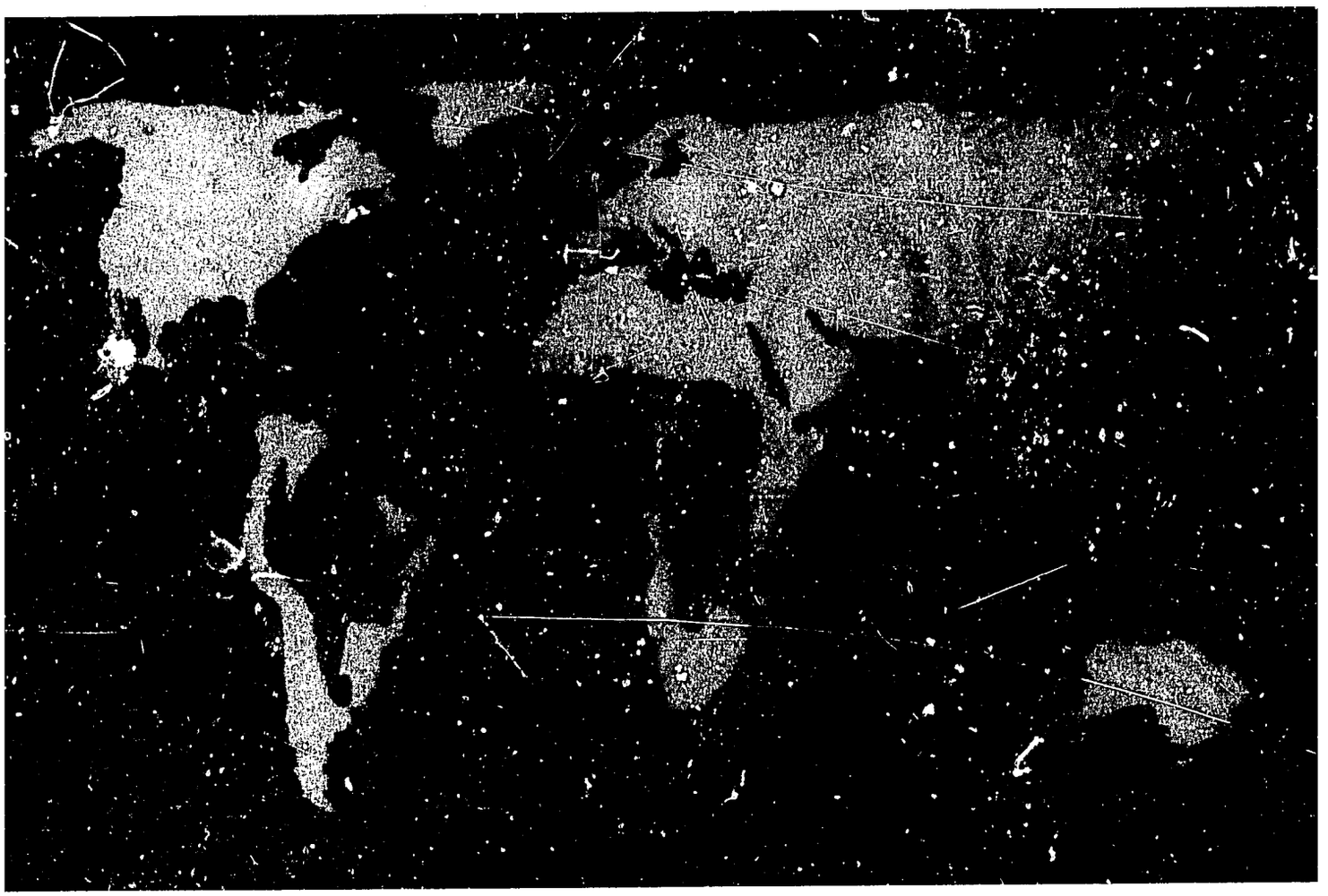
Part I The Plan

Tropical Forests: A Call for Action



Report of an International Task Force convened
by the World Resources Institute, The World Bank,
and the United Nations Development Programme

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World Resources Institute

October 1985

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Foreword

Tropical forests are one of the earth's most valuable natural resources. Throughout history, they have been essential sources of food, fuel, shelter, medicines, and many other products. They sustain people and their environments by protecting soil and water resources and providing habitat for an estimated 50% of the world's plant and animal species. It is likely that tropical forests also influence regional and global climate.

Because tropical forests benefit people in so many ways, the alarming rate of forest destruction should be a matter of grave concern. Every year more than 11 million hectares—an area larger than Austria—is lost.

The lives of more than one billion people in the developing countries, primarily the rural and urban poor, are disrupted by periodic flooding, fuelwood scarcity, soil and water degradation, and reduced agricultural productivity—all caused in whole or in part by deforestation. Scientists estimate that 40% of the biologically-rich tropical moist forests have been cleared or degraded already. In many developing countries they will all but disappear in two or three decades if present trends continue.

Despite this grim prognosis for tropical forests, the basis for hope is strong. Deforestation can be arrested and, ultimately, reversed. Decades of experience have demonstrated many successful solutions to deforestation and related land misuse. However, these efforts have been isolated and far too small to address the problem. There must be greater political awareness of deforestation's negative impacts on human welfare and the environment, and the political will to mobilize all necessary human and financial resources to do something about it.

This positive conviction spurred the World Resources Institute (WRI), in cooperation with the World Bank, the United Nations Development Programme, and bilateral aid agencies, to launch this major initiative in tropical forest conservation and development. *Tropical Forests: A Call for Action* is the report of a WRI Task Force of nine world leaders in agriculture, forestry, and conservation.

This report contributes to the continuing efforts of the United Nations Food and Agriculture Organization (FAO) to raise political awareness of the action needed to combat tropical deforestation. FAO, which declared 1985 the "International Year of the Forest," is preparing a Tropical Forests Action Programme under the direction of its Committee on Forest Development in the Tropics. The FAO Action Programme, which provided the framework for the WRI effort, identifies five priority areas for action:

Fuelwood

Forestry's role in land use

Forest industrial development

Conservation of tropical forest ecosystems

Institution strengthening: research, training, and extension.

The WRI Task Force focused on translating known solutions and strategies into a five-year program of accelerated action (1987–91) that would lay the groundwork for longer term investment. Examples of successful projects are presented that illustrate the range of solutions available. Based on these success stories, and the lessons learned from past failures, priority areas for investment and action are proposed. Major policy issues and constraints that need to be addressed to carry out this program are reviewed.

The examples of successful projects and the lessons they provide are presented as case studies in Part II of the report. Part III presents five-year investment profiles for 56 countries.

The result, we believe, is a path-breaking report that recognizes the great challenges posed by tropical deforestation while offering a positive and practical strategy for its amelioration. *Tropical Forests: A Call for Action* is not just about trees, but about people and their prospects for a better life. We fervently hope that this report will help stimulate financial and policy commitments from developing and industrial country leaders, development assistance agencies, and the private sector for a greatly expanded and coordinated global effort to combat deforestation.

Helpful comments and suggestions were received from over a hundred individuals and organizations. We deeply appreciate these efforts and know that the final report benefited greatly from them.

James Gustave Speth
President
World Resources Institute

In this report, the term "tropical forests" refers to forests in the humid and semiarid/arid areas of developing countries. Thus, the term includes forest formations ranging from moist (or closed) tropical forests to dry (or open) woodlands. In a few instances, developing countries with temperate forests are also included.

A Call for Action

Summary statement of the Task Force

One-fourth of humanity lives in poverty, characterized by poor health, malnutrition, chronic deprivation, and shortened lives. This suffering and wasted potential is one of the great tragedies of modern times. A contributing cause of this desperate situation is the widespread loss of forests taking place throughout the developing world. Tragically, it is the rural poor themselves who are the primary agents of destruction as they clear forests for agricultural land, fuelwood, and other necessities. Lacking other means to meet their daily survival needs, rural people are forced to steadily erode the capacity of the natural environment to support them.

The relationship between poverty and deforestation is clear, but it is not inevitable. Many solutions to this cycle of increasing misery are known and demonstrated. Given appropriate government policies and institutional support, much can be done now through well designed forestry and agricultural investment programs. The evidence is clear that forest conservation and development projects can earn high enough rates of economic return to be self-sustaining. The challenge is to put these solutions to work for the millions of rural poor seeking a better future.

To meet this challenge requires political leadership. The failure of national governments and the international community to respond adequately to the deforestation crisis has led to extremely high costs in developing countries. Much of the environmental damage, decline in agricultural productivity, and human suffering that developing countries are facing today could have been reduced or avoided by greater political commitment to forest conservation and development.

To quote from a recent report of the World Commission on Environment and Development:

> Long range programmes that would have helped to tackle the underlying problems have received comparatively little support. The anti-desertification programme adopted by the UN in 1977, for example, was largely ignored by donor and recipient governments alike. That programme, it is interesting to note, was estimated to cost US$4.5 billion per annum to the year 2000 for the entire globe. A breakdown of this figure reveals that the estimated cost for Ethiopia was US$50 million per year to the year 2000. Neither the political will nor the money could be found to implement this programme, however. Yet, eight years later, faced with a human drama beyond precedent, the world community has had to find an estimated US$ 400 million for crisis-response measures to date for Ethiopia alone, and this figure will undoubtedly exceed US$500 million before the next harvest. It will go well beyond that if the harvest fails again. The arithmetic of prevention is almost always persuasive; somehow we have to invent a politics of prevention that can match the politics of crises.

This Task Force initiative seeks to advance the argument for increased action against deforestation from the narrow confines of the forestry community to the wider arena of public policy. The primary audience includes political leaders and decisionmakers in national governments and development assistance agencies who can influence policies and allocation of resources to promote the conservation and sustainable development of tropical forests.

This initiative is the first time that major development assistance agencies have helped develop a priority action program to address deforestation issues on a broad front. Investment needs for a five-year action program are proposed for 56 countries. These are preliminary estimates for consideration by developing country governments and the development assistance community.

Forestry activities alone cannot reverse current trends in deforestation. The causes of the crisis are rooted in agriculture, energy, and other sectors as well as in forestry—and so must be the solutions. Also, a broad effort involving the public and private sectors—from development assistance agencies to government ministries to local community groups—is needed.

The Task Force estimates the level of public and private investment needed to make an impact on tropical deforestation over the next 5 years to be US$8 billion. About US$5.3 billion (two-thirds of the total) would be needed for the 56 seriously affected countries reviewed in this report.

At least 30% of the proposed investment would be agriculture-related. The main goal would be to provide farmers and landless people living in or adjacent to threatened tropical forests, in overpopulated uplands, and semiarid areas with alternatives to destruction of forests and woodlands.

Half of the total US$8 billion, or US$800 million each year for 5 years, would need to be mobilized by the development assistance agencies and international lending institutions, with the remainder coming from the private sector and national governments.

Investment of US$800 million a year in forestry and related agricultural development would double the present levels of external aid in these areas.

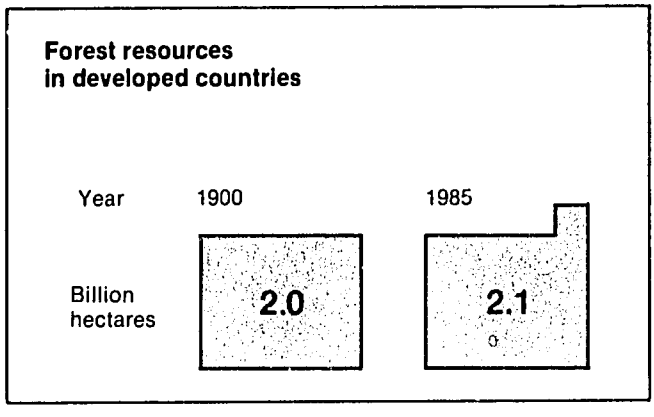
These sums are not small—except in relation to the returns. The initiatives proposed here will alleviate hunger and deprivation, arrest dangerous assaults on the planet's environmental support system, and provide the basis for sustainable economic growth. By any system of accounting that can encompass true costs and benefits, the investment required is nothing more than a small down payment on a far brighter future.

The Task Force

The high costs of deforestation

Deforestation in developing countries

Developed and developing countries differ sharply in the condition of their forests and the status of forest conservation and management.[1] The forest area of many developed countries has stabilized and, in some cases, has increased during this century.[2]



This situation has not always been so. Europe and North America have both suffered severe deforestation in the past, resulting in environmental degradation and human hardship. Fortunately, political leaders became aware of the negative impacts of deforestation and took corrective action. Principles of forest management were developed and put into practice. Laws and other institutional mechanisms were established to promote sustainable use of forest resources.

In addition, overall economic growth and expansion of job opportunities outside of agriculture led to migration of rural populations to cities and towns; this sharply reduced the numbers who depend directly on agriculture for a living and eased the pressure on forest land. The intensification and increased efficiency of agricultural production further reduced the pressure on forests. In many areas, abandoned agricultural lands reverted naturally to forest.

[1]In this report, the term "tropical forests" refers to forests in the humid and semiarid/arid areas of developing countries. Thus, the term includes forest formations ranging from moist (or closed) tropical forests to dry (or open) woodlands. In a few instances, developing countries with temperate forests are also included.

[2]Although the problem of acid rain and other air pollutants is posing a serious threat to forests in some temperate areas.

Having achieved a reasonably stable forest resource base, forest policy planners in the developed world have turned their attention to maximizing forest productivity. Well established forestry institutions now exist in most developed countries. With enough wood production to meet most of its needs for timber, plywood, and paper, the developed world maintains many forests solely for their recreational, protective, and aesthetic values.

In contrast to the developed world, forests in the developing countries have declined by nearly half in this century. Each year more than 11 million hectares of tropical forests are being cleared for other uses—7.5 million hectares of closed forests and 3.8 million hectares of open forests. In most countries, the deforestation rate is rising. If this continues, at least 225 million hectares of tropical forests will be cleared by the year 2000.

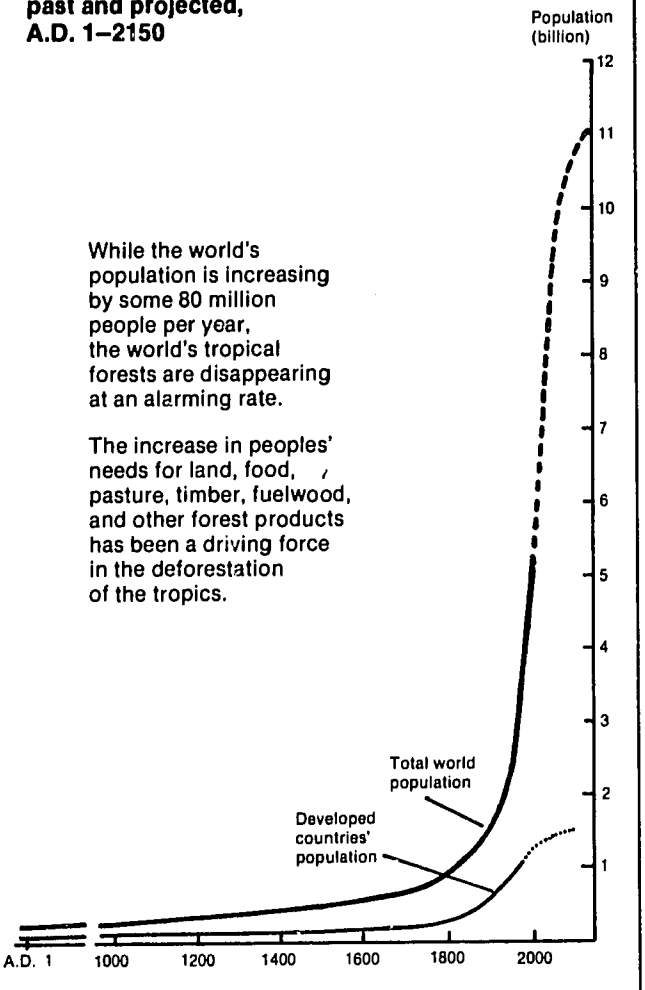
Forty percent of the closed tropical forests have been cleared, logged, or degraded. Most of the remaining 800 million hectares are in the Amazon and Congo basins, where they survive largely because of their vastness and relative inaccessibility.

However, even in countries such as Brazil where the national deforestation rate is relatively low, large areas of closed forests have been cleared in several parts of the country. Open forests—distinguished from closed forests by their discontinuous canopy and substantial grass layer—have also suffered extensive degradation.

Deforestation is a complex problem. The spread of agriculture, including crop and livestock production, is the single greatest factor in forest destruction. The rural poor are often unjustly held responsible. They are often the instruments of forest destruction, caught in a chain of events that forces them into destructive patterns of land use to meet their basic needs for food and fuel. The real causes of deforestation are poverty, skewed land distribution (due to historical patterns of land settlement and commercial agriculture development), and low agricultural productivity.

These factors, combined with rapid population growth, have led to increasingly severe pressure on forest lands

World population past and projected, A.D. 1–2150



Source: *World Development Report*, 1984, World Bank.

in developing countries. As productive land becomes scarce, small farmers have been pushed into fragile upland forest areas and marginal lowlands that cannot support large numbers of people practicing subsistence agriculture. The loss of forests and rising population pressure have forced farmers to shorten fallow periods, degrading the productive capacity of the land and setting in motion a downward spiral of forest destruction. This situation prevails now in many developing countries, and it can change only if rural populations are given alternatives to this ecologically destructive way of living.

Government policies have contributed to depletion and destruction of tropical forests. Many developing countries have forestry policies (such as direct subsidies and lenient forest concession terms) that foster "mining" and unsustainable use of forest resources. Similarly, agriculture, land settlement, and other nonforestry policies often lead to encroachment on forests far beyond what is economically justified or environmentally sound.

Developed countries must share the blame for the plight of forests in developing countries. Developed country demand for tropical timber has been rising steadily. For many developing countries desperate to earn foreign exchange to ease their international debt problems, forests represent a ready source of income. A related problem is the generally low price paid for tropical timber. When prices are too low to fully reflect the growing and replacement costs for forests, there is little incentive to manage the resource for the long term. This results in the "cut-and-run" pattern of commercial forest exploitation practiced in many developing countries.

Given the history of forest exploitation in developed countries, some ask why developing countries should not follow the same path. On the surface, this is a fair question, but major differences between the two situations preclude such a strategy. The most serious difference is human numbers. The pressures of rapidly increasing populations in most developing countries completely alters the context of forest land use.

This does not mean that forests in developing countries should be left untouched. Forests are valuable resources that can provide myriad benefits to people and support economic growth. The real issue is how these resources are put to use. Currently, forest exploitation in most areas is unsustainable. In effect, a renewable resource is being treated as a nonrenewable resource.

Wood scarcity, declining food production, and desertification

Dependence on forests and trees

Almost 70% of the people in developing countries, most of whom live in rural areas, depend mainly on wood to meet their household energy needs. Low incomes restrict their ability to buy any type of fuel, so these families use wood, crop residues, dry dung, twigs, grass, or whatever source of energy can be freely gathered.

The importance of forests and trees extends far beyond their value as a source of fuelwood. Forests and trees provide wood for building poles, furniture, roof timbers, fencing, household implements, and many other uses.

Nonwood resources are also vitally important. Trees are an essential source of fodder for livestock. They also provide fruits and nuts, honey, gums, oils, resins, medicines, tannins, fibers, and other materials. There is growing recognition of the importance of small-scale forest-based enterprises as a source of nonfarm employment and income.

Forests and trees also contribute to agricultural production. In the tropics, trees do not necessarily compete with food crops, and they are often an integral part of farming systems. Trees can play a vital role in sustaining crop yields by—

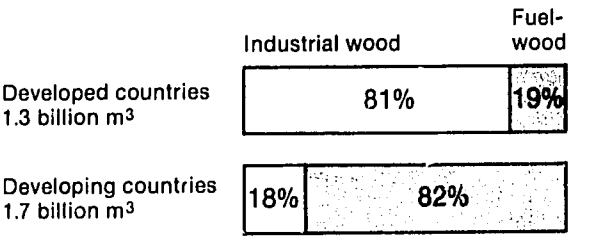
- Helping maintain the soil and water base for agricultural production, particularly in upland watersheds, by reducing erosion and moderating stream flows
- Restoring soil fertility in shifting agriculture
- Increasing farm crop yields by 20-30% in arid and semiarid areas by slowing wind and increasing soil moisture
- Increasing soil nitrogen content through use of leguminous nitrogen-fixing tree species
- Providing a significant proportion of livestock feed requirements, especially in upland and semiarid regions.

As deforestation progresses, it reduces the quality of life of millions of people in developing countries. For the poorest, living close to the land, their survival is threatened by the loss of the vegetation upon which they depend. As trees disappear, so do their source of household energy and many other goods. Worse, a chain of events is set in motion that leads to declining food production, land degradation, and, in extreme cases, desertification.

The fuelwood crisis

More than 80% of the wood harvested in developing countries is used as fuelwood, compared with less than 20% in developed countries.

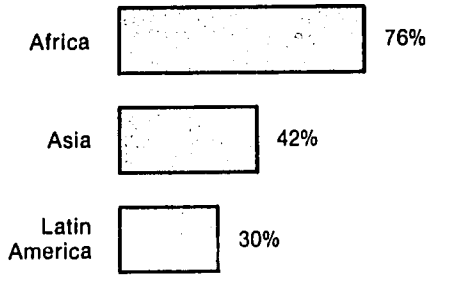
Wood consumption, 1983



Source: *1983 Forest Products Yearbook*, Rome, FAO.

Developing countries rely on forests to meet half of their total needs for energy. In Africa, 76% of the total energy consumed is supplied by fuelwood.

Percentage of total energy supplied by fuelwood, 1980



Source: J. Dunkerley and W. Ramsey, *Analysis of Energy Prospects and Problems of Developing Countries*, Washington, Resources for the Future, 1983.

In rural areas, gathering and transporting fuelwood increasingly dominates the daily lives of millions of people—100 to 300 workdays each year must be devoted to supplying a household. Women and children shoulder

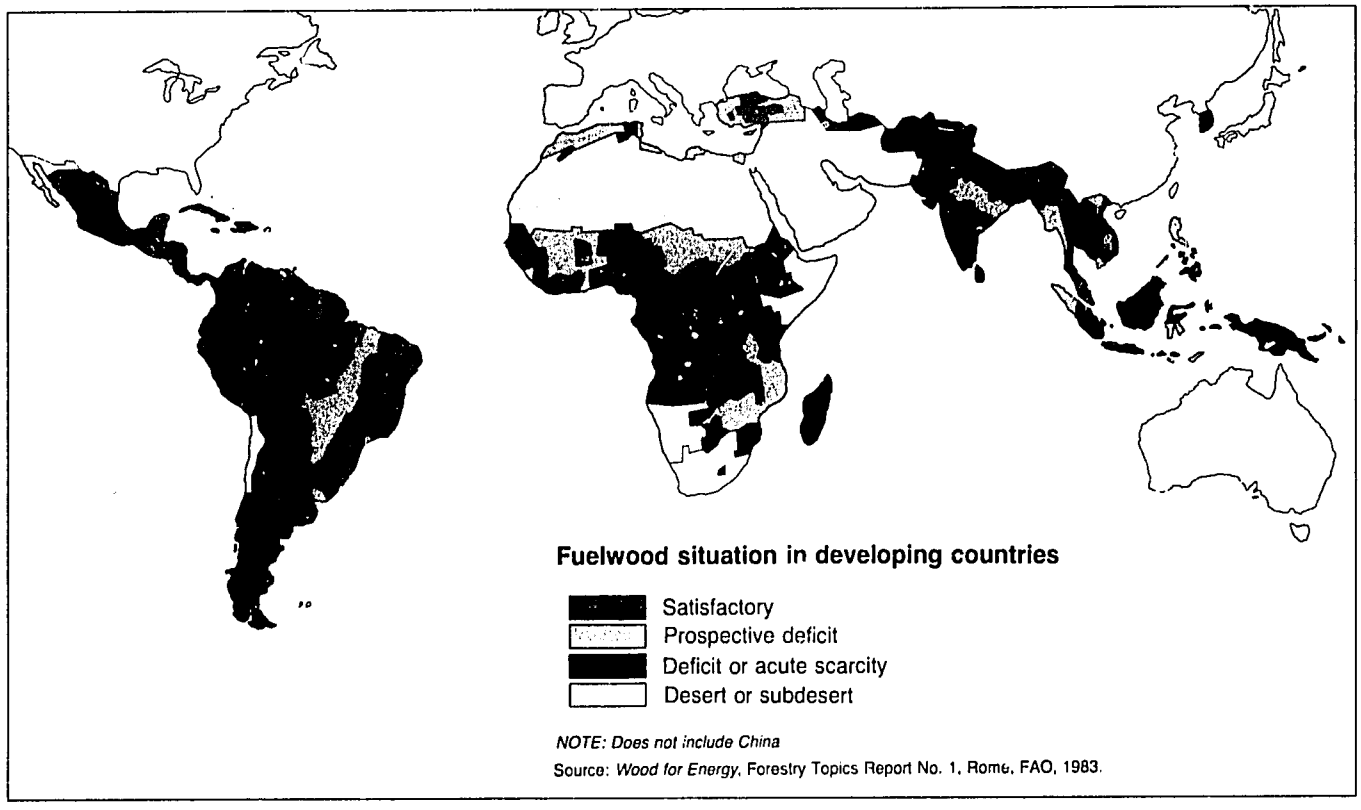
As deforestation spreads, the burden of collecting fuelwood worsens for this Ethiopian woman.

most of the burden for finding and carrying home the wood needed to cook the day's meals. In Nepal, groups of villagers must leave at sunrise in order to return by sunset with a backbreaking load of wood that will last only 3 to 4 days. The increasing time needed to collect fuelwood is disrupting family stability and shortens the time that can be devoted to weeding and tending crops, preparing food, and other domestic activities.

In urban areas, most households must buy fuelwood or charcoal. Prices have risen so sharply in recent years that in many areas the wood used for cooking costs more than the food being cooked. Between 20 and 40% of the cash income of the average urban household must be set aside to buy wood or charcoal. In some countries, malnutrition is due not to lack of food but to the lack of fuelwood for cooking. Families are forced to eat less nutritious quick-cooking foods or even uncooked meals to an extent that impairs their health. Urban demand for fuelwood and charcoal is expanding the economic distance for clearing and hauling wood, leading to ever-widening circles of devastation around cities and towns.

A recent FAO analysis indicates that 1.5 billion people (70% of the 2 billion who rely on fuelwood to meet a major part of their household energy needs) are cutting wood faster than it is growing back. Some 125 million people in 23 countries cannot find enough wood to meet their needs, even by overcutting the forests.

Without major policy changes to ensure better fuelwood conservation and increased supplies, by the year 2000 some 2.4 billion people (more than half the people in the developing countries) will face fuelwood shortages and will be caught in a destructive cycle of deforesta-



NOTE: Does not include China

Source: *Wood for Energy*, Forestry Topics Report No. 1, Rome, FAO, 1983.

tion, fuelwood scarcity, poverty, and malnutrition.

Declining food production and desertification

Deforestation is having serious impacts on food production. As fuelwood supplies are depleted, families turn to whatever substitutes are available, primarily crop residues and animal dung. Their use as fuel robs farm fields of badly needed organic matter and nutrients. The failure to renew soil fertility leads inevitably to declines in crop yields.

The annual burning of an estimated 400 million tons of dung to cook meals in areas where fuelwood is scarce decreases food grain harvests by more than 14 million tons. This loss in the food supply is nearly double the amount of food aid annually provided to developing countries.

The removal of tree cover can further reduce agricultural productivity by loss of the benefits trees provide for farms. Widespread loss of vegetation reduces the effectiveness of rainfall by decreasing the amount of water that percolates into the ground. Water runoff increases, erosion accelerates, the water table is lowered, and springs and wells dry up.

In its most extreme form, deforestation leads to "desertification"—a process of decline in the biological productivity of arid, semiarid, and subhumid lands (or drylands). The result is desert. Drylands are particularly sensitive to human abuse because of the fragility of the soil and low and erratic rainfall. Traditional production systems are breaking down in these areas under the combined pressures of population growth and poverty. As drylands are stripped of woody vegetation through agricultural clearing, overcutting for fuelwood, overgrazing, and bush fires, land degradation worsens and the spread of deserts accelerates.

Desertification is undermining the food-producing capacity of drylands in Africa, Asia, and Latin America. A 1984 assessment by the United Nations Environment Programme shows that desertification is spreading, affecting more and more land and people. Some 1.3 billion hectares are at least moderately desertified in these three regions, and more than 300 million people live in areas at least moderately or severely desertified. The most critical areas in terms of the number of people affected are rainfed croplands, where desertification is accelerating in all three regions. Forestry and agriculture have a vital role in preventing the spread of deserts and in recovering some of the marginal areas already abandoned.

In India, animal dung made into cakes is being burned in ever greater amounts as fuelwood supplies dwindle, robbing croplands of a major source of nutrients. This is reducing crop yields.

Degraded upland watersheds

Upland and lowland populations within a watershed depend closely on one another. On upland hills, violent tropical rainstorms require close protection of the soil by vegetation. For this purpose, forest cover is best, but contour-planted tree crops can be effective. Annually cultivated crops expose bare soil and need full protection by terracing.

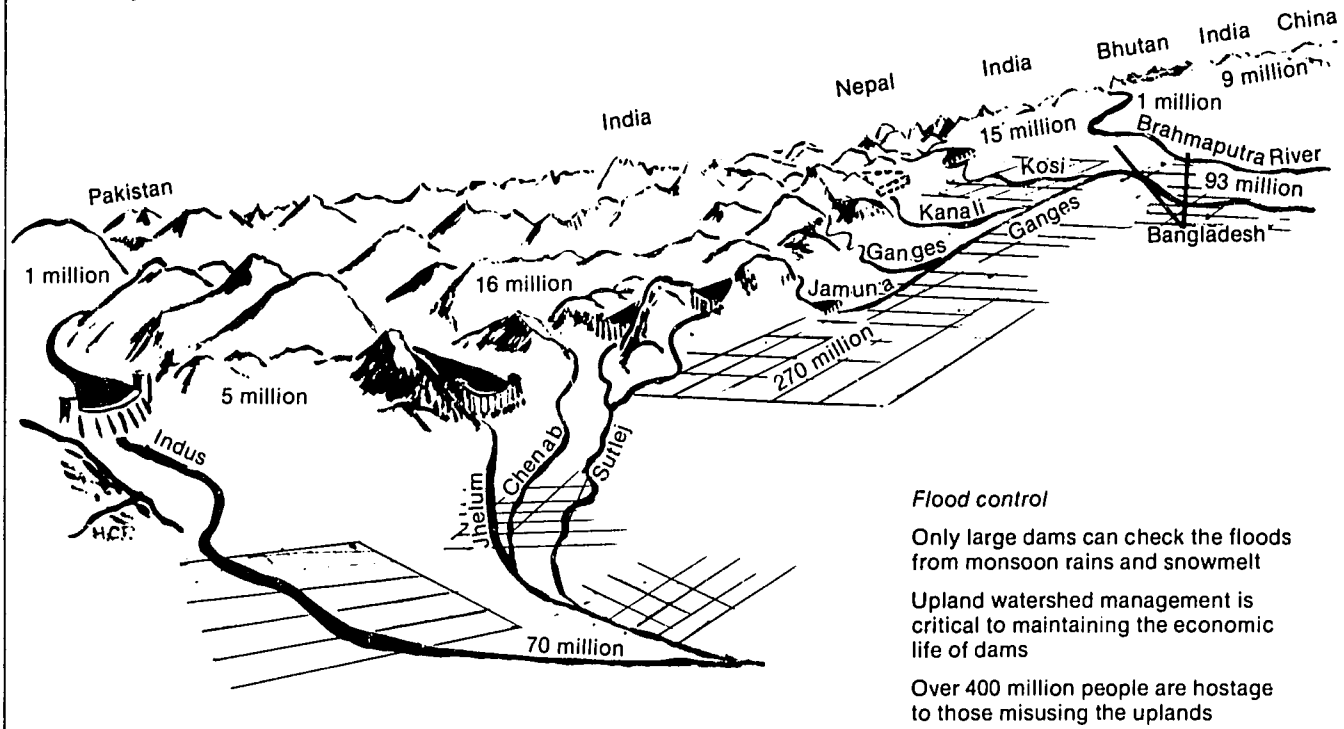
Skillful land use that maintains the environmental stability of upland source areas of streams not only benefits upland inhabitants but can also protect downstream hydropower reservoirs and irrigation systems from silt and debris. Erosion and sedimentation of rivers are kept to natural levels. This minimizes the raising of river beds and spreading of floods, which bring damage and misery to those living below. In return, the hill populations depend on the wealth generated by the larger communities in the valley bottoms and plains for the provision of roads and other services.

