U.N. Environment Program (UNEP) and the U.N. Development Program (UNDP) are in the way of policy, but my feeling is that, again, they have no well-defined tropical forestry policy in operational terms. UNEP is moving in that direction. UNEP's great importance is in influencing opinion in developing countries, but there is still a long way to go.

We must next ask, do the institutions which we are talking about have the necessary resources to carry out these policies? Basically, the answer to that question is a resounding "NO." None of the organizations, with the possible exception of the World Bank, have enough resources to carry out what they say they want to do, let alone what they should do. By this I mean carrying their share of the load.

Let us consider AID first. AID has one forester, who is retiring this month. AID has many people who are very able, but it does not have enough people to do a good in-house job in tropical forestry. AID needs a centrally placed forestry staff which, in my view, can look at the problems and then move in, taking advantage of the various kinds of expertise which undoubtedly exist. It seems to me that it is impossible, in the long run, to depend exclusively either on consultants or on forestry experts in other government institutions. It is essential to have in-house personnel. I don't know whether this is contemplated, but it certainly is imperative if AID is going to make its necessary contribution. AID also needs to combine its forestry oriented activities into some kind of a unit where they can have the force and the influence necessary to execute a policy. I think that it is very important to ensure high level

support for tropical forestry projects. Various high-level people in AID have been very vigorously supporting the idea that the U.S. has the responsibility regarding tropical forestry, but this has not yet trickled down through the ranks. A lot of education remains to be done. There are areas in which people are apathetic, despite the severity of the situation.

AID has indicated that it will spend some \$25 million over the next 5 years for its worldwide forestry activities, much of which will be used in Africa's Sahel. But there is a question in my mind whether this much money can be successfully used in one year in the Sahel because forestry is the toughest problem there is in that area. Although I will reserve my judgment on this problem, I will say that there is still a need for a much broader budget to accomplish in forestry all that AID is capable of.

The World Bank has a growing number of foresters. Certainly the Bank is in a vital position and should assume a role of major leadership. The World Bank is modest and sometimes seems afraid of assuming leadership. That is understandable, because from time to time there is criticism from the regional banks that the World Bank is trying to do just this. But on the question of tropical forestry, these are risks that should be taken. I believe that while the World Bank is now doing a good job, quietly talking to governments about what should be done, there still is a tendency to say that the borrowers are sovereign and they should not be pushed. There is an urgent need for the Bank to take a more aggressive position and to use its resources more effectively and its arguments to this end. The Bank has a number of good forestry projects scheduled, but it must recognize that until some of the other organizations begin to deal effectively with the problems, it has the biggest share of the responsibility.

I will pass over the regional banks because none of them has any foresters except one at the Asian Bank—and none of them seems able to do any major work in tropical forestry.

The bilaterals, aid giving agencies engaged in forestry, the United States, France, Canada, Sweden, Australia, Norway, the Netherlands, and several other countries—have small programs, but none of them, as yet, is organized to effectively deal with any major part of the problems pertaining to tropical forestry. What can one say about the resources of UNESCO? Its role is largely to help convince people in Third World countries with tropical forests to tackle the problems of conservation and preservation in terms that are acceptable to Third World people. UNEP shares in this task. It is an enormously important responsibility. UNESCO's Man in the Biosphere program and the work of the International Union for the Conservation of Nature and Natural Resources (IUCN) seem to be the best things that are being done. Unfortunately, programs to establish preserves are seriously underfunded and badly in need of national support. The United States has given some support, but not nearly enough. We need to do more, and that is true of almost every country in the world.

On the scientific side, there is a real question whether the necessary resources are available. As one looks over a number of organizations, the amount of attention devoted to tropical forestry is minimal and there does not yet seem to be an effective center for mobilizing the resources, the money, and people necessary to examine the many serious problems of tropical forestry. The questions relating to the management of tropical forests are practically untouched as are the questions of natural regeneration, about which so little is known. The question of how degraded lands can best be salvaged; the question of how to use less well-known trees where presently only a small percentage of species is being used; and the question of better cutting techniques to utilize more of the tree, are all problems upon which the scientific community should concentrate its research capabilities to solve. These are areas in which the United States should exert its influence to reorient or procure additional resources.

I have a few additional remarks regarding the performance of institutions in the area of tropical forestry. Everything that AID is doing seems to be in the planning stage. I have had an opportunity to look at some of the AID documents on the Panama watershed project and it seems to me that the Agency is on the right track, but this project still needs a lot of working over. One of the most difficult aspects of the problem is what is being done to insure the cooperation of the residents of the watershed with this project. None of our efforts will be effective unless there is local cooperation. It is also absolutely essential that money be allocated in this fiscal year in order to start some of the work in reforestation in the Canal watershed. Although a good deal of resource base data is available, a lot more is needed if, in the 1979 fiscal year, AID is going to perform effectively. The direction and thrust of this reforestation should be established before the Canal Zone is turned over to the Panamanians.

As far as what they are *not* doing yet, AID should be considering a number of forestry programs. So far none is well defined in the conceptual thinking of the organization. AID should look very closely at the contributions that it can make in establishing preserves. Much more needs to be done about how one plugs forestry components into each of the rural development schemes which are commanding increasing attention today. A start has been made in this direction, but a more systematized approach needs to be undertaken.

It is also important that AID and other aid giving organizations should devote more time to helping colonization schemes. Colonization efforts are currently being supported by the World Bank in Indonesia, Brazil, Thailand, and potentially in Nepal. These are the hardest kinds of projects because not only are unit costs high, but the potential for destruction of tropical forests is also very high. It is very important for AID, the World Bank, and each of the other organizations to become closely involved in colonization efforts because these are projects which represent real human needs. We must accept failures and

partial failures as the cost of trying to make colonization projects operative. This question needs a lot more discussion among organizations, and I would urge that this be started very soon.

Despite the broad thrust of the World Bank's various programs, there remains an enormous amount of work to do, and the Bank still has only limited financial resources to undertake it. The problem of getting enough resources for the World Bank in this sector is one to which the United States government and the people in this country who are concerned with tropical forestry problem should direct some attention. The same thing is true of the tropical forestry work of many other organizations to which the U.S. is a major contributor.

In summary, this all adds up to a picture that is not very optimistic. Although some people in this and other industrial countries, are now beginning to understand the problems of tropical forestry, the major task lies in persuading the leaders of the tropical forest countries to do many things which are against their instincts. Something effective has got to be done to bring home to these leaders a real recognition of the seriousness of the problems and to help them establish a viable political base from which to act. The international development community and the world scientific community also have a very high responsibility for articulating the urgency of the tropical forestry problem in a way which will be understandable to Third World countries. Organizations such as UNESCO, UNEP, and the United Nations itself must provide effective forums in which these ideas can be disseminated.

In the end, leaders react to the wishes of their people no matter what the form of government. It is essential that a way be found to reach not only the leaders but also articulate segments of the public of the nations involved.

Another point that I think we should have on our agenda is the discouragement of a number of destructive practices in the

tropical forests. I mean many destructive practices of logging, slash-and-burn agriculture, and clear-cutting to provide space for cattle grazing, all of which are paramount factors contributing to the destruction of the tropical forests. The international development agencies have an absolute responsibility for seeing that nothing of this kind is done. Despite the obvious difficulties, national and international organizations have a responsibility for overseeing the activities of multinational corporations and for trying to insure that these corporations avoid such practices. Under the present legal system in the United States, I doubt that we have the ability to control the activities of multinational corporations.

The major American thrust should be on the question of planning for correct use of tropical forest areas. We should concentrate on helping the countries concerned to develop the ability to make rational decisions on what should be done with their forests. A lot of basic work on soil surveys, and further work on aerial and particularly satellite surveys needs to be undertaken with our support. There is also the job of defining what needs to be done to establish tropical forest preserves, and to protect endangered species. We must endeavor to reach an early national consensus

concerning the IUCN document "World Conservation Strategy" in order to get to the point where we can begin working on something very positive.

One final note: we must stop talking in generalities. There is an urgent need for an integrated strategy on the part of all organizations, national and international, about what should be done now to save the tropical forests. But we cannot wait for such a development to take place. This will not happen without leadership. What needs to be done now is for AID, the Department of State, and the World Bank to assume the leadership in bringing together small numbers of nations, organizations, and people who are like minded to undertake the most urgent tasks. There are already enough organizations and we should work with those which already exist. Here at home, there is an immediate need now to set up an informal action group which can begin to look at the many facets of the tropical forestry problems. Washington needs to give attention to conceiving government strategy. Resources will be scarce in this day of declining budgets, but we should start by getting agreement on what are the most important things which need to be done to save the tropical forests. The time is short, and the need is great.

MR. ROBERT FISHWICK, The World Bank, Washington, D.C.

The World Bank's "Forestry Policy Sector Paper" says quite a lot of things that have been said before. Its main importance is that it presents us with new guidelines for our lending program.

Many of the Bank's projects, in forestry and other areas, cooperate very closely with FAO. We also cooperate by financing through other development banks and working jointly with a number of bilateral aid agencies. In addition to having a forest advisor, the Bank now has regional foresters for the major regions in the world.

One of the most difficult problems we and all the other agencies operating in West Africa today are facing is the problem of the Sahel. The Bank, in cooperation with FAO, is currently involved in three projects to alleviate the fuel and building material shortages in Mali and Niger. There are two projects concerning tropical forest areas that we have recently been negotiating with governments in West Africa. One project in Liberia in which we are cooperating with the African Development Bank and the federal government of West Germany aims at strengthening the newly created

Forestry Development Association (FDA), which has only recently been established by the Liberian government. We are also assisting the FDA in formulating fiscal policies to maximize government revenues and encourage the use of lesser-known species.

We are also advising and assisting in the maintenance of Liberia's national forests, which now actually have been declared at 1.8 million hectares out of the known total of 2.5 hectares of the country's closed tropical forests. The Liberian government intends to preserve these national forests, and they have requested assistance to achieve this goal. At the same time, we are assisting in what is basically a research program to develop methods and technology to replace degraded, low-value forests with plantations of faster-growing species for industrial wood production. If the program itself is successful, this particular region in Liberia will be kept under productive forest cover and not just converted to bush fallow.

In Nigeria, where there is a legally secure state forest of 95,000 square kilometers, there is pressure by agriculturists and other development groups to bring into development many of forest reserves, particularly for tree crops and farm land. An FAO project in Nigeria, which has been in the field for at least four years, was instrumental in getting the Bank to identify a project to look into the problem of the opening up of previously protected forest areas. Unless the problem is remedied, there will be serious shortages of timber in the domestic market within 20-25 years. Nigeria, within the last two years, ceased being an exporting country and is now having to import certain categories of wood. In Nigeria, both the federal and the state governments have their own forestry departments. The Bank's project is aimed basically at assisting these departments in the establishment of plantations of timber

species to help supply the short-term demand expected in the domestic market, and at the same time ensure that there are adequate supplies of plantation-grown wood from thinnings for the new pulp mills. In addition, the Nigerian project will assist in increasing food production not only by various known growing methods, but also by newly identified systems of agroforestry. Again, this is in close cooperation with FAO.

We are also assisting in the establishment of forest villages to encourage the rural population to become more involved in forestry activities, and we are cooperating with on-going FAO/UNDP projects in evaluating and identifying other forestry problems which could lead to further Bank-assisted projects.

Another situation exists in the Congo, the Cameroon, Zaire, and Gabon, which are all timber-rich countries with comparatively low population densities. In these countries, the problems are not yet those concerned with the rapid destruction of valuable natural resources, but rather how the economic development of these countries can be assisted in rationally exploiting these resources. Although the Bank does not have any forestry projects in these countries as yet, the sort of projects that it will be looking into would be in the areas of helping in inventories of the forest, stocking where forests do not exist, and strengthening institutions. In fact, FAO has done a considerable amount of work in these countries in the last few years on which the Bank hopes to build. In the Ivory Coast, higher technical training in forestry would be assisted by a World Bank project.

Similar types of assistance are being provided for other regions in the world. These are just a couple of examples from West Africa of how the Bank is trying to put into action its policy statements made in the "Forestry Policy Sector Paper."

DR. LOUIS HUGUET, Director, Forest Resources Division, Food and Agriculture Organization, United Nations, Rome, Italy

Because few tree species are exploited in tropical forests, logging does not directly destroy forests. It just selectively cleans the forests, with the possible consequence that some species may disappear—but it does not destroy forests. The shifting cultivators, who are using the roads built by the logging companies, enter and destroy the forests for agriculture.

FAO was closely associated with the preparation of the World Bank's "Forestry Sector Policy Paper" and endorses the paper with enthusiasm. It is a turning point in the policy of the Bank. The paper deals not only with environment, but with social matters, both of which are of extreme importance in solving the problem of degradation and destruction of tropical forests.

Regarding institutions, FAO is not a super-power or a super-ministry of agriculture. It cannot dictate its will to the 144 countries in which it works; it can just obtain from them their experience and diffuse these experiences to other nations. So it is, in a sense, the world forestry conscience. FAO tries to analyze the observations and experiences of these 144 nations and then coordinate and diffuse these experiences through meetings, publications, and field projects. It is much more than a technical assistance organization or a forestry engineering bureau. FAO is laying the foundation of forestry development in association with agriculture, which is important.

FAO has a forestry department which has the same rank as the other FAO departments of agriculture, economics, and fisheries. But the FAO's forestry department budget is small. Nonetheless, it is endeavoring to advise people in how to properly manage their forests for the welfare of their populations. This includes not only the direct uses of the forests, but also the indirect uses. European foresters

have been speaking about environment for two or three centuries, although the word had not yet been coined. It is of interest also that the first U.S. foresters were trained in Europe.