Despite their critical importance, an estimated 160 million hectares of upland watersheds in the tropical developing countries have been seriously degraded. Increasing population pressures and destructive land use have resulted in the loss of fuelwood and fodder supplies, greater flood damage, intensification of drought, sedimentation of dams and reservoirs, and loss of crops and livestock. This has caused unnecessary poverty in the hills and unnecessary damage to the lowlands. More than one billion people in the developing world are hurt by this process.

The Himalayan Range

This region contains the world's most severe watershed problems. On the lowland plains of Pakistan, India, and Bangladesh, over 400 million people are "hostage" to the land-use practices of 46 million hill dwellers. In India alone, the costs of the increasing flood damage and destruction of reservoirs and irrigation systems by sediment from misused slopes have averaged US$1 billion a year since 1978. India now spends US$250 million a year in compensation and damage-prevention measures. There is vast potential for generating hydroelectric power in the Himalayan region that could harness wealth from the watersheds, but investment in reservoirs is unsound because of the threat of sedimentation.

Himalayas — The world's most critical watersheds



Flood control

Only large dams can check the floods from monsoon rains and snowmelt

Upland watershed management is critical to maintaining the economic life of dams

Over 400 million people are hostage to those misusing the uplands

The Andean Range

The eastern plains below the steep foothills of the Andes are typically infertile and sparsely populated, but the foothills are heavily settled and overgrazed. In the foothills, watershed problems caused by land misuse are serious—from Venezuela (where the problem is recognized as acute), through Colombia (where rehabilitation has begun), to Argentina (where clay eroded from the overgrazed watershed of the Bermejo River is carried 1200 kilometers by the Paraná River to the sea at Buenos Aires). The 80 million tons of sediment lost each year from the Bermejo watershed requires costly dredging to maintain access to the port.

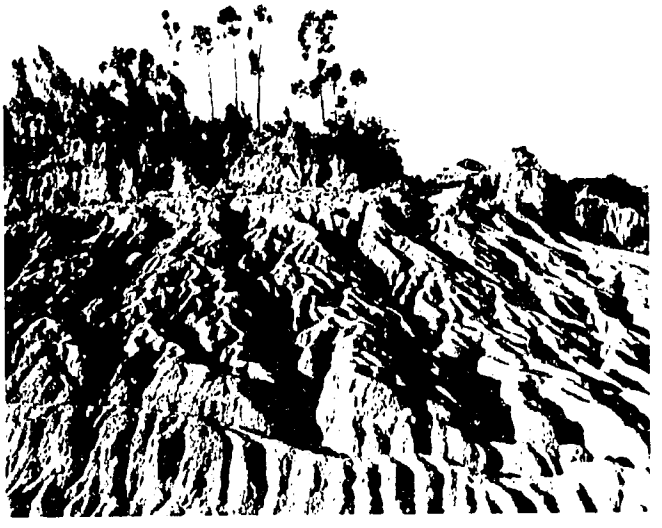
The Central American Highlands

Upland watersheds in Central America are undergoing extensive deforestation, mainly for cattle raising and agriculture. Land misuse after the loss of forest cover, and a general failure to use proper soil conservation techniques, are leading to widespread soil erosion and land degradation in almost all the watersheds in the region.

The problems are most serious on the steeply sloped Pacific watersheds where most of the population lives and most of the region's food is produced. In many areas, soil erosion has become so severe that the productive potential of the land is being destroyed. Increasing rates of sedimentation threaten present and planned hydropower development throughout the region and are damaging coastal mangrove forests and fisheries.

The Ethiopian Highlands

The Central Highlands Plateau in Ethiopia supports 22 million farmers (70% of the population) and contains 59% of the country's cultivable land. Exhaustive farming practices, overgrazing, and fuelwood collection have severely eroded the plateau and destroyed most forest. Loss of soil fertility is widespread and the use of fertilizer is so limited that food production has not kept pace with population growth. Drought has precipitated a major famine.



Each year, some 1.6 billion tons of topsoil are lost from denuded lands in Ethiopia.

China's Loess Plateau

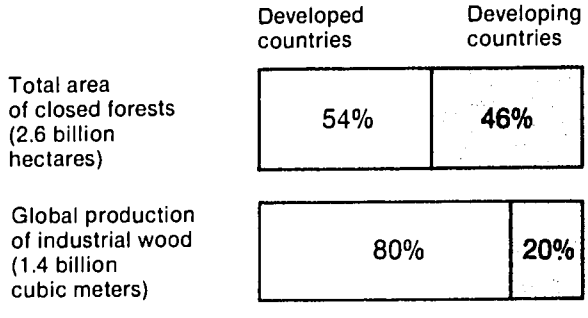
Enclosed by a bight of the Yellow River in its middle reaches, the Loess Plateau has been subject to soil erosion on a scale that is unique to China. Erosion has carved the plateau into steep rounded hills and gorges, and roads and bridges have been swept away by torrents and landslides. South of the Great Wall in this region, erosion caused by overcultivation and neglect of the poverty-stricken rural areas has reduced 100,000 hectares of fertile land to uninhabited wasteland. China already has nine people per hectare of cropland, and it needs this land.

Declining industrial wood supplies

Industrial forest products such as sawnwood, plywood, and paper are important throughout the world. They are a source of essential building materials and of the paper needed for schoolbooks, newspapers, and packing. Sustained development of the Third World implies a steady increase in demand for forest products as literacy increases and as the needs for housing, furniture, paper, and other wood-based industries grow.

Developing countries possess nearly half the world's closed forests, but they produce only 21% of its industrial timber.

Industrial wood production in developed and developing countries, 1983



Source: *1983 Yearbook of Forest Products*, Rome, FAO.

Many developing countries have both large natural forests and ecological conditions that are suitable for fast-growing industrial plantations. However, a decline in the area of accessible commercial forests is causing serious problems. In most of these countries current levels of forest management and reforestation fall far short of what is needed to limit imports and sustain exports. Exports to industrialized countries are very important for some developing countries, but the most critical problem for the future is the growing inability of many countries to meet their domestic needs for industrial forest products.

Rising forest product imports

Imports of forest products by developing countries are increasing sharply, even in such countries as Nigeria, Thailand, and Mexico which should readily be able to supply their own domestic needs. Imports have risen from about US$6 billion in the early 1970s to almost US$10 billion today.

In Mexico, the annual value of forest product imports exceeds US$600 million, even though the country has enough forests to be self-sufficient in industrial forest products. Nigeria, once a significant exporter of timber, now imports industrial forest products at a cost of more than US$210 million annually, which nearly equals the value of the 2.5 million tons of food grains currently imported.

In 14 developing countries with suitable conditions for an expanded industrial forestry program, imports of manufactured forest products now total nearly US$4 billion a year. Unless action is taken, this level of imports will continue to rise sharply.

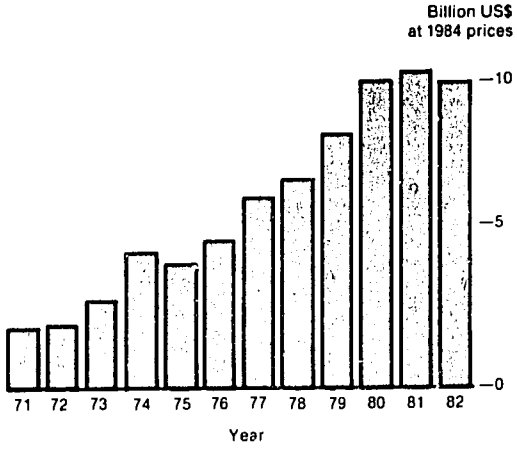
Worsening export outlook

Over the past decade, exports of industrial forest products by developing countries have averaged about US$7 billion (1984 prices) and rank fifth overall in non-oil exports. The value of exports has risen sharply during this time, but it is doubtful that this rate of growth will continue unless additional investment is made to sustain the productivity of industrial forest resources.

In a number of countries, notably Cameroon, Gabon, Ivory Coast, Malaysia, and the Philippines, current rates of timber harvesting and insufficient investment in forest management and reforestation will lead to a sharp decline in exports within 10-15 years. On a smaller scale, the same trend is perceivable in many other countries. In Ghana, for example, exports have fallen from a high of 124 million cubic meters in 1973 to 11 million cubic meters in 1982.

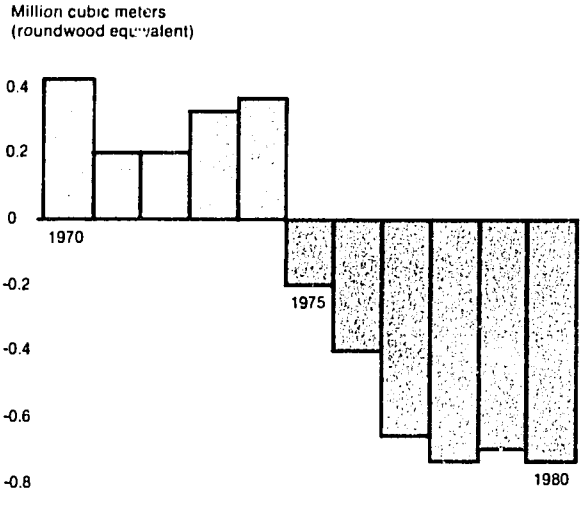
By the end of the century, the 33 developing countries that are now net exporters of forest products will be reduced to less than 10, and total developing country exports of industrial forest products are predicted to drop from their current level of more than US$7 billion to less than US$2 billion.

Imports of forest products by all developing countries



Source: *1983 Yearbook of Forest Products*, Rome, FAO.

Nigeria: Net trade in forest products
(Sawnwood + panels + pulp + paper)



Source: *1983 Yearbook of Forest Products*, Rome, FAO.

Threatened tropical rain forests

Tropical rain forests are the most biologically diverse ecosystems on earth. They are estimated to contain almost half of all known animal and plant species. However, most tropical species, especially the insects, have not yet been described or cataloged by scientists. If destruction of tropical rain forests—which account for 60% of the world's annual loss of forests—continues unabated, an estimated 10-20% of the earth's biota will be gone by the year 2000.

Dr. Alwyn Gentry examines a plant in one of the earth's least studied rain forests—the Chocó region of Colombia. Deforestation is destroying untold numbers of tropical plant and animal species whose potential benefits are still unknown. (Photo by James P. Blair © 1983 National Geographic Society.)

A single hectare of Amazon rain forest has been known to contain up to 230 tree species, compared with the 10 to 15 species normally found in a hectare of temperate forest. The forests of Borneo have a similarly high diversity of tree species. In Madagascar, only 10% of the original forest remains, yet these forests harbor an extraordinarily large number of endemic plants and animals. For example, more than 20 species of primates are found there and nowhere else. Further loss of Madagascar's remnant patches of tropical forest inevitably will jeopardize many of its endemic species.

Tropical forests yield a wide array of useful products such as essential oils, gums, latexes, resins, tannins, steroids, waxes, edible oils, rattans, bamboo, flavorings, spices, pesticides, and dyestuffs. Many of these materials never enter the commercial market; they are gathered free by local people and are essential to their well-being. But they are also the origin of myriad products manufactured and consumed daily in developed countries, including foods, polishes, insecticides, cosmetics, and medicines. In Indonesia alone, rattans (climbing palms used for cane furniture, baskets, and matting) generate substantial export income, and global trade in rattan end-products totals US$4 billion.

More than 50% of modern medicines come from the natural world, many of these from tropical plants. Two anticancer compounds, for example, derive from the periwinkle plant found only in Madagascar. With these anticancer drugs, there is now a 99% chance of remission in children suffering from lymphocytic leukemia and a 58% chance of remission from Hodgkin's disease. Synthesis of many naturally derived drugs is not commercially feasible, and even for drugs that can be synthesized, the chemical blueprints provided by wild plants are often needed. In developing countries, where modern medicines are often unavailable or too expensive, naturally derived medicines from undisturbed tropical forests may be the primary source of health care.

The centers of origin of many food plants are in the tropics. As tropical lands are converted for human use, ancestral stocks of these plants are jeopardized or lost. Only three species—corn, wheat, and rice—produce two-thirds of the world grain crop. The food supply of the entire world depends on maintaining plant resistance to pests and disease, and resistance is often restored or maintained by cross-breeding with wild populations of the same species. Several wild and domesticated food plant varieties have become extinct and many more are seriously threatened. The gene for semidwarfism that improved production in Asian rice came from a primitive Taiwanese cultivar. Resistance to virus came from a different wild donor species, one that probably evolved in the Silent Valley, a seriously threatened region of India. Incorporation of this gene into new rice varieties has greatly benefited people who depend on this major world crop.

Despite the many uses of tropical plants, less than 1% of them have been screened for their potentially useful properties. Further degradation of large areas of tropical forests will deprive future generations of the chance to retain and broaden the genetic base for food crops, medicines, and other useful products.

Deforestation can be arrested

Solutions are known

The prognosis for tropical forests is indeed grim if action is not taken soon. However, there is still a strong basis for hope. Deforestation can be arrested and ultimately reversed. Although there have been many failures, decades of experience have demonstrated successful solutions to deforestation and land misuse. However, these efforts have been isolated and on far too small a scale to address the problem.

Based on lessons learned from both successful and unsuccessful experiences in the past, enough is known to launch a concerted effort on a broad front to combat deforestation. However, the scale of action required cannot possibly be achieved by government foresters alone. An "across-the-board" effort, involving both the public and private sectors, from government ministries to local community groups, is needed in order to rapidly expand tropical forest conservation and development programs.

Governments must take the lead

Success in reversing deforestation will depend on political leadership and appropriate policy changes by developing country governments to support community-level initiatives. Short-term measures will not solve the problem. Neither will narrowly focused action within the forestry sector. A sustained commitment to forestry, agriculture, energy, and related rural development programs is required.

Solutions outside forestry are essential

Because some policies and practices in agriculture, energy, and other sectors lead to forest destruction, many of the solutions to deforestation must come from outside the forestry sector. Priorities include—

- More intensive agriculture and rural development programs to help the 250 million people already living within tropical moist forests establish sustainable farming systems that do not destroy the forest and to help settle the millions of people living adjacent to threatened forests to minimize further encroachment
- Accelerated land reform programs and expanded employment opportunities to provide some of the developing world's smallholders and landless people with alternatives to forest destruction
- Greater efforts and political commitment to channel future agricultural settlement into nonforest areas and into already deforested areas suitable for agriculture
- Integrated land-use planning that optimizes use of land for agriculture, forestry, conservation, and other productive activities on a sustainable basis, while minimizing the negative impacts of transportation, irrigation, and resettlement schemes on tropical forest ecosystems
- Research to develop sustainable farming systems that combine trees and food crops on the millions of hectares of marginal lands or wastelands
- Revision of government fiscal policies outside the forestry sector (such as subsidies for large-scale cattle ranching) that encourage exploitation, depletion, or waste of forest resources to a greater extent than could be economically justified or commercially profitable without government intervention.

The changing role of foresters

To support the changing emphasis in developing countries from industrial to farm and community forestry, foresters and forestry agencies must make some radical changes in their own policies, priorities, and practices. In particular, foresters need to—

- Establish policies that encourage local involvement in forestry activities and work more closely with people at the local level by involving them in identifying, planning, and implementing forest protection and management activities.
- Expand mass-media publicity and extension support for forestry conservation and development on farmlands and wastelands outside government-controlled forest reserves. Through education, extension, and awareness programs, encourage recognition of trees and forests as worthwhile "crops" to be cared for in their own right.
- Decentralize tree seedling production and other forestry operations and involve individuals more directly in these activities through local community groups, nongovernmental organizations, and schools.
- Give more attention to conservation programs that can help to increase protection of and research on tropical rain forests.
- Use lower cost technologies such as direct seeding and more intensive mass-production techniques to accelerate tree planting programs.
- Place greater emphasis on multipurpose trees to provide people with timber, poles, fuelwood, fruit, fodder, fiber, and other nonwood forest products.
- Intensify research on agroforestry, management of secondary or degraded forests, and ways to involve local people in forestry.
- Modify and expand forestry training and education programs to place greater emphasis on extension skills, agroforestry, and conservation of forest ecosystems.
- Refrain from converting natural forests to plantations when other suitable land is available.
- Revise government fiscal policies in forestry, such as lenient forest concession agreements, to encourage sustainable management of natural forests and plantations.
- Quantify more precisely the negative effects of deforestation on agricultural productivity, employment, rural incomes, and the balance of trade.
- Work more closely with planners in agriculture, energy, industry, and other sectors to design broadly based agriculture and energy programs in which forestry will play a vital, though not always the lead, role.

Local participation determines success

As important as political leadership is to a successful action program, the key ingredient is active participation by the millions of small farmers and landless people who daily use forests and trees to meet their needs. Countless rural development projects have failed to make a long-term impact because of inadequate involvement of local people. Greater attention must be given to creating incentives for local participation and ensuring that communities are involved meaningfully in project planning and implementation. The roles of women and nongovernmental organizations are especially important.

Creating incentives

Governments need to establish policies that encourage local participation in rural tree planting programs and natural forest management. Forestry codes and laws affecting land and tree tenure; prices for poles, fuelwood, fruit, and other forest products; and the cost and availability of seeds and seedlings of desired species need to be reassessed as potential incentives or disincentives to participation.

Incentives must also be incorporated into development project design. People will not participate in tree planting or related activities if they do not perceive it to be in their interest. Project design must be based on sufficient knowledge of local social, cultural, and ecological conditions as well as of people's perceptions and attitudes. Local participants in a project must be assured of reaping the benefits of their labor.

Involving women

Women play important and in many regions dominant roles in food and livestock production and in the use and management of trees. An increasingly apparent trend in rural areas is the rise in the number of woman-headed households. As a result, women are assuming new roles and responsibilities.

Women and children often suffer disproportionately from deforestation and its aftermath. Women generally are responsible for collecting fuelwood. As fuelwood becomes scarce, they must spend more and more time gathering it and are thus diverted from other household, childcare, or revenue-earning tasks.

Lesotho women working on a tree planting project.

Despite the important economic and social roles of women, forestry and other rural development projects continue to be designed without adequately considering their effect on women or the role of women in their implementation. Although their role in development projects is often overlooked, women have made important contributions. For example, they have carried out soil conservation measures (Lesotho), planted trees (China, El Salvador, Honduras), done nursery work (India), introduced and promoted fuel-efficient stoves (Honduras), and led conservation movements (the Chipko movement in India).

Better information on women's work patterns, their role in the community, and their perceptions of problems and solutions is needed. This requires more involvement of women in extension work. Women must also be represented at the professional level in program planning and project design.

Nepalese villagers discuss a tree planting project.

Nongovernmental organizations: A bridge to the local level

Special attention also needs to be paid to the role of nongovernmental organizations (NGOs) in managing natural tropical forests and in tree planting. An estimated 5,000 NGOs are involved in forestry worldwide, and hundreds of organizations aim, as their primary purpose, to protect forests or to rehabilitate degraded areas.

By working at the local level, often over a long period and with small amounts of money, NGOs can do much to stimulate community involvement in forestry. NGOs often can act as intermediaries between government bureaucracies and local people, and many projects are carried out by NGOs, often with major funding from the development assistance agencies. The role of NGOs in forestry is expanding rapidly, and their involvement will be a vital ingredient in overcoming forestry problems in most developing countries.

Development assistance agencies can do more

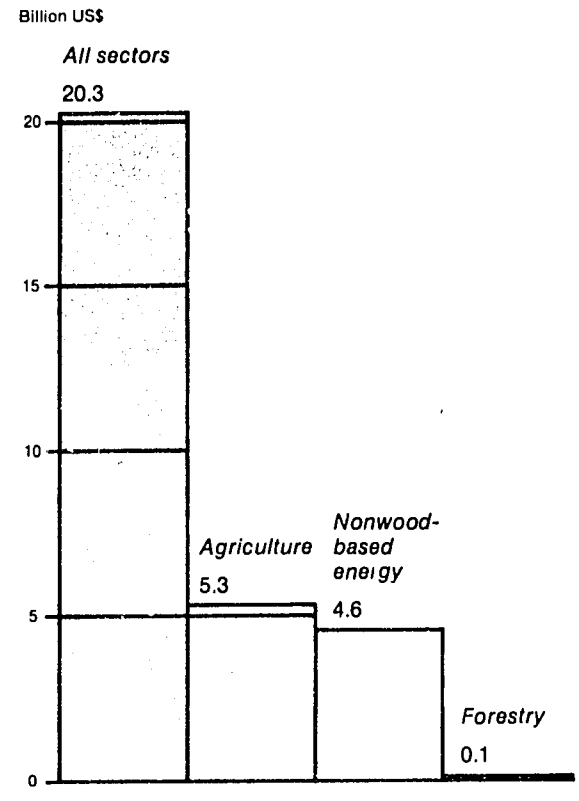
Development assistance to forestry is small, particularly in relation to the magnitude of the problems. Worse, it is declining relative to other sectors. The World Bank and the Inter-American, Asian, and African Development Banks allocate less than 1% of their annual financing to forestry, the U.N. Development Programme (UNDP) only 2%. Forestry's many contributions to development are unrecognized because forestry activities do not always bring short-term political or economic gains. Short-term efforts to expand agricultural production usually take precedence.

Rural development experience has shown that how money is spent is even more important than how much. The greater emphasis on farm and community forestry and watershed management requires new approaches to project planning and operations. These projects, which involve changing people's land-use practices, require local participation in their design and implementation. This has several important implications for the development assistance agencies.

Greater attention must be given to human and social factors. Information on local social and cultural conditions should be systematically collected and incorporated into project design. Project planning and implementation should be more flexible and emphasize a "bottom-up" approach. Decisionmaking should be decentralized as much as possible. Strengthening the capabilities of national forestry and related institutions, particularly in working at the local level, must be a major investment priority. Often, small amounts of funding are needed over long periods for this type of activity.

Better coordination among development assistance agencies and within single agencies is needed to avoid duplication of effort, working at cross-purposes, or burdening developing countries with funding and administrative demands that exceed their absorptive capacity. For example, infrastructure development (such as transportation and irrigation schemes) and resettlement schemes must be planned and coordinated to avoid wasting or destroying forest resources, jeopardizing forest conservation areas, or making accessible to settlers forest areas that are unsuited for agriculture in the long term.

Average annual lending (1980–84) by all development banks*



*Includes the World Bank, Inter-American Development Bank, African Development Bank, and Asian Development Bank.

Source: Agency annual reports and personal communications.

The most successful forestry projects have been those where a combination of national government effort and political commitment, assisted by external aid, has created an investment climate that triggered a spontaneous response from local farmers, communities, and the private sector for large-scale self-sustaining programs.

An Agenda for Action

Planning a five-year action program

The Task Force has developed this action program to address deforestation issues on a broad front. In preparing the program, these guidelines were used:

- High priority countries would be identified based on previous studies by the U.N. Food and Agriculture Organization, leading multilateral and bilateral aid agencies, and such nongovernmental organizations as the International Union for Conservation of Nature and Natural Resources.
- Priorities for action should accord closely with those identified as important by national governments and the development assistance agencies. Accordingly, the five priority areas for action identified in FAO's Tropical Forest Action Programme and endorsed by the FAO Committee on Forest Development in the Tropics were adopted.
- The action proposals should be based on successful and well documented development project experiences and also take into account lessons learned from past failures.
- Special attention was paid to identifying small-scale development projects that have potential for widespread replicability.
- Past projects were examined in terms of their success in involving local people. Special emphasis was given to projects with high economic rates of return that have the potential to be self-sustaining.
- Investment needs were treated in the broadest sense to include support for institution-strengthening activities, including research, training, and extension, which experience has shown account for 15 to 25% of total investment requirements.
- In addition to examining investment needs in the forestry sector, an attempt was made to estimate investment needs for agricultural activities that form an integral component of the action plan.
- In estimating investment needs for the period 1987–91, special account was taken of a country's capacity to absorb new investment. The Task Force perceives this as a key factor in limiting accelerated investment in the short term.

The five-year action program proposed by the Task Force is described on the following pages under these five headings:

Fuelwood and agroforestry

Land use on upland watersheds

Forest management for industrial uses

Conservation of tropical forest ecosystems

Strengthening institutions for research, training, and extension.

Each of the five sections opens with a brief summary of the problem and its underlying causes. This is followed by a review of successful experiences that illustrate the range of known solutions. Major policy issues and constraints specific to each section that need to be addressed are identified. Each section concludes with a summary of recommended actions and investments for a five-year action program.

More detailed case studies of successful experiences and country investment profiles can be found in Parts II and III respectively.

Fuelwood and agroforestry

The problem

The rising demand for fuelwood and poles, tree fodder, and agricultural land has greatly accelerated deforestation, bringing in its wake not only shortages of the most important source of household energy in the developing countries but a disastrous series of food crises.

- 63 out of 95 developing countries are faced with inadequate supplies of fuelwood. More than half of the most severely affected countries are in sub-Saharan Africa.
- 34 of the countries with fuelwood shortages have no proven oil or gas reserves, which, combined with low GNP per capita and low rates of economic growth, severely constrains their ability to switch from traditional biomass fuels to fossil fuels.
- Shortages of fuelwood are most acute in semiarid and mountain areas where the productivity of natural woodlands is lowest and the risk of overexploiting the environment is greatest. Fuelwood deficits are increasingly common in densely settled lowlands and in areas of rapidly growing populations and agriculture.

At present rates of consumption, between 1980 and 2000 the annual fuelwood deficit in developing countries will grow from 407 to 925 million cubic meters. This shortfall, which is now met by overcutting forests, is equivalent to the annual output of wood from 80 million hectares of fuelwood plantations.[1] The current rate of tree planting in tropical countries is estimated to be 1 million hectares per year, or little more than 1% of what is required.[2] However, official statistics on tree planting often underestimate the number of trees planted outside of government-sponsored programs.

Several factors in addition to rising fuelwood demand and clearing of forests for agriculture are contributing to wood scarcity:

- Many rural people do not perceive a fuelwood crisis because they have access to freely available alternatives such as animal dung and crop residues.
- In many countries, disincentives exist that seriously constrain tree planting, such as low fuelwood prices and land and tree tenure problems.
- In many areas where there is open access to wood resources, traditional communal systems of management are breaking down.

Countries with major shortages of fuelwood

Region	*Countries affected by acute scarcity of fuelwood or deficits*	*Other countries with areas of fuelwood deficits*
Africa:	Botswana Burkina Faso Burundi Cape Verde Chad Comoros Djibouti Ethiopia Kenya Lesotho Malawi Mali Mauritania Mauritius Namibia Niger Réunion Rwanda Senegal Somalia Sudan	Angola Benin Cameroon Congo Gambia Guinea Madagascar Mozambique Nigeria Swaziland Tanzania Togo Uganda Zaire Zambia Zimbabwe
Asia:	Afghanistan China India Nepal Pakistan Turkey	Bangladesh Indonesia (Java) Philippines Sri Lanka Thailand Viet Nam
Latin America:	El Salvador Haiti Bolivia Peru	Brazil Costa Rica Chile Colombia Cuba Dominican Republic Ecuador Guatemala Jamaica Mexico Trinidad and Tobago

Source: Based on the 1980 study by FAO of fuelwood supplies in developing countries. Fuelwood scarcity was defined as an inability to meet minimum requirements, even by overexploitation of remaining woodlands. Fuelwood deficits indicate that demand is met by harvesting wood faster than it is being replenished.

[1]Assuming an average annual yield of 5 cubic meters per hectare.
[2]Includes fuelwood produced from nonindustrial and industrial plantations.

Success stories

Fuelwood conservation and the use of substitute fuels

- Improved wood stoves made from a clay and sand mixture have been developed successfully in Senegal as part of a national program launched by the Center for Study and Research on Renewable Energy. The most popular type of stove, the Louga model, was designed and is built principally by women. About 3500 stoves of this type were built in the first 2 years of the pilot program, and 77% were in regular use when the program was later evaluated.
- As part of a community forestry project in Nepal, improved cooking stoves have been introduced to decrease per capita fuelwood consumption. More than 700 stoves have been installed, resulting in an average fuel saving of 38%.
- As part of a program aimed at reducing fuelwood consumption and accelerating reforestation, the Forest Research Institute of Korea developed a more efficient system of underfloor heating that is capable of reducing wood use for heating by 30%. Sale of fuelwood to city residents was prohibited to discourage illegal cutting in rural areas. At the same time, the government pushed ahead with rural electrification. As a result of increased use of electricity and more efficient use of fuelwood, the share of fuelwood in total energy consumption fell from 55% in 1966 to 19% in 1979.

Improved management of forests and more efficient conversion of wood into charcoal

- A degraded forest in Ghana was cleared and replanted for the production of pulpwood. Instead of burning the cleared vegetation, which was the standard practice, the waste wood was salvaged and either sold directly as sawtimber or fuelwood or efficiently converted to charcoal and then sold. Food crops were planted for 3 to 4 years between the rows of tree seedlings to help suppress weeds. Returns from the sale of the felled wood and the crops exceeded conversion costs by several hundred dollars a hectare.
- In Uganda, logging residues once wasted have been recovered for charcoal manufacture, increasing the output of charcoal from 200 to 63,700 tons per year.
- In Niger, Senegal, Ivory Coast, and Chad, the productivity of vegetation has been increased on an experimental basis by 20-100% through various combinations of controlled grazing, regulated fuelwood harvesting, and protection from late annual bush fires.

Waste wood from clearing forest that was once burned is now used for making charcoal in the Subri River Forest Reserve in Ghana.

Reforestation through agroforestry, cash crop tree farming, and farm forestry

In many countries it has become clear that progress in agriculture depends on controlling deforestation, regenerating the vegetative cover, and adopting farming practices that compensate for shortened fallow periods. Agroforestry techniques can restore the tree cover and enhance net output of annual crops, livestock, and a variety of perennial tree crops.

Several reforestation programs show that governments can mobilize widespread support for tree planting and organize large-scale seedling production and tree planting programs. In parts of India, Nepal, Kenya, and elsewhere, it has been possible to build up rural forestry extension programs and motivate farmers to plant trees on their own land. People in these countries have demonstrated their responsiveness to growing urban demands for wood and to increasing scarcity and higher prices for fuelwood and poles, by eagerly participating in programs offering seedlings of fast-growing, multipurpose trees. However, experience has shown that it is easier to motivate people to plant trees than to divert time from other activities to tend and protect the trees. Many planting programs have had very low tree survival rates for this and other reasons.

Decentralized distribution of seedlings is an important incentive for tree planting.

Watering seedlings in a tree nursery as part of a reforestation project in Thailand.

• An agroforestry project in Haiti has proven the effectiveness of using existing networks of nongovernmental organizations to promote tree planting in rural areas. Farmers have been quick to respond to the provision of subsidized seedlings and extension services, because they readily appreciate the income-earning potential of growing trees to produce charcoal for urban markets. In less than 3 years, the project has reached thousands of farm families who have planted more than 10 million seedlings, or double the amount planned.

• In Gujarat State, India, a social forestry project was started with the goal of distributing 30 million seedlings annually. Within 3 years, seedling distribution had increased from 17 million to nearly 200 million plants per year, as farmers recognized the income-generating potential of growing trees to meet the market demand for poles. At first, the density of nurseries had been one per 83 villages. Encouragement of nurseries tended by schools and individual farmers increased the density of nurseries to more than one per 10 villages. By 1983, more than 150,000 hectares had been planted in an effort that involved one in every 10 farmers in Gujarat.

• In Uttar Pradesh, India, another social forestry project had a 5-year goal of planting 8000 hectares of woodlots and 22,000 hectares of strip plantations, distributing 8 million seedlings for farm forestry plantings, and rehabilitating 13,000 hectares of degraded forest. The targets were exceeded within 3 years, and in the process 17 million workdays of employment were generated, including 4 million days for women.

• A recent survey in the Kakamega district of Kenya reveals that 72% of farmers have planted trees and 38% are raising seedlings. Trees are planted for fruit, shade, ornamental plantings, boundary plantings, and windbreaks, as well as for fuelwood.

• Agroforestry studies in Senegal have shown that yields of millet and sorghum were 500-1000 kilograms per hectare higher in fields with *Acacia albida* trees than in open, treeless fields.

• Maize yields in Nigeria declined to 500 kilograms per hectare under continuous cultivation for 6 years in a control plot, but they were sustained at 2000 kilograms per hectare by mulching with leaves from the leucaena tree. In other "alleycropping" trials, crop yields were 18% higher in plots in which grazing and maize cultivation were rotated between the rows of closely spaced, leguminous trees.

• Growing trees for fuelwood and other uses can be designed to have a positive effect on food production. In the Majjia valley of Niger, millet yields were increased 20–25% by planting windbreaks.

• In China, 30 million hectares of trees have been planted since 1949 to form shelterbelts around farmfields, soil conservation plantations, dune reclamation works, and roadside plantings. The total area planted in China is more than double the combined area of fuelwood and industrial plantations established during the same period in all other developing countries. This extraordinary achievement is largely a reflection of government commitment to the program and the massive mobilization that was organized as a result.

Proposals for accelerated action

General strategy and policy issues

The recommended program addresses the need to manage demand and to increase supplies of fuelwood. Because much of the fuelwood needed in developing countries will have to be grown in rural areas, agroforestry has a major role to play. In addition to increasing fuelwood supplies, agroforestry will have a very positive effect on both food production and rural economies.

The main components of the program are identified in the box.

To apply this strategy, these important policy issues need to be addressed:

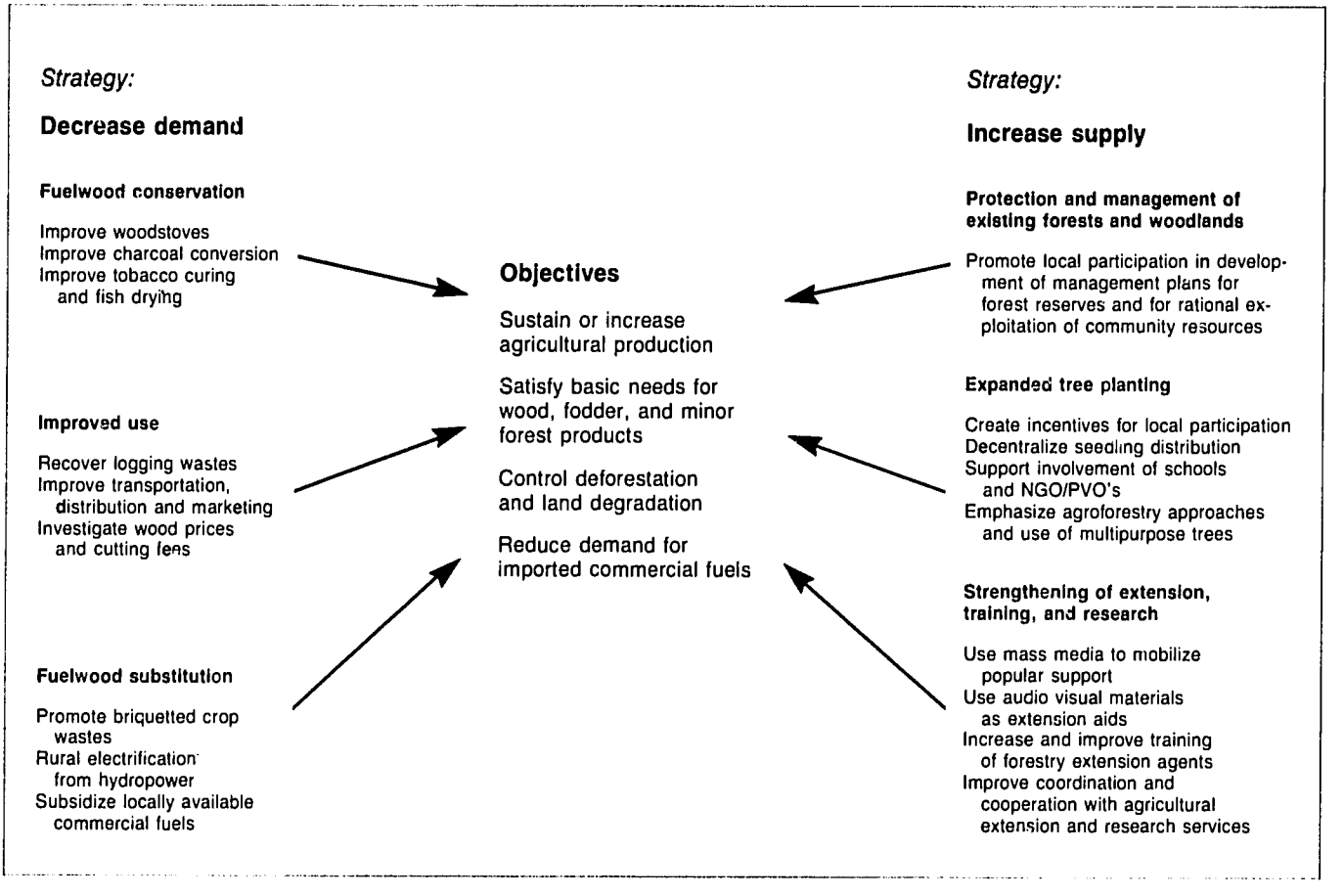
Fuelwood pricing

The low fuelwood prices that prevail in rural areas of developing countries reflect the fact that wood is still "freely available," even if it is collected by overcutting. Low prices constrain investment by farmers in growing trees. Incentives such as subsidized seedling distribution may be used to trigger widespread interest in reforestation. More research is needed on the economic justification for such subsidies and their potential role in helping to reduce deforestation.

Distribution of benefits

Community approaches to reforestation and natural forest management have proved difficult, particularly in semiarid environments. A major difficulty is ensuring that the benefits of tree planting and improved management are distributed equitably. In particular, local people who carry out the project must be assured of receiving the benefits of their work.

Efforts organized at the village level are also constrained by the heterogeneity of local communities and the need to reconcile conflicting interests of herdsmen and farmers. Conflicts also arise between rural communities and urban-based woodcutters and charcoal producers.



Improved development planning

Because clearing of land for agriculture is the leading direct cause of deforestation, agricultural resettlement and livestock development policies need to be reassessed to ensure they promote sustainable development. The potential for integrating fuelwood production, agroforestry, and soil and water conservation techniques into farming systems needs to be systematically reviewed and carried out.

Recommended actions for a five-year program, 1987–91

- Support programs to develop more efficient cookstoves, building on the experiences gained in Senegal, Nepal, Burkina Faso, Guatemala, and elsewhere. Focus on regions most affected by fuelwood scarcity and price increases.
- Promote more efficient wood use and charcoal production technologies, such as improved recovery of logging wastes and briquetting of crop residues from large-scale farms. Support outreach programs with charcoal producers and industrial users of fuelwood (for tobacco drying, brick kilns, bakeries) to increase the efficiency of fuelwood use.
- Evaluate the potential impact and economic rationale for encouraging the use of locally available commercial fuels or renewable biomass substitutes for household energy sources.
- Consider changes in woodcutting fees and current methods of collection that would give rural communities greater control over tree harvesting and eliminate "free" wood. Reassess wood prices and wood distribution networks; evaluate the potential for increasing farmgate prices of wood and for lowering in cities the retail prices of wood produced by private and government plantations.
- Increase local involvement in protecting and managing forests and woodlands. Productivity can be increased by organizing community control over access and use and by using techniques that conserve soil moisture and enhance natural regeneration.
- Strengthen forestry extension activities by training more agents and developing audiovisual materials that clearly demonstrate the relationships between the managed use and sustained productivity of water, soils, pastures, and forests, as was done in Nepal and Burkina Faso.
- Promote tree planting around family homesteads and cultivated areas by removing legal and other constraints and disincentives to on-farm tree planting.
- Develop low-cost technologies (e.g., direct seeding or the "basket" system) for seedling distribution, and promote decentralized seedling production involving schools and nongovernmental organizations, as in Haiti and India.
- Encourage local support and participation in tree planting by increasing the use of fast-growing, multipurpose tree species that meet people's perceived needs. Monitoring and detailed surveys, such as those underway in Malawi, Kenya, and India, are needed.
- Encourage private sector involvement in establishing and maintaining plantations; give priority to planting deforested lands not suited for annual crops.

Investment needs

The proposals cover 32 countries in which large populations are affected by acute fuelwood shortages, and in which agroforestry could play an important role in increasing fuelwood supplies and food production. This is only a listing of the countries where the problem has already been well documented; other countries will need similar support.

- The estimated cost of a 5-year investment program in these 32 countries is US$1.9 billion. Much of the proposed funding would be absorbed by several larger countries (China, India, and Brazil) which have already made considerable progress in developing the institutions for expanded reforestation and wood energy programs.
- For most of the other countries included in this analysis, annual investment averages US$5 million per country and represents a doubling of current assistance to the forestry sector.
- The proposed program includes a marked increase in support for fuelwood conservation, improved management of existing woodlands, and institutional strengthening to support field activities and promote policy changes.
- Investment in forestry research, training, and extension accounts for 20% of the investment needs.

Fuelwood and agroforestry

Summary of needed investments, 1987–91

Africa	*Million US$*
Botswana	15
Burkina Faso	25
Burundi	20
Cape Verde	15
Chad	14
Ethiopia	40
Kenya	48
Lesotho	10
Madagascar	30
Malawi	24
Mali	30
Mauritania	16
Niger	20
Nigeria	50
Rwanda	30
Senegal	25
Somalia	15
Sudan	35
Tanzania	30
Uganda	15
Asia	
Bangladesh	52
China	250
India	500
Nepal	30
Pakistan	40
Sri Lanka	30
Latin America	
Bolivia	25
Brazil	400
Costa Rica	15
El Salvador	10
Haiti	15
Peru	25
Total (32 countries)	1899

Land use on upland watersheds

The problem

Destructive land use on upland watersheds is taking place on a vast scale throughout the developing world. The degradation of upland stream source areas results in massive soil erosion and sedimentation of rivers, dams, and reservoirs. The consequences in the lowlands are increased severity of flooding which leads to losses of crops, land, buildings, and even human life; disruption of irrigation systems and reduced crop yields; and decreased power generation for urban areas. The problem of watershed degradation is complicated because downstream impacts can occur far away from the source of damage and across political boundaries.

An estimated 160 million hectares of upland watersheds have been seriously degraded in Africa, Asia, and Latin America. Countries with serious upland watershed problems include—

Africa	*Asia*	*Latin America*
Burundi	China	Argentina
Ethiopia	India	Bolivia
Guinea	Indonesia	Brazil
Kenya	Nepal	Chile
Lesotho	Pakistan	Colombia
Madagascar	Philippines	Costa Rica
Mozambique	Thailand	Ecuador
Tanzania		El Salvador
Uganda		Guatemala
Zimbabwe		Haiti
		Jamaica
		Mexico
		Nicaragua
		Panama
		Peru

Land misuse in rural areas stems in great part from increasing population pressures and political and administrative neglect by urban-based government authorities. Other major causes of watershed degradation are described below.

High-rainfall uplands

Rapid population growth and the search for food, fuel, and fodder have caused invasion and destruction of upland forests. Subsequent misuse of exposed slopes through intensive overgrazing by free-ranging livestock and unprotected cultivation is causing widespread degradation of soil and water resources.

Medium-to-low-rainfall uplands

Because of their harsher environment, particularly low and erratic rainfall, medium-to-low-rainfall uplands have lower carrying capacities for people and livestock. When undisturbed, these areas develop a continuous tree, shrub, and grass cover that protects the soil. This cover is vulnerable to misuse and at low rainfall levels it recovers slowly. Rising human and livestock populations are reducing these areas to unproductive wastelands on a vast scale by fuelwood gathering, uncontrolled and unproductive overgrazing, and depletion of soil fertility through continuous cropping.

Success stories

High-rainfall uplands

- In Nepal, increased fodder and fuelwood supplies from planting grasses and multipurpose trees, and tethering or stall-feeding livestock, have provided enough manure for a second grain crop each year and quadrupled family incomes. The key incentive was to offer wages for tree planting for the first 2 years only.

Stall-feeding of livestock reduces grazing pressure and allows for revegetation of denuded slopes.

• In India, reforestation and soil conservation measures have stabilized watersheds above major dams. In the Damodar Valley, floods have been moderated, the rate of sedimentation has been reduced, more water is available for human and livestock use, and crop yields have increased.

• In tropical southern China, reforestation by manual contour ditching and intensive tree planting has checked erosion and permitted fish farming and small-scale hydropower development. One commune put 10,000 men, women, and children into the field and planted 3.4 million trees in one year. Their income is now twice the average for the province.

• In Colombia, an innovative program to transfer resources from lowland beneficiaries of hydropower development to upland farmers is being started. A sales tax on electric power from major hydroelectric plants will be used to promote proper land use for stabilizing upland watersheds through soil conservation and reforestation.

Medium-to-low-rainfall uplands

• In the Ethiopian Highlands, the largest soil conservation program in Africa is being supported by many multilateral and bilateral donors. More than a million people from 8000 Peasant Associations are carrying out Food for Work programs. Under the program, each worker is provided a family food payment of 3 kilograms of wheat or maize and 120 grams of vegetable oil for each day's work on conservation projects such as terracing of steep slopes and tree planting. Peasant Associations have played a major role in the success of the projects because of their ability to mobilize labor quickly and efficiently.

Members of Peasant Associations in the Ethiopian Highlands are rehabilitating degraded land through food for work programs.

In China, watersheds are being rehabilitated on a vast scale through massive deployment of hand labor using conventional soil conservation methods.

• In the low-rainfall loess plateau region of China, abandoned agricultural land destroyed by soil erosion is being successfully reclaimed. On the edges of the wasteland where road access remains, conventional soil conservation methods have been successfully applied by massive deployment of hand labor. In the past 5 years, Chunhua County has planted 15 million trees and sediment transport from the watersheds has already been halved. Bare hills that are inaccessible by road are being rehabilitated by aerial seeding. Some 10,000 hectares have been established successfully in experimental programs using common alfalfa seed at 2 kilograms per hectare.

• In Uganda, severely overgrazed watersheds were equipped to measure floodflow and rainfall penetration into the soil. After 4 years of measurements, excessive grazing was allowed to continue on one watershed while the adjacent watershed was treated by bush clearing and controlled grazing. Simple rotational grazing fattened more livestock on the managed watershed than were starving on the traditionally grazed control valley. Rain penetrated one meter further into the soil and flood peaks were halved on the managed area.

Proposals for accelerated action

General strategy and policy issues

The recommended program addresses the need to change land-use practices to stabilize and rehabilitate degraded upland watersheds. Technically proven and economically sound methods are available for different social and ecological conditions. Experience has shown that proper land use can sustain and improve the productivity of both forests and agricultural land. Solutions vary with local conditions, and pilot projects are needed in countries that are only beginning to address their upland watershed problems. The recommended program focuses on three main activities:

- Establishing tree and grass cover to stabilize upland areas and provide adequate supplies of fuelwood, fodder, and building poles
- Controlling livestock grazing
- Developing sustainable farming systems.

To apply this strategy, these important policy issues need to be addressed:

Interdependence of upland and lowland communities

- Government policy must be based on the interdependence of upland and lowland communities.
- Governments must provide more support for upland communities to deal with problems of poverty and remoteness from technical help, both of which cause land misuse.

Multidisciplinary approaches

- Because several disciplines are needed to rehabilitate and manage degraded watersheds, action cannot be carried out by government foresters alone; they must include agriculturalists, water resource engineers, community administrators, and others.
- In-service training is needed to ensure that sound technology is applied in each of the several disciplines involved.

Incentives

- Changes in land-use practices require incentives and the full participation and support of local communities. The most practical incentives are short-term daily wages for soil conservation and tree and fodder planting. Another important incentive is provision of seed and fertilizer at subsidized prices.
- Hill farmers on land that can sustain agriculture must be assured security of land tenure and protection from invasion by migrants. Farmers on land unsuited for agriculture should be resettled to areas capable of sustaining them.
- Better pay and status for administrative and professional staff in remote rural areas are essential. Career prospects now depend on working in the cities.

Recommended actions for a five-year program 1987–91

The proposals for accelerated action over the next 5 years cover 11 countries that have begun to take corrective measures known to have achieved success. These are some of the countries from which evidence is available because they have seen the need to correct the current misuse of their uplands and have begun practical rehabilitation with the support of external aid. However, in all these cases, the means are not yet adequate to win the race against time to preserve critical upland soil and water resources. The countries are China, Colombia, Ethiopia, India, Indonesia, Kenya, Madagascar, Nepal, Pakistan, the Philippines, and Zimbabwe.

This list will need to be expanded as other countries take up the challenge of their rural watershed problems and seek help in solving them. No developing countries can afford either to ignore the dangers to their soil and water resources as populations increase or to ignore the capacity of their lands to sustain future population growth.

High-rainfall uplands

- Provide incentives for local communities to reforest upper slopes and increase fodder and fuelwood production through tree planting and protection of remaining resources.
- Tether and/or stall-feed livestock.
- As fuelwood supplies increase, maintain soil fertility by applying animal dung and crop residues instead of using them as fuel.
- Reduce soil erosion by simple manual techniques, such as repair and construction of bench terraces and plugging of gulleys with check dams. Plant trees and grasses along the terrace edges or lines.

• Encourage farmers to adopt sustainable agroforestry practices.

• Expand small-scale water resources development. Plastic pipe to carry water from springs is a major incentive to stall-feeding of livestock.

Medium-to-low-rainfall uplands

• Maintain essential vegetation cover on steep slopes; this requires that community needs for both fuelwood and fodder be met by planting trees and grasses.

• Rotate livestock to preserve cover on mild slopes and exclude grazing on steep land.

• Intensify production through agroforestry on the more fertile areas to relieve pressure on marginal lands.

Investment needs

No data for the total area of eroded watersheds are available on a worldwide basis such as that collected for fuelwood by FAO. Both the scale of the damage and the timetable for remedial action are highly specific to the social, political, and economic circumstances of each country. No global total for investment can be estimated with confidence, but the 16 countries listed in the table, for which proposals for action total US$1231 million, represent about two-thirds of the problem.

Land use on upland watersheds

Summary of needed investments, 1987–91

Africa	*Million US$*
Ethiopia	100
Kenya	35
Madagascar	10
Zimbabwe	46
Asia	
China	135
India	500
Indonesia	100
Nepal	15
Pakistan	45
Philippines	120
Latin America	
Brazil	10*
Colombia	50
Ecuador	15*
Jamaica	10*
Panama	20*
Peru	20*
Total (16 countries)	1231

*Preliminary estimate, pending additional research.

Forest management for industrial uses

The problem

Many developing countries have both substantial natural forests and ecological conditions suited for fast-growing industrial plantations. Nevertheless, in most such countries current levels of forest management and reforestation fall far short of what is needed to limit imports and sustain exports.

Consumption of forest products has outstripped increases in domestic production. As a result of inadequate attention to management and development of their industrial forest resource base, more and more developing countries face burdensome bills for importing forest products. In several countries, exports of forest products have increased, but this growth cannot be sustained without increasing investments to maintain supply. The critical countries are—

Africa	*Asia*	*Latin America*
Cameroon	Burma	Argentina
Congo	China	Brazil
Gabon	India	Chile
Ghana	Indonesia	Colombia
Ivory Coast	Malaysia	Costa Rica
Liberia	Pakistan	Ecuador
Nigeria	Papua New Guinea	Guatemala
Swaziland	Philippines	Jamaica
Uganda	Thailand	Mexico
Zaire		Peru
		Venezuela

Several factors have contributed to this situation:

- Every year, 5 million hectares of closed tropical forests are logged. Frequently, only a few of the highest valued and more easily marketed species are extracted from uncut forests. This process disturbs much of the remaining vegetation and reduces significantly the commercial value of the secondary forest that grows back.
- Reforestation has not kept pace with logging and deforestation. Less than 600,000 hectares of industrial plantations are planted each year in developing countries. This compares to the annual logging rate of 5 million hectares and an annual deforestation rate of 11.3 million hectares.
- Industrial forest resources have not been well managed. Over the past 30 years, there has been minimal investment in protecting and intensively managing forests that have been logged. Many plantations are not well maintained, protected from fire, or regularly thinned and harvested. Because of an inability to properly manage existing plantations, yields have sometimes been lower than expected.

- When new roads provide access to forests, uncontrolled encroachment by farmers (and in some areas ranchers) often follows. Each year, more than 7.5 million hectares of closed forests are lost by conversion to agriculture.

- Forest management is also hampered by a shortage of well trained personnel, insufficent investment in research, and inadequate administrative structures and financing mechanisms.

Success stories

More intensive management of natural forests

Attempts to manage natural forests to reproduce the valuable species removed in a first cut have not been widely successful, but there have been encouraging results in a few locations, including Ghana, India, Congo, Gabon, and Suriname. In Gabon, species like the mahoganies *(Okoumea)* have been naturally regenerated and enrichment planting has increased the value of the forest resource.

Increased use of lesser-known hardwoods

Malaysia has successfully developed local markets for many lesser-known hardwood species once regarded as "weed trees." By 1981, unexploited hardwood species accounted for about 12% of the total log intake of sawmills in Peninsular Malaysia. The intake of these species in plywood/veneer mills was even higher (27%). In Cameroon, Indonesia, Colombia, and the Philippines, previously noncommercial species have also been successfully used for pulpwood.

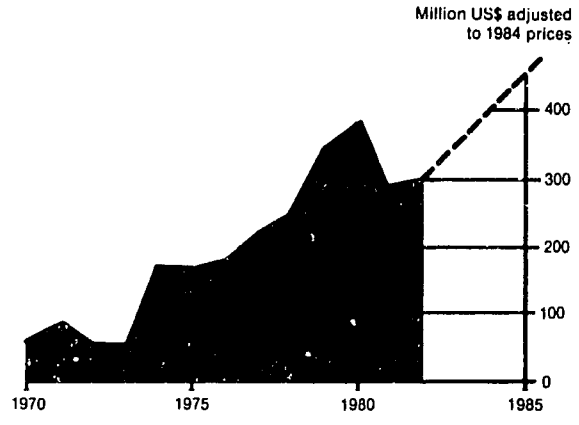
Fast-growing industrial plantations: Zambia, Chile, and Brazil

The most dramatic successes in industrial timber production are large-scale industrial plantations.

Over the past 20 years, Zambia has established industrial plantations capable of meeting its projected industrial timber needs through the end of the century. Beginning in the mid-1960s, a sustained program of industrial reforestation (primarily pines and eucalypts) surpassed its targets and by 1983 had successfully established 45,000 hectares of plantations. This has helped reduce pressure on the country's diminishing natural forests and developed a highly productive source of roundwood needed in its copper mines and other industries.

Chile has established 1.1 million hectares of pine plantations over the past 20 years through the combined efforts of government and the private sector. Favorable forestry policies, including specially designed tax laws and subsidies, also played a major role in the success of the reforestation programs. By the end of this century,

Chile: Exports of forest products



Source: *1983 Yearbook of Forest Products*, Rome, FAO.

Chile will have the potential to produce nearly as much industrial wood as Finland does today.

Sawmills and pulp and paper mills have been built. Chile is now supplying all of its domestic demand for forest products and is exporting logs, sawnwood, pulp, and paper. The value of forest-based exports has reached US$350 million per year.

Within 20 years, Brazil has established more than 4 million hectares of plantations of both eucalypts and pines, not only meeting a rapidly growing domestic demand but also providing the basis for a profitable export business. Industrial wood production in Brazil rose from 24 million cubic meters in 1973 to more than 58 million cubic meters by 1983.

Small landholder tree planting for cash crop and industrial wood production

Plantations of various fast-growing species have become a profitable cash crop for farmers in a number of developing countries. Poplars are grown as a cash crop in Pakistan, and farmers in India have enthusiastically planted eucalyptus to produce poles for sale in local markets. In the Philippines, a combination of technical

and financial assistance to smallholders provided by the Paper Industries Corporation of the Philippines and the Development Bank of the Philippines has led to the participation of more than 3800 farmers in planting *Albizzia falcataria* to produce wood for a pulp and paper mill on the island of Mindanao. A total of 23,000 hectares of tree farms had been established by 1984.

Plantations of valuable hardwoods

Slower growing but higher valued hardwood species such as teak have been planted successfully in many tropical countries in Asia, where teak originates, as well as in Africa and Latin America. These plantations can help replace cutover forest and increase future wood production.

Proposals for accelerated action

General strategy and policy issues

The recommended program focuses on three major types of activities:

Protection and management of natural forests

More intensive use of existing resources, particularly lesser-known hardwood species

Accelerated industrial reforestation.

The potential for greater production is significant. Assuming annual yields of 2 cubic meters per hectare from managed natural forests, existing areas of logged-over forests (about 210 million hectares) could be more intensively managed to supply 85% of developing countries' demand for industrial timber in the year 2000.

Alternatively, assuming average annual growth of 15 cubic meters per hectare in plantations, total demand could be met by converting only 33 million hectares (or about 15%) of the existing logged-over area into fast-growing plantations.

In terms of technical requirements for certain types of wood, the best solution probably is some combination of these two approaches.

To apply this strategy, these important policy issues need to be addressed:

Improved management of natural forests

- Much greater political commitment to the goal of sustainable resource management is needed. Some progress in this regard can be found in Peninsular Malaysia, for example, and in Indonesia.
- Government policies that encourage unsustainable forest exploitation—such as inappropriate forest concession agreements—should be identified and changed.
- Proven techniques for regenerating natural forests after logging need to be more widely disseminated, and economic criteria need to be introduced. Further development of techniques for the use of lesser-known species could greatly improve the economics of natural forest use.

Industrial plantations

- Forest land must be controlled or allocated to (1) protect industrial forest areas from invasion by migrants to allow sound silivicultural management; (2) assure landowners that they will be able to market industrial wood at a reasonable price; and (3) assure wood-consuming industries, particularly those requiring large long-term investment, that they will have access to a steady supply of wood at reasonable prices.
- Financial incentives are needed to encourage investment in reforestation and forest management. The time that it takes to grow industrial timber and the prevailing interest rates in many countries discourage investment in industrial reforestation. Where planting can be justified on economic grounds, governments can help overcome this problem by using fiscal and other incentives. Mechanisms also are needed to ensure higher standards of plantation maintenance, fire protection, exploitation, and regeneration.
- Well conceived research programs are needed to capitalize on the potential for fast-growing industrial plantations and to increase our knowledge of multiple-use management. Better management is needed for closed forests that have been logged and forests on sites that are steep, infertile, inaccessible, or otherwise unsuited for agricultural development. Through improved management, these lands can yield large benefits in watershed management, protection of wildlife habitats, and nonwood as well as wood products.

Recommended actions for a five-year program, 1987–91

Specific recommendations for action have been developed for 28 countries. On the basis of these country-specific analyses, the following actions are recommended:

- Increase the area of managed tropical forest from 34 million hectares to 67 million hectares over the next 5 years by protecting areas that have already been logged and by improving logging practices. Given current manpower constraints in most countries, "management" will usually constitute no more than the development of forest management plans. On this basis, assuming an average annual management cost of US$5 per hectare, the cost would be on the order of US$165 million annually by 1990, or about US$550 million over the 5-year period.
- Increase the rate of industrial plantation establishment to 950,000 hectares annually by 1990. The additional cost, assuming an average cost of US$500 per hectare, would total US$750 million over the next 5 years.
- Establish forestry funds and otherwise assist appropriate administrative and commercial organizations to provide more intensive management of existing and future plantations.
- Greatly accelerate research on regeneration and sustained-yield management of natural and planted forests; research should be better coordinated and assistance should be provided for disseminating the results.
- Increase the efficiency of harvesting and use of tropical timber resources.

Investment needs

The estimated cost of a 5-year investment program for the 28 countries listed in the table is US$1.6 billion. Perhaps half of the needed investment could come from the private sector if favorable tax policies and other incentives were adopted.

Forest management for industrial uses

Summary of needed investments, 1987–91

Africa	*Million US$*
Cameroon	20
Congo	20
Ghana	10
Ivory Coast	75
Liberia	15
Nigeria	35
Uganda	25
Zaire	10
Asia	
Burma	30
China	285
India	190
Indonesia	50
Malaysia	40
Pakistan	20
Papua New Guinea	15
Philippines	40
Thailand	35
Latin America	
Argentina	100
Brazil	325
Chile	50
Colombia	45
Costa Rica	15
Ecuador	20
Guatemala	15
Jamaica	10
Mexico	90
Peru	30
Venezuela	25
Total (28 countries)	1640

Conservation of tropical forest ecosystems

The problem

Destruction or conversion of tropical forests, particularly tropical rain forests, is resulting in widespread disruption of ecosystems and loss of species.

Agricultural clearing by more than 250 million people who live in tropical forests is increasing. Not only has the population of subsistence farmers grown, but in many nations the absolute amount of cleared land available to them has decreased. The concentration of land ownership, which has characterized land tenure in the developing world, has become even more pronounced in recent years. Much of this land is used to produce export products, while in many areas per capita food consumption continues to decline.

Expanding agriculture into tropical forests often is futile because the soils are poor or unsuited to continuous production. This is exacerbated by the shortening of fallow periods because of increasing demands for food. In addition, much good agricultural land now lies fallow, and an even larger amount is managed inefficiently and nonintensively. Improving agricultural efficiency, especially for the small farmer, could greatly reduce pressures on forests.

In Colombia, for example, small farmers produce three times as much food per hectare as do owners of large farms. But because of population pressure and land degradation, these same farmers do not now have enough land to pursue their traditional farming lifestyles, and increasingly they move into urban areas or into the forests of Amazonia, where there are now nine times more people than in the mid-1950s.

Cattle ranching causes widespread loss of tropical forests, particularly in Latin America. Overgrazing degrades pasture and limits forest regeneration. Compared with growing crops, raising livestock is a low productivity use of arable land. Much of the meat goes to the cities or is exported to developed countries, with the income primarily benefiting a small number of large landholders.

Commercial logging affects an estimated 5 million hectares of undisturbed forests each year, and this does not include estimates of illegal logging. Trade records from Thailand and the Philippines, for example, indicate that more trees are logged illegally than legally. Careless logging can lead to ecological damage that is much greater than simply the loss of the logged trees: often 30-60% of residual trees are injured beyond recovery. Large areas are often left bare, leading to soil loss. Logging machinery compacts the soil, reducing water infiltration rates, and increasing soil erosion. Most important, logging roads increase access for farmers who clear additional land for agriculture. Such unintentional opening up of forests occurs worldwide, and it is particularly serious in Amazonia and tropical Asia.

Success stories

The global system of conservation areas

- More than 3000 parks and equivalent reserves covering more than 400 million hectares have been established worldwide. The number of sites has more than doubled over the past 15 years, and many of these areas are in tropical forests. Preservation of wildlife and strict protection of areas such as parks are only one part of the much broader scheme of conservation. New land designations and management methods, allowing a variety of uses and types of exploitation, have been developed. The International Union for Conservation of Nature and Natural Resources (IUCN) is leading a major international effort to determine the gaps in ecosystem coverage in the global system of conservation areas.

Henri Pittier National Park in Venezuela protects tropical rain forest for the future.