FAO is working with nine priorities, approved just one month ago by our committee of forestry, in which seventy nations are represented. FAO's priorities include the inventory of the global and regional forestry resources. We are now studying the rate and pattern of the degradation of the tropical forests. We are also devoting part of our program to plantation improvement because we think that eventually many destroyed forests will have to be replaced by planted forests. Activity in the field of forest industries is another of our priorities. But our orientation is directed toward small-scale forest industry because we think that the western type of forest industry is not suitable for the small, poor developing countries. They need appropriate technology and, as much as we can, we are dealing with appropriate technologies in this area. We are also dealing with conservation, improvement, and multi-purpose management of tropical and arid zone forests and the close integration of forestry with agriculture, particularly through agroforestry. We are working in these areas with our colleagues from other FAO departments. We are trying to promote forest projects by organizing discussion about the use of various species and preparing statistics about existing and possible market strengths. We also have issued numerous publications. We are also active in many countries in education and training at all levels for forestry and forest industry. FAO has created some 20 to 30 schools at all levels throughout the world. We are also active in strengthening and modernizing the forest administrations in numerous countries. We have a new program which started about one year ago which deals with forestry for local community development. This program is financed mostly by the Swedish Develop-

ment Association, but FAO also makes a contribution. We are trying to help on the community level in association with people from the countries involved. We realize the difficulties of the task. And finally, a traditional activity of the Food and Agriculture Organization is to compile and publish statistical information about the

forestry trade: pulp and paper; hardwoods and softwoods; trends of the market; extension and composition of the forests, as far as we can; and other kinds of statistics.

Now my colleague Dr. Lanly will discuss a specific program which is highly relevant to the discussion of today's meeting.

DR. P.J. LANLY, Forest Resources Survey Officer, Food and Agriculture Organization, United Nations, Rome, Italy

I don't think that forest degradation has been discussed enough. Until now we have been speaking about forest depletion; but for many forest areas—especially the open woodland areas—it's not so much a question of forest depletion as it is a problem of slow degradation of the tropical woodlands. This is due not only to shifting cultivation or to deforestation programs, but also to fires, which are now an important problem in most tropical areas.

For a long time FAO has been helping tropical countries in assessing their forest resources in the framework of forest development projects. This was mainly with the aim of developing production forestry for timber, pulp wood, and fuel wood, and not so much in the field of the environment services which forestry can provide. It might be useful to note that almost half of the large-scale forest resources surveys which have been carried out in the tropics since the early 1950s were carried out in collaboration with FAO. This is a very important point because this shows that FAO, from the very beginning, has been involved in trying to collect forest-resources information at a regional and world level for almost thirty years. These activities gave rise to the world forest inventory publications which, unfortunately for lack of means, were discontinued after 1965.

In the area of methodological assessment of forest resources, FAO has been organizing a lot of training courses for developing countries. The most recent was held a few

weeks ago in Rome, on the application of new remote sensing techniques to assessment of tropical forest resources. FAO has also produced several seminars. The next one will be on the integration of forest resources surveys in forestry and land use planning.

In 1971, FAO prepared a publication for the UN Conference on Environment which was held in Stockholm in 1972. The publication, which I think is still valid as far as tropical deforestation is concerned, made a recommendation which was then endorsed by the UN Conference on the World Forest Appraisal Program. FAO and UNESCO were asked by the UN Conference to undertake the World Forests Resource Appraisal Program. In cooperation with the countries concerned, we were charged with using existing documentation and new remote sensing techniques to construct our appraisal.

In 1974 we had a meeting of experts on the formulation of such a program and one year afterwards we undertook a pilot project on tropical forest program monitoring. This pilot project is due to be completed by the end of this year. It has been implemented in three countries of West Africa. We are also coordinating our work in these three countries with the work being carried out in Nigeria by the Nigerians themselves. The basic aim of this pilot project and the implementation phase of this program, which we are carrying out with the assistance of UNEP, is to help the countries in developing their capabilities;

their first concern being to develop an assessment of deforestation and then to help in developing their capabilities in the field of forest resources monitoring. As you can imagine, it's a very long process because in each country we have to be present for a certain time and we have to work with the forestry officers and the people concerned with the problem. We have to train personnel and sometimes we must work on critical areas where we have to assess deforestation and its impact on other segments of the biosphere. We intend to continue this program with UNEP, but this will be a long process because we must work in each of the many tropical countries concerned.

With UNEP, we are also trying to assess tropical forest resources at the world and

regional levels. Statistics in this area are very poor, and we don't know very much about the magnitude of deforestation in the tropical regions.

Thus, FAO has two parallel activities. One is developing each country's capability for coping with the problem of assessing the present rate and pattern of deforestation. The second activity, which is not exclusive of the first, is to try to develop an information intelligence about the magnitude and various facets of the problem at the regional and international levels. So, as you can see, FAO is working extensively in this field and, while one may regret that we are not working more quickly, ours is basically a problem of the limited means available to us to cope with the magnitude of the problem.

Discussion

In response to a suggestion that a general publication concerning the state of the art in forestry be undertaken, it was noted that "A State of Knowledge Report" would soon be released by UNESCO. The report, which encompasses a broad view of tropical forestry, including aspects of human use, contains the contributions of numerous authors.

Response to Date—Scientific and Technological State-of-the-Art¹

CO₂-Deforestation Relationships

DR. GEORGE WOODWELL, Marine Biology Laboratory, Woods Hole, Massachusetts

The relationship between the world's forests and the atmospheric problems associated with carbon dioxide (CO₂) is not unanimously agreed upon by the scientific community. However, there is a problem with carbon dioxide in the atmosphere.

The best data we have come from a series of studies conducted by David Keeling, a chemical oceanographer at the Scripps Institute of Oceanography, in La Jolla, California. In 1958, Dr. Keeling began

measuring the carbon dioxide content in the atmosphere on an island in the Hawaiian Islands and accumulated, over the following twenty years, the best data we have on the changes in CO₂ that have occurred in that period. Based largely on these measurements the following conclusions can be drawn. First, without much

¹Panel discussion moderated by Dr. Warren Doolittle, Associate Director for Research, Forest Service, U.S. Department of Agriculture, Washington, D.C.

question, there is an upward trend of roughly one part per million (ppm) per year in the atmosphere. The second point is that there is an obvious winter/summer oscillation. The peak concentration of CO₂ occurs at the end of the northern winter in April, and the minimum concentration at the end of the northern summer in September or October. This trend occurs regularly throughout the study. There is a series of other fluctuations in the level of CO₂ which remain substantially unexplained. These may well be due to the changes of surface currents in the Pacific Ocean, but we have to say that we really don't know why they occur. There are various other records, including one that was taken by Dr. Keeling and his colleagues at the South Pole.

Some variance in the oscillation seems to be related to the cycle of photosynthesis. Fixation of carbon and removal of carbon from the atmosphere results from photosynthesis during the summer, and its release through the respiration of plants and animals during the winter, when photosynthesis is very much less than respiration. When we examine this in a variety of critical ways and try to figure out just what part of the biota might be causing that oscillation, the temperate zone forests—not the tropical forests—appear to be the cause. The temperate zone forests—the largest vegetation mass in the world—store carbon in the summer and release it during the winter through respiration.

The oceans, if they were doing this at all, would probably be storing the carbon as a dissolved element in the water, not in the biota. The oceans don't really have a place to store carbon in living systems, so the algae in the oceans are probably not causing this. If the oceans, through temperature changes, were causing this oscillation, we'd expect the amplitude to be greater in the southern hemisphere than it is in the northern hemisphere. So we rule out the oceans as a cause of this oscillation and we focus on temperate zone forests.

This point is important because it means that forests loom large in the CO₂ balance of the atmosphere. It means that in the short term they have the potential for changing the CO₂ content of the air worldwide. There are several other reasons for pointing to forests. One of which is that the amplitude is greater in the northern hemisphere than it is in the southern hemisphere. Looking at a map of the world, one sees that most of the forest area lies in the northern hemisphere. There exists a variety of other analyses that also point to forests.

In considering the sizes of the pools of carbon that are exchanging carbon with the atmosphere, we find the atmosphere with about 700 billion metric tons, with 10¹⁵ grams of carbon in it. The land, with the biota, has about 830 billion metric tons, with 10¹⁵ grams of carbon present. This represents the same carbon units as occur in the atmosphere.

As to whether Whittaker and Likens are correct or not in their appraisal of the magnitude of the carbon pool held in the biota, I have personally tested various elements of their analysis and am pretty well convinced that it's as good an analysis as one can do at the moment, based on the data that are available. I have seen the carbon pool tested by others, and I have participated in one test in Europe a year ago in which a group of ecologists tabulated the various appraisals of the carbon held in the biota. We came to the conclusion that the range of appraisals was from roughly 400–500 × 10¹⁵ grams to about 1,100–1,200 × 10¹⁵ grams. The Whittaker-Likens data, which is the analysis that I am using here, falls right in the middle of that.

Another very large pool of carbon, even larger than that held in the biota, is found in the humus. However, the magnitude of the earth's humus is difficult to appraise, with the appraisals varying from less than 1,000 × 10¹⁵ grams to about 3,000 × 10¹⁵ grams. The atmosphere is, of course, receiving carbon from the combustion of

fossil fuel—an amount that is thought to be currently about 5×10^{15} grams—and it travels as a net movement of carbon from the atmosphere into the oceans. First, it moves into the mixed layer, which contains another pool of carbon that's roughly the same size as the pool in the atmosphere. Most of the dissolved carbon dioxide in the ocean is in the mixed layer. That pool is very small, but represents a long-term exchange, so there is a slow flow of carbon from the atmosphere into the mixed layer and then into the abyssal waters. This represents a pool of carbon—most of it inorganic—stored in the abyssal waters.

There is quite a bit of organic carbon which may approximate the humus of the land. With the major pools of carbon that interact, the pool of carbon held within the plants is large enough to affect the CO_2 content of the atmosphere appreciably. The metabolic activity of the plants also affects the CO_2 content of the atmosphere appreciably, month by month.

Looking at this in slightly different terms, the atmosphere has about 700 carbon units. The biota is divided into the continental land plants with about 827 units. Humus is variously estimated as up to 1,000 to 3,000 of these units. Marine populations, however, are very small in stature. They have a high rate of fixation with a small pool of carbon being held within the plants of the ocean, but another pool of carbon is held as dissolved organic matter which occurs as maybe one ppm throughout the waters of the abyss. The mixed layer has about 580 inorganic carbon units and the abyssal waters have a very large quantity. This doesn't mention the carbonates at all.

Now we will consider only the carbon that's stored in the plant population, because that is what's in immediate exchange. How much is it and where is it? There's probably less carbon in the biota now than twenty years ago because of the continuing destruction of forests, but that point will no doubt be argued by some of my colleagues. I would like to call your at-

tention to where most of the carbon is. Of some 829 billion metric tons in the world, 827 billion of those units are in the land biota. So the land biota is very important. This does not include the humus. This is only the living plants. I distinguish here between the standing crops of organic matter, which is just a pool of carbon held on land, and the capacity of plants for fixing carbon in excess of the needs of the plant populations for their own metabolism. This is called net primary production by ecologists. It represents the energy that is left over after the metabolic needs of the plants have been met. It is what is available to support people and other consumers. There are approximately 50 billion of these units on land and about 25 billion in the oceans. This set of data represents one of the absolutes of the earth and, as far as supporting life is concerned, this amount of carbon determines the limits for the number of people and other consumers which the earth's atmosphere can support.

Most of this stored carbon occurs in the forests. Whittaker and Likens estimate that some 55 percent of the stored carbon occurs in the tropical forests. Thus, the tropical forests are viewed as being particularly important. What is the rate of change in the tropical forests? We came to the conclusion, after reviewing the available literature, that the annual rate of harvest probably lies somewhere between 0.5 percent to 1.5 percent of the remaining standing crop of carbon in the world's tropical forests. What we're really interested in is the net release for the total for the world, including the humus. The net release may average somewhere around 8 billion of these units, but the range is very large. Most of the release occurs in the tropics. For a world total, the release is roughly equivalent to the release of carbon from fossil fuels. This means that most of the models that have been used in the last decade to predict the future CO_2 content of the atmosphere are probably incorrect because these models have assumed that the biota was not a source of CO_2 for the atmosphere, but a small sink. We now think that the biota is not absorbing carbon dioxide out of the atmosphere but that it is

releasing carbon dioxide into the atmosphere. Thus, we have no really adequate explanation for the details of the world carbon balance, and it becomes impossible to predict what the CO₂ content of the atmosphere is likely to be in the future. Although there are various predictions produced by various models based on various assumptions, I have to say that at the moment there is substantially no basis for favoring any one of these predictions. We don't have a sufficient understanding of the mechanisms involved pertaining to inputs of carbon to the atmosphere or of the movement of carbon into the oceans to make a prediction as to what's going to happen.

The CO₂ content of the atmosphere is important because climatologists think that an increase in CO₂ in the atmosphere has the potential for modifying climates, causing a general warming of the earth. As I understand it, this will cause a differential warming towards the poles. The tropics will not necessarily get hotter, but the climate zones, and therefore the vegetation zones, will move poleward. This would probably result in a substantial destabilization of agricultural areas to the detriment of agricultural production. If I read the data correctly, when this occurs in a period of intensified land use of the earth by ever-increasing numbers of people, it means a substantial disruption of human interests.

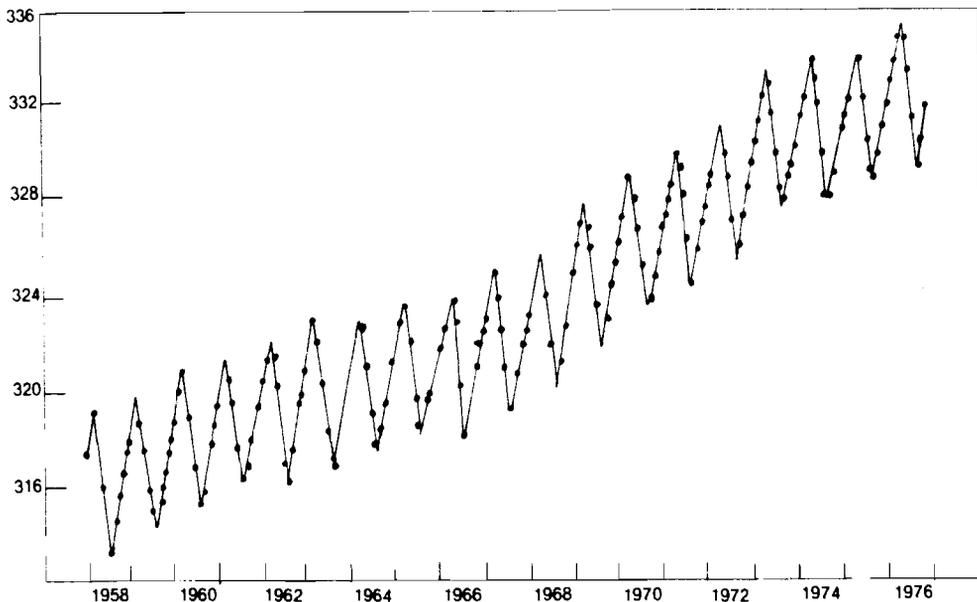
What is the time scale of this? Of course, it is occurring at the moment, but if we wait until there is absolute proof that the increase in CO₂ is causing a warming of the earth, it will be twenty years too late to do anything about it. If we decide that this is a substantial problem and that something should be done about it, then it is clear enough what we should do. One of the things we do, of course, is to stop the destruction of the largest forests of the world, the tropical forests, if we can. We must preserve them and start programs of reforestation, because the storage of carbon in the vegetation and in the humus which is associated with the forests is a substantial pool of carbon, and deforesta-

tion of the tropics has the potential for affecting the CO₂ content of the atmosphere. At the same time, we should restrict the use of fossil fuels.