• UNESCO's Man and the Biosphere Programme (MAB) promotes the establishment of Biosphere Reserves—multiple-use conservation areas containing both natural land and areas modified by human activity. Undisturbed core areas are managed to maintain biological diversity and ecosystem processes. As environmental monitoring sites, they serve as benchmarks for measuring long-term changes. Other zones of a biosphere reserve are managed to allow a variety of human activities, including farming or logging on a sustainable basis. There are now 59 reserves in 29 tropical countries alone, and several of these biosphere reserves are important centers of research on tropical ecosystems.

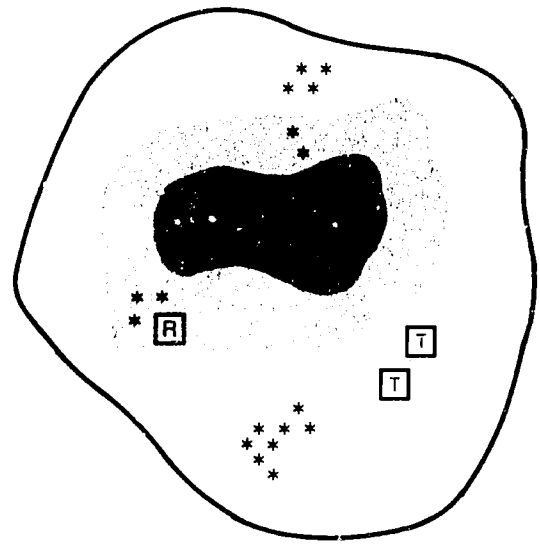
International conventions

• World Heritage Sites are designated by convention. They protect natural features considered to be of outstanding and universal value. So far, 57 "natural" sites have been designated under the convention, and 25 are in tropical countries.

• Important wetland areas have been recognized: 301 sites have been designated by 37 countries under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat. Some of these sites are in or adjacent to tropical forests and protect critical ecosystems such as mangroves.

• The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has monitored threatened and endangered species since 1975. The convention restricts trade in many tropical forest species, and 88 nations are now party to the convention.

A typical biosphere reserve



Core area
Buffer zone 1
Buffer zone 2
R Research station
T Tourism
Human settlements

Source: Man and the Biosphere Program, UNESCO.

Conservation data centers and national conservation strategies

• Conservation data centers collect and analyze information on critical ecosystems and species of a country or region. The data are used in setting conservation priorities and guiding land-use planning. Global databases on species and protected areas are maintained by the IUCN Conservation Monitoring Centre. National conservation data centers now exist in five tropical countries, and 24 others are planned.

• More than 40 National Conservation Strategies exist or are being developed worldwide. They are an outgrowth of the World Conservation Strategy developed by IUCN, the World Wildlife Fund, and the United Nations Environment Programme.

Protected areas to conserve tropical ecosystems

• The endangered mountain gorilla and its habitat are being protected in Parc National des Volcans in Rwanda, one of the world's poorest and most densely populated countries. Besides protecting a critically threatened species, the park protects an important watershed. Water yields are higher from the region because of the forest areas protected within the park, and farmers can reap multiple harvests including during the summer dry season. The development of the national park has received strong support from a consortium of international and developed country nongovernmental organizations.

• In Panama, 30,000 Kuna Indians live in more than 60 villages on the small, near-shore islands of the Caribbean coast. Working with the government and development assistance agencies, they have developed boundaries, multiple-use areas, and management plans for a 60,000-hectare tropical forest park. The site includes a core area of undisturbed, primary forest. Facilities are being built to carry out scientific research and to encourage tourism in the area. The Kuna are creating an environmental education program for their own people and they are helping researchers with studies of traditional agroforestry techniques.

• The Dumoga-Bone National Park, on the island of Sulawesi in Indonesia, covers 300,000 hectares. Over 90% of the park is primary tropical rain forest. It contains populations of Sulawesi's protected endemic mammals and many of the island's 80 endemic bird species. A major international research project is now underway. The Dumoga Irrigation Project was designed originally to increase rice production in the area; the park was planned with the irrigation project to protect the watershed. The World Bank channeled funds to international nongovernmental organizations (IUCN and WWF) to support the conservation elements of the project—an excellent example of the way nongovernmental organizations can complement the programs of development assistance agencies.

• Nonhuman primates are important in biomedical research. By 1970, there were signs of a shortage in animal stocks for research. The Pan American Health Organization, with the governments of Peru, Brazil, and Colombia, began maintaining a captive primate breeding center near Iquitos, Peru, taking genetic stocks from tropical forests in the region. The captive breeding program has helped curtail illegal trade in the primate species. As an outgrowth of the project, Peru is now collaborating with several groups to develop management plans for the Pacaya-Samiria National Reserve, and two additional sites are being evaluated to ensure protection of primates and other tropical forest wildlife.

Proposals for accelerated action

General strategy and policy issues

Tropical forests can only be conserved if the human pressures on them are reduced. Economic development and expanded social services are needed to improve the quality of life of the people who live in and around threatened forest reserves.

Natural forest management can yield many nontimber products of value to local populations and should be practiced wherever possible, especially to safeguard the way of life of indigenous peoples.

The full range of conservation techniques and designations should be used along with strictly protected zones or core areas. Multiple-use zoning and other land management techniques are more appropriate for the great majority of conservation units within tropical forests. Privately-owned lands and lands under lease agreements can contribute to the global system of protected areas. Incentives such as property tax relief and management agreements should be used to encourage private sector involvement. Good examples exist in India, Great Britain, Australia, Malaysia, South Africa, and the United States.

Governments should accede to the major international conservation conventions. They should endorse and implement the World Conservation Strategy, the Bali Action Plan, and the Biosphere Reserves Action Plan. Tropical forest conservation is a major goal of these international instruments.

Nongovernmental organizations are often more effective than government agencies in establishing and managing conservation areas. Their role in managing and conserving tropical forests should be recognized, expanded, and supported by development assistance agencies and national governments.

Off-site *(ex-situ)* conservation techniques, such as zoos, botanical gardens, and gene banks, are essential to conservation. Their use should be expanded. However, conservation areas serve as sources of the biological raw materials for all these activities, and therefore the highest priority must continue to be placed on protecting intact tropical forest ecosystems.

Governments and development assistance agencies should consider withholding investments from highway projects, hydroelectric development, and settlement programs in undisturbed tropical forest. Large resettlement schemes and related economic incentives often work against forest conservation and development. They should be used only when it is clear that degradation of primary forest will not result.

To apply this strategy, these important policy issues need to be addressed:

- There must be greater government commitment to conserving tropical forest resources. This commitment will come as conservation awareness increases and as the real costs of forest loss are made clear.
- Development agencies must consider conservation priorities in project planning, recognizing that conservation and development can be complementary.
- Government agencies need to be strengthened considerably. For example, more trained personnel are needed in most developing country departments of forestry, parks, and wildlife.
- Attention must be paid to the intangible benefits of tropical rain forests. The remoteness of these forests from the daily life of most people leads to public skepticism about the value of investment in their conservation. Difficulties in quantifying the long-term economic costs of tropical rain forest destruction will be the most intractable issue to resolve.
- Unregulated migration and national resettlement schemes continue to cause widespread forest loss. Governments must try to channel population growth and movement into areas already deforested.

Recommended actions for a five-year program, 1987–91

- Reduce pressures on tropical forests by intensifying agriculture on nonforest lands; incorporating trees into farming and pastoral systems; and establishing plantations on degraded, already cleared land rather than cutting undisturbed forest.
- Expand substantially the global system of conservation areas in tropical countries. All remaining tropical moist forests should be managed to ensure their long-term conservation and incorporation into national land-use plans. Only a few of the new conservation units designated should be national parks. Other types of zoning and management—such as forest reserves and wildlife management areas—should be used more widely.
- Establish additional conservation areas to include centers of origin of wild crops and other useful plant species; centers of high biological diversity; centers of high species endemism; areas considered suitable for long-term ecological monitoring and related ecosystem research in the tropics; and areas of primary tropical forest under extreme threat of conversion or destruction.
- Take immediate steps to minimize or eliminate further destruction or conversion of national parks and other conservation areas identified as being under severe threat of unlawful exploitation or encroachment. Examples of high-priority areas are given in the table.

Africa	*High-priority areas*
Cameroon	Korup National Park (proposed) Dja National Park (proposed) Pangar-Djerem National Park (proposed) Mt. Cameroon
Gabon	Forests in Gabon-Cameroon border region All protected areas
Ivory Coast	Tai National Park Mt. Nimba Nature Reserve (region)
Liberia	Sapo National Park Mt. Nimba Nature Reserve (region)
Madagascar	All forest on east side of island
Zaire	Garamba National Park Forests bordering Rwanda
Asia	
India	Andaman and Nicobar Islands Gir National Park Silent Valley National Park Manas Tiger Reserve Mangrove ecosystems Western Ghats (several areas)
Indonesia	Irian Jaya (several areas) Kutai Game Reserve Kalimantan (several areas) Siberut Kerinci-Seblat National Park
Papua New Guinea	Western PNG—Fly to Sepik Rivers Huon Peninsula
Philippines	Mt. Apo National Park
Thailand	Lowland forests on Malay Peninsula Thung Yai Wildlife Sanctuary Huai Kha Khaeng Wildlife Sanctuary
Latin America	
Bolivia	Entire protected areas system
Brazil	Southeast Atlantic Coastal forests Araguaia National Park Amazon basin: several areas

Colombia	Choco region Sierra Nevada de Santa Marta Amazonia
Costa Rica	La Amistad International Park Zona Protectora La Selva Corcovado National Park
Ecuador	Cuyabeno and Cururay Reserves Pajan and Paute Protection Forests Mangrove ecosystems Yasuni Research Station Amazonia Coastal forests of northwest
Nicaragua	Saslaya National Park Mosquitia forests near Honduras border
Panama	Darien National Park La Amistad International Park Kuna Indian Forest Park
Peru	Manu National Park Amazonia Coastal forests (Loma formation)
Venezuela	Peninsula de Paria National Park Sierra de Imataca Altiplanicie de Nuria Laguna de Tacarigua National Park

- Develop a national conservation strategy in most developing countries.
- Develop conservation data centers building on models that exist in Peru, Costa Rica, Puerto Rico, and Colombia. Formal links should be developed between the data centers, government agencies, international development assistance agencies, and nongovernmental organizations, especially IUCN's Conservation Monitoring Centre.

Investment needs

The estimated cost of a 5-year investment program for the 21 countries listed in the table is US$548 million. Investments in the following categories are proposed:

Development of sustainable agriculture near existing conservation areas to relieve pressure on tropical forests

Improvement of protection and management of existing conservation areas

New conservation units in various categories

National conservation strategies

National conservation data centers

Building national parks and wildlife agency capability

Conservation education, training, and extension

Conservation of tropical forest ecosystems

Summary of needed investments, 1987–91

Africa	*Million US$*
Cameroon	30.5
Gabon	12.7
Ivory Coast	23.7
Liberia	13.0
Madagascar	24.9
Zaire	23.8
Asia	
India	32.2
Indonesia	42.7
Malaysia	3[illegible]3
Papua New Guinea	10.0
Philippines	30.4
Thailand	27.7
Latin America	
Bolivia	31.3
Brazil	50.0
Colombia	30.0
Costa Rica	20.5
Ecuador	17.1
Nicaragua	17.4
Panama	20.9
Peru	35.6
Venezuela	19.6
Total (21 countries)	548.3

Strengthening institutions for research, training, and extension

The problem

In many developing countries, two of the most formidable constraints to expanding forestry are weak research programs and shortages of trained forestry personnel, including extension workers.

Because of inadequate data, weak monitoring capabilities, insufficient operating funds, and the shortage of trained personnel, many forestry administrations are unable to implement policies and effectively plan and manage research, training, extension, and other forestry programs.

Recruiting and retaining highly qualified and motivated researchers, teachers, field managers, and extension agents is often difficult, because of poor career opportunities, low prestige attached to forestry, and low salaries. In all regions, there are shortages of trained forestry staff, particularly at the vocational and technician levels. FAO has estimated that Latin America has the capacity to train a sufficient number of professional foresters, but in 1980 the region had a shortage of 12,000 forestry technicians.

Forestry training institutions have been neglected in many countries. Curricula for education and training must be revised to reflect the changing needs and priorities in forestry, particularly the emerging emphasis on farm and community forestry and local participation. Foresters, traditionally trained to protect government forest reserves and to manage them for industrial wood production, generally lack experience in working with local people and community groups and often are insensitive to their needs. There is an urgent need to increase the amount of practical training, to improve teacher training and training techniques, and to modernize and expand training centers.

Most forestry research institutions, particularly in Africa, are weak. They have shortages of trained researchers, equipment, and operating funds. As with training, forestry research priorities must be made more relevant to the problems facing developing countries.

Technology transfer is poor because of weak links among research, training, and extension and the lack of information sharing among countries. Few countries have well developed forestry extension services, and too often foresters are drawn to urban areas where career opportunities are greatest.

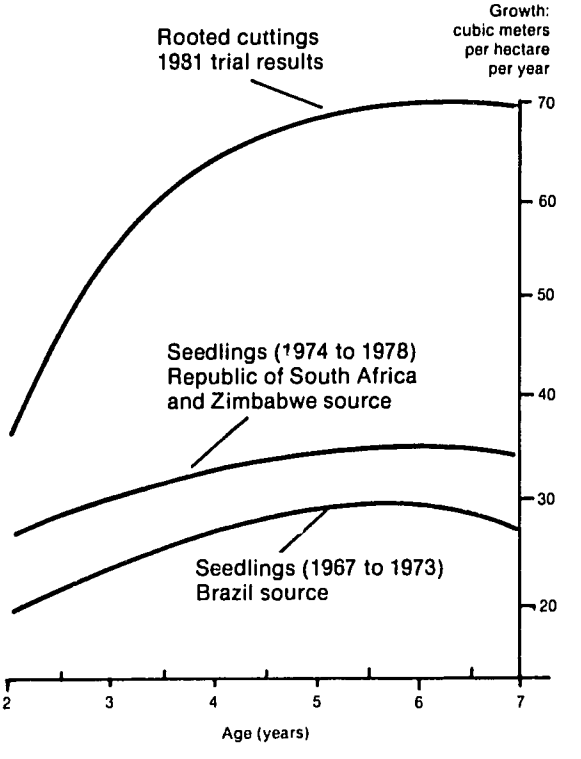
Success stories

Research

In temperate regions, forestry research has resulted in higher yield and commercial value of tree species through genetic improvement of planting stock and better management practices. Similar benefits could be expected for many tropical tree species on which research to date has been limited.

- The potential for higher yields from plantations through genetic improvement of trees has been shown dramatically by Aracruz Florestal, a Brazilian paper company. The first step in raising the yield of its eucalyptus plantations was to import seed from Africa to replace low-yielding trees in Brazil. Researchers then

The potential for increased productivity through genetic improvement of trees has been demonstrated in Brazil



Source: dos Santos, Ney Magno. A evolucao da pesquisa florestal na Aracruz Florestal, S.A. Unpublished manuscript, Aracruz, E.S. Brazil, 1983.

selected genetically superior trees, cloned them, and produced better planting stock, doubling plantation yields from 33 to 70 cubic meters per hectare per year.

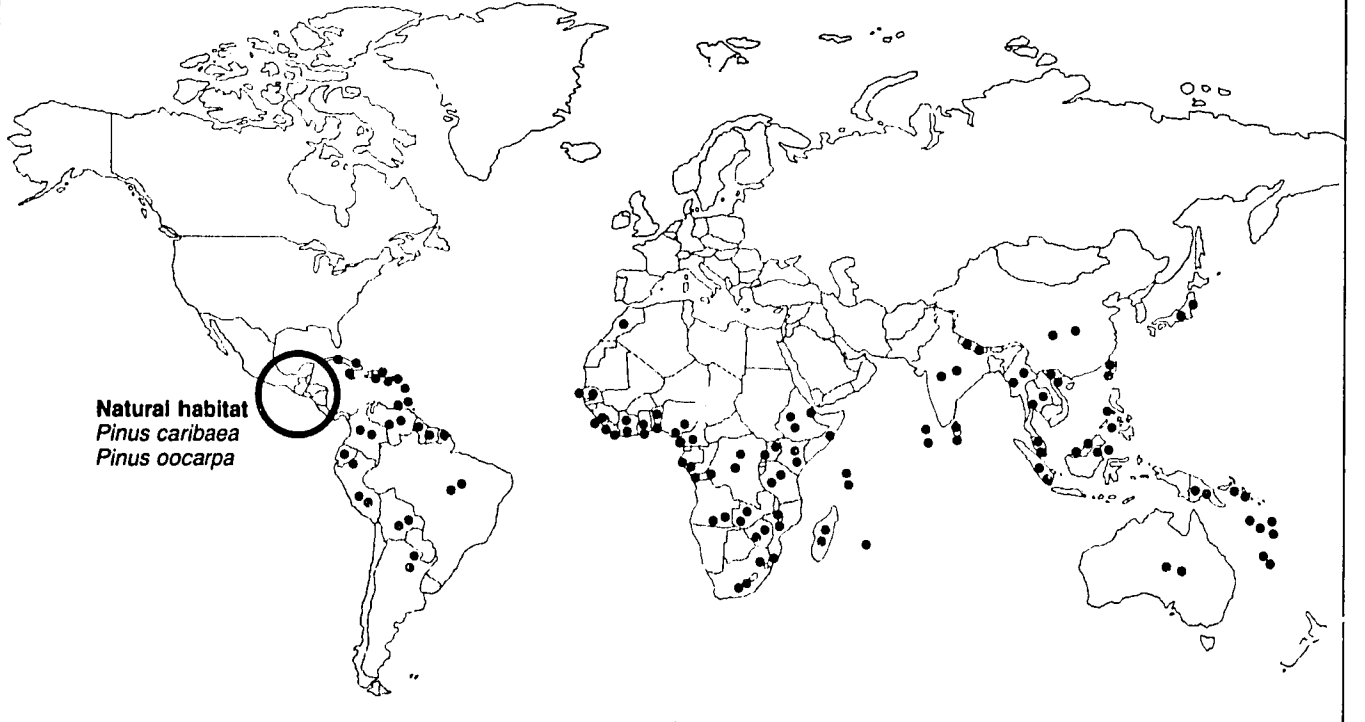
• Carton de Colombia, a forest products company in Colombia, pioneered research in the 1950s and 1960s on technologies for pulping mixed tropical hardwoods. At the time, Colombia faced a rising import bill for paper products, yet its large hardwood resource scarcely was being tapped commercially because the great diversity of tropical hardwood species made their use difficult. Pulping technologies were available for temperate softwood species but not for tropical hardwoods. The company's research on processing technologies has enabled it to use more than 265 tree species for pulping and to develop a large and successful pulp and paper industry important to Colombia's economy.

• By investing in wood utilization research over the past 20 years, Malaysia has been able to increase the number of tropical forest tree species it uses commercially from 100 to more than 600.

Research networks among countries can be highly useful for coordinating research, sharing information and materials, and carrying out training. Although well developed for agriculture (such as the networks of the Consultative Group for International Agricultural Research), only a few narrowly focused networks exist for forestry (for lowland tropical pines, eucalyptus, poplars, leucaena).

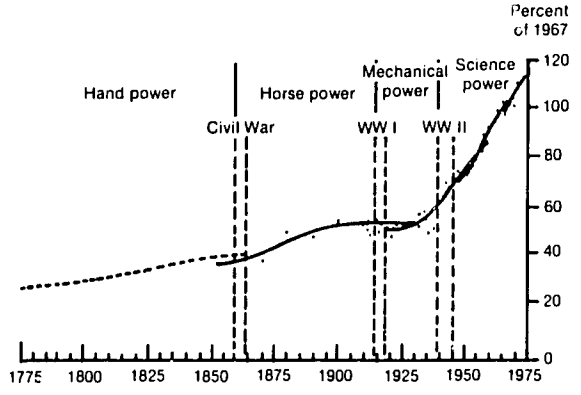
• The Commonwealth Forestry Institute (CFI) in Oxford has promoted the worldwide distribution and use of Central American tropical pines through its research network. When CFI started its work in 1962, large plantations of these species were being established with seed collected from only a small portion of their natural ranges, thus failing to take advantage of the species'

Research networks have helped bring about worldwide distribution and use of Central American tropical pines



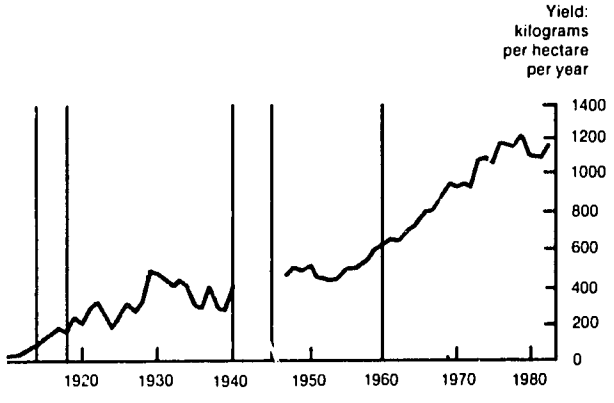
Source: Commonwealth Forestry Institute, Oxford, England.

Growth in U.S. agricultural productivity over 200 years (1775–1975)



Source: U.S. Department of Agriculture.

The impact of research and development on rubber production in Malaysia



Source: Malaysian Rubber Research Development Board

genetic variability. Through the networks, CFI has helped collect, distribute, test, and evaluate various genetic stocks of these pines. Hundreds of trials of two species have been carried out in 50 tropical countries. By exchanging seed, standardizing experimental design and assessment methods, and developing data management systems for information sharing, the networks have enabled countries to match the genetic material to a site, thereby increasing plantation yields.

Research has had a key role in agricultural development in temperate and, more recently, in tropical countries. Forestry can learn important lessons from agriculture.

- The most rapid increases in U.S. agricultural yields have occurred since 1930 as a direct result of intensified research and development.
- A 5.5-fold increase in rubber yields in Malaysia between 1920 and 1980 resulted from planting improved stock and better management, both made possible by research.
- International agricultural research centers and networks have had a great impact on agricultural yields in developing countries. Concentrated research efforts brought about the "green revolution," best shown by dramatic increases in wheat and rice yields.

Training

Many forestry training institutions have been established in the past few decades. Today, 190 institutions in Asia, 104 in Latin America, and 87 in Africa provide forestry training at the university or technical level. Most are new and small and still face serious problems, but some effective national and regional institutions have been developed.

- In the past 22 years the Department of Forest Resource Management at the University of Ibadan, Nigeria, has grown from 3 small rooms to a well equipped facility that is one of West Africa's leading institutions offering postgraduate forestry training. By 1979, it had graduated 223 B.Sc., 15 M.Sc., and 13 Ph.D. students, thus greatly strengthening Nigeria's capabilities in forestry.
- The College of African Wildlife Management in Mweka, Tanzania, serves anglophone Africa and has trained more than 1000 wildlife managers since 1963. Virtually all protected areas in east Africa employ Mweka graduates, and some graduates have attained high-ranking government positions. Mweka has served as a model for newly established national and regional wildlife schools in Africa and Asia.
- The National School for Forestry Sciences in Honduras is the only institution in Central America that provides training for forest technicians. Since 1969, it has graduated more than 500 students, conducted numerous short courses for regional forestry personnel, built an extensive physical plant, earned a reputation for high academic standards, and created a world-renowned seed bank.

Students at this forestry training center in Ecuador will go on to work for the Forestry Service.

A forestry extension agent demonstrates a chainsaw to members of a tree-growing commune in China.

• The Tropical Agricultural Research and Training Center in Costa Rica serves Central America and the Caribbean. It has trained more than 275 master's level students and provided specialized short-term training to more than 1000 professionals from the region. Its research programs have helped to improve research capabilities of national institutions and to strengthen regional cooperation. In-service training courses provide essential updating of skills and short-term training in areas not yet well developed in technical schools and universities. The center recently has given national and regional short courses in watershed management, agroforestry, park management, fire prevention, and fire fighting.

• The East-West Center's Environment and Policy Institute in Hawaii has extensive training and research programs in 5 program areas, including forest lands policy and water resources management. Over the past 10 years, the institute has hosted and trained hundreds of participants from Southeast Asia.

• The University of Michigan's International Seminar on National Parks and Other Protected Areas, sponsored by the U.S. National Park Service and Parks Canada and now in its 19th year, is a 4-week mobile course that provides senior-level park administrators from around the world an opportunity to compare various forms of park administration and management in North America. Its success has led to a similar course for forest managers from the developing world.

Twinning a developing country institution with one in another country is a cost-effective way to train staff and students, transfer information, and build up management capabilities. Examples in forestry include the State University of New York and the University of the Philippines; the University of Freiburg, Germany, and Curitiba, Brazil; and the University of Toronto and Universidad Nacional Agraria, Lima, Peru.

Extension

While effective forestry extension services in developing countries are still rare, several countries—such as Nepal, Kenya, India, South Korea, and Burkina Faso—recently have developed forestry extension programs.

• Extension has been an essential part of Nepal's Community Forestry Programme. A large number of field staff working locally and using written and audiovisual materials and mass media such as radio, have effectively promoted community forestry efforts and provided technical support to participating villages. Between 1980 and 1984, extension was important in establishing and managing 400 nurseries, planting 7500 hectares of plantations, and installing 6000 stoves.

• India has made considerable progress in adding forestry to agricultural extension training. Forestry staff have organized short courses in forestry techniques for village level agricultural staff who provide forestry advice to farmers and communities.

Proposals for accelerated action

General strategy and policy issues

Concentration of effort is recommended in 6 main areas. National governments and development assistance agencies should—

Strengthen the capabilities for policy formulation and planning by national forestry administrations.

Improve integration of agriculture and forestry in research, training, and extension through collaborative research programs, revised curricula, and restructuring of extension programs.

Emphasize agroforestry, socioeconomic factors in forestry and land use, low-cost technologies for rural forestry programs, and extension techniques in training programs.

Strengthen national research, training, and education institutions and develop stronger links between national and regional institutions.

Concentrate on a few high-priority research topics with high potential impact on rural poverty.

Involve local people in extension and outreach programs.

To apply this strategy, these important policy issues need to be addressed:

- Steps must be taken to raise the generally low political and financial commitment of national governments to forestry institutions.
- High-quality, committed staff must be recruited and retained; to do so will require that national governments upgrade career paths and reward structures for all levels of personnel.
- Governments need to examine incentive programs to encourage personnel to seek posts in rural rather than urban areas.
- A general skepticism toward research will have to be reversed before research will receive adequate financial support.
- The building of strong extension programs requires a commitment to retraining personnel on all levels; making structural changes in forestry, agriculture, or rural development departments; and allocating adequate financial resources to extension activities.
- Regional training and research institutions fulfill essential roles, but they typically suffer from serious financial constraints. Sustained international funding is essential to the continued development of such institutions until long-term financing can be found. Endowments should be used more widely to gain some measure of financial security.

Recommended actions for a five-year program, 1987–91

National activities

Sector planning and project preparation

- National governments, with the help of development assistance agencies, should carry out sector planning studies.
- The sector studies should examine the organizational structure and capacity of the forest department; forestry and related resource policies; research and training needs; and legislation that affects forest resources. Forestry codes, land and tree tenure laws, as well as agricultural, land use, and rural development laws should be revised to include incentives for tree growing at the farm and community level.
- Following these sector reviews, national governments should be helped to prepare and appraise forestry projects that could be suitable for support by external aid agencies. FAO's Investment Centre has played a leading role in this area in the past and it should be further strengthened to carry out this important work.

Research priorities

- Fast-growing, multipurpose tree species, including selection and breeding research to maximize sustainable yield of the desired products
- Biophysical and socioeconomic research on incorporating trees into farming and grazing systems
- Improved use of wood and nonwood products from native and introduced species including use of lesser known species, logging wastes, and minor forest products, ranging from appropriate small-scale technologies to large-scale, capital intensive applications
- Natural forest management for wood and nonwood products, including silvicultural research, harvesting research, multipurpose management of savanna woodlands, and basic ecological research
- Forest inventory, monitoring, and resource analysis.

Training

- Strengthen national training capabilities to meet needs for trained personnel at all levels.
- Strengthen regional training institutions to serve smaller countries without national facilities or to provide training in special subjects.
- Organize short courses to change attitudes and upgrade skills.
- Improve the content of forestry, agriculture, and natural resources training programs to put greater emphasis on agroforestry, fuelwood production systems, integrated watershed management, natural forest management, and conservation.
- Provide more fieldwork in training programs.
- Support twinning relationships between universities in developing and developed countries and similar links between universities in developing countries.

Extension

- Develop forestry extension capability within the forestry, agriculture, or rural development departments and ensure that it is adequately linked with research and training institutions.
- Develop extension materials, such as pamphlets, flipcharts, and audiovisual presentations.
- Increase the use of mass media and other outreach mechanisms to raise public awareness of the importance of forestry, to promote forestry as a rural development activity, and to provide useful technical information to local people.
- Increase participation of private voluntary organizations, community groups, and schools in extension work.

Regional and international activities

- Strengthen professional and technical training programs for Africa, including the new program in professional forestry training for warm regions at the National School of Waterways and Forest Rural Engineering in Montpelier, France, and the proposed Natural Resources Institute in the Ivory Coast.
- Expand agroforestry and farming systems research in Africa, particularly the programs of the International Council for Research in Agroforestry in Nairobi.
- Increase financial support for regional training institutions to cover operating costs and to provide scholarships.
- Fund the 5-year regional training project in Latin America proposed by the World Wildlife Fund. The project would review training requirements in natural resources and environment, guide technical and financial cooperation, support individual institutions, and sponsor activities to meet the needs of the region.
- Establish a separate fund within development assistance agencies to which developed and developing country universities and research institutions could apply for funds for twinning relationships, scholarships, conferences, and workshops.
- Strengthen FAO's ability to promote regional cooperation; to carry out regional workshops, training courses, and seminars; and to develop networks in watershed management, agroforestry, arid zone forestry, desertification control, and forest land-use assessment.
- Fund the forestry research networks being developed in Africa, Asia, and Latin America by the Special Program for Developing Countries (SPDC) of the International Union of Forestry Research Organizations. Support longer-term SPDC activities including training in forestry research management and execution, information transfer to developing countries, twinning arrangements, and an international fund for forestry research and training.
- Provide adequate financial support for the UNESCO Man and the Biosphere (MAB) Programme, particularly MAB's Project 1 on Ecological Effects of Increasing Human Activities on Tropical and Sub-Tropical Forest Ecosystems and Project 8 on Biosphere Reserves.
- Strengthen FAO's ability to develop extension materials, to advise regional instructors on designing extension programs, and to develop teaching materials and provide training workshops on forestry extension (such as the UNDP/FAO Asia and Pacific Programme for Development Training and Communication Planning in Bangkok).
- Support efforts to increase the participation and effectiveness of developing country nongovernmental organizations involved in tree planting and related rural development work (such as The Tree Project, based in the U.N. Non-Governmental Liaison Office, and the Environment Liaison Centre in Nairobi).

Summary of needed investments, 1987–91

International development assistance agencies generally allocate between 15 and 25% of their total forestry investment to research, training, and extension. Twenty percent of the total investments recommended here, or $1,064 million over the next 5 years, should be invested in institution strengthening activities. About 15-16% should be allocated to strengthening national institutions, while the remaining 4-5% should be devoted to the regional and international activities outlined above.

Strengthening institutions for research, training, and education

Summary of needed investments, 1987–91

Million US$

Activity	*Africa*	*Latin America*	*Asia*	*Total*
Fuelwood and agroforestry	68	100	155	323
Land use on upland watersheds	52	30	233	315
Forest management for industrial uses	43	141	140	324
Conservation of forest ecosystems	25	48	29	102
Total	188	319	557	1,064

Summary of total investment needs

Estimated costs* in million US$ for the period 1987–91

	Fuelwood & agro-forestry	Land use on upland watersheds	Indus-trial forestry	Ecosystem conser-vation	5-year totals
Africa					
Botswana	15	—	—	—	15
Burkina Faso	25	—	—	—	25
Burundi	20	—	—	—	20
Cameroon	—	—	20	31	51
Cape Verde	15	—	—	—	15
Chad	14	—	—	—	14
Congo	—	—	20	—	20
Ethiopia	40	100	—	—	140
Gabon	—	—	—	13	13
Ghana	—	—	10	—	10
Ivory Coast	—	—	75	24	99
Kenya	48	35	—	—	83
Lesotho	10	—	—	—	10
Liberia	—	—	15	13	28
Madagascar	30	10	—	25	65
Malawi	24	—	—	—	24
Mali	30	—	—	—	30
Mauritania	16	—	—	—	16
Niger	20	—	—	—	20
Nigeria	50	—	35	—	85
Rwanda	30	—	—	—	30
Senegal	25	—	—	—	25
Somalia	15	—	—	—	15
Sudan	35	—	—	—	35
Tanzania	30	—	—	—	30
Uganda	15	—	25	—	40
Zaire	—	—	10	24	34
Zimbabwe	—	46	—	—	46
Subtotal	507	191	210	130	1038
Asia					
Bangladesh	52	—	—	—	52
Burma	—	—	30	—	30
China	250	135	285	—	670
India	500	500	190	32	1222
Indonesia	—	100	50	43	193
Malaysia	—	—	40	34	74
Nepal	30	15	—	—	45
Pakistan	40	45	20	—	105
Papua New Guinea	—	—	15	10	25
Philippines	—	120	40	30	190
Sri Lanka	30	—	—	—	30
Thailand	—	—	35	28	63
Subtotal	902	915	705	177	2699

	Fuelwood & agro-forestry	Land use on upland watersheds	Indus-trial forestry	Ecosystem conser-vation	5-year totals
Latin America					
Argentina	—	—	100	—	100
Bolivia	25	—	—	31	56
Brazil	400	10**	325	50	785
Chile	—	—	50	—	50
Colombia	—	50	45	30	125
Costa Rica	15	—	15	21	51
Ecuador	—	15**	20	17	52
El Salvador	10	—	—	—	10
Guatemala	—	—	15	—	15
Haiti	15	—	—	—	15
Jamaica	—	10**	10	—	20
Mexico	—	—	90	—	90
Nicaragua	—	—	—	17	17
Panama	—	20**	—	21	41
Peru	25	20**	30	36	111
Venezuela	—	—	25	20	45
Subtotal	490	125	725	243	1585
Total	1899	1231	1640	550	5320***
	36%	23%	31%	10%	100%

*All totals rounded
**Preliminary estimate, pending additional research
***Approximately 20% of this investment would be allocated to research, training, education, and extension.

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All photographs in this report are from the archives of the United Nations Food and Agriculture Organization except the National Geographic Society's photograph on page 12 and the photograph of the Henri Pittier National Park in Venezuela on page 34 by F. William Burley.

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The World Resources Institute is a policy research center created in late 1982 with a grant from the John D. and Catherine T. MacArthur Foundation to help governments, international organizations, the private sector, and others address a fundamental question: How can we meet basic human needs and nurture economic growth without undermining the natural resources and environmental integrity on which life, economic vitality, and international security depend?

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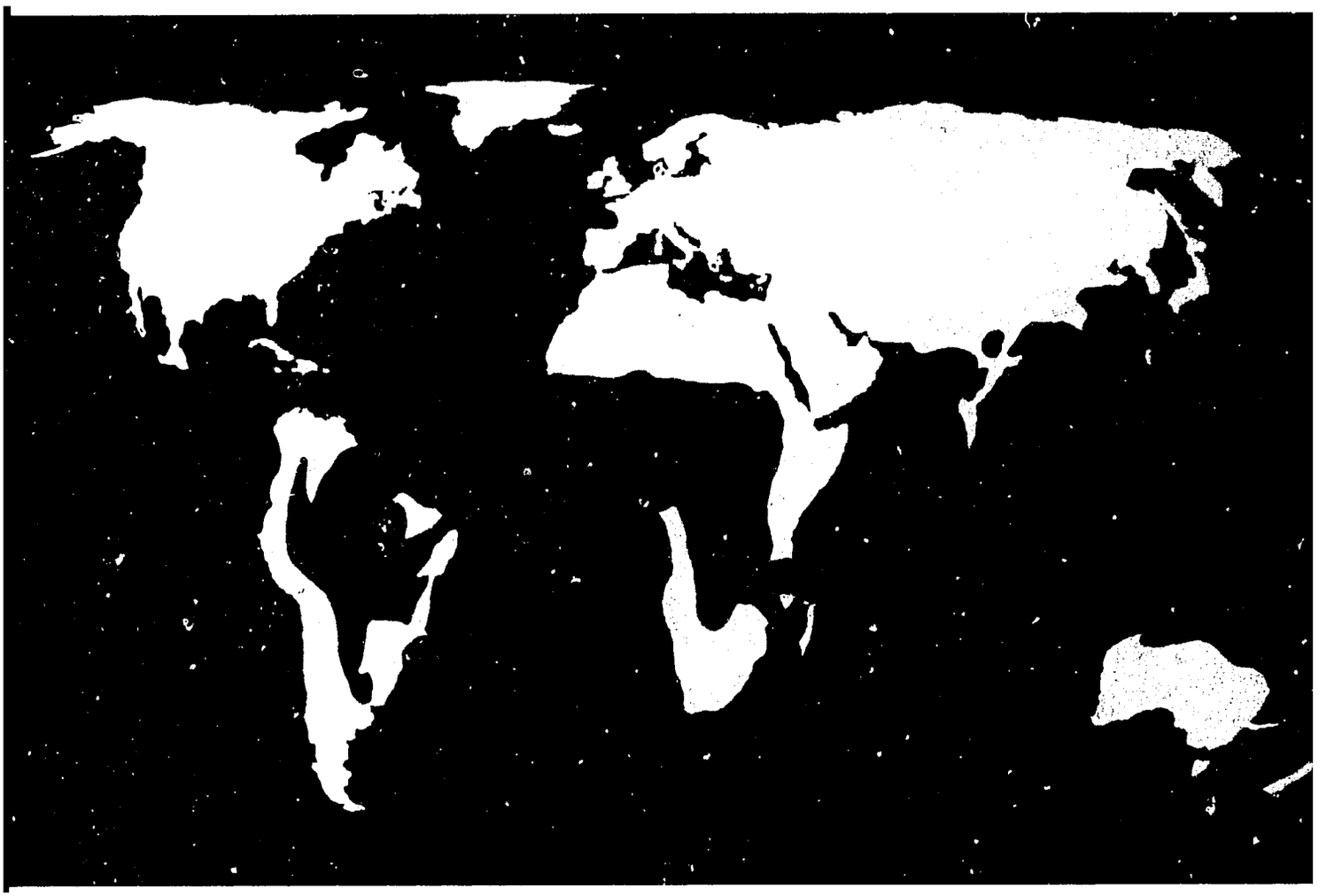
Part II Case Studies

Tropical Forests: A Call for Action



Report of an International Task Force convened
by the World Resources Institute, The World Bank,
and the United Nations Development Programme

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Tropical Forests: A Call for Action

Part II
Case Studies

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World Resources Institute

October 1985

Each World Resources Institute study represents a significant and timely treatment of a subject of public concern. WRI takes responsibility for choosing the study topics and guaranteeing its authors and researchers freedom of inquiry. It also solicits and responds to the guidance of advisory panels and expert reviewers. Unless otherwise stated, however, all the interpretations and findings set forth in WRI publications are those of the authors.

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In this report, the term "tropical forests" refers to forests in the humid and semiarid/arid areas of developing countries. Thus, the term includes forest formations ranging from moist (or closed) tropical forests to dry (or open) woodlands. In a few instances, developing countries with temperate forests are also included.

Fuelwood and agroforestry

The following examples of successful fuelwood and agroforestry projects reflect varying social, cultural, and land tenure situations, and they take into account the economics of forestry in different marketing situations. The case studies cover a wide range of ecological conditions. They show, for example, that solutions for forest protection in the arid Sahelian zone differ markedly from those needed to protect and develop forest resources in areas with favorable ecological conditions, such as the east African and Central American uplands and the temperate Himalayan uplands.

Farm and community forestry

Where access to wood from a forest is limited, intensively managed trees on farmlands may account for 60 to 90% of the fuelwood, fodder, or timber used by a household. Different pollarding,[1] coppicing,[2] and pruning techniques have been reported in many parts of the world—such as Bangladesh, Burkina Faso, the Philippines, and India—that allow a sustained yield of wood or fodder from trees in farmfields. The lifetime yield of a tree used in this way can be much greater than the volume it will produce if it is simply allowed to grow and is then felled for use of its stem volume. Freestanding farmtrees managed in this way can produce more than five times the volume of individual trees grown in block plantations.

Voluntary tree-planting programs produce impressive results when local people believe that such activities are feasible and in their interest. In the mountain village of Nyandira, Tanzania, almost every family has a private tree plantation, and most individuals claim to have planted at least 100 seedlings.

In the area of Fatick, Senegal, almost all heads of household have engaged in tree planting on their own and with good success. In Panama, fruit trees are planted on almost every small farm. Nearly half the farmers interviewed in the Valle Occidental region of Costa Rica said they had planted trees as windbreaks. In Peru, spontaneous private tree planting accounts for about 30% of all trees planted, even though the government only sponsors large-scale reforestation.

Many tree-planting programs were launched with the aim of producing more fuelwood. However, it has become clear that people are particularly interested in planting trees that provide fruit, fodder, and building poles, as well as fuelwood. The availability of multipurpose tree species helps to increase significantly the involvement of small landholders in tree growing.

In Central America, the Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE) has explored new ways of introducing different types of trees into small-farm production systems. CATIE persuaded 900 farmers in the Piedades Orte area of Costa Rica to plant 50,000 trees by encouraging them to try different planting strategies, such as live fences, shade trees, and windbreaks. A variety of multipurpose species were made available at local nurseries, and farmers were quick to incorporate trees into their farming systems. In a recent survey, these farmers gave no single motive for planting; they always mentioned secondary or complementary as well as primary uses for the trees they planted.

Farming systems that incorporate trees have the potential for being more productive and sustainable than those that do not. Not only does the farm produce wood, fruit, and other products along with cultivated annual crops, but integrating trees and farm crops in agroforestry systems decreases farmers' exposure to environmental risk by increasing the stability of the farming sytem. Furthermore, trees often grow better on agricultural lands because of better site conditions. Most important, agricultural crops often grow better because trees help to maintain or even increase soil fertility.

[1] A silvicultural technique that makes use of a tree's natural ability to resprout from the stump after harvesting.

[2] A system that involves lopping the upper part of the stem of the tree when it reaches 20-30 feet in height and then periodically pruning branchwood.

Farm forestry in Kenya

A recent study of tree cover in the Kakamega District of Kenya, which is under intense population pressure, revealed that 72% of rural households had voluntarily planted trees on their land. A survey of farmers who had planted trees found that people had planted them for a variety of purposes: for fruit, for shade, ornamentally, as boundary markers, and for windbreaks. Few trees were planted explicitly for fuelwood, but farmers expected to obtain some fuelwood from trees planted for other purposes.

The survey also revealed that 38% of the farmers were raising seedlings. Many farms raised very small quantities of seedlings, but it appears that on-farm nurseries (89,000) far outnumber and even outproduce the state-managed Forest Department nurseries and do so at virtually no cost to the government. This conforms with experience elsewhere (India, Nepal, Haiti) and suggests that the most cost-effective way to raise seedlings for rural afforestation is for local people to establish their own low-cost nurseries in the area where the trees are to be planted.

Percentage of Kakamega farmers engaged in on-farm forestry activities

Activity	Percent
Raising seedlings	38
Buying seedlings	43
Collecting seedlings	45
Direct seeding	26
Planting seedlings	72

Another noteworthy feature of Kenya farm forestry experience is the extent to which coppicing and pollarding contribute to local wood production. The pollarding of *Grevillia* trees growing on agricultural lands is common. Pollarding of these trees may be carried out 15 or 20 times over a span of 50 years. Whenever the farmer decides the tree is large enough or that he needs the money, the trunk is felled and sold for timber. Similar experience with neem trees has been well documented in Nigeria, where it was demonstrated that pollarding can increase yields, particularly where ground-level shoots would be subject to animal grazing or bushfires.

Agroforestry outreach in Haiti

Haiti has the lowest annual per capita GNP (US$260) and one of the highest ratios of people to arable land in the western hemisphere. It faces extreme land-use pressures and declining agricultural production, which are being aggravated by severe deforestation.

Eighty percent of Haiti was forest as recently as 1950, but forests now cover less than 10% of the country. People depend on fuelwood and charcoal for 90% of their cooking and heating needs. At the current rate of depletion, supplies of fuelwood and charcoal will probably be exhausted within 15 years. Earlier efforts to plant trees emphasized environmental benefits and erosion control, but they have not been very successful.

In 1981, the U.S. Agency for International Development (USAID) funded an US$8 million Agroforestry Outreach Project to promote the planting of trees as a cash crop, to motivate farmers to plant trees in their fields, and to learn more about the technical, economic, and social feasibility of reforestation in Haiti. After six planting seasons during 1981-84, 20,000 farmers have responded to the extension efforts and decided to plant trees. More than 13 million seedlings have been planted, and it is projected that more than 16 million trees—or double the design target—will be planted by the end of the project.

USAID provided grants to three private voluntary organizations (PVOs) to implement the project. Operation Double Harvest (ODH) has responsibility for experimental work with nursery techniques, large-scale tree plantations for charcoal production, and producing and distributing seeds and seedlings. The Pan American Development Foundation (PADF) and Cooperative for American Relief Everywhere (CARE) are responsible, either directly or through subproject grants, for training and supervising a network of extension workers to promote the distribution and oversee the planting and care of the tree seedlings. CARE and PADF are also involved in research that aims to increase the effectiveness of their agroforestry efforts.

Many farmers have taken part in the project because they have been convinced of the benefits of planting trees as a cash crop. Small, easily carried seedlings of fast-growing species are distributed at no cost to farmers who want to establish a small "tree farm." Most farmers annually plant 250-500 trees, equivalent to a block planting of about one-tenth of a hectare.

Despite the obviously damaging effects of deforestation, farming marginal land, and overgrazing steep slopes, it appears that Haitian peasants will not change their ways just to "protect the soil," even if they recognize it will result in long-term declines in yields and environmental degradation. Rather, they are forced to think about satisfying today's needs for food, wood, and fodder. However, farmers will engage in activities that are seen as income-generating in the relatively short-term. Most farmers in Haiti are experienced in growing cash crops and do not consider themselves subsistence farmers. Tree farming for the production and sale of wood for charcoal, poles, and fuelwood seems to meet the farmers' test of "profitability" in most areas of Haiti, and they are quick to accept free seedlings.

The project has also proven the value and efficiency of working through PVOs that are familiar with the local cultural environment and have already established grassroot networks of people committed to rural development. Through CARE, PADF, and the more than 50 local PVOs that have obtained subproject grants through PADF, the project has been able to mobilize quickly a large number of "moniteurs," "animateurs," and "coordinateurs," who have been trained and organized into an extension network for agroforestry and tree-farming efforts. Project success is closely linked to the selection, training, and supervision of these extension workers who have ties with the local communities.

The efficient management of nurseries, seedling distribution systems, and related socioeconomic and technical research have also had a key role in the success of the project. A final factor has been the relatively secure land tenure of Haitian farmers.

Cash-crop tree farming in India

In areas where tree resources have become increasingly scarce, wood has gradually entered into the market economy. The markets for building poles, fuelwood, and charcoal can be substantial, and in some situations have provided a significant incentive for farmers to take up farm forestry.

The demand for wood-based commodities has been the driving force behind most cash-crop tree farming success stories. Perhaps the most widely reported example is Gujarat, India, where markets for construction poles (and for fuelwood) have provided a significant incentive for farmers to plant trees. This scheme was started by the state's Forest Department in the early 1970s as one part of its social forestry program. The purpose was to encourage farmers to plant seedlings on unused or marginal lands around their holdings.

As the project evolved, some farmers realized that it was more profitable to grow trees instead of the usual cash crops, primarily cotton. Trees turned out to have several advantages over conventional crops.[1] For instance, it was found that farm forestry was less labor intensive, and labor requirements could be spread out more evenly over the year. This meant that trees could be harvested during dry seasons when demand for labor was less. Reduced labor demands lessened household labor requirements and reduced management problems where farm laborers had been hired.

Tree farming, primarily with eucalyptus, has turned out to be very lucrative in Gujarat. Because of high market prices for building poles, the rate of return from growing trees on irrigated and fertilized lands is now quite high. A financial analysis of tree farming by one of Gujarat's first farm foresters (who intercropped eucalyptus and cotton during the first year) showed investment costs of around US$1700 per hectare and total returns, after 5 years, of US$5900 per hectare. While the internal rate of return was 129% in the first rotation, it increased to 213% for each successive coppice crop.

Farmer response to the profitability of this type of farm forestry has been impressive. The rate of planting increased fourfold between 1975 and 1979, from 12 million to 48 million seedlings per year, doubled again to 100 million by 1981, and yet again to 195 million by 1983. With a state population of about 15 million, this amounts to an average annual planting rate of more than 10 trees per person. At least 10% of Gujarat's farming population has been involved in farm forestry, and by 1983 the equivalent of more than 150,000 hectares had been planted. About 20% of the seedlings in 1982 were distributed to farmers on land holdings greater than 4 hectares, about 45% to farmers on holdings of between 2 and 4 hectares, and about 35% to farmers on holdings of less than 2 hectares.

[1] In some cases, farmers have invested in tree farming because, in addition to high returns, the incentives to produce cotton, the next best-paying cash crop, have been constrained by the pricing policies of the government's Cotton Marketing Board.

An important feature of this project has been the involvement of schools and private farmers in growing seedlings under guaranteed buy-back arrangements with the government's Forestry Department. The number of school nurseries increased from 100 to 800 over a 4-year period. In 1984, school nurseries raised 7% of all the seedlings in the State. Similarly, the number of private nurseries has increased from 563 to 884 in a 3-year period, accounting for 13% of all seedlings raised in the State.

Initially, farmers could obtain as many as 10,000 seedlings free.[2] At a cost of about US$2 per hundred seedlings, this represented a significant subsidy for farmers who chose to take advantage of the program—especially considering the wage rate of an agricultural laborer of about US$1 per day.

Another noteworthy feature of the Gujarat experience is the successful introduction of low-cost technologies for distributing seedlings. Farmers are given bamboo baskets about a half meter in diameter and several centimeters deep in which about 2,000 eucalyptus seedlings have been germinated. These baskets can be transported more easily and over longer distances than if the same number of seedlings had already been transferred into the commonly used polyethylene pots. When farmers return home, they can transplant the young seedlings into larger containers and are encouraged to sell them to other farmers.

The Gujarat farm forestry experience has not been without its critics. The criticism can perhaps best be understood in light of the fact that the main goal of the activity was to produce fuelwood, but the primary output has been construction poles. However, farmers have had little interest in growing trees only for fuelwood when the markets for construction poles are much more profitable.

Despite this, a large amount of fuelwood is being produced as a byproduct of construction pole production. Thinnings, warped logs, "tops," and nonmarketable poles account for perhaps a third of total production, and these are most often used for fuelwood. In addition, some trees are being planted explicitly for fuelwood production, but there are relatively few of these when compared with those planted for construction poles. The fact remains that farmers will be unlikely to plant trees primarily for fuelwood until it becomes more profitable for them to do so.

Variations of the Gujarat program have been adopted in many other Indian states. One of the largest programs is in the state of Uttar Pradesh where seedlings are, for the most part, provided to farmers at cost. During the 1982–83 planting season, 156 million seedlings were distributed—nearly 30 times the number planned. Seedling production now has to be greatly increased in order to meet the demand.

Forestry for the landless in India

Most farm forestry activities have been carried out on private land where small landholders have been assured of receiving the benefits of tree growing. A few programs, however, have successfully involved landless people by making state-owned lands accessible to them on a leasehold basis.

In Gujarat, for instance, shifting cultivators have been settled on degraded lands and given formal land-use rights, although they are not given official title. Each family is allocated 37.5 hectares of degraded land, which are planted with trees at a rate of 2.5 hectares a year over 15 years. Groups of 10 to 12 families are usually allocated land in a single block. Land preparation is carried out by the Forest Department, and seedlings and other inputs are provided free. The family is given responsibility for protecting and managing the trees and is paid for 25 days of work per month. Families are settled on adjacent lands and allowed access to the plantation to collect building materials and other forest products. The trees officially belong to the Forest Department, but the settled families receive 20% of the net profits after they are harvested. By 1982, close to 18,000 hectares of degraded forests had been planted under this scheme.

A program now underway in the Indian state of West Bengal has successfully promoted the involvement of landless farmers in reforestation of denuded government-owned land. West Bengal is representative of densely populated, intensively farmed, subhumid areas. Population

[2]Because farmers on large landholdings are better able to take advantage of these potentially large subsidies and because of consequent concerns about equity issues, it is very likely that the number of freely distributed seedlings will be restricted in the future to as few as 200 per farmer.

density averages 615 persons per square kilometer, and 63% of the land is cultivated. Less than 15% of the area is still forested and 6%, or nearly 550,000 hectares, is uncultivated, deforested "wasteland." These government-owned lands support some grazing during the rainy season, but they are generally unproductive. Neither the government forestry department nor any other state agency has had the personnel or other means to restore and manage these once-productive lands.

With assistance from the World Bank, the West Bengal Social Forestry Project was launched in 1981 with the goal of increasing wood and fodder supplies in the region. A variety of approaches were planned: demonstration plantings of community woodlots; strip planting along roads, irrigation canals, and railroad rights-of-way; distribution of seedlings in rural areas and promotion of on-farm tree planting by individuals; and reforestation of degraded lands.

After a modest beginning, the project has gained momentum and will undoubtedly surpass the 6-year target of 93,000 hectares of tree plantations. In the 1984–85 planting season alone, 24,000 hectares of trees were planted by more than 51,000 farmers participating in the various project activities. Total program costs for 1981–86 are expected to be US$43.5 million.

During the first 4 years of the program, the Forestry Department was able to replant 14,430 hectares of degraded forest and oversee the planting of 10,147 hectares of strip plantings. Despite much effort to persuade local leaders to organize community woodlots, this part of the program has not generated much enthusiasm, so only 1639 hectares have been planted in 4 years.

In contrast, the increased production and widespread distribution of fast-growing, multipurpose species (primarily *Eucalyptus* and *Acacia auriculiformis*) has proved very popular. More than 100,000 farmers and small landowners have responded to the availability of seedlings, and by 1984 they had planted nearly 37,000 hectares of on-farm woodlots. The trees are recognized as being drought-hardy, tolerant of animal browsing, and capable of vigorous regrowth after cutting.

Most of the farmers plant less than one-fourth hectare annually (about 275–325 seedlings), and 76% of those participating in 1982 had holdings of less than 2 hectares. A recent evaluation determined that the program had involved 10 to 15% of the population in farm forestry in its first few years.

The project has responded to the desire of landless people to participate in tree planting. Early in the project, it was recognized that the Land Reform Authority was committed to providing land for the landless and, at the same time, the Forestry Department recognized that it could never adequately protect, restock, and manage large areas of unproductive land without the support and participation of local communities. Accordingly, the government endorsed a policy to accelerate the transfer to landless farmers of government-controlled land that had been deforested and heavily grazed. As a result, land deeds ("patta") were given to these landless people. The new owners did not have the right to sell the land, but they were entitled to all the benefits of using the land.

Because most of the "patta" lands were eroded lateritic soils unsuitable for irrigation, agriculture was not a profitable venture. However, demonstration plantings convinced people that a relatively low investment in tree planting could pay handsomely: after 8 years, a plantation could generate about US$1600 to US$3200 per hectare, depending on the specific site condition. Seedling costs totaled about US$63 per hectare for 2000 seedlings (2.5-meter by 2.5-meter spacing, plus 25% replacement). Labor was required for hole digging, planting, mulching, and protection. To increase the efficiency of extension efforts and to make the task of protection easier for the farmers, the Forestry Department allocated adjacent parcels to groups of households.

To encourage the poorest farmers, the program provided free seedlings, fertilizer, insecticide (to control termites), and incentive payments over the first 3 years after planting. The incentive payments were tied to the number of trees planted and surviving. A few years into the program, the cash incentive payments were dropped, but the Forestry Department continued to provide tree seedlings, fertilizers, and other assistance. The forestry extension agents also made a point of assisting the most willing and committed members of the community in order to later convince others by the example of their neighbors' success. In addition, the use of fast-growing species was promoted so the farmers not only benefited from a relatively short rotation for poles but were able to use twigs and branches for fuelwood within a few years.

The number of landless people who benefited from the program more than doubled each year between 1981 and 1984, and the area of land transferred has grown from less than 100 hectares in 1981-82 to 360 hectares in 1982-83, 2000 hectares in 1983-84, and more than 5000 hectares in 1984-85.

The West Bengal program has encountered several problems. Delays in meeting goals for staff training, infrastructure improvements, and occasional problems with low survival or growth rates of seedlings can be largely attributed to shortages of local staff. In particular, the initial lack of extension foresters led to reliance on the "territorial" agents of the Forestry Department who lacked the special extension skills and approach needed to implement a program of this type.

Fortunately, the program included a variety of approaches to promote tree planting because not all efforts proved to be cost-effective and socially feasible. Less than 2000 hectares of community woodlots were planted, accounting for barely 3% of the 63,077 hectares planted by 1984. This approach cost nearly three times as much as farm forestry, and local participation was constrained by several other factors. It was difficult for the village leaders to organize a collective effort, even where the communities were quite homogeneous. Also, individual families hesitated to become involved because of a feeling that the benefits to a family were uncertain and would be small. Questions about protection of planted seedlings were unresolved, and surveys indicated that 70 to 100% of the communities polled felt that land was not available for such an undertaking.

The initial success of the strip plantations was also threatened by local concerns about the benefits of such plantations. Early surveys showed that 70% of the people living near the plantations were "indifferent" to them—apparently because they had no sense of how they would benefit on an individual basis and were sensitive to the loss of grazing rights in the planted areas. As a result, the Forestry Department is meeting with the concerned communities to devise a system whereby benefits from the strip plantations would be distributed equitably.

The farm forestry approach itself has been somewhat constrained by limits on seedling production from government nurseries and the need to recruit and train large numbers of extension agents. Recently, efforts have been increased to involve private farmers in the production of seedlings, and recruitment and training of extension agents have been accelerated.

Finally, there has been some controversy over the transfer of government lands to the landless because it represents a major shift in the traditional policies of the Forestry Department. Foresters in India, as elsewhere, have a tendency to look at the forest estate as their land, entrusted to them for protection against encroachment and use by the local populace. Traditionally, the Forestry Department's involvement in the management of these lands was oriented toward producing commercial wood products.

It will take time for foresters to adjust to this new role: negotiating with villagers to take over management responsibilities and assisting the villagers in agroforestry techniques for increasing food and fodder production and income from the sale of poles and fuelwood. However, new attitudes and perceptions are emerging, as indicated in this statement by the Divisional Forest Office, East Midnapore Division, West Bengal:

> The forestry programmes which bring forestry closer to the people are one of the best weapons to combat and halt for good the wanton destruction of forests. It must be accepted that the forest is a system with people in it and that for forestry development to proceed and succeed the people in the system must also be considered and taken into account.

As a result of the West Bengal experience, more and more people in and outside the forestry profession realize the benefits from such nontraditional approaches to involving the landless in tree planting. In West Bengal, the following conditions have led to the successful results achieved to date—

- Intense pressure on available farmland, with large numbers of people without access to adequate holdings of fertile land and willing to invest their effort in restoring land that has been cutover and heavily grazed
- Recognition by the Forestry Department that operational constraints—such as limited staff and logistical support—will prevent it from intensively managing all the government-controlled forest lands, particularly when these areas are used as common grazing lands
- Availability of sufficient government land to enable large numbers of landless people to participate and lease or gain title to plots large enough (1-2 hectares per household) to generate significant income

- Existence of incentives for planting and managing tree crops, including open local markets for poles, fuelwood, charcoal, and other forest products or local demand for green manure from fodder (these incentives must be combined with a favorable legal and policy environment regarding individual control over protection and harvesting to ensure that people will directly benefit from their efforts)
- Ability of the Forestry Department to mobilize local interest, organize local participation, and provide the technical assistance and other help needed by farmers to successfully plant, protect, and manage their tree crops

Reforestation and improved management of privately- and communally-owned forests in Korea

Nearly three-quarters of the forest lands in South Korea are privately owned; yet a lack of policy guidance and support at the village level in the past resulted in progressive overcutting and depletion of large areas of these forests. Much of the overcutting was due to fuelwood harvesting because most of the country's household energy needs for cooking and heating in both rural and urban areas had traditionally been met by burning wood.

In response to increasing problems of soil erosion and flooding caused largely by denudation of steep slopes, the government of Korea launched a Village Fuelwood Program in 1973. The program centered around the establishment and intensive management of tree plantations to meet village fuelwood needs. Within 5 years, more than 1 million hectares had been planted, including 240,000 hectares of woodlots, to supply the needs of about 20,000 villages; 600,000 hectares of existing fuelwood plantations and more than 3 million hectares of additional forest land were brought under more intensive management; and more than 3 billion seedlings were produced and planted.

To organize local community participation, the government encouraged the establishment of Village Forestry Associations (VFAs). The VFAs were locally elected organizations that operated as village cooperatives. Financial support for reforestation was provided through a specially created Village Forestry Authority. Seedlings, fertilizer, and other materials were subsidized to encourage participation in the program. During 1973–78, total program costs were US$600 million.

Community forestry was introduced in Korea as part of the Saemaul Undong—the New Community Movement—which was initiated to balance the rapid growth of the industrial sector with the development of the rural economy through self-help programs at the village level in agriculture, forestry, and fisheries. The Forest Development Law of 1972 empowered the government to require landowners to reforest private lands through community-based efforts. In return, the villagers could keep 10% of the output from their lands. Owners entered into contracts with the local VFAs. At first, local participation was the result of authoritarian government pressure, but the VFAs provided an exceptionally strong base of local support that helped make village forestry a popular movement.

A key feature of the Korean approach to the fuelwood problem was its holistic nature. The Koreans attacked the fuelwood problem on all fronts—including not only a massive planting effort but also improved end use and appropriate use of substitute fuels.

To reduce fuelwood consumption, the government began efforts to improve the efficiency of the traditional "ondol" system for heating and cooking. A more efficient system of underfloor heating developed at the Forest Research Institute can reduce fuelwood consumption by 30%. The new system is now in widespread use.

The sale of fuelwood, particularly to city residents, has been prohibited. This has helped reduce demand for fuelwood at the local level and reduced illegal cutting for fuelwood sales. At the same time, the government pushed ahead with rural electrification. As a result of increased as well as more efficient use of electricity, fuelwood consumption fell from 55 to 19% of total energy consumption between 1966 and 1979.

Several factors contributed to the success of the Korean program—

- There was a commitment by the government and villagers to balanced economic and rural development.
- Villagers had a strong tradition of community spirit directed toward improving living standards, which facilitated participation through VFAs.
- Villagers were encouraged by the potential for early returns from plantations because of favorable climatic and ecological conditions and the use of suitable fast-growing species.

- The consistently strong government policy encouraging private landowners to plant or give up nonagricultural land was important in making land available for planting. New laws also resolved ambiguities about the villagers' responsibilities for protecting their own forest resources.
- Through the locally-organized VFAs and the government Village Forestry Authority, bottom-up and top-down participation and planning were effectively combined.
- Because of the efficient administration of the program by the Village Forestry Authority, villagers were provided with the financing, materials, and information they needed promptly and regularly.
- The program was supported by well designed research and development to select the most appropriate species and planting techniques.

Community forestry in Nepal

In Nepal, a community forestry program is underway that attempts to build on traditional systems of communal forest management. Historically, communal forests around villages in the hills of Nepal were managed by the local people. Management was based on rules defining the use of dead wood for fuel and the felling of standing timber for use as building material.