There is a topic that has come up at this Conference several times and which I think is extremely important when one thinks about the tropics. We have mentioned the importance of loss of species. The emphasis often comes back to the values that we have realized from exploiting diverse species of the earth in medicine, agriculture, and other areas. Certainly, if we're interested in sustaining agriculture under increasing intensification of the use of the earth, we ought to work hard to preserve the germ plasm from which we have drawn our agricultural strains and on which we depend to maintain those strains.

That alone is a perfectly valid reason for preserving species. But we might ask what happens when we start to lose species in large numbers? What kinds of species survive? What is the character of the habitat that is left? Many of us are familiar with the species that occur in roadsides and other constantly disturbed places. Some of us have seen the landscapes around big smelters where fumes of sulfur dioxide and toxic metals have accumulated to the point where the vegetation has become impoverished. This is not just an aesthetic matter, because the vegetation has become toxic and just doesn't support life. In this we lose not simply species but the capacity for fixing carbon—for producing the net primary production for supporting any life. At the same time, what happens is that the species which do survive are the hardy, small bodied, rapidly-reproducing species which we often recognize as pests. Impoverished landscapes are hard to live in, not simply because the number of species is low or because the primary productivity is low, but because they are plagued by organisms that are pestiferous. So, from the standpoint of making it easy for man to live, we need to preserve the full diversity of the earth's species—because it is this diversity itself which most successfully controls life on this planet.

CARBON DIOXIDE IN ATMOSPHERE (PARTS PER MILLION)



TREND IN ATMOSPHERIC CARBON DIOXIDE has been measured since 1958 at the Mauna Loa Observatory on the island of Hawaii by Charles D. Keeling of the Scripps Institution of Oceanography. The dots indicate the monthly average concentration of carbon dioxide. The seasonal oscillations are caused by the removal of carbon dioxide by photosynthesis during the growing season in the Northern Hemisphere and the subsequent release during the fall and winter months. The Mauna Loa measurements and those made elsewhere show that the average carbon dioxide content of the atmosphere has risen more than 5 percent since 1958. Rate of increase has varied from year to year from causes not yet known. Current rate is one part per million per year, equivalent to 2.3×10^{13} grams of carbon.

Figure 3. "The Carbon Dioxide Question," by George Woodwell, *Scientific American*, Vol. 238, No. 1, p. 37, Jan. 1978

Biological Research

DR. S.H. SOHMER, National Science Foundation, Washington, D.C.

I will not address ecological research *per se*, but will discuss my mandate at the National Science Foundation (NSF) this year, which is to examine the basic biological research which we are conducting. In particular, I will describe the NSF's Division of Environmental Biology and the commitment we've made in financial resource allocations to tropical forest research.

The division's areas of concern include programs for systematic biology, ecology, ecosystem studies, and population biology, which is a new program this year. In attempting to assess the division's earlier research work in tropical biology, we had to first arrive at an operational definition of tropical biology. For the purpose of the statistics we have engendered

over the past months, we are calling any research that occurs either in the tropics or deals with organisms that are derived from the tropics, research in tropical biology. So if someone is dealing with a plant species from Colombia but they're working with it in Poughkeepsie, New York, that will be considered tropical biology.

The Division of Environmental Biology has been interested in the tropics for at least twenty years. We believe that it is important to know as much about these tropical ecosystems as possible because as far as terrestrial organisms are concerned, the humid forest ecosystem is probably the most diverse in terms of biota.

There are a large number of things that the National Science Foundation has supported over the past 15 years, particularly in the 1960s, which have had great significance in terms of current trends. The Organization for Tropical Studies, which was started and supported by NSF, has produced a reservoir of researchers who are coming to the Foundation now for support of their endeavors. There is not really any other agency that these biologists can come to for the funding of their important research. There are a number of large-scale projects which have received support from the NSF. One of these is a nutrient cycling study in the tropical forest of southern Venezuela, which also receives financial assistance from UNESCO/MAB and the government of West Germany. More studies of this kind are necessary because the questions that might be answered in southern Venezuela may answer questions elsewhere in the world.

At the end of the 1977 fiscal year, the Division of Environmental Biology had committed about \$80 million to basic biological research. Included in this are two and three year commitments as well as on-going grants that are four to five years in duration. Our budget for the 1978 fiscal year is about \$30 million. The \$80 million represented some 950 active awards. Of these awards, approximately 150 were involved with tropical biology. This

represented about \$8 million or about 10 percent of our total commitment. As a tropical biologist, I think that is a rather low figure. Unfortunately, many of our clientele cannot undertake their studies in the tropics without financial help. I think a lot of the things that we are sponsoring now require multinational participation.

In terms of geography, approximately 50 percent of the \$8 million for tropical biology was committed to work being done in various types of forests, more than half of which are humid tropical forests.

In the Division of Environmental Biology there are currently two major thrusts in tropical biology. One is called Research Priorities in Tropical Biology, which hopefully will answer some of the questions that have arisen at this Conference, particularly in terms of rates of destruction. The NSF has handled this particular project via a \$200,000 grant to the National Academy of Sciences. This study will take place over a two-year period, after which we hope to have a better estimate of the extent of tropical forest destruction as well as just how much time we have before the forests are gone. This project began in December of 1977.

Another major project, although not yet receiving financial support from NSF, is Proyecto Flora Amazonica. This particular project is one of five that were initiated by the Brazilians, who are interested in inventorying their areas that are subject to imminent development. The project has a bi-national approach with bi-national representation on the field trips. The United States' contribution to the project is being handled by a grant to the New York Botanical Gardens. If this project is successful, it can serve as a model for the kinds of things which the NSF can support in the future.

Future endeavors depend principally on funding, which depends ultimately on our ability to convince the American public of the importance of supporting research in the tropics. This sometimes gets to be a very sticky point, particularly with some

congressmen who wish to know, for example, where their constituency is in Brazil or other places. Thus, one has to provide the reasons why this work is important. We think the research is important purely on its basic biological return. How can we understand the ecosystems that are being destroyed or modified without understanding first how they function? What is the structure of these ecosystems? What relationship do these individual species have to one another? One cannot undertake ecological work, which is extremely important, without knowing what they have there to begin with. And ultimately, what is the biological effect of the uncontrolled and/or indiscriminate destruction of these forests, aside from the obvious environmental and economic factors?

I hope that it will be possible for the Division of Environmental Biology to initiate a Biology of Humid Tropical Forests program. This would be composed of at least three phases: one dealing with systematic and structural inventories; a second dealing with ecological and biological studies such as pollination and reproduction; and the third, with ecosystems analyses. In conclusion, the most important thought that I wish to address to the Conference is that we should never lose sight of the fact

that we know little or nothing about the way most humid tropical forests are structured and how they function, not to mention the component species and how they evolve. Indeed, it is reputed that only about one-sixth of all the plant and animal species in the humid tropics are known to science today and most of these will become extinct before they will be collected even once.

I believe that within the context of a global strategy developed by the United States and other countries to deal with the problems of tropical deforestation, there should be a definite commitment made to some basic research. This commitment would be evidence that the United States, at least, is cognizant of the fact that without the understanding of the humid tropical forest ecosystem that basic research can supply, there is little or no chance that most of the problems associated with deforestation can be handled in a manner conducive to the benefit of all mankind, and particularly to those people who make their living in the humid tropics. What will follow from this Conference, I hope, is a great opportunity for basic and applied research to work hand in hand toward a common goal.

Monitoring and Assessment

MR. MICHAEL CALABRESE, Resource Observation Division, National Aeronautics and Space Administration (NASA), Washington, D.C.

I want to discuss the capabilities of space remote sensing, particularly of the ERTS Landsat satellite system, as a tool in the monitoring and assessment of forestry activities in the tropical area. We now have two Landsat satellites in orbit providing us with the capability of nine-day coverage in cloudfree areas. When the Landsat program began in 1972, NASA funded a number of foreign investigations along with domestic research investigations. That activity represented one of our principal

thrusts in the foreign arena. Most of those investigations have been documented and are readily available.

Since that time, however, I must admit that most of our work has been done in the domestic sector. Internationally, we have done extensive work in agriculture, working with the U.S. Department of Agriculture. But other than that, we have not done a lot. Of course, the satellite is a generic tool, and it is available to everyone. But

among the problems are those of extent and adequacy of geographical coverage, which I am sure you all appreciate. Domestically, we have fairly stringent data needs pertaining to timber inventories, detection of pests and infestation, tree farming, and multiple-use work in monitoring and managing our forests. We are working with the U.S. Forest Service, the various states, and numerous companies. The needs internationally seem to be for information on geographic forest distribution, an identification of major forest types, and a statistical summary of how much acreage exists. We can do that kind of thing on a photo-interpretation basis. If one wants to get more sophisticated, we can do it on the digital analysis basis. So there are a lot of things that Landsat can do in obtaining information around the world. I don't think we need to get into the detailed kind of problems we have in the United States. But as research progresses, we can transfer that technology also.

The role of Landsat is to provide synoptic remote sensing coverage, and I believe *its greatest strength is in complementing an existing data base—where one exists*. In the United States, we generally have some kind of data base; it might be from aircraft or windshield surveys, or it might be from slope elevation aspects or soil data. One can digitize that information and merge it together with Landsat data. Then a comprehensive view of the total problem emerges. Certainly in some of the foreign investigations one may not have a data base; Landsat, therefore, may provide the best information available. However, when Landsat looks at something, it will look at the total phenomena that is under it—not just the forests, agriculture, or urban areas but total land surface. And when one does a land cover inventory, one has a very integrated kind of analysis that can provide information for land use problems and provide a resource manager with a total picture. The integrating aspect that Landsat has with a capability of bringing various data bases together make it a very powerful tool.

The Landsat program presently has seven receiving stations, as well as tape recorders on the satellites. But our future needs require a global land mass coverage. More receiving stations are planned and there is a Tracking Data Relay Satellite—a communications satellite—scheduled to begin operation with Landsat D in 1981. Currently, if one wants coverage and there is no foreign station, one has to ask NASA to turn on a Landsat tape recorder. But the demand is very heavy and the recorder has a very limited life. So, there are many competing demands. Certainly as NASA begins operating more receiving stations and we have the capability of the Tracking Data Relay Satellite to gather data from anywhere in the world, we should be able to increase our coverage.

We currently have nine-day repeat coverage with two Landsat satellites. We need to increase that, and we need to get higher temporal resolution for many of the kinds of problems we are dealing with—like using a portable multi-linear array, which is an instrument that provides higher resolution in dealing with smaller areas, like 20 kilometers as opposed to the 185 kilometers that Landsat currently provides. This is the kind of device that we're hoping to use by 1984. It is planned, but not yet approved.

A thematic mapper, our next generation scanner, has been approved in lieu of the 80-meter multi-spectral scanner now operating on Landsats 1, 2, and 3. The thematic mapper will have seven bands instead of the four bands that we have now. It also has higher radiometric sensitivity. *Stereosat*, another planned program, will be used principally for the geology community to give stereoscopic data and higher resolution.

We really need to utilize microwave bands because there is a lot of cloud cover in the tropics particularly. *Seasat-A*, which is going to be launched this month, will have a microwave capability. It is to be used primarily for ocean coverage, and will have

a synthetic aperture radar aboard which has 25-meter resolution. It represents NASA's first big step in the active microwave area, and it will also have some passive microwave sensors. *Nimbus G*, to be launched in August, will also have a passive microwave sensor and a microwave multi-channel radiometer. *SIR-A* (Space Imaging Radar) which is a version of the *Seasat* will be launched in 1979. It will aim more at land coverage as opposed to *Seasat*, which is more for ocean coverage.

Ultimately, as we get higher temporal resolution, we will be able to examine more closely such deforestation problems as the change detection aspect and what is happening to the forests over time. And we may be able to analyze problems pertaining to pests and diseases, and establish an early warning system, when we have information we can see from the foliage.

Looking at some of the applications, I would like to note the efforts of Dr. Lee Miller of Colorado State and Dr. Darry Williamson of the Goddard Space Flight Center, who have been working with the problems of monitoring forest alteration around the world with Landsat.

In another project, the Philippine government and the U.S. General Electric Company have carried out a forest inventory of the entire country, using 30 Landsat scenes covering some 300,000 square kilometers. General Electric processed these scenes in four months and there now exist land inventory cover maps of the Philippines. The project indicates that some 38 percent of that nation is forested, which is considerably less than the Philippine government estimated in a mid-1960s inventory. Work is progressing now into site-specific analysis, and they are beginning to merge data bases and do some multi-stage sampling. This is a good example of one of the first large significant remote sensing application efforts carried out independently by a foreign government contracting with a private company.

In other work, Dr. Miller has looked at the dynamics of shifting cultivation in the tropical forests of northern Thailand. This was a relatively small study area of 300 square kilometers, as opposed to the large Philippine project. Dr. Miller developed a 20-year landscape model, merging data bases from satellite imagery with conventional aircraft and map data, and utilizing photo interpretation. He found that while deforestation due to shifting cultivation seemed to have fallen off in the mid-1960s, by 1972 it had increased to the point that little forest remained in the region. These results are corroborated by other Landsat research work, which indicated that there was a forest reduction from 55 percent to 39 percent. The 55 percent was obtained in 1961 with aircraft, and the 39 percent figure was obtained by Landsat in 1972.