In 1957, the government nationalized all forests with the aim of introducing more intensive forest management. Subsequent legislation included lands adjacent to the forests that had been left fallow for at least 2 years. In the absence of communal control, forests were progressively overused and degraded.

In response to the worsening situation, a new law was passed in 1978 that began to reverse nationalization by gradually transferring control of the forest back to local populations. Management was to be based on a new, higher level of local government—the panchayat. The government established a series of rules and guidelines to assist the panchayats in controlling the use of forest lands. To assist with these changes, a new Community Forestry and Afforestation Division was formed within the Forestry Department and a Community Forestry Development Project was initiated in 1980 with external assistance.

Two new forms of forest management were introduced—the Panchayat Forest (PF) and the Panchayat Protected Forest (PPF). Panchayat Forests are new plantations of up to 125 hectares that are planted and protected by the local panchayat on government wastelands. The panchayat has all rights to the produce of these forests.

Panchayat Protected Forests are areas of natural forest of up to 500 hectares that need protection and management. Panchayats that undertake these activities are allowed to keep 75% of the revenue generated by the forests. It was planned to eventually return 1.5 million hectares (45% of natural forest land) to panchayats that request it. Since the Community Forestry Development Project began in 1980, 8000 hectares of PPFs have been established and 7300 hectares have been reforested in PFs and PPFs involving over a third of Nepal's 79 districts.

Experience to date suggests that the panchayat may be too large an organizational unit to manage communal forests. Many of them cover a large area of severe terrain and lack basic communication and transportation facilities. Panchayats are often composed of a large number of heterogeneous groups which can make management of common lands difficult. Informal forest management systems have been found in 36% of the panchayats participating in the project, and virtually all have come into being since nationalization of the forests in 1957. These management units, at the level of the village or ward, seem to have a greater homogeneity of interests than the panchayat and may be a better and more effective way of addressing local concerns and needs.

Reforestation in China

For the past 30 years, forestry has been a subject of much attention in the People's Republic of China. The population of nearly 1 billion creates a great demand for wood for construction, cooking, heating, furniture, and paper products. Because funds for imports are limited, the wood must be supplied chiefly from the country's own forests, which total only 122 million hectares, or 0.13 hectares of forest per capita (one-tenth of that in the United States).

Reforestation and afforestation have had high priority. Using such slogans as "Green the Nation" and "Cover the Country With Trees," the leaders are enlisting the support and participation of the people. Forest area in relation to total area increased from an estimated 8.6% in 1949 to 12.7% in 1979. The national goal is 20% by the year 2000. China is reported to have reforested nearly 30 million hectares since 1949 and has an additional 136 million hectares classified as potential forest land.

The afforestation program in China is an extraordinary achievement by any standard. The rate of planting achieved, even allowing for low survival, far outweighs that of all other developing countries. As a rural forestry success, it remains the single largest example in the world. Despite the differences in political systems and means of mobilizing popular participation, the Chinese experience in designing optimal approaches to farm forestry that maximize both food and tree crop production contains much of relevance to other countries.

Arid zone forestry

Windbreaks to protect agricultural land

In a windbreak project in the Majjia Valley of Niger, millet yields have been increased by 23% by planting rows of neem trees *(Azadirachta indica)*. Between 1975 and 1980, more than 100 linear kilometers of trees had been planted—every kilometer of windbreak protects at least 10 hectares of agricultural land. A study in Burkina Faso compared 47 tree-enhanced plots with 48 control plots. Millet and sorghum production increased an average 10% on the experimental plots.

Impact of shelterbelts on crop yields[a]

Country	Crop	Increase in yields
Egypt	Maize	13–17%
USA (Nebraska)	Maize	10–25%
China	Rice	3–33%
Denmark	Potatoes	16%
Niger	Millet	23%
USSR	Wheat	10–35%
USA (Missouri)	Livestock	43% gain in liveweight, plus increased milk production[b]

[a]Magrath, 1980.

[b]Cattle with access to shade gained 676 grams per day; herd without shade gained 472 grams per day. Milk yield also increased when cattle had access to shade.

Sand dune stabilization in Senegal

Sustained national commitment to a program aimed at stabilizing sand dunes along the coast of Senegal has been an important factor in the program's success. Initial efforts to cope with the problem of dune encroachment in this area date back to 1925, when the Agriculture Service (and later the Forest Service) began to plant trees to stabilize the blowing sand. The shifting dunes have been a chronic problem along the 182- kilometer coastline between Dakar and St. Louis where the dunes threaten adjacent, highly productive farms and gardens.

For decades, Senegal's farmers have intensively cultivated the coastal "niayes," or fertile pockets of land located in depressions a short distance inland from the coastal dunes. A high water table facilitates irrigation of vegetables and fruit. In 1973, these gardens produced more than 73,000 tons of vegetable crops worth more than US$12 million and provided a livelihood to thousands of families. The income-earning potential of these lands, in fact, spurred population growth and development in the area to a point where the clearing of new fields, collection of fuelwood, and livestock grazing had sharply reduced the grass cover and density of *Acacia* trees and shrubs which had held the dunes in place. Wind erosion increased and the shifting dunes began to encroach on the garden plots.

A series of efforts by the government of Senegal up to the late 1960s resulted in the stabilization of a 20-kilometer stretch of dunes in the vicinity of Thies and Cap Vert. In 1973, the government requested assistance from UNDP and FAO to improve the techniques used in sand dune stabilization to protect and rehabilitate the "niayes," and to introduce forage species into the dune stabilization program. UNDP financed a first phase of a program in the area of Lompoul in 1975–77, and extended the program to include a second phase (1977–82). Combined program costs were $1.7 million.

By 1982 the UNDP/FAO program had considerably exceeded its original targets and objectives. The program had aimed to stabilize the coastal dunes along a 6- kilometer strip and protect 3000 hectares of farmfields. In 7 years, a distance of 67 kilometers (11 times the target) and a total of 1352 hectares of coastal dunes was stabilized. Inland from the beach dunes, 2544 hectares of *Acacia albida* and *Acacia tortilis* were planted in and around the farm fields to control wind erosion, regenerate soil fertility, and provide livestock forage. In addition, 637 kilometers of eucalyptus and cashew windbreaks were planted to protect 9000 hectares of adjacent inland dunes. Mean height of the

best stands was 16 meters after 5 years. Two hundred hectares of roadside plantings were also established as well as more than 52 hectares of community woodlots.

The costs of stabilization ranged from US$50 to US$240 per hectare. Woven palisades of twigs from a shrub common to the area *(Guiera)* were the most effective, least-cost technique. Reforestation costs averaged US$175 per hectare.

A key feature of the project was the incorporation of applied research on the best-adapted strains of eucalyptus and on the technical and economic feasibility of dune stabilization and reforestation techniques. The project also served as a site for practical training of technical students from the region's schools, and strong support was given to scholarships and workshops for all levels of staff training.

Concurrent with the UNDP/FAO program west of Kebemer, additional assistance was made available by the Canadian International Development Agency (CIDA) and USAID (P.L. 480 program) to extend the dune stabilization activities up and down the coast. Thirty kilometers of coastal dunes and 650 hectares of land were protected near Gandiole, south of St. Louis, by the CIDA-financed program. An additional 33 kilometers of dunes and 550 hectares of land north of Cap Vert were protected by the use of P.L. 480 food-for-work resources, under supervision of the UNDP/FAO project staff. Choice of species, nursery techniques, and planting methods developed by the UNDP program contributed to the success of the CIDA and USAID efforts.

The sand dune stabilization program in Senegal illustrates a number of important points—

- National commitment is essential to sustain efforts that can only be achieved over the long term.
- Development assistance can be coordinated to accelerate the progress of national programs.
- Relatively small investments (US$1.7 million for the 7-year UNDP/FAO program) can result in enormous benefits through the protection of farmland that annually produces millions of dollars in income.
- Carefully implemented "pilot" programs, with sufficient emphasis on training and carefully designed and documented research, can form the basis for large-scale programs.

The dune stabilization program in Senegal also demonstrates the need to address the root causes of environmental degradation. Without measures to control removal of protective vegetation, the stabilized dunes will be subject to another cycle of deforestation, uncontrolled grazing, and destabilization. In this regard, future programs in the area need to put more emphasis on extension activities. Farmers need to be convinced that they have the means to sustain the fertility of their farmfields and restore a balance between the productivity of their environment and their daily requirements for food, water, fuel, fodder, and other basic needs.

Replanting gum arabic in Sudan

Among the oldest farm forestry strategies is the cultivation of *Acacia senegal* for the production of gum arabic. Gum arabic has been commercially traded since at least 40 B.C. It is still widely used in food and textile preparations, in medicines, and in the preparation of paints and printing ink. Historically, gum was collected from natural stands.

In the Kordofan region of Sudan, *Acacia senegal* has increasingly been managed as a fallow crop. This tree fallow system has evolved to include four stages or types of land use: cleared and cultivated land; land with a cover of very young *Acacia* regeneration; land with young *Acacia* trees aged 5–8 years; and land with 9-12 year-old *Acacia*. Gum could be tapped from the trees in the last two stages by cutting through or pulling pieces of bark from the stem and branches.

The gum collected by local farmers is sold through an extensive network of traders and marketed internationally. Fluctuating global supply and demand for gum arabic cause considerable changes in the producer price, but it has generally been high enough to provide a substantial income to the farmer. Given the low average annual rainfall of 300-400 millimeters in this region, gum from trees is often more reliable than production from annual crops.

The income potential from gum arabic trees and their role in the farm fallow cycle have been sufficient incentives for farmers to practice long-term management. In the course of a complete cycle, the *Acacia* trees do more than produce a cash crop of gum arabic. They also produce shade and forage for livestock and fiber and wood for home construction, fencing, hand implements, and a regular supply of fuelwood.

Equally important, these leguminous trees help renew soil fertility during the forest fallow period (about 10-12 years between cropping cycles of 3-6 years). In effect the *Acacia* trees have eliminated the need for regular use of manure and fertilizers. Because the trees are also an effective means of controlling wind and water erosion, keeping fallow about three-fourths of the cultivated forest area protects soil fertility better than would be possible with the simple addition of fertilizers.

Unfortunately, a number of factors have led to the gradual breakdown of this traditional land-use system. Population growth and economic development have increased the pressure on farm and range lands. Demand for fuelwood and forage have risen sharply, as has the desire for cash income. Mechanized agriculture has displaced nomads and small landholders and further increased the pressure on remaining land used for subsistence agriculture. All of these factors have contributed to a shortening of the tree fallow period, reduced the regeneration of *Acacia*, and caused overexploitation of the remaining *Acacia* trees. Recent droughts have intensified the degradation. As a result, soil fertility and production of food crops, livestock, and gum have declined.

In 1981, a 3-year afforestation program funded by the goverments of Sudan and the Netherlands was initiated as part of the government's long-range plan to reverse this rapidly deteriorating situation and control desertification in the Kordofan region. The project area was centered on a 5000-square kilometer zone that included 500,000 herders and farmers. Within this area, the project aimed to reach more than 150,000 people in 180 villages with an extension program and a supply of seeds and seedlings sufficient to plant more than 10,000 hectares of *Acacia senegal*. Six nurseries were to be established by the Forestry Department, with a combined production capacity of 1.6 million seedlings per year. Total costs amounted to US$1.5 million.

By contributing to the restocking of gum arabic stands, the program aimed to increase local incomes, employment, and food security and contribute to higher export earnings. At the same time, the project was to select and improve seed sources for *Acacia senegal*, research and improve tapping techniques, assess the mechanism for marketing gum, and propose ways to promote investment in the sector and increase the returns to producers.

Small landholders responded enthusiastically to the initiative. The Forest Department registered 2100 farmers in 27 villages to participate in direct-seeding and planting—well above the target of 240 families. However, last-minute administrative changes just before the planting season required that farmers had to have at least 3.5 hectares before they would be allowed to participate. This limit excluded many farmers from the scheme. Despite these changes, nearly 1000 farmers participated during the first year. In some villages, well organized farmers' societies saw to it that seedlings and seeds were distributed equally among farmers; but in others, wealthier farmers were favored.

Despite management problems, the program has achieved a good degree of success. The targets of collecting 2400 kilograms of seed and producing 1.6 million seedlings per year were exceeded, but demand for seed and seedlings was still not satisfied. The planting targets were exceeded by 11% as nearly 4 million seedlings or roughly 15,000 hectares were planted in 3 years.

Six forest rangers and 32 forest guards were assigned to the program to manage the nurseries and to carry out the extension activities. Some problems were encountered as the guards assumed their new roles, and more agents were needed to cover a larger number of villages in the region.

This effort succeeded in meeting its production targets and in demonstrating the technical feasibility of restocking gum arabic stands, but it also illustrates a number of shortcomings characteristic of many rural development projects:

- Longer-term efforts are needed to sustain or increase development activities to affect more people and restore larger areas of degraded land. In this case, the 3-year funding was just enough to develop and implement a program that affected less than 1% of the region's population and replanted trees over only 3% of the project zone. Obviously, a US$1.5- million program cannot be expected to reverse decades of environmental deterioration, but a continuing effort must somehow be provided.
- Seedling production and extension activities were limited by the inability of the Forest Service to adequately staff, train, and carry out the program with their own personnel. Much more encouragement and technical support should be given to local entrepreneurs, schools, and nongovernmental organizations that have access to land and water resources and the willingness to produce seedlings. Likewise, extension foresters should put more emphasis on

promoting and supporting community-level organization and leadership of tree-planting and management activities. In this respect, the extension agents themselves need much more training in extension techniques and skills required to transfer their knowledge to villagers.

- The project responded to the symptoms of desertification and environmental degradation in the Kordofan region, but it did little to relieve the pressures that caused the initial breakdown of a centuries-old, stable agroforestry system. In particular, policies with regard to agricultural settlement schemes, gum arabic pricing, urban demand for charcoal and fuelwood, projects to increase livestock production, and other development programs still need to be examined for their impact on sustainable land use and conservation of the soil and vegetation in the region.
- More detailed accounting of social, ecological, and financial project costs is needed. A preoccupation with reporting on the number of seeds collected or villagers enrolled apparently obscured the need to carefully analyze the potential impact of the project over the long-term, in raising incomes and export earnings, generating employment, and on increasing soil fertility and crop production. Until the merits of different approaches and would-be "development" activities are more fully monitored, analyzed, and documented, it will be difficult to judge the success of a given project. More important, development planners will not be able to determine which type of program will be most beneficial and therefore deserving of investment and political support.

Conservation and improved use of fuelwood

As awareness of people's dependence on fuelwood grew, the main response was to focus on the need to produce more seedlings and plant more trees. However, it quickly became apparent that rural tree-planting programs were more complex and often more costly an undertaking than originally assumed. As a result, more attention was given to reducing the demand for wood and to technologies for conserving wood or using it more efficiently.

Recovery of logging wastes and improved charcoal production in Ghana

Significant amounts of charcoal can be produced by recovering the large volumes of wood from noncommercial timber species that would otherwise be burned in land clearing for shifting and settled agriculture or be left behind after logging. With the rise in clearfelling and planting in tropical forestry, charcoal manufacture based on the noncommercial residues is becoming an important tool of forest management. In Uganda, for example, successful introduction of charcoal production as a part of forest management increased charcoal production over 10 years from 200 to 63,700 tons, and increased the cost effectiveness of the management operations.

In many parts of Ghana the high forest has been extensively cutover to remove the best quality and most valuable hardwoods, leaving behind "degraded" forest which was not very productive economically.

In 1971, Ghana embarked on a reforestation program to convert degraded natural forest to plantations of fast-growing exotic tree species, mainly for the production of timber and pulpwood. The traditional conversion technique involved cutting and burning the remaining forest cover and replanting the entire site. This program fell behind schedule because of very high costs and finally was stopped when funds were no longer available. The main reason for very high costs were—

- The energy potential of the remaining waste wood was not being recovered to reduce clearing costs.
- Newly planted trees could not compete with the heavy invasion of secondary vegetation (especially *Eupatorium odoratum*), which arises when the high forest is cleared, burned, and left unattended.
- Local people moved in without authorization to plant food crops (chiefly maize) in the cleared areas of forests, adversely affecting the growth and survival of the planted seedlings.

In 1974, the government asked for help in producing and marketing charcoal from trees being cleared from the tropical high forest. A UNDP-financed project was begun in 1976 in the 58,000-hectare Subri River Forest Reserve. It quickly demonstrated that clearing costs could be drastically reduced by converting waste wood to charcoal (using new kilns developed by the project) instead of burning it and that the operation could be carried out at a profit provided that certain basic equipment and trained technicians were available. It also demonstrated that it was uneconomical to use large residual trees for charcoal production because they could be successfully sawn into merchantable timber on the site. The project acquired a mobile sawmill and was able to sell sawnwood profitably on the open market.

An inventory of the forest reserve showed that there was a very large proportion of young trees present which in time would mature to sawtimber size. The original plan to clear the high forest and replace it with a single species had to be abandoned. Instead, a new approach to forest management was developed which is now known as the "subri conversion technique." This technique selects and protects young, potentially valuable trees from the natural forest to grow to maturity. These trees also provide partial cover for crops that are interplanted among them and help to reduce the invasion of weeds. Only after these young trees have been selected is the remaining vegetation removed as timber or fuelwood, converted to charcoal, or left on the ground as mulch. A new crop of fast-growing tree species is interplanted in any open area. In the Subri River Forest Reserve, fast-growing seedlings of *Gmelina arborea* were planted to further increase the productivity of the reserve.

After removing enough trees to accelerate development of the new fast-growing crop, interplanting with plantains (cooking bananas) and cassava was encouraged to suppress weeds (and therefore reduce weeding costs) and to help meet the food needs of the local community and forest workers.

In time it became apparent that the *Gmelina* trees planted as part of the newly developed conversion system grew faster (32 cubic meters per hectare per year) than those which grew on cleared ground (22 cubic meters).

While the direct costs for regenerating the high forest with selective cutting and enrichment planting were higher than the direct establishment costs of the traditional "cut and burn" method, the subri conversion method yielded immediate financial benefits that exceeded the regeneration costs by US$2156 per hectare. Additional benefits resulted from the increased employment.

The Ghana experience has demonstrated several advantages of the subri conversion technique in tropical high forests—

- Overall, it is a less costly method for clearing and preparing the ground for reforestation.
- Damage from burning is avoided, erosion is reduced, and most forms of wildlife are retained.
- Several crops of food are produced in addition to sawtimber, charcoal, and fuelwood, and wood that otherwise would be wasted is profitably used.
- Local employment is generated and the value of local resources that formerly were underexploited is increased. It also reduces conflicts between the satisfaction of local needs and the forest management goals of the Forest Service.

Summary cost/benefit analysis of traditional forest conversion compared to the Subri conversion technique:

	Costs per hectare	*Short-term* benefits per hectare*
Cut and burn		
Ground preparation	678	0
Planting and weeding	1,350	0
Equipment and fuelwood	90	0
Total	$2,118	0
Subri conversion method		
Ground preparation	2,604	
Planting and weeding	180	
Equipment and fuelwood	3,431	
Total	$6,215	
Sawn timber		3,799
Charcoal		2,400
Fuelwood		850
Plantain**		1,322
Total		$8,371

Difference (benefits minus costs) = $2,156

*Does not include benefits of forest products harvested at end of rotation.

**The plantain crop's second-year value discounted 10%.

- In addition to a positive cost/benefit ratio with respect to establishment and conversion techniques, the volume increment of the forest managed under the subri conversion technique is considerably higher (45%) than that formerly obtained under the cut-and-burn system.

The program has also shown that technically feasible, economically sound, and socially acceptable "solutions" are not by themselves sufficient; the long-term success of the program has been constrained by the limited ability of the Ghana Forest Service to keep the necessary staff in the field and to maintain or replace essential equipment.

Provided that these institutional constraints are addressed, experiences gained with the subri conversion technique could be successfully adapted for many other countries. Recent FAO studies have indicated that the volumes of

wood that cannot be used for lumber but that could be recovered as fuelwood and charcoal are considerable, ranging from 50 to 200 cubic meters per hectare in countries such as Ivory Coast, Brazil, and Suriname.

Introduction of improved stoves

In the 1970s, improved stoves appeared promising and very cost effective. Laboratory tests showed that traditional "three-stone" open cooking fires had a very low efficiency—only 5 to 10% of the wood energy actually served to cook the meal.

Tests of improved stove prototypes demonstrated potential increases in efficiency of 20 to 40%. Many of the improved cookstove models were made from mud-brick, sand, clay, and other low-cost materials, which meant that a relatively small investment (less than US$5) could result in annual savings of 1.5 cubic meters of wood.[1] This is equivalent to half the production of a 1-hectare woodlot, which in most areas was costing nearly US$1000 to establish.

The early promise and potential return on investment of woodstove programs precipitated a rush into stove development and dissemination. Dozens, if not hundreds, of "improved" stove designs were promoted, but testing, evaluation, and monitoring in the field revealed that only a handful offered much improved efficiencies over carefully-tended 3-stone cookfires. Further, it was recognized that even the truly successful models could not be distributed in a variety of cultural environments without first adapting the design to local conditions. Future stove development programs must continue to recognize the need for detailed surveys of user preferences, needs, and constraints, and for carefully designed and monitored field testing—"fine-tuning" before one can expect an improved stove prototype to be effective and widely adopted.

The impact of an improved stove program will depend on the number of households that use the stoves, the amount of time the stove is used, and the actual gains in efficiency obtained from the stove. For example, if only 10% of the households in a region use the stove, and cook only 50% of their meals on it, the projected 20% decrease in fuelwood consumption per household is reduced ($20\% \times 10\% \times 50\% = 1\%$) to a 1% reduction for the entire region even if one assumes that 100% of the fuelwood is consumed in cooking—and disregards fuelwood consumed for other uses. To achieve a large-scale impact with improved woodstoves, it is necessary to train enough local artisans to build, install, and repair the stoves; ideally, one would build on existing skills and enterprises. It is also necessary to strengthen the extension service's ability to publicize and promote the new stoves and to ensure that the new technologies are understood and properly used and maintained.

Despite a number of programs that never got beyond the pilot stage, there are examples of successful development and dissemination of improved cookstoves in Kenya, Senegal, and Nepal.

In Nepal, a concerted effort is being made to introduce improved woodstoves as part of a Community Forestry Development and Training Project. To date, 710 stoves (mainly ceramic-insert and double-wall design) have been installed. A survey of a 10% random sample shows that 83% of households use the stove (22% exclusively, 56% regularly). Given their varied requirements for cooking and heating, these figures are quite encouraging. Users perceive a 38% fuel saving on the average. Training of local potters, stove installers, and stove promoters has been undertaken for 10 districts. A high-altitude stove model has been developed and is now being tested.

A recent study in the Kathmandu Valley, a region containing some 800,000 people (100,000 households), estimated that these improved stoves could save up to 92,000 tons a year of fuelwood valued at US$6 million. This is equivalent to the annual yield from a 14,000-hectare fuelwood plantation.

[1] Assuming an average household of 8 persons, with normal consumption of 0.75 cubic meters per person per year, and a 25% decrease in wood consumption with an improved stove.

Land use on upland watersheds

These case studies review developing country experiences in rehabilitating and managing degraded upland watersheds. Lessons are drawn from social, economic, and technical factors that have influenced project outcomes. The examples show a range of proven approaches and technical options from large, medium, and small projects in environments ranging from wet forest to dry rangeland.

High-rainfall uplands

For uplands that have annual rainfall greater than 1500 millimeters, the technologies for recovery are known and have been demonstrated. Examples of successful rehabilitation range from a high-capital watershed development for hydropower in eastern India to a subsistence farming economy in Nepal. In such areas, incomes rise and soil erosion lessens when livestock are stall-fed; fodder trees, grasses, and legumes are planted; steep slopes are reforested; and crops prosper from better terraces and more generous supplies of manure.

Such rehabilitation can diminish the severity of floods and greatly retard soil erosion and transport, but it cannot prevent flooding of lowlands during intense seasonal rain. Only a series of dams can hold such vast seasonal surpluses of water. Yet, investment in such dams will continue to be inhibited as long as land misuse in upland areas increases sedimentation of rivers. For example, the governments of India and Nepal, with support from the World Bank, are investigating large dam projects to tap the vast hydropower potential of the Himalayas and reduce flooding of the plains, but progress will hinge on better management of the upland watersheds.

Watershed management to protect hydropower development in India

The Damodar River rises in the rocky heartland of the Chotanagpur Plateau. Owing to its history of devastating floods and destruction, it has come to be called "a river of sorrow." The floods of 1943, which hindered the war effort, prompted the British Government to make plans to tame its waters. However, it was left to the postindependence Parliament of Free India to pass the Damodar Valley Corporation (DVC) bill in 1948. The DVC project was modeled after the Tennessee Valley Authority in the United States with the hope that the DVC would bring the benefits of flood control, irrigation, power for industry, and increased employment.

The DVC has created a significant infrastructure in the Damodar River basin, which covers some 23,220 square kilometers. Four dams have been built at Tilaiya, Knoar, Maithon, and Panchet. Floods have been moderated, as documented by records from 1958 to 1982.

Three hydroelectric stations with a total capacity of 104 megawatts have been built. The availability of water throughout the year has made it possible to generate thermal power on a large scale (1468 megawatts as of early 1983). This, in turn, has spurred the expansion of mining (coal, iron, copper, and aluminum), the growth of large complexes of manufacturing and support industries, and the generation of power for rail transport. Besides using the water for power generation and for cooling its own thermal plants, the DVC sells water for domestic and industrial use. The reservoirs have also been a boon for fish production.

A 137-kilometer canal built for irrigation and navigation has enlarged the annual irrigated area from 89,000 to more than 350,000 hectares. The total cost of these developments between 1951 and 1983 was US$600 million.

Thus, the Damodar River basin has been transformed into a valley of prosperity. Since its inception, one of the DVC's main functions has been to carry out watershed management activities to protect the large investments. Field work was started during 1951–52 after preliminary soil survey work.

Between 1951 and 1983, progress has been marked by—

- A reconnaissance soil survey of 1,245,822 hectares (69% of the total catchment area of dams)

- A detailed soil survey of 436,214 hectares (24% of the total catchment area of dams)
- Afforestation of 142,641 hectares (75% of the area needing treatment)
- Soil conservation treatment of 148,526 hectares of agricultural land and 106,252 hectares of gullied land (54% and 85% respectively of the area found to need treatment), including graded terraces, land levelling, and small- and medium-sized check dams
- Renovation of 39 (of a total of 10) old water storage tanks
- Measurements at 55 sediment observation posts.

This work has been achieved at a total cost of US$35 million. In addition, the Soil Conservation Directorate of DVC conducts farmers' fairs and crop demonstrations, tests soil samples for farmers, distributes tree seedlings, and helps farmers reclaim degraded land.

Major benefits have been realized in upland and lowland communities, by such measures as—

- Reducing the sedimentation rate in Panchet and Maithon reservoirs
- Reclaiming and irrigating fallow and degraded lands upstream and downstream of the silt-detention check dams
- Adding an estimated 900,000 workdays of employment per year through the increase in arable land, better farming practices, and increased crop yields
- Swelling the annual yield of rainfed crops by an estimated 60–100 kilograms per hectare over a base yield of 300 kilograms per hectare through soil conservation work on agricultural lands
- Increasing water supplies for people and cattle from water stored in silt detention dams.

Even with such successful watershed development, sustained government commitment is needed to secure stable and productive land use. For example, increasing populations are now deforesting the upper Damodar watershed; open-pit coal mining has increased in the lower valley, generating new sources of sediment; and the stripped areas need rehabilitation. As a result, administrative decisions and technical help are needed before the damage destroys the progress of the past 30 years of watershed improvement.

Watershed rehabilitation under subsistence farming in Nepal

For 7 million people living in the "Middle Mountains" of Nepal, time is running out. Without a major change in their methods of farming, they will have consumed or destroyed the resources basic to their survival over the 15 years between now and the year 2000. The traditional method of farming is continuous and exhaustive cropping of limited areas of terraced hillsides. Crop production on the terraces is possible only by continuously harvesting mineral nutrients from the remaining land area. Excellent growing conditions have supported a vigorous vegetation which has sustained this nutrient-harvesting for centuries, with small numbers of free-ranging livestock as the harvesting agents.

Rapid population growth of people and livestock have destroyed this land-use system in the past three decades. Treefelling for fuelwood and elimination of regeneration and seedling growth by intensive grazing, which also destroys any grass cover, has shutoff the supply of mineral nutrients to the terraces. Three quarters of the original forest cover has been destroyed and most of the remainder, apart from inaccessible areas, is in a terminal stage of advanced degradation because regeneration is eliminated. Because livestock range freely during the day, only an estimated 40% of their manure reaches the terraces, further restricting the replacement of nutrients. There is limited access to fertilizer inputs owing to the lack of roads in steep areas of the Middle Mountains. Many terraces have been abandoned through depletion of nutrients and this effect will quicken unless corrected. Moreover, with the loss of vegetation, runoff and erosion have increased sharply, and landslides have become more frequent. At least 5 million people will be driven out of the mountains by shortages of food and fodder. This exodus has already begun.

The need for rehabilitating and managing upland watersheds has been recognized by the people and government of Nepal. In 1974, the government with the help of international aid agencies set up a new Department of Soil Conservation and Watershed Development. A strong international team worked with the new Department on the steep, overcrowded, and severely eroded watershed of the Phewa Tal, a lake whose development for fisheries and hydropower was threatened by rapid sedimentation. At 2000 meters altitude, under 3000 millimeters of rainfall, these mountain slopes have high potential for food crops where terracing is possible.

Ten years of successful experience have revealed the measures essential for rehabilitation. The strategy required basic changes in the farming system to return uncultivatable areas of the mountains to their full potential productivity. Strong incentives were needed to encourage farmers to change their land-use practices. As a first step, the government transferred forest land to the village panchayats (a form of village organization) for their control and benefit. The offer of wages for a limited period of 1 or 2 years to plant fodder grasses and trees provided communities on eroded watersheds an immediate incentive to join the project. Technical guidance was essential in helping communities set up nurseries to produce tree seedlings, collect seeds of fodder trees, and build or repair terraces.

Recovery of areas closed to grazing, which is usually rapid because of the good growing conditions, was hastened by the planting of bulky fodder grasses in eroded gullies and drainage lines, together with the planting of fodder and fuelwood trees on the denuded slopes. Livestock was kept away from these areas to allow the vegetative cover to establish itself. Farmers were encouraged to tie up all livestock and stall-feed or graze on tether. Once the livestock were penned, the great increase in fodder produced by the remaining forest and wastelands became, in one season, more than they could use, so that surpluses were available for sale to neighbors. After these changes were adopted, improved strains of livestock could be introduced by organizing (subsidizing if necessary) the exchange of two or three scrub cows for one buffalo cow (giving 4-and-one-half litres of milk a day instead of one-half litre). Bull calves could be reared for meat because slaughter of the buffalo species is permissible.

These measures have been very successful and the following results were achieved:

- Stall-feeding eased the task of collecting dung, and the supply for use on crops more than doubled. This permitted farmers to plant a winter wheat crop after the hill-rice, for which there is ample water in the soil.
- Average family income in each of three wards of the Kasnikot Panchayat quadrupled in 3 years.
- Very rapid growth of the nitrogen-fixing Nepalese alder provided prunings within 3 years and thinnings thereafter for fuel.
- A small spring that had dried up 7 years previously, when its steep catchment area became denuded, began flowing again 3 years after the livestock had been tied up. This could happen because of the recovery of soil infiltration rates and reduced water runoff once the grasses and herbs again covered the ground.
- Seven neighboring communities that had initially rejected the proposal for stall-feeding applied to join the project when the benefits became apparent, and they immediately began to plant fodder.

International aid projects have proliferated over the past 5 years in attempts to forestall a crisis in Nepal's mountain areas and national economy. Ten such projects, with a total investment of US$166 million now cover more than half the hill districts, albeit in a "pepper-pot pattern" of localized effort. Community forestry is a common theme, organized and supported by a World Bank/FAO Community Forestry Project with both silvicultural and sociological expertise.