Dr. Miller also did some land use planning in Taiwan, using about 12 categories of digital classification. The study encompassed heavily vegetated mountainous terrain with small, complicated land use patterns. Dr. Miller achieved 89 percent accuracy of classification in the first level with a single image. This can be improved utilizing multi-data imagery. With just a qualitative examination, one could develop summary statistics from the digital data without any difficulty.

To conclude, I think that Landsat's improved capability and improved coverage show great promise for the future in foreign analyses. The technology transfer of Landsat as a generic resource monitoring tool is an important element. Deforestation monitoring is, of course, but one of the uses. When we move into a geographical area, we need to validate the existing data base with photo interpretation techniques utilizing appropriate technology. As the user becomes more sophisticated, the program can be extended to digital imagery analysis. I think a series of highly collaborative demonstration projects in developing countries that desire better resource information is the best way to proceed.

Commercial Forestry

MR. GORDON FOX, Forestry Consultant, Washington, D.C.

The commercial forestry sector is not a separate subject but cuts across social, environmental, and economic concerns and issues. It should be emphasized that except for certain situations, a large majority of commercial logging operations in the tropical forests have not resulted in deforestation.

Despite the many thousands of different species in the humid and sub-humid tropics, no more than 2 or 3 percent presently have commercial acceptance in the world market. About two-thirds of the world's total hardwood exports are derived from Southeast Asian countries. The trees used commercially are cut from relatively small areas, and the results of the degraded timber stands may be termed economic rather than environmental deforestation.

We need to accept the fact that population pressures are going to accelerate destruction of the tropical forests because of their increased utilization for firewood and industrial purposes. Our mission at this Conference could be to agree on assistance measures acceptable to the countries involved which will guide economic forestry development towards more sustained production on lands that are classified for forestry, thereby minimizing the undesirable environmental impacts.

This does not mean that no attempts will be made to preserve substantial areas of tropical forest in their natural states. An example of what can be done is the World Wildlife Fund's appeal to South American countries to safeguard viable representative samples of the rain forest of the Amazon basin. Brazil has already designated areas to be retained in that category—although they are designated only on paper. Deforestation occurs when access roads through the forest, either for timber or other purposes, make the forests accessible to colonists who move in, largely on public forest lands, to practice slash and burn agriculture on a few hectares for subsistence crops.

One partial solution to this problem is to expand markets for the secondary species so that trees have value to the colonists. This applies not only to natural stands, but also to reforestation efforts combining tree planting with crops for the first year or two on soils with the highest capabilities for forestry. By following this approach repeatedly, one is providing rural employment in the timber field. Of course these practices require more intensive use of smaller areas in accordance with realistic land use plans.

Reforestation merits greater international and bilateral support. The tropical countries, despite their mixed hardwood species, have traditionally been importers of pulp and paper. Latin America, with about one-fourth of the world's forests, produces only about 5 percent of the world's pulp and paper. Reforestation with conifers, particularly on the more degraded sites, provides an opportunity to furnish the long-term fiber requirements for certain paper products.

There's a wide variation in the extent of reforestation programs in Latin America. About three-fourths of Chile's industrial production is from reforestation, principally with *Pinus radiata*. Chile is the first Latin America country to be a net exporter of paper products. Brazil is an example of a country in which income tax incentives are provided for reforestation. About ten years ago, FAO recommended an annual reforestation goal of 90,000 hectares for Latin America. During the past few years under its tax incentive law, Brazil has annually reforested about three times the entire Latin American goal set 10 years ago. It has, however, made some reductions in the tax exemption now permitted. Some other countries have made substantial progress under similar tax incentive laws that are promoted by FAO, but there has not been enough substantial progress made. Many countries need technical and financial assistance in developing adequate reforestation programs.

The increased utilization of secondary species is also a high priority need in mixed hardwood tropical forests. Increased utilization would provide an opportunity for the retention of native species under commercial forest management practices more in harmony with the ecosystem. This is a viable alternative to converting forests to a few species of commercial value. In fact, a meeting financed by an AID grant was held in May of this year which demonstrated the technical and economic feasibility of using many of these secondary tropical species to produce a wide range of reconstituted products including paper and particle board. The U.S. Forest Products Laboratory's (USDA/AID) international meeting recommended an integrated processing system. However, this approach could contribute to accelerated forest destruction under cut-out and get-out logging operations.

Another proposal for using an increased number of secondary species is the establishment of the Tropical Timber Bureau. Promoted initially by FAO, it obtains data on the characteristics and volumes of potentially commercial secondary species and promotes their acceptance in the market place. There exists much more data on secondary species which should have commercial acceptance. The ever-increasing world demand for tropical hardwoods requires additional research and development of secondary species, to be funded by the appropriate banks and nations.

The utilization of wood residues and less valuable species for energy purposes will be considered for tropical forests in the U.S. Department of Energy's current mission to Peru. Also being considered is the pyrolytic process in converting wood to charcoal and to gas and oil. A mobile system may be employed on barges in order to reach into otherwise inaccessible tropical areas. Basically a substitution of a renewable natural resource for fossil fuels, wood conversion is a commercial development that needs close attention, particularly regarding its possible effects on the forests. Without proper control this

could lead to large-scale forest destruction. Brazil is presently using wood for fuel in some pulp and paper mills.

The important point here is that commercial use of forests can have permanent effects. Economic development of a resource depends upon the interest of the respective governments in a resource, and the degree of interest appears to be related to its relative importance in the overall economy. Forestry development follows a pattern in which labor intensive sawmilling is the first step, followed by secondary species production, and finally by capital investment in intensive pulp and paper operations. It is towards the last stage that the economic importance of the forest is more fully recognized and the government accelerates the actions necessary to maintain the resource.

Another phase occurs when it becomes apparent that timber may be in short supply unless positive action is taken. This is like locking the barn after the horse is stolen. Persuasion should accompany any form of forestry assistance. The industrial complex in developing countries also has an interest in focusing attention on maintenance of the raw material supply. Foresters frequently contribute to the training of local technicians. The success of most of the forestry proposals mentioned in this presentation depends upon the capability of each country's forest service and the support given it by its government.

A study was made a few years ago in which the forestry institutions of the developing countries were classified in three capability classes. The highest rated forest services were found to be in the countries in which industrialization was farthest advanced. The extent of industrialization was not a factor in the rating system, but the results indicated a close relation. This does not imply that countries in the highest category do not need assistance. There are many areas in which assistance is needed, even in the best forest services. One of these is how to increase administrative effectiveness. FAO has carried the primary assistance role in the various

categories of forestry development including the institutional aspects. There are many countries now with comprehensive forestry laws which generally include regulation of cutting in private forests, but there is still a long way to go.

Many of the developing tropical countries are small and individually can never afford the sophisticated technical laboratories and other facilities and skills needed in a professional forestry program. There is a need, therefore, to provide many special services including forestry research through regional organizational units under direct control of the participating countries. Such a proposal was made in a study that Weyerhaeuser conducted for the Inter-American Development Bank and should be followed up.

Of all the needs, strengthening the forest service institutions should be considered

as the most important. While some countries' forestry organizations have been developing, the work load has been increasing even faster than the institutions. Some new approaches are desirable, including a greater contribution by the developing countries. There's a need to awaken and develop a forestry conscience in the developing countries.

One final suggestion: if the U.S. State Department and AID have lost their capability in forestry, and if there's serious concern about the forest/environmental situation, it is imperative that a forestry unit be set up with a group of people competent in tropical forestry. This unit could maintain contacts with the Forest Service's Office of International Forestry as well as with bilateral, technical, and financial institutions and attempt to coordinate its activities with FAO.

Agroforestry

DR. LOUIS HUGUET, Director, Division of Forestry Resources, Food And Agriculture Organization, United Nations, Rome, Italy

Historically, when people needed to be fed, forests were cleared for new cultivation. It was not until the first agricultural revolution started in England at the beginning of the 18th century that land productivity was multiplied more than three times in one century. The phenomenon expanded to Europe, and the same increase occurred. Through developments in agricultural technology, man was able to feed a slowly growing population on the same area of land. So forests remained stable. Then there occurred an agricultural revolution based on the Industrial Revolution. And finally, another revolution started about 50 years ago with the use of high energy consuming inputs like fertilizers, heavy equipment, pumped water, and pesticides. With these, production in agriculture was multiplied by three, four, and five times—and sometimes more. I would like to say that this new era is probably very short.

Returning to the comparison, we could assume that the same phenomena will occur in the developing countries, which are mostly tropical countries or countries with difficult climates like the arid lands of the Middle East or North Africa. This would be a great mistake. In the developed world, forests are actually encroaching on agricultural areas. France's forest area has, for example, increased by possibly 50 percent in 50 years. In the United States, I am sure that forests are encroaching on agricultural lands. Forestry needs require organization, roads, industry outputs, ports, and resources.

But for the rest of the world, the forestry situation is much different. Agriculture is encroaching on the forests for the simple reason that people need food. According to FAO's first estimates—which are not yet official but will be official, possibly in October, for the World Forestry Congress

in Asia—there is a dire shortage of forestry protection and management activities. We are not very concerned about permanent agriculture, because this agriculture is based on trees—on oil, rubber, coffee, and artificial forest plantations. In the tropical regions when natural forests are replaced cautiously with managed tree cover, the environment is not extensively destroyed and the soils are more or less maintained. A large amount of permanent agriculture has been created in Malaysia where there are good soils.

The problem of deforestation lies largely with small-scale shifting cultivators. It is the common people, who have no alternatives because of inequitable land distribution, who have no other choice than to practice shifting cultivation on the poor soils of the tropical forests.

In a naive way, we may think that the methods employed in the rich world could work in the poor world. This would be the greatest of mistakes for at least four reasons. First, the population growth rate average in the developing nations is today about 3.5 percent. This means that their populations will double about every 20 years. Second, most of the soils in the less developed countries are very poor—unsuitable for long-term agriculture. Third, the second agricultural revolution in the rich countries was based on high energy inputs. Now the rich countries are wisely revising their energy policies. We will be obliged to use less energy, less fertilizer, and fewer pesticides. The poor people of the developing countries will have to do the same, although they never used such high energy inputs. And fourth, many developing countries are still lacking the institutions and trained people to extend new methods to the poor people of their own countries.

Is the situation desperate? I don't think so because there are ways to integrate forestry in agriculture. There are ways to create the symbiosis which can exist in the forestry and agriculture sectors. If there is no symbiosis, you may be sure that just to

survive, poor farmers will destroy the forests in spite of all the police and military people. In some countries there may be reserve forests established. Countries with low population densities can determine rational land use plans for permanent forests, tree plantations, and agriculture. These actions are essential for each country and for the world community. But don't expect a country whose people are in need of food today to make generous plans for tomorrow.

We must, therefore, develop the association of agriculture and forestry which will protect the environment while producing the food that people need. Where population densities are not very high, there's no reason to give up shifting cultivation. As long as the areas cleared for agriculture are not too large, the forest will be able to regenerate itself after the shifting cultivators move on. Wildlife species disturbed in one small area can take refuge in other parts of the forests. It is when the population increases that there are problems. The threshold is difficult to determine, but it has to be calculated in each case according to the fertility of the soils, species, and other factors. We can improve shifting cultivation with what we call taungya agriculture, invented more than a century ago in Burma and India. This system utilizes the association of forest trees and food. The forests are cleared, crops are planted, and then, when they are harvested, new trees are planted. Cultivation of crops continues as the trees mature until, after 10 to 20 years, there exists a good forest. A mixed forest can be maintained nearby. Improvements in both shifting cultivation and the taungya system have to be undertaken not only technically—because much has to be done in the field of research with association, with best type of tree, and with best spacing—but also in the field of social research, in order to involve the farmers.

How can we pass from the present situation to the ideal situation? We must find a way to deal with the problems of institutions, of land distribution, and of social

and political change. We must find ways to create new conditions and deal with the problem of helping the poor people. These are not easy tasks. But FAO is an organiza-

tion which undertakes utopian goals. It is the reason we were created—because what is not utopian has already been undertaken by other people.

Energy Alternatives

MR. ALAN JACOBS, Director, Office of Energy, U.S. Agency for International Development, Washington, D.C.

The supply of energy in the less developed world comes, to a very large extent, from the forests. Thus, there is a close relationship between energy needs and the forests. As much as 50 percent of many developing countries' total energy demands are supplied by the forests. I think that's a sufficient reason to understand why the forests are disappearing.

There are alternate ways that the less developed countries (LDCs) can approach energy self-sufficiency. Alternative resources such as bio-mass, water, direct solar radiation, and wind have been discussed recently with great enthusiasm. There has been a great deal of experimentation in the use of various technologies to convert renewable resources to useful energy. However, there has not been enough concern with the priority of the choice of resource, the scale of effort for utilization, how to introduce the alternative energy production into national energy systems, and the appropriateness of technologies selected to create an important impact on a country's national energy situation. It seems when we are talking about using renewable energy resources, we immediately turn to the question of technology; not the question of how to decide what technology to use or how to introduce the technology. This is a subject that gets relatively little discussion.

Another problem is that the utilization of renewable energy resources has usually been relegated to small-scale individualistic responses to meet energy demands—as for a single farmer or a single village. While there are good reasons to pursue

this objective in the LDCs, this is not the approach that will provide the energy alternatives needed to replace fossil fuels. The LDCs have an abundance of renewable energy resources, and they are capable of maintaining these resources at a level that will produce a major share of their energy needs. It seems to me that significant consideration should be taken to stimulate and support programs in the LDCs to develop their renewable energy resources on the largest possible scale and in a manner consistent with their most effective and efficient uses.

Potentials for this come readily to mind when one thinks of the opportunity of using bio-mass for solid and liquid fuel. Large-scale development of bio-mass for this purpose would benefit the grower, the user, and the environment. Conversion of fossil fuel-fired energy producers to bio-mass users is not a complicated technical job, but it will take a great deal of political skill and management ability.

Water has been a traditional source of energy. Our concept of large central electric power stations has never been able to produce the share of electric power that water should supply. There is a belief today that smaller-scale decentralized one to 10 megawatt water power stations are a better approach than the large central stations. If the hydraulic characteristics of a country stream are suitable, a very large potential for dispersed power exists.

Direct solar radiation and wind power should be thought of as contributors to systems that are already established and

that have management or institutional capability for effective distribution and use. I know a lot of people won't agree with me entirely on this, but I see absolutely no way to introduce the use of alternate energy sources unless we incorporate them into the energy systems that already exist. Not forgetting the isolated conditions of the hill people or the island people, it will be necessary to pursue the idea of very small-scale energy production using renewable resources. However, doing that in conjunction with a national effort is going to be much more effective and useful than pursuing this objective in isolation.

Returning to the question of the forests and their potential for supplying energy, the forests are already supplying that energy—to such an extent that they are disappearing. The alternative is the cropped forest or farm—not only for energy, but for wood and other products. The World Bank is currently conducting an interesting experiment with the Philippines on growing trees for use in the wood products industry. I think that this is a notable activity, and AID is following it with a similar operation related to the production of electrical energy. The possibilities of using agricultural bio-mass for liquid fuels are extraordinarily promising. This is an area which could well contribute a great deal to large-scale energy production. I am talking about large-scale in the aggregate sense; but the actual process of producing the energy may not always involve such a large-scale activity.

Revegetation Using Selected Species

DR. NOEL VIETMEYER, Board on Science and Technology for International Development, National Academy of Sciences, Washington, D.C.

I am in a program at the National Academy of Sciences where we look at exotic areas of science—anything beyond the conventional. A number of our projects have looked at little-known plants with the

AID will soon begin working with a number of American universities and the Forest Service of the U.S. Department of Agriculture on a variety of new non-conventional energy projects. These include research and demonstration on the use of liquid fuels, wind energy, photo-voltaic cells and, also, the development of energy systems for special environments, such as coastal areas. We are expecting to undertake all of these approaches in conjunction with various host countries in an effort to see how renewable energy resources can be devoted to providing large amounts of energy for not only rural areas, but also urban areas. We have gotten into the alternate energy program relatively late, although I don't know that there is anybody that's been in it for very long. Looking to the future, we can foresee a large amount of AID money being allocated to energy production which includes support for growing trees for energy and, consequently, the protection of the forests.

In addition to the general AID support for energy production in the LDCs, we will be working on review and assessment of energy problems in various countries, the support to and strengthening of institutions that deal with energy problems, training on matters that are relevant to energy, and support to fairly large pilot programs. AID is also very active on the question of using remote sensing for assessments of various kinds. I believe this provides a rather comprehensive overview of the alternate energy scene and the type of future role I envision for AID.

result that some of these species are now receiving millions of dollars for research and development. In a few months, the NAS will issue a publication containing information on about 150 little-known

species which have enormous promise to become crops of the future.

Agronomists have been appallingly parochial in their choice of crops. In fact, 85 percent of the weight of the food and the calories that are eaten come from only eight species of plants—all of them cereals. It seems to me that foresters have been similarly parochial in their choice of tree species for planting in the tropics. I'd like to highlight just a few of the leguminous woody plants that seem to have been largely overlooked by professional foresters, many of which would fit in exactly with the small-scale tree use proposed by FAO and others.

Many people think that legumes are something that are served with the main dish at a French restaurant, so it comes as a surprise that legumes are also trees. There are actually 18,000 species of legumes, the majority of which are tropical. Many of these are virtually unknown to science and while some are used extensively in one localized part of the world, they are unknown in other areas. A few are widespread already, but have yet to reach their full potential.

There are many reasons why legumes are promising species to use against deforestation. Legumes can quickly overcome potential competition and preempt the space. Many of them are readily planted on a large scale by direct and even aerial seeding. Legumes tend to have a hardy and irrepressible character suited to a wide range of environments, which is exactly the kind of thing we need to combat deforestation. They tend to be adaptable to a wide range of soils, particularly nutrient-deficient ones. They become fertile at an early age and seed copiously, and many of them occur naturally in pure stands, which indicates that they can be grown in monocultures without tremendous decimation by diseases and pests. Generally, legumes tend to be suitable poor man's plants because they are hardy, easy to plant, easy to cultivate, and require little maintenance. But the most important thing about legumes is that many of them have the

capacity to provide their own nitrogenous fertilizer through the bacteria that live in nodules in their roots. This bacteria can chemically convert nitrogen gas from the air into soluble compounds that the plant can absorb and utilize so that most legumes require little or no additional nitrogenous fertilizer—an extremely important point today.

Another thing about legumes is they tend to be multi-purpose. They yield food, forage, and fuel wood and some species are even used for plywood. Some of them can be grown very close together. A plantation of the legume *Leucaena leucocephala* in Hawaii yields some 60,000 stems per acre—which is a reasonable figure for a corn planter but pretty unusual for a forester. Because the nodules provide the plant's nitrogen, the foliage tends to be rich in protein and nitrogen. The leaf fall provides a fine amount of nutrients to the soil underneath, and legumes have long been used as a shade tree for plantation crops such as coffee.

Another legume, *Albizia alcuteria* can surpass *Leucaena* in its growth. In four years of average growth, one can expect *Albizia* to reach a height of about 21 meters, with a yield of about 50 cubic meters of wood per hectare. This species of *Albizia* has recently come to be better known among foresters, but there are actually nine other species that are virtually untried.

Acacia auriculiformis comes from the islands between Australia and New Guinea, and is a tremendously hearty plant which grows in dry areas and on impoverished soils with high acidity levels (pH₄) in northern Australia and even on sand dunes. It can get to be six meters tall in two years or 17 meters in eight years in Indonesia and Malaysia. But I should mention that *Acacia auriculiformis* has rather poor form; it gets crooked trunks. Foresters have found that *Acacia mangium*, which comes from northern Australia, can equal the growth rate of *Acacia auriculiformis* and has a beautiful form. Foresters have been getting an annual production of close to 50 cubic meters per hectare per

year and on poor sites *Acacia* has surpassed *Gmelina arborea*, *Pinus caribaea*, and *Albizia falcataria*.

Sesbania grandiflora, a legume from northern Australia, has outgrown all of the woody species of any kind that have been tested to date. Some of them reached more than eight meters in a year. This is a very fine multipurpose plant. The flowers, perhaps the largest of legume flowers, are edible and they are a delicacy in Southeast Asia, while the foliage is used for forage and the young leaves and parts go into salads. They contain about 56 percent protein.

Calliandra calothyrsus was introduced to Java from Central America as an ornamental. It has beautiful flowers which are quite well known around the Tropics. In Indonesia, it has been getting growth rates

of up to 3.5 meters in height in just six months. Indonesians are considering harvesting *Calliandra* on a rotation of just a year. The cut stumps regrow very readily and although it has very small stems, it seems to be an exceptionally good plant for fuel wood purposes.

Other valuable species of legumes which bear mentioning are *Dalbergia sissoo* and *Acrocapus fraxinifolius* from India, which have shown exceptional growth rates on appropriate sites, and *Schizolobium parahyba* and *Mimosa bracinga* from Brazil.

In closing, I would like to say that these fast-growing pioneer species of legumes have demonstrated a potential for helping to solve many of the problems associated with deforestation and fuel wood shortages in the less developed countries.

Perspectives on Future Needs and Opportunities

MR. ERIK ECKHOLM, Worldwatch Institute, Washington, D.C.

I would like to begin with some good news—which has been something of a rarity at this meeting. From my perspective it appears that a significant convergence in thought between those in the economic development field and those concerned about environmental quality is occurring. Though they have traditionally been at loggerheads, developers and conservationists are beginning to realize that they need each other if their respective goals are to be met.

Economists are learning that certain development patterns can provoke severe ecological backlashes—that they can have a negative net impact on human welfare. The attention given desertification following the Sahelian famine of the early 1970s has done a lot to raise awareness about environment and development, but, more generally, issues such as firewood, watershed disruption, and erosion are now

receiving extensive attention in Third World media and even national development plans.

One consequence of the new awareness is the incorporation of an environmental assessment process into the project planning of the World Bank and AID. While obviously a good development, this process does not, however, provide positive guidance about what sorts of projects are needed in the first place. Equally important in the long run may be the new willingness of some agencies to support environmentally oriented forestry and other projects, as indicated in the World Bank's new "Forestry Sector Policy Paper" and recent additions to AID's authorizing legislation.

For their part, many conservationists are beginning to realize that the preservation of natural diversity will be impossible if the basic material needs of people are not met;

that rapid, labor-intensive, socially equitable development needs to occur if there is to be any hope of protecting reserves, watersheds, and wildlife.

Turning to deforestation in particular, one continuing problem has been convincing skeptical planners about the economic significance of current forest trends. A large amount of literature exists on the potential contributions that productive forestry can make to economic development. However, surprisingly little has been written about the economic costs associated with a lack of proper forest management. An opportunity exists for creative economic analysis of the forest sector that will justify far greater investments in tree planting, forest protection, and so on.

What does it mean to suffer timber scarcity of the sort already apparent in many developing countries? Lumber prices in poor countries can be higher than those in rich countries. How does this affect construction and other economic activities? What are the social costs when families must devote a day a week, or a fourth of their incomes, to firewood procurement? Or when dung is diverted from fields to fireplaces? To what extent is paper scarcity a consequence of tree scarcity, and how much does it hamper government, education, and communications? We have heard projections that the per capita amount of marketable timber standing in the world will be nearly halved by the year 2000. This will surely have major social and economic consequences, yet economists seem to have little if anything to say about it.

Even more creative economic analysis is needed of the indirect economic costs incurred when the ecological functions of forests are impaired. Quantification of the

costs of reservoir and river siltation, hydrological disruption, and soil degradation would give forests a great boost in the project analysis process. Of course, some important forest contributions, such as to biological diversity and the storage of carbon, probably cannot be quantified economically. Forest preservation for such reasons will simply have to be analyzed and defended in its own right.

An additional obstacle to better forest management—even where planners are convinced of the need—is the lack of national and local institutions able to design and enforce proper strategies. In fact, I would argue that, despite the major gaps in the technical knowledge of tropical forestry, the biggest impediments to halting deforestation are sociological and political rather than technical. At this point, it would be useful for someone to compile information about forestry success stories in the Third World so that lessons about institutional mechanisms could be gleaned from them. To give one example: South Korea's village woodlot program, which is managed by village forestry associations that enjoy popular participation, provides one of the few significant firewood successes of recent years.

Finally, I would emphasize that neither forestry nor biological reserve needs can be viewed in isolation from broader economic development patterns. If people have no jobs or land, they are going to move onto forested mountain slopes and into natural preserves. If people have no other fuel, they are going to cut live trees for firewood. A broadly shared development process, together with a rapid slowdown in population growth, may be the prerequisite of a long-term solution to the deforestation problem.

DR. WILLIAM GLADSTONE, Manager of Tropical Forestry Research, Weyerhaeuser Company, Tacoma, Washington

I would like to say at the outset that I am presenting *an* industrial perspective and not *the* industrial perspective, and that my presentation represents a relatively narrow industrial perspective. As most of you know, Weyerhaeuser is very much engaged in plantation management domestically. We invest very heavily in forestry research throughout the United States because our continued existence depends on sustaining a flow of wood. We believe that plantations are also appropriate for the tropics as one tool—and I emphasize the phrase one tool—which would be useful in the resolution of the tropical forestry problems we have been addressing at this Conference. I am talking about plantations in the context of integrated land use.

There is an increasing population pressure on tropical resources. The resettlement of Javanese in Kalimantan near Santa Maria, which I have recently observed, brings home very intimately to me that problem. There is an increasing demand for food and wood, both renewable resources, and a continuing quest by developing countries with forests for capital. In Indonesia, I believe, as far as export dollars are concerned, timber is second only to petroleum. There is a continuing displacement of forests by agriculture. There also exists the fact that the ecological diversity and complexity of tropical forests presents us with problems of conversion and utilization in silvicultural efficiencies. We need to better understand how to utilize the spectrum of species in the forest. This leads to the point that depletion of useful species, in spite of current manipulative silvicultural practices, is probably inevitable. In addition, we are faced with relatively low rates of growth of currently useful species under natural management systems. What then, is our best direction? Man is a pervasive monoculture himself which relies on other monocultures and technology for sustenance.

Extensive life support systems, such as uncontrolled shifting agriculture, will be increasingly inadequate. Displacement of some proportion of shifting agriculture and natural forest harvesting systems by intensively managed plantations, we feel, is logical and desirable. Sustained management, at least for several rotations of forest plantations on soils which are unsuitable for permanent agriculture, is biologically and socially feasible. The problem of reduced growth in subsequent rotations is a high-priority research item. We are working on this problem, but it should be pursued on a broader basis. But it should not hold up the establishment of plantations on harvested or abandoned hectares. Successful plantations in many tropical areas can produce four to 10 times the useful wood produced by a natural forest harvest system. For a constant wood supply, this implies release of forest land for other uses. Although reliability and homogeneity of plantation harvests will permit investment and integrated conversion facilities, we recognize that the risks associated with tropical plantations are undoubtedly higher than those associated with temperate zone plantations. Weed competition and insect and fungal problems generally increase the tempo of biological cycles, thereby exacerbating problems. But, by the same token, rotations are shortened.