The essential lessons from the Nepal experience are that—

- Existing technologies succeed in restoring eroded hill slopes where rainfall and temperature support vigorous growth of vegetation.
- Even the best-known technologies must be tested by trained staff under local conditions before implementation on a large scale.
- Even the most resistant subsistence farmers react positively when they see their neighbors showing a profit, but a substantial subsidy is needed to ensure change in their practice.
- Farmers will plant, tend, and protect trees and change their farming practices substantially when they are confident of sharing the produce.
- Foresters in tropical developing countries have historical and logistic responsibilities for the supply of fuelwood, fodder, and building timber.
- In-service training in the necessary technology is an urgent requirement within Forest Departments.
- Protection of forests from destruction depends on the development of sustainable supplies of fuelwood, fodder, and building materials to be grown in cooperation with neighboring communities.
- Watershed rehabilitation and long-term management will succeed only when a strong extension service is built up and trained. Improvements begun in earlier projects have lapsed when the project staff departed and government support dwindled.

Reforestation of barren slopes in China

A case study from the Province of Jianxi in the watershed of the Yangtse (Chang Jiang) River reveals rural China's potential for recovery from needless poverty. Tall mixed forest, with some excellent stands of *Cunninghamia*, still cover the least accessible 10% of the province, which is bounded by rocky mountains. Another 25% of the mountain slopes are heavily cut secondary growth, much of it *Pinus massoniana*, which has remarkable hardiness and capacity for self-establishment.

The vegetative cover of these well watered slopes has been destroyed by relentless harvesting of all woody growth, often by uprooting, together with the stripping of topsoil as fertilizer for the paddy fields. The lower areas of the hill slopes are thus reduced to a barren wasteland, shedding much of the 1500 millimeters of rainfall as surface runoff.

At Shang-Jiu in Youdu County of Jianxi, the government offered to build a small dam if the farmers would restore the badly eroded watershed of about 5000 hectares. The Ze-Shan Commune mustered 10,000 men, women, and children to the task. Hand-dug contour ditches were built and trees planted in them over the entire area. Species included "Cedar" *(Cunninghamia lanceolata)* on the upper slopes; *Pinus massoniana* on the midslopes; tea *(Camellia sinensis)*; oil tea *(Camellia oleosa)* for cooking oil; an edible nut species; and, finally, citrus undersown with a legume *(Lespedesa)*.

The entire 5000 hectares were treated in one season "working 14 hours a day and also on moonlit nights." Control of soil erosion was rapid, and within 3 years the water in the reservoir was clear enough for fish culture. Carp polyculture with three species is maintained by annual stocking and the villagers boast of a "thousand-ton fish harvest." Individual income of the whole community had risen in 1981 to US$270 a year per working member of the family, in addition to more food and better housing. This was then about twice the average individual income of the province.

Medium- and low-rainfall uplands

Lands of high temperatures and lower rainfall (below 1500 millimeters) with long dry seasons are more difficult to manage and to restore when damaged. The savanna-woodland and semiarid tropics have fragile ecosystems with highly adapted vegetation. Livestock form a dominant part of the subsistence economy. Under erratic rainfall seasons, the livestock multiply in good years, as in the Sahel in the 1950s, and create an excessive grazing burden in dry years which follow, as they did in the Sahel in the 1960s. The major harvests by the subsistence populations are fuelwood and fodder, both of which are "free goods." Land degradation is inevitable in these areas when greatly increased populations persist in traditional grazing systems.

The simple logic is that both fuelwood and fodder must be planted, protected, and managed. Croplands must be contour-planted on terraces and supplied with manure or crop residues. Burning of cattle dung and crop residues to meet household energy needs causes a very serious loss of crop nutrients and must be avoided by growing fuelwood.

Irrigation is limited by scarcity of water resources, but it should be developed to the fullest possible extent and improved in efficiency. Under present conditions irrigation management urgently needs improvement. Many irrigated tropical drylands are so poorly drained, starved of nutrients, poorly weeded, and subject to erratic water supply that they yield little more than rainfed croplands. Misuse of land, mainly by burning and overgrazing, causes the loss of scarce water supplies as surface runoff, taking the thin topsoil with the flashflows.

Reclaiming a wasteland in China

Enclosed by a bight of the Yellow River in its middle reaches, the loess plateau has suffered soil erosion on a scale which is unique to China. Soil transported by wind (or "loess") from the Gobi Desert covers 530,000 square kilometers, varying in depth from 80 to 100 meters. The loess deposit is bounded by four hill ranges. Annual rainfall varies from 500 millimeters in the southern sector, formerly under subtropical forest, through a 400-millimeter sector of former natural grassland, to a northern desert zone of less than 200 millimeters.

More than 3000 years of human settlement, disrupted repeatedly by wars, droughts, and floods, have destroyed the natural vegetation. Erosion has carved the plateau into a pattern of steep rounded hills and deep gorges. Roads and bridges have been swept away by torrents and landslides, so that about 28 million hectares of the formerly forested southern area now lie abandoned as uninhabited and inaccessible wasteland. Soil losses continue at rates which have been measured at 2000 to 20,000 tons per square kilometer per year. The Yellow River carries the world's greatest sediment load, with massive mudflows that contain more than 50% by weight of solids; these destroy reservoirs and block irrigation channels in the fertile lowlands. China carries 23% of the world's population on only 10% of the world's arable land and cannot afford to waste soil resources.

Conventional methods of restoration

Responsibility for the technology needed to rehabilitate this great loess wasteland has been given to the Northwest Institute of Soil and Water Conservation at Wugong (Shaanxi). On the edges of the wasteland where road access remains, conventional soil conservation methods have been successfully applied by massive deployment of hand labor. Major gulleys have been reshaped and planted with apples and walnuts, using legumes as groundcover on broad-level bench terraces. Very extensive plantings of poplar windbreaks were damaged or destroyed during the "Cultural Revolution," but they are being rapidly restored with fast-growing varieties. In the past 5 years, Chunhua County has planted 15 million trees (100 per capita of resident population). Of the county area of 965 square kilometers, 885 were severely eroded. So far, 42% of the eroded areas have been treated. Engineer reports show that sediment transport from the watersheds has already been halved.

A new technology

The Northwest Institute has carried out some 7 years of large-scale experiments on aerial seeding of the bare hills which cannot be reached by road. In the 500-millimeter rainfall zone, the best of many species tested were *Pinus tabulaeformis* and the familiar "black locust," *Robinia pseudoacacia*. These succeeded on the milder slopes. On the steep-sided gulleys, aerial seeding of the hardy pioneer shrub *Astragalus adsurgens* succeeded. This grows only 1 meter high but roots to a depth of 5 meters.

In the 400-millimeter grassland zone, 30 indigenous species and some exotics were tested. By far the most successful was common alfalfa/lucerne *(Medicago sativa)* when sown at 2.25 kilograms per hectare. Striking results were obtained just 3 years after aerial seeding. The seed was sown naked, without fertilizers or dressing.

Some 10,000 hectares have already been established successfully. For the next phase, there is work to be done to followup this initial stabilization by tree planting to anchor the erodible slopes by stronger roots. However, for such access, light bridges and jeep tracks will be needed. Chinese-built, 4-wheel drive, light trucks are available. There is a good supply of literate field assistants, but technicians and survey instruments are scarce.

Flood moderation by grazing management in Uganda

Firm scientific evidence of the restoration of water control by grazing management is rare. Violent overland flows require expensive measuring equipment. Soil and water studies on a watershed scale require scientific and technical effort that is difficult to deploy in remote areas of eroded grazing lands.

A watershed study on two adjacent valleys carried out in the Karamoja Province of Uganda, bordering the Sudan, provided such evidence from 1956 to 1965. On land grazed to a surface of bare subsoil, removal of thorn scrub with 2 years of complete protection from grazing in one of the watersheds produced a remarkable regeneration of many species of grasses. Annual depth of rainfall penetration increased from 30 centimeters in the control watershed to more than 1 meter in the protected valley, in which the floodflow peaks were halved. Good grazing management permitted an increase in stocking rate. More cattle per hectare were fattened than the numbers starving on the adjacent control watershed.

Watershed restoration in Ethiopia

Some 22 million subsistence farmers (more than 70% of the population of Ethiopia) live on the eroded slopes of the Central Highland Plateau, both ploughing and grazing deforested lands. Their traditional methods of farming persist unchanged, while the rapid growth of human and livestock populations have resulted in severe degradation of soil, water, and vegetation.

Some 30 years ago, restoration was demonstrated on a large scale by reforestation of steep slopes with eucalyptus planted behind handmade, roughstone contour bunds to protect the railway. By 1968, soil erosion on the cultivated slopes was severe. A British soil conservation study reported downhill ploughing and gully development from denuded hillside forests. Stunted crops growing on degraded subsoils showed acute nutrient deficiencies. A new government Soil and Water Conservation Division was supported by an FAO laboratory, but it was unable to check the countrywide increase in soil erosion.

The drought that hit the Sahel in 1968–70 intensified land degradation. By 1973, a World Food Programme campaign had begun rehabilitating some of the most severely damaged watersheds. Fortunately, the Food for Work Programme has persisted and is still continuing after 12 years. In 1979, UNDP financed an FAO training scheme under which 104 technicians were trained in land use and soil conservation, and 650 rural group leaders were trained in simple field works.

By 1980 the program was working on 19 watersheds and was the largest soil and water conservation project in Africa. In the 12 months from mid-1980, 34.3 million workdays of conservation work were carried out by 8000 Peasant Associations. By the end of 1982, these results had been achieved:

125,000 hectares of arable land was terraced
70,750 hectares of hill lands were reforested
20,400 hectares of hill slope pastures were terraced
20,000 hectares were closed to grazing and rested
2,000 kilometers of terraces were sown with grasses
30,000 fruit trees were planted
4,200 kilometers of roads were built.

In 1983, an evaluation mission reported that the work was of a good standard. Substantial support was then provided by the European Economic Community and Australia, so that the Food for Work Programme for 1984–86 is running at more than US$66 million a year.

The UNDP/FAO training program was increased to US$2.6 million over 3 years for the training of 270 technicians, 1,067 district agents, and 18,250 Peasant

Association leaders. The program has expanded from 19 to 35 watersheds covering 2,200,000 hectares.

However, although impressive progress has been made, the current program covers less than 5% of the area in urgent need of improvement. The 1983 evaluation mission warned that, despite any improvements that could be made in land use, these slopes could not carry a continuously increasing population. The fragile balance between the population and the food supply has been tragically demonstrated by the current 1984–85 drought.

A strong government economic policy to raise the profitability of farming, together with a strong social policy to restrain birth rates, are the only measures that will prevent further famine in Ethiopia. Given such commitment, a strong case can be made for a further increase in the watershed rehabilitation program. Reforestation is an essential component, but the increase in food production also requires the continued reform of agricultural technology.

Operational research in watershed management

The technologies of watershed management are well known and well tested for the tropics, but each valley is unique in detail. Good management requires simple but systematic monitoring by routine measurement of rainfall and streamflow and by standard meteorological stations that can be operated by junior field assistants.

Full-scale watershed research is costly in time, professional staff, and equipment, needing 5 to 15 years to achieve results in the tropics as compared with 25 years or more in temperate climates. Enough knowledge has already been accumulated to permit improved watershed management to begin immediately under sound technical guidance.

Before planting over large areas, new species of trees or other crops should be introduced as pilot schemes for observation and measurement.

Routine monitoring provides basic information on upland water resources that is critical for large-scale investment in irrigation, hydropower, or urban water supply, and it should be paid for by the downstream community.

All such pilot-scale testing, routine monitoring, and measurements of crop yields or growth increments, is best described as "operational research." It can be supervised by field managers, but it needs the support of a laboratory center to handle the data, prescribe the measurements, and maintain the instruments.

Forest management for industrial uses

These case studies review developing country experiences in managing natural and planted forests to produce industrial wood. Attempts to manage natural forests for sustained production of industrial timber have not been universally successful, but there have been encouraging results in some locations.

In the production of large volumes of industrial timber, the most dramatic successes are related to the establishment of large-scale industrial plantations. The lessons learned from these cases may help solve the problems of industrial wood supply in other locations.

Managing natural forests

In this report, managed natural forests are restricted to those for which there are cutting regulations, silviculture treatments, and protection—all to sustain commercial extraction. Managed forests also can include forests maintained and used primarily for their nontimber products, including wildlife. Forest reserves and other protected forests could also be considered managed.

Felling practices in most countries are now controlled to some extent, and regulations on the minimum diameter which can be cut and the condition of the forest after logging are widely applied. However, these forests often are not considered "managed" because there is no provision for subsequent silvicultural treatment and maintenance.

Current situation in natural forests

In tropical America, few forests today would be considered managed, and most of these are coniferous forests in Honduras, Nicaragua, and Cuba. Also included are several thousand hectares of broadleaved forest, some of it experimental, in Trinidad and Tobago, Costa Rica, El Salvador, Suriname, and Colombia.

In tropical Africa, forest management at a fairly intensive level was practiced in many former British colonies. In 1960, it was estimated that more than 4 million hectares of forests in the region were managed. However, subsequent population pressure, a shortage of technical staff, and other resource constraints have led to a gradual abandonment of management in more than half of this area. Only five African countries have intensively managed forests—Ghana (1,167,000 hectares, or about two-thirds of all the managed forest in Africa), Uganda (442,000 hectares), Kenya (70,000 hectares), Sudan (50,000 hectares), and Zambia (5,000 hectares). The managed forests of both Ghana and Uganda are now being encroached upon.

In tropical Asia, intensive management is limited to the Indian subcontinent (Burma, Bangladesh, India, and Pakistan) and Malaysia. India alone has 32 million hectares of managed forests. Forest management plans have been prepared over more than 100 years in some areas of India, and extensive silvicultural and management information has been accumulated.

Excluding the Indian subcontinent, only 2 to 3% of the cutover tropical forests in the world are under intensive management. This proportion has declined and is probably continuing to decline One of the most difficult issues to address in planning forest development is this lack of commitment to forest management.

Obstacles to forest management

Obstacles to introducing natural forest management include: (i) low rate of return on investment; (ii) lack of technical knowledge, (iii) intense human pressure on forests because of population growth, agricultural expansion, and poverty; (iv) lack of skilled personnel and materials needed to manage forests; (v) lack of political commitment.

A low rate of return is probably the most critical obstacle. Most other problems could be solved if there were immediate financial and economic benefits from reforestation and management in logged-over tropical forests. Rates of return measured in traditional ways are low for this type of activity, particularly when compared with wood production from fast-growing industrial plantations. Given the clear superiority in financial terms of plantation forestry over silvicultural enhancement of

logged-over natural forests, it may be more practical to try to stimulate massive afforestation to meet the principal requirements for industrial wood and, by this means, slow the rate of extraction from natural forests. The emphasis will differ from country to country according to the specific situation.

Lack of technical knowledge is a barrier to intensive management of tropical forests. Yet much is known about many aspects of managing different types of forest. The future of tropical forestry would be much more secure if the knowledge already available were used more widely. Moreover, actual application would provide opportunities to expand the information base and allow continual improvement of forest management practice.

In a few countries, human pressure on forests is a major barrier to introducing intensive forest management on logged-over lands. Elsewhere, such lands are remote and undisturbed. In vast areas of tropical forests, the population is so low that the question of introducing intensive management techniques can be considered separately from the question of human pressure on forests.

There is a serious shortage of trained personnel and material resources to manage forests in many countries. This results more from a lack of political commitment than from any problem inherent to development of such expertise or procurement of the necessary materials. In forest education, however, there has been much progress recently, and several tropical developing countries have established forestry schools that graduate foresters in substantial numbers.

Lack of political commitment is another important obstacle. High rates of return would generate political commitment, which in turn would rapidly provide solutions to the other problems noted above. From a political point of view, the reasons for not introducing intensive management to newly-logged areas generally follow this sequence—

- A contractor is licensed to log a specific section of forest and to pay a royalty on the volume extracted. Prices and royalties are internationally competitive, thus maximizing immediate return from the forest.
- The contractor will only log trees larger than a certain diameter, leaving young trees of commerical species to grow and provide a basis for subsequent cutting. Regulations that govern the condition of the logging site will be followed. The area will quickly reforest itself so that erosion and soil damage are not a problem. However, it is still uncertain whether young commercial trees will grow.
- The commercial viability of this forest is questionable. Further, there is little evidence that with later enrichment of the stand with similar species the long-term results would be better.
- Given people's growing needs for forest products and the decline of natural forests, plantations of suitable species in convenient locations are considered superior. This guarantees a wood supply at reasonable cost in a relatively short time, compared with the uncertain time and low rates of return in natural forest management.

From the political and commercial viewpoints, this reasoning is difficult to refute—the resources are generating an immediate benefit; the natural forest is not unduly degraded; there is a possibility of subsequent commercial logging; and industrial plantations will ensure that future demand for industrial forest products will be met.

Current management systems

With a few important exceptions, the situation described above is the management system applied to most of the world's tropical forests. Even this system is not applied perfectly: actual followup of logging operations is rare, and although industrial plantations are being established in many countries, in only a few countries are these areas likely to be adequate to meet domestic timber demands. However, a major deficiency of this system is the lack of information on long-term trends in forests which have been selectively logged. The areas which were selectively logged several decades ago, and which therefore would be best to study, are usually the most accessible and have later succumbed to pressure for conversion to agriculture.

Nevertheless, there are numerous selectively logged but unmanaged forests, some of which have been inventoried several times after logging. Compiling and presenting data from these forests, starting other studies in suitable areas, and publishing the results, would be a valuable contribution to solving the question of how best to manage tropical forests.

More intensive management systems are found in some forests. In India for example, where most of the world's managed closed tropical forest is located, the system varies according to forest type. Variations on the

shelterwood system are used in *Pinus, Cedrus*, and broadleaved forests, whereas *Picea and Abies* are managed under a selection system. While management is effective, productivity is low with the annual allowable cut ranging from about 0.7 cubic meters per hectare in the sal and teak forests to about 2.9 cubic meters per hectare in the coniferous forests. In predominantly broadleaved forests, the cut is about 1.0 cubic meter per hectare, which is the average for all of India's managed forests. In contrast, annual growth rates in industrial plantations in India are generally reported to be from 5 to 20 cubic meters per hectare.

In Malaysia, which is the only one of the three major dipterocarp-producing countries with any significant area of intensively managed forests, the management system varies from state to state. In all regions, the Forest Department has the primary responsibility for forest management which is now based almost exclusively on the selection system. The target after logging is to leave at least 33 undamaged trees greater than 30 centimeters in diameter at breast height per hectare, together with traditional fruit trees to provide food for local people. In Peninsular Malaysia, some states require the concessionholder to be responsible for forest regeneration after logging, or, alternatively, will charge a fee to do this work. There are studies on the volume of merchantable species remaining after logging, but the current assumption is that the growth increment is 1 to 3 cubic meters per hectare per year. A major debate exists in Malaysia today whether natural forest management can be cost-effective. The present emphasis is focused on establishing large-scale industrial plantations (in Sabah and Peninsular Malaysia), expansion of the number of species used, and greater efficiency in wood processing.

In Ghana, which contains two-thirds of all of the managed natural forest in Africa, a selection felling system has been used for many years with an annual cut estimated at 1.8 cubic meters per hectares. A shelterwood system was tried in the 1950s but abandoned in 1967 because results did not justify the cost. The Forest Department currently lacks the material resources to manage the remaining forests effectively, and, as a result, serious encroachment is occurring.

Conversion of woodlands to plantations in Zambia

About 37 million hectares, half the area of Zambia, is classified as forest land. However, natural productive forests cover only about 6.5 million hectares, of which 35% is closed forest or dense woodland and the rest open broadleaved woodland. These forests have been exploited commercially for more than 60 years, primarily for the copper industry (round and slabbed poles for underground support) but also for sawnwood, railway ties, and parquet.

Industrial roundwood production over the past decade has been 0.4 to 0.5 million cubic meters per year, of which about two-thirds has been used in the mines. In contrast, over the same decade the estimated production of fuelwood and charcoal has averaged 4.5 million cubic meters per year.

In the 1950s, it became evident that to ensure supplies of industrial timber for mining operations, it would be necessary to establish industrial plantations. Earlier plantings had not been successful because of the combined effects of shallow soils, a 7-month dry season, and competition from aggressive grass and woody vegetation. The Forest Department began an intensive research program to determine appropriate species and silvicultural techniques.

By the mid-1960s, using its own resources, the government was successfully planting about 800 hectares of pines (primarily *Pinus kesiya*) and a similar area of eucalypts (primarily *Eucalyptus grandis*) each year on sites near Ndola in Zambia's copperbelt. By 1968, about 6,000 hectares had been established. Most technical problems had been overcome and the government began to think in terms of large-scale, long-range afforestation. World Bank financing was sought for assistance in the first phase of this program.

First-phase industrial forestry project

The first-phase aimed to establish 8,000 hectares each of pines and eucalypts between 1969 and 1976. Project cost was estimated at US$11 million, of which half was foreign exchange to be financed through a World Bank loan. The project was to be managed by the Industrial Plantations Division of the Forest Department. It was considered the first phase of a long-range program that would lead eventually to establishment of 40,000 hec-

tares of plantations to supply most of Zambia's future industrial wood requirements. Demand projections for mine timbers, poles, and sawnwood showed that essentially all of the output from the plantations could be consumed in Zambia. Financial returns of 10 to 12% were projected for the long-range program and the first-phase project.

Planting rates exceeded projections and the 16,000-hectare target was achieved in 7 instead of the 8 years originally envisaged. On reassessing projected demand, the proportion of eucalyptus planted was increased from 50 to 72% of the area. Growth rates were revised upward for eucalyptus (from 18 to 25 cubic meters per hectare per year) and downward for pine (from 17 to 14 cubic meters per hectare per year). Primarily because of inflation, project cost was double the appraisal estimate, but with higher product prices the estimated rate of return was essentially unchanged.

The government decided to continue with its long-range industrial forestry program and World Bank support was requested for a second-phase Industrial Forestry Project.

Second-phase industrial forestry project

With a successful first-phase project, and the prospect of substantial industrial timber production in the near future, the second-phase project was expanded to include industrial processing. Feasibility studies were conducted for industrial use, including production of sawnwood, wood-based panels, and paper. Sawnwood production could clearly be justified. Questions remained about the economic feasibility of panel and paper production, primarily because of the limited domestic market potential and the poor possibilities (because of high transport costs) for exports. Because of these uncertainties, the project was evaluated assuming that the only industrial use would be sawmilling. This would mean that much of the smallwood (thinnings, logging waste, and sawmill waste) would have no commercial use. Even under these circumstances the projected rates of return for the entire industrial plantation program (about 11% financial and 14% economic) were considered satisfactory.

Another concern during preparation of the second-phase project was the desirability of continuing such large-scale planting operations, timber sales, and industrial processing with an organization that was simply a division of the Forestry Department. To some extent, commercial activities and goals were being hindered or obscured by the government bureaucracy. If potential benefits from industrial plantation and processing operations were to be gained, it would be necessary to form a commercially oriented industrial forestry corporation. The government agreed to take this important step.

On this basis, a second-phase industrial forestry project was organized. The project would finance planting operations over a 5-year period (1978–82), during which 17,500 hectares would be established. The project also provided for replacing 2,000 hectares of older eucalyptus plantations which would be felled during the project period; maintenance of all existing plantations; additional logging and transport equipment; construction of a sawmill (40,000 cubic meter per year sawnwood capacity); and related technical assistance. Project cost was estimated at US$34.5 million, of which half would be foreign exchange financed by a World Bank loan.

The project was completed in 1983. Planting targets were surpassed (20,500 hectares were planted), but replanting was less than anticipated because much of the area was not logged. The heavy emphasis placed on new planting was seen to be a factor in less than anticipated performance in logging, road construction, maintenance of existing plantations, training, and sawmill construction. Establishment of a commercial organization to handle industrial forestry operations and construction of the sawmill were delayed but were completed toward the end of the project period.

At the end of the second-phase project, 45,000 hectares of pine and eucalyptus plantations had been established. There is now a clear need to direct future activities toward maintenance of existing plantations, logging, and processing activities. A third-phase project has been designed and is now being implemented.

Development of forest industries in Chile

Chile's natural forests cover about 20 million hectares, or slightly more than 25% of the country. Forests include protected forests (12.6 million hectares—mostly in the south of the country), and commercial forests (7.6 million hectares). However, only about half the commercial forests are economically accessible.

In the most productive stands, the exploitable volume is about 100 cubic meters per hectare. The native woods are highly regarded for sawnwood and decorative panel products, but the high cost of exploitation tends to limit their use for other purposes. The annual cut from the natural forests was about 4.3 million cubic meters in 1974 but it had declined to 2.9 million cubic meters by 1979. It has remained at about this level.

In the late 1940s and early 1950s, experimental planting with various species led to the discovery that *Pinus radiata* was particularly well suited to the soil and climate of Chile and would be an excellent species for establishment in industrial plantations. Before 1954, the state-owned National Forestry Corporation (CONAF) had successfully established 17,000 hectares of this species, and the government decided to accelerate reforestation by supporting a large-scale planting program. Annual planting undertaken by CONAF increased from about 6,000 hectares in the late 1950s to more than 30,000 hectares in the early 1970s.

By 1984, 320,000 hectares of plantations had been established, most of it by the government. By then, Chile was producing and exporting sawnwood, pulp, and newsprint from plantation wood. The value of forest product exports in 1973 was US$40 million. The government decided to enlist private support for a major expansion in the planting program.

The forestry law

In October 1974, the government enacted Decree No. 701 to encourage private afforestation in two ways. First, 75% of the cost of establishment and subsequent management was to be reimbursed by CONAF, once it was demonstrated that an acceptable share of the seedlings had survived. Second, these subsidies would be exempt from income tax but could be capitalized and amortized at the time of exploitation or sale of the forest. The law stipulated that all forest areas must be reforested after harvesting and that forest lands are exempt from expropriation. Land first had to qualify for afforestation and a management plan had to be submitted to CONAF for approval.

This law had an extraordinary impact on the rate of afforestation in Chile. Between 1974 and 1978, 420,000 hectares of new plantations were established, an average annual planting rate of 80,000 hectares, or more than double the pre-1974 rate. For the first time, there was substantial private sector involvement, accounting for more than half the area planted during this period. However, the subsidies to private planters were a substantial public cost.

The program was later modified. Tax exemption was extended from 10 to 20 years. After 1979 and the severe crisis in the banking system, lines of credit were temporarily suspended, but later they were reinstated. For 1984 and 1985, the subsidy level was raised to 90%. Direct government planting essentially stopped between 1979 and 1982, but the government established an additional 22,000 hectares in 1983.

Current situation

By 1984, 1.1 million hectares of pine plantations had been established. Sawmills and pulp and paper mills had been constructed, and Chile now is meeting all its domestic demand for forest products. It also is exporting logs, sawnwood, pulp, and paper. The value of forest-based exports is now US$350 million annually. The current annual allowable cut from plantations which are now mature is 10 million cubic meters and actual extraction is close to this level.

When the heavy planting which took place during the 1970s reaches cutting age, there will be major increases in available wood. Government projections, supported by data on area and growth rates, indicate that the allowable cut will double to about 20 million cubic meters by 2000, or nearly the level of industrial wood production in Finland today.

With this major potential, Chile is examining a range of development possibilities, including production of logs for export, sawnwood, and various grades of pulp and paper. It appears, however, that none of these options will effectively use all the available resource. Regional trade in coniferous logs and sawnwood is relatively modest—about 15 million cubic meters of sawnwood and 20 million cubic meters of roundwood annually. Chile is

already active in these markets (about 1 million cubic meters of each) and has some potential to increase its market share. However, growth in Chile's contribution to this trade has not been limited by wood availability but rather by the nature of the resource and the characteristics of the markets themselves. Even in pulp and paper, which consumes about half the annual cut of *Pinus radiata*, the potential volume of Chile's pulpwood could supply a substantial part of the projected increases in world demand for pulp and paper by the year 2000. The investment required to install the processing capacity to use the projected pulpwood volume would be US$4-5 billion in 1984 prices.

Replicability

A number of conditions in Chile contributed to the success of the afforestation which has taken place. Whether these conditions are found in other countries will determine to what extent the Chilean experience can be replicated elsewhere.

First, the exceptionally good growing conditions for *Pinus radiata* and the availability of large areas of suitable land for planting were essential. Second, land for planting is well located with respect to suitable industrial sites which themselves have ready access to domestic and overseas transportation facilities. Third, during much of the program, the government had the financial resources (primarily from copper exports) to support an ambitious planting program. It also maintained its commitment to afforestation during difficult financial periods. Fourth, there was significant interest by private landholders and private industrialists to participate in the planting program and to establish the industrial facilities on which forest industry success depends.

The example of Chile would not be complete without pointing to some of the difficulties and questions that inevitably arise when such a major program is undertaken. First, part of the reason why Chile is competitive internationally in forest products markets is the low cost of wood—a direct result of government subsidy. The extent to which the economy benefits from forestry and forest industry development is significant, but it is not clear whether the program leads to full economic cost recovery. Second, resource availability has expanded rapidly requiring equally rapid investments to ensure efficient use. Some of the companies that have made these investments are now in financial difficulty and their future is not certain. Finally, the planting program, being continued at a high rate, is so large as to raise the question whether the necessary investments to use the trees can realistically be made and sustained.

Despite these questions there can be no doubt that Chile has created an immensely valuable resource that will bring long-term benefits to its economy. With large areas of new plantations approaching maturity, the country is entering an exciting and challenging phase in the development of its industrial forests and forest-based industries.

Smallholder production of pulpwood in the Philippines

Natural forests of the Philippines are being rapidly depleted by commercial exploitation and shifting cultivation. Partly as a result of this depletion, and partly because of legislation aimed at conserving the remaining resource, industrial log production has declined from more than 12 million cubic meters per year in the early 1970s to about 7 million cubic meters today. At the same time, domestic demand for industrial forest products, particularly pulpwood, is expanding. The result is more pressure on the domestic wood resource.

The Smallholder Treefarming Project began in the early 1970s to expand reforestation to alleviate the problems of declining industrial wood supply in a specific region. Its success led to its replication in other parts of the Philippines and it may provide a basis for developing similar solutions to comparable problems in other parts of the world.

The Paper Industries Corporation of the Philippines (PICOP) was formed within the Soriano group of companies with the specific goal of manufacturing pulp and paper from local hardwoods. In 1969, it acquired another Soriano subsidiary, the Bislig Bay Lumber Company, which operated timber concessions in eastern Mindanao. PICOP's integrated timber-processing facility at Bislig has the capacity to annually produce 154,000 cubic meters of plywood, 23,500 cubic meters of veneer, 49,500 cubic meters of lumber, and 5,200 cubic meters of blockboard. The pulp and paper mill can produce 87,000 tons of newsprint and 70,000 tons of kraft containerboard per year. The annual log requirement for this complex is about 1 million cubic meters, or 14% of the present annual cut for the Philippines. This timber is supplied from two concessions covering some 183,000 hectares of rain forest dominated by dipterocarp species, including red and white lauan, tangile, almon, bagtican, and mayapis.

The pulp and paper mill was designed to operate primarily on forest waste and chips produced from residues in the sawmill and plywood mills. However, even if these plants are operating at full production, they do not produce enough residues to meet the need. Moreover, market conditions and shortages of logs mean that wood-industry plants are seldom run at full capacity. Supplementary pulpwood supplies are therefore required to secure full operation of the pulp and paper mill. These could be either secondary species not suitable for sawnwood or plywood, or plantation pulpwood. Early experience has shown that plantation species were technically preferable to either dipterocarp residues or secondary species.

The pilot tree-farming project

In the late 1960s, PICOP launched its Agroforestry Development Plan to ensure raw material supplies for its mill complex and improve the socioeconomic position of small farmers surrounding the company's concession. Under the plan, a participating farmer would devote 20% of his land to food and livestock production and 80% to fast-growing pulpwood trees on an 8-year rotation. PICOP would supply the seedlings (at cost) and technical assistance (in exchange for first rights to the mature pulpwood).