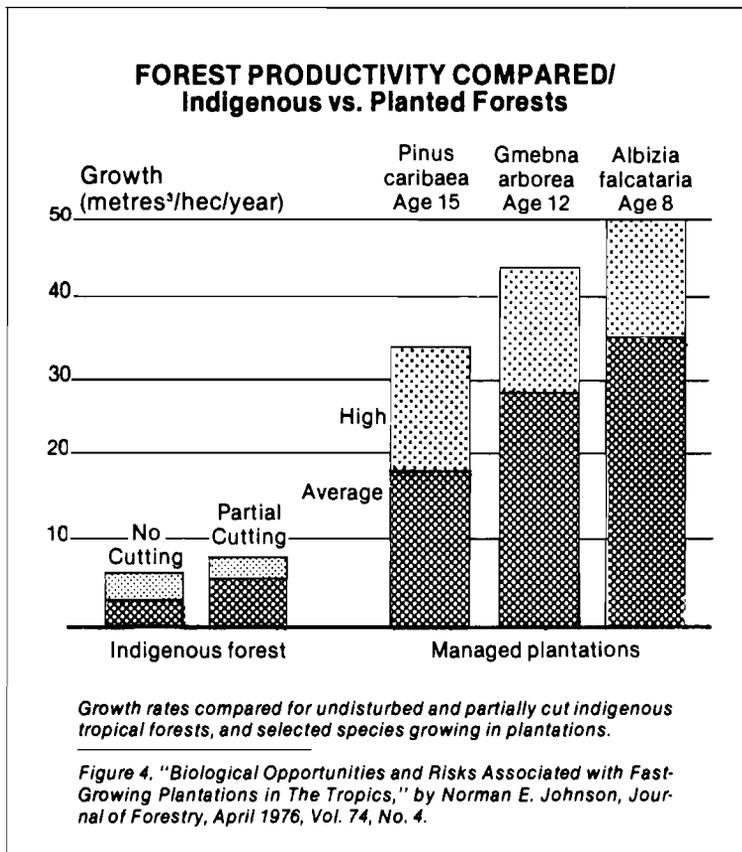
Forestry needs require a conviction that intensive plantation management is a useful tool in the resolution of tropical forestry problems. They also require commitment by local governments, international agencies, and industry to identify and minimize the risks associated with tropical plantation management in order to develop plantation systems for tree species of diverse origin and utility. We need to establish or refine multiple use silvicultural management systems for the natural forests. We also need research designed to optimize

the distribution of land use for agriculture, forestry, and combinations of the two. And finally, incentives are needed for the establishment of industrial scale plantations and complementary agroforestry systems. One facet of incentives must be stability in business relationships, in the administration of tax laws, in import/export regulations, and the dedication of land to various uses.

Figure 4 is a generalized schematic of our estimates, based on information from forest plantations around the world, illustrating the relative growth rates of uncut and partially logged forests in terms of current commercial wood production versus what can be produced in managed plantations of *Pinus caribaea*, *Gmelina arborea*, and *Albizia falcataria*.

The objective of our forestry research program is the establishment of biologically sound plantation yields. At Kalimantan, areas of research include nursery practice, in which we are looking at seeds and soils in the nursery; fertilizer regimes; and insect and disease control. In the nursery, we are experimenting with different kinds of containerization, germination procedures, and fertilization and productivity in nursery containers.

We are planting experimentally about 1,000 hectares per year and have dealt with some 30 species in this area, giving special attention to plantation establishment, planting practices, protection, fertilization, and spacings. However, I think that even on a domestic basis we have not even begun to scratch the surface of the scientific and



technical problems pertaining to optimizing productivity. We are constantly dealing with problems such as root configuration and how to best establish trees in the field. *Albizia* plantations, for example, are subject to predacity by deer and monkeys. Our *Eucalyptus deglupta* plantations are among our oldest, having been established about four years ago. Weeding and other protective functions are mostly done manually.

In agronomic research, we consider soils, tree-site relationships, and test certain agronomic varieties. The soil we are working with is very much like the soils we work with in the southern United States. We are working with *Albizia* as a nurse crop for cocoa and oil palm on a relatively limited basis, but the prospects for success are not good because of the soil types. We grow such crops as sweet potatoes, radishes, and papaya on a relatively large scale to help support the contract laborers who work on the planting and clearing crews.

Discussion

In response to a question regarding the statistical differences in growth rates among various species, **Dr. Gladstone**, using *Pinus caribaea* as an example, said that wood quality is determined by such factors as species variability and growing environment.

Noting the increasing costs of high-intensity forest management due to the use of fertilizers derived from fossil fuels, a Conference participant asked how Weyerhaeuser planned to sustain artificially high production yields. Dr. Gladstone replied that his company's efforts in Indonesia were fundamentally labor intensive and very low in energy input. Certain species, such as *Albizia*, respond well to this system, according to Dr. Gladstone, and should be developed.

A Conference participant representing a forestry company suggested that unless plantation technology in the tropics is developed to achieve the maximum utilization of relatively small areas, other natural forest areas and their potential genetic resources will be destroyed by activities such as shifting agriculture.

We are conducting growth and yield activities on a *Pinus caribaea* plantation, and are also looking at the productivity of the secondary forest. Genetic improvement, species testing, provenance testing, selection of superior trees, and seed orchard management are among our planned research activities.

What began as a provenance test in *Eucalyptus deglupta* turned out to be a species trial. The seed which was supplied turned out to be that of another species and obviously there is quite a difference in performance between those two species. *Eucalyptus* flowers bear seeds at 16 months in Kalimantan.

Although *Pinus caribaea* is not indigenous to the equatorial zones, there are excellent phenotypes in the Kalimantan population of not only *caribaea*, but also *Pinus ocarpa*, which promise to increase the productivity of the plantations we establish. We are currently conducting progeny tests of material from both species of *Pinus*. To date, a single generation has demonstrated improvement with *Pinus caribaea*.

DR. LAWRENCE S. HAMILTON, Sierra Club and Cornell University, Ithaca, New York

Even a concerned environmentalist, which perspective I am endeavoring to represent, has to recognize that there *will* be more deforestation, and there probably *must* be more deforestation. However, I would like to raise seven questions for the considerations of this Conference.

First, can the deliberate *needed* clearing be controlled and confined to the most rewarding, least damaging sites?

Second, can we not identify "critical areas" of forest which because of their natural functions should be kept in forest, even if it would be rewarding to clear them in the short term?

Third, can the haphazard, accidental, or careless by-product type of deforestation be reduced or even eliminated?

Fourth, can we reverse the trend toward clear felling and "all tree-any tree" logging for wood fiber?

Fifth, can we slow the removal of forests for fuelwood and try to stabilize the use of energy forest?

Sixth, can we stabilize somewhat the shifting cultivating and grazing which is an important cause of deforestation?

And seventh, can we minimize the adverse impact of our forest activities on the native inhabitants?

To address the first question, surely we have the technical capability to sort out sites which are suited to clearing for sustained agriculture and grazing, from those which are not. Needed, however, is a more appropriate land classification scheme—appropriate in terms of cost and speed, and adapted to the culture and existing technology of the country area to which it will be applied. Most of our transfer methods in land-use classification and planning are too detailed, too slow, too expensive, and geared to high technology agriculture, *e.g.*, the soil survey. Not that we don't need the detailed soil survey, but

we need something else more integrative and broad which can get on top of the problem, *i.e.*, classification of land before it gets converted to inappropriate use. For instance, I have recently been involved in a land capability-suitability classification developed in the 160,000 hectare Guanare River watershed in Venezuela. At a cost of \$2.3 per hectare, and accomplished in two man-years (\$45,000), data on climate, soils, geology, vegetation, and water resources were integrated for the delineation of biophysical and economic and cultural suitability of these units to support grazing, seven kinds of agricultural crops, and forests for production as well as for protection. The work of two of the present Conference participants—Dr. Jack Ewel and Dr. Frank Wadsworth—was used in developing this method which appears more applicable to developing countries than methods of land classification now used by the Soil Conservation Service and others, and which can be easily taught to anyone who has some facility in airphoto interpretation.

The Conference heard about the critical problem in the watersheds of the Panama Canal. The same kind of problem is being increasingly recognized in other watersheds of the tropical world as the importance of water resources in economic development is recognized by these countries. Every hectare is part of some watershed. Perhaps, because of the relationship to water problems, the importance of land use classification can be sold before options are removed on forest lands.

There remains, of course, the major hurdle of achieving the desired land-use pattern based on such classification. There are basically three methods: education, financial incentive, and police power. Which ever one or combination of these methods is used, a planning document which shows the suitability of certain areas for certain uses is a powerful aid, especially if it is logically and clearly based so that it is understandable to politicians and landowners.

Regarding the second question, can we not identify critical areas of forest which, because of their natural function, should be kept in forest, even if they have the capability for conversion to other use? I believe this kind of critical areas survey is one of the most urgent needs in tropical countries.

Examples of such areas to be preserved include areas with rare or endangered species of flora or fauna. Moreover, areas of unusual interest to science must be preserved so that we can learn more about the function of these ecosystems. Also requiring preservation are water-captive areas at high elevations, such as cloud forests, whose function is eliminated or reduced if the forest is replaced by other vegetation; areas of superlative interest from a scenic or cultural standpoint that are precious parts of the national patrimony; and areas where forest must be maintained as protection for sensitive sites with unstable soils. Do these sound familiar? Dr. Frank Wadsworth proposed such a priority system in land use planning back in 1969 to evaluate public forest lands.

In response to the third question, can the accidental or careless environmental "externality" from some other use which causes deforestation be controlled? I think, for instance, of fire, which is used in agriculture and grazing so frequently in the tropics. Even the moist tropical forest will burn in the dry season if fires are allowed to go unchecked from adjacent lands. Development of fire-suppression capability, and an educational program to go with it, are important considerations in a tropical forests policy.

I think particularly of road construction, which is accompanied in any area of relative land hunger by the deforesters who then find the forest accessible. New roads need to be planned with the eventuality in mind that they will bring in the slash-and-burners. Could their location be modified so that areas suitable for clearing are made available and unsuited areas avoided? Could there be land capability

classification before the road is constructed, and some system of "zonation" put into effect based on capability? Outright prohibitions will not work in most cases, but would "selective" opening-up be feasible by productivity zones? This offers some options.

Considering the fourth question, clearfelling as a forest harvesting method is the most drastic perturbation to the resilience of a forest, and often leads to disappearances of forest. I am, however, of the opinion that low-intensity forest harvesting is not a villain in the process of tropical deforestation. Clearfelling, which is coming into increasing prominence, is a horse of a different color. Clearfelled areas are the harvested areas most rarely converted to non-forest use. The areas felled are often large and, as a result, natural regeneration becomes impossible. There is great disruption to the wildlife, soil protection, scenic, cultural, and water-handling functions of the forest. Even when followed by immediate reforestation (usually with single species), some of these functions are not restored (e.g., wildlife habitat). Moreover, the state of knowledge about tropical reforestation is still somewhat low, and plantation failures are common. The future pest problems are unknown, but the risks are high. Until we know more, a conservative course on harvesting would seem to be warranted. Let's shift the burden of producing wood fiber in "factories" to the multitude of degraded and derelict land already cleared, or to some of the degraded woodland, before we knock down any more primary forest to convert it to plantations. Utilization is a two-edged sword.

In response to question five, can we slow the deforestation action due to the search for fuelwood? Most promising is the possibility of developing community energy forests and managing them on a sustainable basis. This would include the establishment of community fuelwood forests close to settlements. Surely this is worthy of a major global campaign, expensive though it may be. Community ownership is important, but also represents the

hazard of common property resources. Protection of the commons will need to be integrated into the particular cultural conditions of specific regions within countries and incorporated into their value system.

The sixth question asks can we somewhat stabilize shifting cultivation or grazing? We need a recognition of the fact that a stable system of shifting agriculture exists where population density and technology are at low levels. It is the intensive slash-and-burn method that degrades a site and intervenes in adjoining forest areas. Surely, here we can do more to promote appropriate systems of agroforestry where tree crops and food crops are incorporated into the process of producing annual crops, or grazing, on the same area. Agroforestry seems entirely feasible in theory, but difficult to implement. I believe

we are correct in making a new thrust in promoting this system, which in some areas is a very old and proven one, developed over centuries of man's living close to nature.

And finally, can we minimize the adverse impacts of any of our activities in tropical forests on the native peoples living there? We have neglected this problem for too long in our projects of forest development. The work of various Man and the Biosphere projects under MAB 1 should be mentioned here as initiating very sound work in this connection, particularly with the Gagol Project in Papua, New Guinea, the East Kalimantan Project in Indonesia and the Tai Forest Project in Ivory Coast. The United States should look to MAB research and strengthen it for important answers to this thorny problem.

Discussion

One Conference participant noted that the U.S. Government's recent decision to increase beef imports would encourage further deforestation activities by cattle ranchers in Latin America. Hamburger prices in the United States, the speaker said, do not reflect the environmental costs of extensive cattle ranching in tropical forest areas.

Dr. Hamilton agreed with another speaker who said that agriculture and grazing, rather than most forestry activities, were responsible for most of the deforestation taking place in the humid tropics. It was generally agreed that a stable system of shifting cultivation, in which relatively small areas of land are left to regenerate themselves following two to four years of cultivation, is not a serious cause of deforestation.

Historical data indicate that both man and nature have caused ecological changes in the humid tropics over the last 500 years, according to one speaker. Therefore, rather than concerning itself primarily with reforestation as an answer to the deforestation problem, the speaker said the Conference should consider better land use practices than seem to be occurring currently.

DR. FRANK B. GOLLEY, Director, Institute of Ecology, University of Georgia, Athens, Georgia

In our concern for the deforestation of the humid tropics, we must recognize three facts. First, forests are being destroyed and are not being regenerated. Second, we know relatively little about these forests. And third, there is very little historical

evidence that over the last 2,000 years modern man can be motivated to reduce his demands and suffer sacrifices so that forests can be preserved. These facts make one pessimistic about the future of the tropical forests, yet there are counter

currents that allow one at least a glimmer of optimism.

First, mankind has available unprecedented material and energy resources to use in the future. Second, science has developed methods that allow logical, rational exploration of the natural world and logical application of resources to meet human needs. And, third, we have available a network of transportation and communication that can potentially link all mankind into one population so that concerted action is possible. As we all know, there is a danger that we may apply science and use communication so that resources meet the demand of the rich and powerful only, creating a worldwide feudal state rather than the community dreamed of by Jefferson, Simon Bolivar, and other founding fathers. Thus, we must evolve a long-term strategy for man, as well as short-term tactics, to assure sustained productivity, an equitable distribution of resources, and a quality life for future generations. My comments on scientific opportunities will be presented in this context.

Certainly, there is great opportunity to know and understand tropical forest life. You have heard and will hear a great deal about this need. We know few of the animals or plants that live in tropical forests—in many instances we do not even know the names of the species that occur there. The richness is bewildering. For example, in the Amazon we have found 120 species of trees on plots five meters wide and 50 meters long. Insect traps yielded over 100 morphotypes of Dipteran flies. The great species richness of tropical forests is an unending challenge to the field biologist and taxonomist.

Equally interesting from a theoretical viewpoint are questions raised about richness. Are all species significant or are there redundant species in these forests? Is the mixture of species a chance phenomenon or is it due to organizational principles of the living system? Is the behavior of forests dependent upon the richness or not?

Other important questions concern the stability of tropical forests. How do forests resist disturbance? How rapidly can they regenerate after destruction? How does the type of disturbance and the size and shape of an area influence the rate of recovery?

If one asks an ecologist or a biologist why tropical forests should not be destroyed, these and other questions will be raised to answer the query with the caveat that such questions are interesting in themselves, as well as being significant to mankind. And considering science from the context of our own country and western culture, these questions and responses are completely valid. Yet to make research addressing such questions relevant depends upon a context that is often not characteristic of our culture or science. It depends on the social-cultural milieu of the tropical country, their use of science, and their perceptions of the West in general or the United States in particular. This contradictory state of affairs underlies our difficulty in dealing with deforestation. This point is, in my opinion, so central to the problem that I will devote the remainder of my time to it.

Modern man has developed a complex hierarchy of organization, each level or stage of which has placed certain demands on resources and views on how resources should be allocated. In some cases these demands are contradictory, as, for example, when an individual wishes to do something counter to the rules of the larger society. We constantly search for ways to optimize between conflicting demands—that is, to seek solutions which meet the perceived demands at all levels of the social-political hierarchy. Plans to halt deforestation that ignore the needs of marginal farmers invading forests or the demands of suburbanites who desire tropical hardwood-faced plywood for their dens—and all levels between—will fail to be effective.

Examining the scientific aspect of the optimization problem, I feel that we need focus more than anything else. The scien-

tific cadres available to study tropical forests are very few. Considering all tropical ecologists in the world, there are only about 25-30 per country. There are very few facilities for research as well. Africa, in particular, has been ignored, both in research by non-Africans and in development of trained cadres of scientists.

The UNESCO Man and the Biosphere Program provides such a focus, and obviously it can concentrate the limited scientific resources on areas of great potential. Otherwise, we will see individuals examining an animal here or vegetation there unrelated to the studies of other individuals in the next country. This is particularly serious for the scientists of the United States who have developed individualistic research into a fetish. However, we have organizations such as the Organization for Tropical Studies and the Smithsonian Tropical Research Institute, which increasingly have been able to continue first rate tropical science with an increasing concern for linkages with the scientists of the countries in which they are located.

There is another need to accomplish a focus, however. Science is not done in a vacuum. It depends upon communication among scientists. Communication can be through international congresses, symposia, conferences, and seminars. It can be through journal papers, books, and letters. The fact is that scientists in the tropical forest regions speak and write in a great variety of languages, do not (often for economic reasons) see each other's journals, and find it easier to communicate with Paris, London, or New York than with counterparts in a neighboring country. In the International Society of Tropical Ecology, we are trying to build an international communication network by newsletter, journal, meetings, and regional centers. It is not easy—indeed, it is incredibly difficult. And we encounter active hostility on the part of some U.S. scientists who resent using funds for international scientific organizations. Who knows what might happen if young scientists from

Nigeria could regularly meet, work, and study with their counterparts in Venezuela? In my mind, it is better that they meet directly and build bridges east and west than remain tied to the north-south lines of communication built during the colonial era.

However, besides a focus of effort, we also require a mental model to organize the research and application of research. We find that the most useful device to accomplish this is a system model which describes the hierarchy of structure present in the system of interest. I am not suggesting an esoteric modeling system here, but rather an organized, logical, and structured approach to understanding the systems of concern to mankind. In my view, a science policy that assumes that it is possible to "design up" from detailed study of all of the parts of a system will fail. Of course, science is an activity that has a cultural value, and individualistic science must be carefully nurtured for that reason alone. But if we seek solutions for landscape problems such as deforestation of the humid tropics, then we must focus systematically on the landscapes and ask questions relating to that system. Ecosystem science is basic to the solution of the problems of deforestation.

I am hopeful that our understanding of ecosystems and the application of this understanding to our personal lives is increasing around the world. The appreciation that one is part of a complex of systems and that personal action is always carried out within an environmental-social-economic-cultural context is central to our question today. If we interpret our lives as parts of ecosystems, then we see that the task before us is rebuilding ecosystems, not preserving the remaining undisturbed systems (not that preservation is bad). The scientific expertise should be focused on how to rebuild soils, vegetation, faunas, and societies. Let me suggest that we need a world-wide effort, comparable to putting a man on the moon, in order to rebuild a tropical forest. Do we know enough to put one together? What do we need to know to put one together? There is

no question in my mind that the future of mankind will focus on rebuilding, maintaining, and nurturing the human-natural ecosystems of the planet. Action based on exploitation of people and resources is no longer appropriate.

Finally, I should add that rebuilding forests is appropriate to the American cultural view that technology has positive at-

tributes, that wealth and resources can be used for good, and that man is the dominant, but caring, steward of the landscape. When one builds, one understands, and further in a philosophical sense, one becomes a part of this object of one's creation. Man has built soils and civilizations that have lasted hundreds and thousands of years. We can do so again. We have the wealth and the information to begin this change. Do we have the vision?

IV. WORKSHOPS: DISCUSSIONS AND RECOMMENDATIONS

Deforestation problems unique to the *humid tropics and the semi-arid regions* were examined in separate, concurrent Conference workshops. Co-moderators for each workshop assumed responsibility for preparing a report on the major conclusions and recommendations of the sessions, and for presenting it to the final plenary meeting of the Conference.

This chapter summarizes the workshop discussions which were carried out over a one and one-half day period and identifies the specific recommendations that were included in the reports to the Conference. The workshop on humid tropical forests was attended by approximately two-thirds of the Conference participants. The semi-arid workshop attracted fewer people for two reasons: first a number of the U.S. experts participated in a simultaneous meeting convened by AID's Africa Bureau on "Firewood in Africa"; and second, arid and semi-arid land problems have received a greater degree of analysis over the past few years, primarily because of the Sahelian drought. The Conference organizers anticipated this imbalance, but felt that the spectrum of tropical deforestation issues should be addressed at this meeting.

Deforestation Problems of the Humid Tropics

Co-Moderators: DR. GHILLEAN PRANCE, New York Botanical Gardens, Bronx, N.Y.
DR. IRA RUBINOFF, Smithsonian Tropical Research Institute,
Balboa, Canal Zone

General Discussion

It was recognized that the deforestation problem is symptomatic of a much more fundamental problem—accelerating human population growth. *If the population problem is ignored, activities related to solving tropical deforestation are only holding actions at best. The firewood problem, commonly associated with the developing countries and arid and semi-arid lands, is also a problem of the humid tropical countries.* Much attention was focused on the mass extinctions of plant and animal species, the loss of fertile soils, and the associated problems of decreased water supplies, erosion, flooding, and siltation that emerge as the forests are removed.

The workshop recognized that quantitative data on rates of forest losses in the humid tropics lacked precision, but that the deforestation problem was clearly serious and increasing in severity. Most participants felt that U.S. forestry efforts to assist developing countries should be better coordinated, and that these U.S. efforts in turn be more closely coordinated with the work of other international donors.

"Forestry" was used in its broadest sense during workshop discussions, and interpreted to subsume general concepts relating to landscapes, watersheds, ecosystems, and agriculture. Agroforestry and its potential for the humid tropics was

stressed by many. Clearly, the participants felt that *agriculture and forestry should be integrated into rural development projects, and should not continue to be treated as separate, unrelated activities.*

Many of the workshop's recommendations initially were addressed to AID or to the Department of State, even though the Conference was to consider an overall U.S. strategy. During the course of the workshop discussions, however, it became clear that many of the recommendations

were more appropriately directed toward U.S. institutions in general than to AID and State specifically.

Workshop participants discussed possible follow-on activities to this Conference. Some favored an international meeting on tropical deforestation; others felt that regional meetings would be more effective. Still others stated that no further meetings were needed but that it was time to implement what has already been identified as critical programs. The question of follow-on conferences was not resolved.

Recommendations

- The Department of State and AID should take the lead in establishing a U.S. policy and strategy for addressing tropical deforestation.
- The United States should give special emphasis to the preservation of watersheds in formulating its policy on agriculture/reforestation; where possible this policy should take into account related activities and efforts of other international agencies.
- The Board on International Food and Agricultural Development (BIFAD) should include forestry as an integral element in dealing with the food system and on an equal status with agriculture.
- AID should increase its in-house competence in the area of tropical forestry.
- A U.S. interagency body should be formed (including State/AID, Agriculture, Interior) which would meet periodically to coordinate international forestry activities, and serve as an advisory body for the preparation of a new U.S. policy in this area.
- The United States should provide incentives to American logging and paper companies operating in developing countries to assist in reforesting denuded or devastated lands even though the damaged land may be the result of the activities of others.
- The United States should assess the environmental damage that logging companies are causing in humid tropical forests, and consider applying the National Environmental Policy Act (NEPA) to all U.S. overseas activities related to forest clearing.
- The Department of State should examine the environmental impacts on tropical forests in Central America and the Amazon region of South America caused by land clearing for beef production related to U.S. demand for meat; and the United States should promote activities in these areas to the extent possible to foster increased pastureland productivity.
- Biosphere Reserves of tropical areas should be expanded. The United States should increase support to and improve coordination with research and training activities undertaken through UNESCO's Man and the Biosphere Program.

- Simple methods should be developed for tropical soil analysis and for land classification; and such methods should be faster than those presently in use because land clearing in the humid tropics is taking place much more rapidly than the land's capabilities to sustain various proposed uses can be determined.
- Forestry and agricultural organizations should periodically publish state-of-the-art information on the varied aspects of tropical forest management suitable for use by the developing countries.
- "Tropical forests" should be clearly defined and identified, inventories should be prepared using expanded remote-sensing applications, and the availability of forestry survey, classification, and analysis facilities should be increased in developing countries.
- AID should support tropical forestry and tropical ecology projects and research in developing countries.
- Research should be expanded on modified tropical forests in the areas of agroforestry or agro-silviculture.
- Research on humid tropical forests and forest technology should be expanded. The emphasis should include analysis of annual deforestation rates in specific areas, the socio-cultural patterns of who does the cutting and how much is cut, and what the reasons are for the cutting. These data should then be used to develop models for predicting forest use.
- Educational and public awareness tools and techniques should be improved to assist developing countries to increase sensitivities of the general populace to the environmental consequences of tropical deforestation.
- Improved techniques should be developed for the preparation of charcoal, the production of firewood, and for the efficient use of these fuels in cooking and heating.

Deforestation Problems of the Semi-Arid Regions

Co-Moderators: DR. LEONARD BERRY, Clark University, Worcester, Massachusetts
DR. PAUL BENTE, Bio-Energy Council, Washington, D.C.

Discussion

The geographical area discussed was defined at the outset by the workshop participants to include those parts of the semi-arid tropics receiving about 15 to 35 inches of precipitation annually. This would isolate a set of problems which are clearly distinguishable from those of the humid tropics.

In the semi-arid regions, trees serve multiple functions in that they provide firewood, browse for animals, shade for people and

animals, erosion control, dune stabilization, soil nutrients, and moderation of soil temperature fluctuations. Since all plant life is sparse in such areas, and because whatever is present performs at least some of the important functions listed above, not just trees but *all vegetation* should be considered within the context of "forestry" problems in semi-arid regions.

Deforestation was considered to range from significant to critical in most coun-

tries with sub-humid to semi-arid ecosystems. Though deforestation has serious effects on many aspects of life in such areas, the most urgent is the loss of wood for fuel. Much of the discussion focused on this problem. Deforestation (if that term is appropriate for semi-arid regions) has been caused largely by the demands of growing human populations for firewood and charcoal for cooking and heating, by livestock overgrazing, and also by changing rights of access to land. In many parts of the world, the land around settlements has been denuded of trees for miles, necessitating long trips to get wood or the payment of very high prices for firewood or charcoal. Eventually, a point is reached where many people have to switch to dung for fuel. This means loss of fertilizer and a further drop in nutritional levels.

The next 10 to 15 years were seen as a critical period for solution of fuelwood problems. Increased supply, better management of wood, and improved technologies for more efficient use of fuel will be imperatives until additional and alternative sources of low-cost energy can be developed. An ultimate solution will depend on, among other things, stable populations.

Deforestation was also seen as a symptom of changing people/land relationships. The increasing numbers of people are clearly outpacing the ability of local and national institutions, and the political, economic, and legal systems, to adapt rapidly enough to prevent or curtail the problem.

An important part of the deforestation problem is the lack of perception at national, regional, and local levels. Where recognition exists, methods and resources for dealing with it are often not available.

Recommendations

The following recommendations were developed by the workshop participants with clear recognition that little can be

Perception of this particular problem was considered to be generally less in cities than in the countryside; however, in some countries, the central government is more concerned than are local governments.

The workshop discussions revealed a great deal of concern about management capabilities. At the national level, institutions for demonstration of anti-deforestation principles and techniques, and training of field personnel, either do not exist or are generally inadequate.

At the village level, a forest protection and management philosophy and capability must be introduced. Local people must become aware of the direct benefits of forestry projects and share the responsibility for their success. Foresters who represent central governments are often disliked because they try to prevent overuse of tree resources, which is seen by villagers as a denial of their basic needs.

Though technical people within the affected countries understand the problems, it is often difficult for them to reach the people who control money and programs. Furthermore, since the benefits of most traditional forestry projects do not become apparent quickly, they are not popular with politicians faced with a spectrum of competing needs.

Increasing attention is being given to deforestation problems by some international organizations—the World Bank, FAO, and the newly formed International Center for Research in Agroforestry. A number of bilateral assistance programs are expanding their activities (Canada, Sweden, Australia, Norway, France, the Netherlands, and the United States). However, these efforts are meager in relation to the scale of the problem.

done by outside organizations until there is awareness and commitment on the part of the countries most seriously affected.

- The firewood situation in developing countries should be recognized as a serious and urgent world-wide problem. The U.S. Government (including the Department of State, AID, Peace Corps, and the departments of Agriculture, Interior, Energy) should make a commitment to treating it with high priority. Fuelwood shortages are critical not only in Africa, but also in Southeast Asia and parts of Central and South America.
- The United States should initiate a dialogue with fuelwood deficient countries where it has not already done so aimed at the provision of greater U.S. assistance toward solving the problem, and extend its present initiatives beyond the African context.
- In light of the tremendous need to raise the level of political awareness of the firewood crisis both internationally, nationally and locally, two types of meetings were suggested: first, regional meetings of senior technical experts convened by FAO which would take a cross-regional look at the problems; and second, regional conferences involving both political and technical representatives. (While the possibility of a global conference was discussed, it was felt that this would be more appropriate if focused on problems of deforestation in the humid tropics.)
- As action is important in the next 10 to 15 years, and as no serious alternative energy sources will be available in that time frame, the United States, if appropriate, should take the initiative in organizing a group of donors to look at the technical aspects of a global fuelwood strategy, defining and dividing responsibilities for technical and financial assistance.
- The United States (particularly, the Department of State, AID and the Department of the Treasury) should use its influence in the World Bank, in regional development banks, and with other bilateral donors to raise awareness of the firewood problem and urge more effective contributions to its solution by these organizations.
- The particular issue of firewood, and more generally the role of trees and forest resources, should be included in the agenda of the 1979 United Nations Conference on Science and Technology for Development.
- AID should examine all of its current rural development projects to insure that, whenever appropriate, they incorporate forestry/firewood components.
- As many of the solutions to this set of problems involve relatively small scale, but widespread efforts, the Peace Corps can form a very important component of any U.S. initiative. If necessary, volunteers could receive short-term training. Better technical backup for the Peace Corps may also be necessary. The technical capabilities of AID, the Peace Corps, and other U.S. agencies dealing with deforestation should be strengthened.
- A more integrated approach needs to be taken in agriculture and rural development activities which recognizes the importance of trees and forests. A variety of mechanisms need to be explored for expanding institutional capability and for educating people locally, nationally and internationally to communicate the value of this approach:
 - At the local level, better communication is needed between forestry officials and rural communities to lessen antagonisms and develop methods for meeting the needs of both groups;
 - Agricultural extension officers need training in the use of trees. International agriculture research institutions need to focus on the integra-

tion of forestry in their current research programs;

- Donor agencies, such as the World Bank and AID, should promote the integrated approach concept. As an example, Title XII of the U.S. Foreign Assistance Act which sets forth the mandate for the Board for International Food and Agriculture Development should be amended to include management of natural resources in its set of activities;
 - In general, increased attention should be given to institution building in integrated natural resource management and land-use planning in developing countries; and
 - In some cases, mechanisms may need to be developed at a regional level to provide technical and training services for smaller countries.
- A great deal more research is needed in a number of areas:
- *Alternative energy sources* including bio-gas, solar, small-scale hydroelectric plants, and wind;
 - *Quick-growing tree and plant species* including adaptation of species to different rainfall and groundwater regimes, development of or identification of trees with natural fertilization capabilities, better production of tree crops; etc.;
 - *Rare plant species*, including their identification, analysis of their utility and economic value, and development of measures to insure their survival;
 - *Reasons why fuelwood and reforestation projects* have succeeded or failed;
 - *Improved combustion* of wood and alternative fuels to extend supplies; and
 - Quantification of some of the *benefits of woodland and environmental protection* in general.
- Whenever appropriate, research should be focused on particular problems within a country and directed toward a closely defined end product.
- Support should be provided to the newly formed International Council for Research on Agroforestry (ICRAF). U.S. efforts or initiatives in this area should be closely coordinated with those of ICRAF, FAO, UNEP, IBRD and other international and bilateral donors and technical assistance agencies.

V. REACTIONS AND NEXT STEPS

The final session of the Conference was devoted to presentation of the two workshop reports, followed by a general discussion of the major conclusions and implications of the meeting, and specifically of what the Department of State, AID and the rest of the U.S. governmental and non-governmental committees should pursue as "next steps."

Mr. Noel Brown, UN Environment Program, had been invited (in advance) to present his reactions to the Conference discussions. Highlights of his statement are reproduced in this chapter along with other views and summary comments.

Response by MR. NOEL BROWN, United Nations Environment Program (UNEP), New York Liaison Office, New York, N.Y.

Commendation is due the Department of State for hosting this meeting and for attempting to place the issue of tropical forests on the national agenda of the United States.

As I listened to the discussion, I discovered that a number of key components for any strategy were articulated. I don't think that a final strategy has been developed here, but I doubt that that was the intention. Nonetheless, a number of key ideas have been suggested. One of the problems that must now be dealt with is the extent to which these ideas can be fed into the leadership stream, because unless there is leadership in this area, the future of any strategy will be doubtful.

The World Bank's "Sector Policy Paper on Forestry" (February 1978) reflects a reorientation of the Bank's thinking, especially to the extent which the whole rural sector has now been included into a field of vision that had been excluded for some time. Within the U.S. aid community and the foreign policy sector, Mr. Robert McNamara's leadership could carry the strategy forward and offer many possibilities for success.

I am not sure that some discussions clearly delineated the specific roles and responsibility of the United States in relation to other nations and institutions involved in dealing with the problems of tropical deforestation. One thing is certain: the

United States can't do everything, and even if it could, it ought not to. Therefore, in trying to formulate a strategy, one has to consider the overall global context as to what is being done elsewhere and by whom, and what is effective and what is not, and what remains to be done? It is in the areas where there are gaps that the United States—through its position in the world community, its technical expertise, and its financial capability—can make a very decided contribution.

I was concerned by the fact that very little was said about the range of international activities that are currently underway. The United Nation's Food and Agriculture Organization continues to play a large role in dealing with deforestation problems. The world forest inventory which the FAO publishes every five years and the various conferences which they sponsor are among the agency's many important works. Similarly, the United Nations Environment Program has a basic interest in deforestation problems, and since 1974 has invested \$3 million in such areas as the formulation of ecological principles and guidelines for the development of humid tropical forests in Latin America and Southeast Asia; the convening of regional meetings to develop integrated ecological research and training activities in Latin America, with special emphasis on tropical forest ecosystems; and currently, as part of the Global Environmental Monitoring System (GEMS), the implementation of a

large-scale project for monitoring forest cover in tropical and sub-tropical areas. Everything done by United Nations agencies is in the public domain. The results of past and current efforts would certainly be useful to the United States as it attempts to formulate a strategy.

President Carter, speaking at the United Nations in October 1977, said that one of the difficulties his administration faces is the funding of U.N. activities. Because the American public tends to focus on the political problems confronting the organization, they don't seem to have a full understanding of the range of other activities in which the Specialized Agencies of the United Nations engage. Mr. Carter also said that United States aid efforts often duplicate those of many U.N. agencies and that it would be beneficial if there was a systematic way in which U.N. activities could be brought to his administration's attention. Mr. Carter also proposed the designation of a White House office to maintain liaison with some U.N. agencies. I mention this because I believe that U.S. government agencies concerned with tropical areas, such as the Department of State or AID, may wish to examine, with various U.N. agencies, the activities currently underway and the extent to which we can design cooperative ventures, thus avoiding duplication and competition in our respective efforts. This is important because too often we find that not only do we treat problems sectorally, but also our field operations are isolated from other problems. The forests are the victims of this lack of coordination.

As we talk about formulating a strategy, it seems that a case could be made for better working relationships between international agencies currently involved in the problems associated with tropical deforestation. An appropriate starting point would be a systematic review and coordination of our work. While it is recognized that need exists for more research in many areas, I think it is necessary to organize the substantial information which now exists. This not only

might complement the strategy, but also may give it a faster, forward movement. If we are going to research the problem again and devote undue emphasis to additional basic research, I think that by the time the forests are able to be affected by all this information, it may be too late.

When one looks at the literature pertaining to the problems of the humid tropics, one becomes totally pessimistic. And yet there are some instances where there have been successes. If the United States formulated a strategy in identifying the success stories, a "south to south cooperation" might develop. The Third World has begun to discover that the technical expertise of the northern nations tends to be developed in terms of the northern cultural context. The scale of life in the north is different, and the perceptions of the problem may be different. By looking at the problem from the southern cultural context, it may be possible to encourage a better flow of appreciation and information across a south-to-south type of boundary. One occasion where this might be possible is at the Conference for Technical Cooperation Among Developing Countries that is being convened in Argentina this August at which the developing nations will exchange information. We might be able to place the problems of tropical forests on the agenda with the result that that Conference might design channels of communication and possibilities for exchange of information among the states of the south.

I was concerned at the small extent to which the human component of tropical deforestation was nibbled at. The population problem was discussed, but I am not sure that the proper emphasis has been given to the human groups that are caught in the dilemma of having to depend on the forest, having to utilize it ruthlessly in ways that may be detrimental to their long-term interests. A strong case was made for protecting the forests as a resource for future generations. I don't think that the desperate poor have any feeling for future generations; most are concerned with their next meal. As we formulate a strategy, I

think that a great deal more emphasis might be given to the human beings who depend on firewood for their fuel and who have no alternatives to practicing shifting cultivation in forested areas. We should look at the resource questions within the framework of human livelihoods.

I was glad to see a good deal of attention paid to the role of forestry within the larger development framework. This is important as it is often examined from a conservation point of view, rather than as a working resource which should be considered as part of an overall development scheme. The issue of deforestation should be looked at as part of each nation's development policies. Although we are in an age of environmental awareness in which we consider the basic links that allow for human well-being, many countries still emphasize that their sovereignty over natural resources is a national prerogative. Until we can take these realities into account, I don't think we will be successful in any strategy.

Because the forests as forests may have little meaning for many of the developing countries, it is often easier to gain the attention of governments for park development rather than for setting aside areas as biosphere reserves. The reason for this is the potential economic value of parks as tourist attractions. So the protection is not necessarily for the wildlife or the habitat, but because the areas have an economic dimension for which many governments feel justified in making the necessary investments.

The issue of institution building should be linked to the setting of standards. If sound standards for the management of tropical forests are established, then institutions supportive of these standards may logically follow. Otherwise, we might end up with institutions without establishing a basic framework of standards within which they should operate. Many governments, no matter how sympathetic they are to the

cause of forest protection, may find that they lack the institutions to implement their concern at the national and local levels. Thus, any type of strategy that would be significant must take this dilemma into account.

I wished as we looked at deforestation and the firewood shortage that more was said about the hardware dimension of these problems. It is not enough to simply produce more fuel wood; more efficient wood-burning facilities are necessary. There is approximately a 60 percent heat loss in most of the facilities now in use. The technologically advanced nations can help by designing facilities that are more efficient in wood utilization.

And finally, we must recognize the political restraints that any strategy will face. I'm not sure that many governments can demonstrate that the long-term benefits to be derived from forest protection are in the short-term interests of national communities. I think that any strategy must recognize these limitations and provide the climate where governments might find additional incentives for taking the necessary measures. This would be one of the values of a global conference. If the problems of tropical deforestation could be placed on the global agenda along with population, food, water, and deserts, governments may then be able to take the necessary actions in defense of this valuable resource.

Dealing with the countries of the world that have fewer resources than we and that have other pressing claims on them means that even if the technical nature of a problem is understood, the human dimensions of the problem will be very real. Bearing in mind this human element, I hope that you can help us in deciding whether the things UNEP is now starting to do are on the right track or whether there are other things we should be doing. We look forward to your guidance and help in this respect.

Other Reactions

The following are highlights of the interests, concerns, and views expressed during the general discussions which followed Mr. Brown's statement:

- Tropical deforestation problems are particularly serious in countries which lie within the world's arid tropical zones. By the year 2000, the more developed, temperate zone countries will probably continue to have acceptable life styles and adequate resources. However, many tropical developing countries will be severely impacted by deforestation-related problems with present day timber-rich nations forced to import wood and wood products.
- Forestry and forest protection should not be viewed in isolation. They must be perceived as vital elements of overall development strategy. Proposed solutions must be sensitive to the social and economic needs and customs of the local people.
- The absence of viable alternatives to the use of the forests, and the continued application of inappropriate technologies, are key problems. The lack of firewood alternatives today and in the foreseeable future will pose a particularly serious problem and dilemma for government planners and local citizens. With respect to technologies, there is need for nurseries for indigenous and exotic species of trees for reforestation purposes and firewood plantations. People often use the wrong species of trees because they cannot get others. Also, development of more energy-efficient wood and charcoal stoves should receive high priority.
- U.S. participation in international tropical forestry programs has, to date, been minor. The United States should try to define and play a larger role on both humanitarian and self-interest grounds—the latter deriving from the possible global environment impacts of widespread deforestation, a desire to ensure the future availability of wood and wood products at an acceptable price, and the fact that deforestation problems are offsetting benefits anticipated through U.S. investments in development assistance programs (e.g., shortening of reservoir life-times, degradation of land counted on for food production).
- Improved coordination and joint programming on the part of UN organizations (e.g., FAO, UNESCO, and UNEP) is required if the limited financial and manpower resources available for the forestry sector are to meet expanding current and projected needs.
- Biosphere reserves offer an excellent approach to maintaining valuable, representative forest ecosystems for scientific research and testing of various management techniques. The international community should seek to expand the number and variety of biosphere reserves (under UNESCO's Man and the Biosphere Program), particularly within humid tropical forest ecosystems, and also increase support for associated programs of biological and ecological studies.
- Participants expressed a great deal of interest in the World Forestry Conference scheduled in Djakarta, Indonesia, for October

1978; and in ensuring that the United States and other nations use it as an opportunity to examine tropical forest management problems and needs in depth.

- A recent AID-sponsored conference on Utilization of Tropical Woods, held in Madison, Wisconsin, in June 1978, was described by Mr. Henry A. Arnold.

It was attended by 150 experts from the United States and other nations, and emphasized the need to bring into balance the use of forests to fill immediate raw material needs and their sustained management to meet other sociological, economic, and environmental objectives over the long term.

Closing Comments

In his closing comments, the Conference moderator, Mr. Bill L. Long, reviewed the original objectives of the meeting and thanked the participants for their hard work and intellectual contributions. He noted that the responsibility now is with the organizers (the Department of State and the Agency for International Development) to digest and respond to the extensive guidance and recommendations the Conference had generated. As a first step, a "Proceedings" will be published for widespread distribution to U.S., foreign, and international organizations: to symbolize the U.S. government's interest in the deforestation problem; to provide others with the information, the many useful ideas, conclusions, and observations which emerged from the Conference; and, hopefully, to help stimulate and catalyze an intensified international dialogue and coordinated action program. Recommendations and guidance which were addressed to specific U.S. agencies and other organizations will be extracted and referred directly to them. Finally, the Conference organizers will consider how the U.S. interest and views on tropical deforestation as manifested at this meeting might be reflected and broadened at the international level.

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