At PICOP's request, beginning in 1972 the Development Bank of the Philippines (DBP) agreed to finance the establishment of treefarms by smallholders. To qualify for a loan, a farmer had to have titled possession of at least 10 hectares and a signed marketing agreement with PICOP. The loan was mainly to cover the cost of planting 8 hectares of *Albizzia falcataria*, and the balance was for crop and livestock development. Planting was to proceed at 1 hectare per year. The loan was at 12% interest for 15 years, including an 8-year grace period. Close supervision and technical assistance would be provided by DBP and PICOP.

By 1984, 868 tree farms had been established under this scheme, of which 127 had applied for and received DBP financing. A total of 1,816 hectares had been planted. The pilot program was considered a success and the government requested World Bank assistance to help DBP finance major expansion of the project.

The expanded project

A number of changes were introduced with the expanded project. First, farmers would be required to contribute at least 25% of the cost of their plantation establishments in the form of labor. Second, the minimum landholding for eligibility was reduced from 10 to 5 hectares. Third, smallholders who had occupied suitable land for at least 10 years were to be eligible, even if they did not have legal title to the land. Fourth, there would be no restrictions on the annual rate at which land could be developed. The terms of the loan to the farmers would remain

the same. In May 1974, the World Bank approved a loan of US$2 million to DBP through the government for this purpose. The goal was to supply 284,000 cubic meters of pulpwood per year to PICOP by 1985, equivalent to 44% of the pulp and paper mill's requirements. Without this pulpwood, the mill would have had to close. By 1979, the World Bank loan was fully committed by DBP to 1,159 landholders, who accounted for nearly 9,000 hectares of plantations.

Although the Bislig area on the east coast of Mindanao, where the PICOP Agroforestry Program is being implemented, is normally outside the typhoon belt, a major typhoon hit the area in March 1982, seriously damaging company and private tree plantations in seven municipalities. The damage was particularly bad in plantations over 2 years old. To help the tree farmers, PICOP bought all the wood they could salvage and deliver to the mill. This helped substantially, but a number of farmers became discouraged. To make matters worse, in August 1982, the Development Bank of the Philippines suspended its financing program, thus slowing down the development of new areas. However, in mid-1983, the Development Bank began a program to finance rehabilitation of typhoon-damaged tree farms originally financed by them.

In 1982, several large agribusiness corporations planting oil-palm, coconuts, coffee, and cacao began operating in the Agusan area not far from the PICOP project. A number of tree farmers shifted to these crops, and it is estimated that 2800 hectares of tree farms have been converted. However, in 1983, Taiwan started importing *Albizzia* logs grown in tree plantations. While only the best and largest logs are exported to Taiwan, interest in the tree farms is reviving.

In 1984, PICOP started a major information campaign to encourage new interest in tree farming and to ensure availability of pulpwood. Competition from exporters was increasing. The "total tree" concept of wood buying, whereby the company undertook to buy the whole tree from a minimum diameter of 5 centimeters, was introduced. This makes it more attractive for tree farmers to sell their trees to PICOP than to skim the plantation for premium logs for export.

Despite the absence of Development Bank financing, tree planting increased considerably. By the end of 1984, 3,986 tree farmers were planting 23,081 hectares.

The marketing agreement

Two elements that have been crucial to the success of the PICOP project are—

- The marketing and technical assistance agreement with PICOP for the production and purchase of the pulpwood
- The financing package offered by the Development Bank of the Philippines.

The marketing agreement sets forth the responsibilities of the landowner and of PICOP. Depending on the size of the landholding, a particular area is set aside for plantations of *Albizzia*. The landowner agrees to provide all necessary labor and capital needed for clearing, preparation, planting, fertilization, maintenance, improvement, and security of the planted area for the duration of the agreement. PICOP agrees to provide the landowner with tree seedlings at cost and free technical advice on pulpwood planting, development, and management. Assistance is also given on production, processing, and marketing of food and other agricultural crops and livestock and in other self-help community projects.

The agreement obligates the landowner to sell, and PICOP to buy, pulpwood based on PICOP's specifications and standards. The pulpwood price is defined in the agreement as the "current price," although minimum prices were set for stumpage alone. PICOP withholds part of its payment for pulpwood to repay the farmer's loan from the Development Bank. The landowner retains the option to sell his wood to any purchaser prepared to pay a higher price (after notifying PICOP), but PICOP has the right of first refusal at this higher price.

Assistance from PICOP and the Development Bank

PICOP was primarily responsible for getting the project started and implemented, and it arranged for bank involvement. Technical representatives of PICOP would visit the farmers, explain the program to them, help them to arrange for a bank loan, and generally ensure that any problems that arose during the early phase were resolved before they discouraged the farmer from continuing with the project. This assistance and initiative were probably the most important factors in the success of the project.

Of the 3,986 farmers who have entered into agreements with PICOP, about 3% was financed by DBP under the

pilot scheme. A further 30% was financed through the World Bank project initiated in 1974, and another 12% through the subsequent World Bank-financed project. More than half the farmers did not need any external financing. Nevertheless, the availability of financing was clearly important in the decision of many farmers to participate in the program.

Impact of the program

Despite the difficulties encountered in 1982 and 1983, the PICOP Agroforestry Development program is moving forward with renewed vigor and 23,081 hectares of tree farms have been established. Together with PICOP's own plantations, the pulpwood from these farms will adequately supply PICOP's requirements projected from the mid-1980s. Further expansion in the tree farming project is anticipated. Eventually, this could support Philippine pulpwood exports or an expansion of PICOP itself.

Conservation of tropical forest ecosystems

The case studies that follow show the progress that has been made in conserving tropical forest ecosystems, and they illustrate methods or systems that can be used much more widely in the three tropical regions. A major international effort is underway to identify ecosystems and species that are threatened by overuse or development pressures and to find ways to stem the loss of tropical forests and the biological resources they contain.

All conservation methods need to be used. Ultimately, most tropical forests should come under some form of management to ensure their long-term sustainability. This management can include designating additional protected areas, but real conservation of the tropical forests will come about only when agricultural and other pressures on the forests are reduced and eliminated.

Conservation of forest ecosystems depends on having good information available and using this information in land-use planning. Conservation data centers and national conservation strategies are designed to do this and they should be developed in most tropical countries addressed in this report.

The global system of conservation areas

The first national park was established a little over a century ago. Since then more than 3000 parks and equivalent reserves have been established on more than 400 million hectares. The number of sites has more than doubled over the past 15 years. Many of the new areas conserve forest ecosystems in the tropics.

The global network of protected areas is being refined by using a variety of designations and management systems. The International Union for Conservation of Nature and Natural Resources (IUCN) has led the international effort to build the global system. In regular meetings and regional analyses, the IUCN parks commission is identifying major gaps in protected area coverage. The Protected Areas Data Unit at IUCN's Conservation Monitoring Centre maintains information and a database on conservation areas worldwide.

Some examples of the global system:

- UNESCO's Man and the Biosphere Programme is one of the most ambitious attempts to develop multiple-use planning for protected areas. Biosphere Reserves contain natural areas and areas modified by human activity. There are now 244 Biosphere Reserves in 65 countries, 59 of them in 29 tropical countries.
- World Heritage Sites are designated by nations that are party to the Convention Concerning the Protection of the World Cultural and Natural Heritage. There are 57 natural sites, 25 of them in tropical countries.
- 301 wetland areas have been designated by 37 countries under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Wetlands Convention). Several of these wetlands are in or adjacent to tropical forest ecosystems.
- Brazil, which contains about a third of the world's tropical forests, recently has made impressive progress in developing an extensive system of protected areas. A wide range of conservation categories has been used. When all proposed Ecological Stations and Reserves are established in Brazil, coverage will be 3 million hectares. At least 90% of the natural area of each station is left undisturbed; the rest is dedicated to research on burning and other forms of human interference. The stations will be used for long-term monitoring of tropical ecosystems. They supplement Brazil's protected area system that includes more than 12 million hectares of parks, biological reserves, forest reserves, hunting parks, game farms, and private reserves.
- Similarly, Peru has established an extensive system of more than 20 parks and other protected areas that cover more than 4.3 million hectares. Four of the largest conservation areas are in tropical forests of the Amazon basin.
- Indonesia has gazetted more than 500 conservation units in 8 categories ranging from strictly protected areas to areas with multiple-use zones. The government has set the goal of placing 15% of the country's land area in some form of conservation status. It is also developing an extensive system of marine conservation areas.
- India is establishing 13 Biosphere Reserves. These will function as multiple land-use units containing en-

vironmental centers to encourage participation of local people in managing the reserves. The reserves represent 9 of the 12 major biogeographic provinces in India and will supplement India's 44 national parks and 207 wildlife sanctuaries. The total conservation area is 8.7 million hectares.

- Private conservation efforts are significant in several developed countries. For example, in the United States, the Nature Conservancy manages more than 750 reserves, with considerable help from volunteers. No comparable private systems yet exist in tropical developing countries, but several countries (e.g., Venezuela, Costa Rica, Indonesia) have begun to encourage conservation work by the private sector.

Despite these recent accomplishments, many of the world's ecosystems remain poorly represented in the global system. For example, Venezuela has designated large conservation areas in its tropical moist forests, but tropical dry forests are almost entirely unprotected or unrepresented in reserves. Although Brazil already has several million hectares of parks and reserves in tropical moist forest zones, more reserves need to be established to conserve most of the diversity found in tropical moist forests.

As important as establishing new protected areas is the need to better manage existing parks and other reserves. Few parks have management plans, and even fewer have been able to carry them out. To permanently protect these areas, management plans must take into account the needs and enlist the participation of local people. More money is needed to effectively manage conservation units, increase the number of trained staff, develop park infrastructure, and improve visitor access. There needs to be a broad campaign aimed at increasing public awareness of conservation.

Conservation data centers

The U.S. Nature Conservancy has developed an extensive system of state and regional biological inventories called natural heritage programs. They are designed to collect, organize, and analyze information on ecosystems and species to determine conservation priorities and to be used in land-use planning in general.

The 35 programs now operating all use a standard methodology, and enough data has been gathered to determine regional and local conservation priorities in the United States. The information is available to local, state, and federal agencies, and agency personnel have cooperated closely with the heritage program staffs in building the databases.

A key part of these programs is their close relationship to other private and public organizations. The Conservancy has not funded these programs alone, and much of the core funding has come from public agencies. Direct agency involvement has ensured that the databases are used more widely and that the biological and ecological information is considered in general land-use planning.

Working with government agencies and nongovernmental organizations outside the United States, the Conservancy has helped establish conservation data centers (CDCs) in Latin America and the Caribbean (Peru, Colombia, Costa Rica, Netherlands Antilles, Puerto Rico). These CDCs are built on the model of the natural heritage programs in the United States, but they are modified to take into account widely varying institutional relationships, a lack of data and information on neotropical ecosystems and species, and a much more diverse biota (there are more bird species in Peru, for example, than in the entire United States).

Extensive manual files that back up computerized data and large-scale maps form the heart of the information system. Information is gathered systematically on ecosystem types, plant communities such as tropical forests, species of flora and fauna (especially those considered endangered, threatened, or declining), parks and other protected areas, land-use planning regulations, economic development plans, development projects, trade in

endangered species, and other factors that may affect the biological resources of the country or region. After 12 to 18 months, each program is mature enough to produce reports on conservation priorities for a particular country or region. The information is used to identify new areas for consideration as parks, wildlife refuges, fauna conservation areas, or other conservation areas.

These data centers are modest efforts by the usual development standards. In only 1 to 3 years, a small staff can accumulate and organize enough useful ecological information to serve most development planning needs. In Costa Rica the program was started with only US$25,000 for the first year's operation. A staff of five worked in offices provided by the National Museum, and, although this budget proved to be too small for long-term operation, it was sufficient to establish the program which continues operating today on US$60,000 per year. In Colombia, US$120,000 was budgeted for the program's first 2 years. Peru's conservation data center is being maintained on an annual budget of US$100,000. Most of the funding for these programs has been raised from the private sector. Additional funding will have to come from a combination of private and public sources.

Having the correct institutional home for a conservation data center has been as important as having an ample budget. No generalization can be made about which agency is most appropriate, but the CDC must be functionally close to natural resource agencies such as forestry and parks. The long-term usefulness of the CDC depends on how well these institutional links are established. Ultimately, the government agencies that use the biological information from the CDCs carry the costs of further developing and maintaining the information system.

The conservation data centers do not duplicate or supersede the work of IUCN's Conservation Monitoring Centre (CMC). The latter gathers conservation information worldwide, and its products are useful in global and regional analyses for development planning. The in-country conservation data centers serve the more specific planning needs of a particular country (e.g., development project review and conservation system planning).

CDCs also do not replace the primary biological research needed in many developing countries, and all efforts should be made to continue basic inventories of flora and fauna and the more geographically localized inventories of parks and other protected areas. However, CDCs have already proven useful to development planning in several countries, and the model can be easily and inexpensively used elsewhere. Costs are US$125,000 to US$200,000 per year per country, during the first 3 years. Longer-term costs can be lower, depending on how extensive a system is developed and how much data is computerized.

National conservation strategies

In the late 1970s, the International Union for Conservation of Nature and Natural Resources was commissioned to develop a strategy for achieving conservation on a global scale. The product, the World Conservation Strategy (WCS), is not simply the view of one organization but the outcome of extensive consultations with experts from many fields, countries, and organizations. It was launched in March 1980 and has been widely endorsed by international organizations, governments, and nongovernmental organizations throughout the the world. The strategy emphasizes that conservation is an integral part of development and of sustainable use of natural resources. Preservation of wildlife and the strict protection of special areas, such as parks, are only one part of the much broader scheme of conservation.

Because world politics and economic development are constrained by issues of national sovereignty, conservation activities must ultimately be carried out at the national level where long-term development aims can be defined and where administrative and professional capabilities are already in place. The WCS, a useful scheme in which to view conservation activities, is now being used as a basis for discussion, programming, and action in many developing and developed countries.

The WCS proposes that national and subnational conservation strategies be written to guide nations in developing their natural resources, especially renewable resources such as forests and wildlife. National strategies have been written or are being developed in more than 40 nations. In the developing world, for example, the initial work on a national strategy has been completed in Indonesia, Malaysia, the Philippines, Thailand, Zambia, Nepal, Vietnam, Sri Lanka, and Uganda. In the industrialized world, final strategies or drafts have been prepared in Australia, South Africa, Spain, the United Kingdom, New Zealand, Italy, Canada, the Netherlands, and Norway.

The WCS contains three main conservation objectives: (1) to maintain essential ecological processes and life-support systems, such as soils and forests; (2) to preserve the full array of biological diversity contained in species and ecosystems; and (3) to ensure that the species and ecosystems used by man are exploited on a sustainable basis. The three objectives are being incorporated in all national conservation strategies being developed.

An important part of developing these national strategies has been the role of international and national nongovernmental organizations in the entire process. For example, IUCN has served as a catalyst to develop guidelines and to get the process started in many countries, and in several cases, local NGOs have helped draft the national strategy. Public participation in the process in some countries may be essential, and several countries have gone through an extensive process of holding public hearings and soliciting comments from a wide audience.

The nation state may not always be the most suitable entity for a strategic approach to conservation. In Malaysia, for example, several state strategies are being developed. It is important to maintain flexibility in how the strategy is developed. The process necessarily must vary from country to country.

The costs of preparing a national conservation strategy depend entirely on how much of the cost can be considered part of the normal operations of existing government agencies. Often such agencies can simply absorb much of the cost of convening meetings and drafting background documents. Development assistance from the outside, however, either in the form of bilateral grants or loans from development banks, often can be the catalyst needed to get the process started. USAID, for example, has recently helped to initiate strategy development in Belize and Nepal. The Swedish aid agency, SIDA, supported NCS development in Nepal, Sri Lanka, Vietnam, and Zambia, and the Norwegian agency, NORAD, similarly has supported the efforts in Botswana, Bangladesh, and Zambia.

Mapimi and La Michilia Biosphere Reserves in Mexico

Biosphere reserves, a major element of UNESCO's Man and the Biosphere Programme, contain representative examples of the world's ecosystems. Mexico has taken the lead in promoting this type of conservation area designation, with 3 reserves already established and 2 more proposed. Mapimi and La Michilia, established in 1977, illustrate how an area can be used for long-term environmental monitoring, research, and education, while also encouraging sustainable development that fosters the support and participation of local people. Both reserves contain core zones where scientific research is conducted but no other activities are allowed. Around these core areas are management zones where farming and other land uses occur. The objectives of the reserves have been explained to the local people whose needs have influenced the research programs on the reserves. Local ranchers have voluntarily allocated a part of their income for this research, and cooperation between these groups has led to effective protection of the reserves.

The Mapimi Reserve lies within a semidesert basin, and it contains a rich flora and fauna adapted to arid conditions. Before the reserve was established, the natural resources of the area were being overexploited. This was shown by the plight of the desert tortoise which, because it provided an easy source of meat, was in danger of extinction.

La Michilia Reserve has a central core of relatively unmodified, mountainous terrain covered in evergreen vegetation. Pine and oak woodland is typical of the surrounding management areas. Hunting and grazing pressures had eliminated animals such as the black bear and reduced populations of herbivores such as the white-tailed deer. The area was potentially rich for grazing cattle, but new management systems were urgently needed to avoid exhausting its natural resources.

Research began in 1976 with intensive field studies to assess the ecological potential of each reserve. This led to a program to supplement and diversify traditional land-use practices and to develop profitable crops and small labor-intensive industries based on local resources:

- New forage plants adapted to the area, such as the nonspiny prickly pear cactus, were introduced.
- A study of white-tailed deer in La Michilia showed that, if hunted wisely, this animal is a valuable source of meat and need not compete with cattle for grassland.
- Experimental strawberry growing at La Michilia has been highly successful, and fruit is now marketed with other fresh vegetables, jams, and preserves in major Mexican cities.
- Basketmaking and cutting and polishing semiprecious stones provide further employment for local people.
- Beekeeping has been introduced successfully in both reserves.
- A small wood-packaging industry has been developed to make crates for fruits, vegetables, and beekeeping equipment.

Parc National des Volcans in Rwanda

Protecting the endangered mountain gorilla and its habitat in this park is a recent success story in conservation biology. The park is in one of the world's poorest nations, the most densely populated country in Africa.

During the 1920s, Belgian colonial authorities established a section of the Virunga forest (including parts of what are now Rwanda and Burundi) as Africa's first national park. Some small-scale encroachment continued for the next three decades, until 1958, when the colonial government allowed 7000 hectares of forest to be cleared. In 1969, the Rwanda Government allowed an additional 10,000 hectares to be cleared for agriculture. Only 12,000 hectares, the present size of the park, remained. Another 5000 hectares were proposed for clearing in 1979, but the proposal was abandoned.

Although difficult to quantify, the economic benefits of preserving the park exceed those that would result from converting it to agriculture. Soils are rocky, and the land is steep, above the elevation where most crops can thrive. Even if the entire park could be inhabited at the high density occurring on the more fertile lands, it would only provide for 36,000 people—or 3 months' population increase at the current 3.2% growth rate.

A much stronger economic argument can be made for protecting the park as a watershed. Several rivers flow out of the park, providing a regular supply of clean water for human and livestock consumption. Water tables are higher in the region because of the forests, and farmers are able to get multiple harvests, including during the 2-month summer dry season. Deforestation of the park would decrease the longevity and productivity of a proposed hydroelectric dam across the lower Akagera River. The park itself contains less than 1% of Rwanda's area, but it receives more than 10% of the country's total rainfall.

The success of the park can be attributed to the Mountain Gorilla Project, initiated in 1978 by a consortium of international conservation groups, including IUCN. Funding for guards quickly stopped the poaching which had been responsible for the great reduction in the gorilla population between 1960 and 1978. By habituating gorillas to humans, it was possible to ensure that tourists could see the animals, and thus tourism increased dramatically. The number of visitors to the park has increased more than fivefold since 1978. Natural history enthusiasts are willing to pay the expense of getting to the park now that they can be guaranteed the opportunity of observing gorillas. In Rwanda, tourism now is the third source of foreign revenue and the fastest growing economic sector.

Education is an important component of the project. Posters, calendars, radio broadcasts, and a self-contained mobile unit for slide and film presentations have reached thousands of Rwandans. The importance of this public awareness campaign is shown by the increasing support the park receives from local people despite the modest economic benefits that have accrued directly to the local population. Efforts to educate the public about the biological significance of the park, both nationally and internationally, were aided by its designation as a Biosphere Reserve in 1983.

Without detracting from the success of the Mountain Gorilla Project and park, it is important to remember that this example focused on an animal that is enormously attractive to people. Wildlife groups were quick to respond to funding requests, and this seed money started a conservation education campaign. Other regions with spectacular bird species, for example, could follow a similar pattern to develop tourism. Many tropical ecosystems, however, lack such spectacular fauna or flora. They require different strategies for gaining the support and funding needed for conservation activities.

Kuna Indian Forest Park in Panama

The Kuna Indians are an exception in a world in which the indigenous people of the tropical forests are as threatened as their homelands. Like most indigenous groups, they know how to draw on the forests for food, medicines, and other resources and to do so without destroying the resource base. The Kuna have been unusually successful, however, in maintaining their traditional values in the face of outside development pressures. Recent evidence of this is their decision to put part of their land into a wildlife reserve with research facilities for scientists from around the world. The revenue from tourists and scientists will be used to protect and preserve an area the Kuna consider an important part of their heritage. This is the world's first forest park created by an indigenous group.

The 30,000 Kuna are spread out among more than 60 villages on small, near-shore islands. In response to an armed uprising by the Kunas in the 1920s, the Panamanian government established the San Blas Reservation (the Comarca). Although less than 160 kilometers from Panama City, the Comarca is separated from the rest of Panama by a mountain range and nearly impenetrable forest. The region was inaccessible except by boat or plane but, with the development of a road in the 1970s, the Kuna began to face pressures of encroachment by illegal squatters. Realizing the most vulnerable point was an area where the road entered the Comarca, they tried to establish an agricultural settlement there. Attempts at agriculture in this steep terrain failed, however. Foresters, invited by the Kuna, confirmed their realization that the land was unsuitable for crops.

As another means of establishing their presence in the area, the Kuna consulted with scientists from CATIE, the regional research organization, and with others about developing a park. By mid-1983, newly trained Kunas were collaborating with the Inter-American Foundation, CATIE, World Wildlife Fund-US, and the U.S. Agency for International Development in establishing the park.

The Kuna have always preserved small areas of the forest, excluding agriculture and most other activities except the gathering of medicinal herbs. The idea of the park fits well within Kuna culture, and they realized its potential for protecting the larger Comarca region as well. The 60,000-hectare park will include 2000 hectares of completely undisturbed forest. Facilities are being improved to house scientists and natural history enthusiasts interested in the biological diversity and scenic resources of the park.

Many parks throughout the world, including those in Latin America, suffer from conflicting land-use pressures and neglect. In the case of the Kuna Indians and their forest park, the interests of a group whose dependence is so closely tied to the natural resources of the area very likely will provide the incentives necessary for conserving the area over the years.

Dumoga-Bone National Park in Indonesia

Dumoga-Bone National Park, on the island of Sulawesi, occupies 300,000 hectares, more than 90% in primary forest. The development of the area is closely related to the World Bank-funded Dumoga Valley Irrigation Schemes. Concern about deforestation led to agreement between the government of Indonesia and the World Bank to develop and protect the watershed by establishing the Dumoga-Bone National Park. This is an unusual example of a large development agency recognizing conservation as complementary to development.

The area had no conservation history before 1977. Population densities were low, and most of the area was undisturbed primary forest. Demand for agricultural lands by a rapidly growing population, and the explosive increase in timber exploitation in the past few decades, stimulated interest in conserving part of the island before it was developed.

Based on work conducted between 1977 and 1979 by the Indonesian Directorate of Nature Conservation, IUCN, World Wildlife Fund, and the World Bank, three protected areas were established (Dumoga Wildlife Reserve, Bone Wildlife Reserve, and Bulawa Nature Reserve). In 1982 the 3 sites were combined to form the Dumoga-Bone National Park.

The park contains large populations of most of Sulawesi's endemic mammals and many of the island's 80 endemic bird species. It is the site for a major international research effort, Project Wallace, involving 150 scientists. Upon completion in December 1985, its base camp will be used as a permanent field station. Research programs will provide information on the ecology of a tropical rain forest, agricultural entomology, medical entomology, forest regeneration, insect diversity and conservation, and the geophysics of the region. The park has several buildings including an education center, field research station, staff and guest houses, and facilities for recreation and tourism. It is also used by a newly developed Regional Nature Conservation School.

Watershed protection provides a strong economic justification for the park's protected status. The Dumoga Irrigation Project aims for a threefold increase of the valley's rice production through irrigation of more than 13,000 hectares of prime agricultural land. To ensure the capacity of the upstream area to deliver regular and abundant water for irrigation, the World Bank incorporated plans for the park into the irrigation loan. By preventing forest clearance the park will also decrease the threat of flood to a nearby city, Gorontala, and reduce erosion that would otherwise lead to silting of the harbor.

The Primate Project in Peru

Nonhuman primates serve a vital role in biomedical research as models for the study of human diseases, in drug testing, and in evaluation of chemical compounds. By the early 1970s, there were signs of impending shortages of animal stocks, and a more general concern about destruction of tropical forests where these primates live.

The Non-human Primate Program was started by the Pan American Health Organization (PAHO) in 1972. Later, through its contract with the U.S. National Institute of Health, PAHO collaborated with the governments of Brazil, Colombia, and Peru to establish and maintain captive and semicaptive breeding centers on Isla Padre and Isla Iquitos, in the Amazon River near Iquitos, Peru. Several thousand monkeys have been made available from these centers since 1981, with the number increasing each year. The breeding programs provide enough money to run the centers.

Funding is also provided to ensure *in situ* conservation of nonhuman primates and the ecosystems in which they live. Studies underway will determine the distribution, biology, and conservation status of wild primate populations. National conservation plans are incorporating this information to establish and manage parks and reserves necessary for protecting these natural resources. For example, PAHO has facilitated collaboration between the Peruvian government, U.S. Fish and Wildlife Service, and WWF-US to develop management plans that will ensure adequate protection of the Pacaya-Samiria National Reserve in Peru. Two additional sites, one in the area of Gran Pajaten and the other between the Amazon and Yavari rivers in Loreto, are also being evaluated for the protection they could provide for primates and other wildlife.

In operation over a decade, the PAHO Primate Project has succeeded in reducing illegal trade in threatened species. The lessons learned from it may be useful in establishing similar projects elsewhere. Much depends, however, on the behavior and breeding success of the animals in seminatural conditions, and researchers have had only modest success with some species.

Strengthening institutions for research, training, and extension

The case studies presented here illustrate successful experiences in research, training, and forestry extension. They include examples at the local, national, and international levels and cover a range of institutional settings in both the public and private sectors. The case studies demonstrate the significant contributions of well developed research, training, and extension programs to forest conservation and development. In addition to expanding and improving the technical basis of these programs, greater attention needs to be given to social and economic considerations. The central role that such programs have played in agricultural development in many parts of the world must be repeated in forestry.

The College of African Wildlife Management in Tanzania

Established in 1963, in Mweka, Tanzania, to serve anglophone Africa, the college was the first African institution to provide professional training in wildlife management. Previously, most personnel of African game departments and national park services had no formal training in wildlife management. Most of the trained upper-level park managers were expatriate wildlife biologists. Training for mid-level personnel was needed and, as countries gained independence, a cadre of upper-level managers had to be trained to replace the departing expatriates. In 22 years Mweka has trained more than 1000 game assistants and game/park wardens from 16 countries. Today, virtually all protected areas in eastern Africa are staffed by Mweka graduates.

The college owes its existence to the Tanzanian government's commitment to wildlife management and to strong international support. In 1961, President Julius Nyerere, in his Arusha Manifesto speech, proclaimed full support for conservation of wildlife and wildlands and for training in wildlife management. National governments and multinational and nongovernmental organizations provided financial assistance, and 2 years later the college was established. Since then, operating costs have been covered by student fees and a substantial subsidy from the Government of Tanzania. Capital development costs have been provided by international donors.

Located in northern Tanzania, the college is near many parks and reserves representing many kinds of ecosystems, from alpine moorlands to marine habitats. These areas are useful for training, and 30% of student time is spent in field training. For classroom work and residence, Mweka's extensive physical plant includes an administration building, faculty offices, two lecture halls, an auditorium, laboratory, library, museum, taxidermy room, weapons training area, student dormitories, and staff housing. Personnel include a principal, deputy principal, 14 instructors, and 60 support staff.

Mweka offers three courses of study: a 2-year certificate for assistant wardens; a 2-year diploma for wardens and senior field officers; and a 1-year postgraduate diploma for university graduates who will take senior posts in park and wildlife management. An average of 80 students attend the school. About 90% of them are enrolled in the certificate and diploma courses. The college also runs special courses lasting 6 to 12 months.

The curriculum has been revised in response to changing needs of wildlife managers. Reflecting a balance between ecology and management skills, the three main subject areas are—

- Natural sciences: Zoology, botany, ecology, earth sciences, geography
- Wildlife management: Inventory, utilization, range, and wildlife management; research; vehicle maintenance; and ballistics
- Estate management and conservation education: Park management, administration, construction, law, first aid, survival techniques.

Mweka's success is shown by placement of its graduates and adoption of the school as a model for other programs. Although more difficult to link directly to Mweka, the increase in conservation activity in Africa over the past two decades has been due partly to the many college graduates working throughout the continent today.

The nationalities of the 957 students graduated by Mweka between 1963 and 1983 show the regional nature of the college. Students have come from Tanzania, Kenya, Ghana, Zambia, Uganda, Nigeria, Ethiopia, Sudan, Botswana, Malawi, Sierra Leone, Liberia, Cameroon, Somalia, Egypt, and the United Kingdom. A survey conducted in 1983 revealed that most graduates were satisfied with Mweka training and felt it prepared them well for duties in wildlife conservation. Training at Mweka has helped wardens and managers to advance within their own agencies, and 82% of the graduates have been promoted soon after completing their studies at Mweka.

The survey also showed that 83% of Mweka graduates remained in wildlife-related occupations, mainly in duties related to protection and wildlife law enforcement but also in administration and training. The majority of wardens and subwardens in eastern Africa's protected areas were trained at Mweka. Some graduates have attained high positions in their national governments. For example, the Director of Wildlife in Tanzania, Zambia, and Malawi; Deputy Director in Ghana; and two Assistant Directors with the Kenya Wildlife Department were trained at Mweka. Former students now head other wildlife training institutions, including Garoua (Cameroon), Bussa (Nigeria), Pasiansi Institute (Tanzania), Ghana Game Scout School, and Mozambique Game Ranger School. Former Mweka instructors are in leadership positions in international organizations, such as IUCN, FAO, UNDP, and UNESCO.

Having proved itself as an effective training program, Mweka has served as a model for newly established institutions. The success of Mweka encouraged Cameroon to establish Garoua College of Wildlife Management in 1970 as a regional wildlife training center in francophone Africa. The new Naivasha Institute in Kenya also has been patterned after Mweka.

Mweka's programs have had direct and indirect effects on national support for wildlife management and conservation. Since 1965 more than 12 million hectares of land in eastern African countries have been designated as some form of conservation area. The World Wildlife Fund has recognized Mweka's efforts by awarding the college the International Award for Conservation Merit in 1981.

Several factors have contributed to Mweka's success, including—

- Its establishment at the right time and place for the fulfillment of a recognized need
- Strong and consistent support from high-level Tanzanian officials
- International financial support.

Despite its good record, the school suffers from a lack of funding and is faced with the prospect of lower enrollment. Since Mweka's inception, six bilateral programs, three U.N. agencies, and five nongovernmental organizations have contributed funds for staff positions, training, and student scholarships, but such contributions are irregular and do not cover recurrent operating costs. Financial insecurity and rapidly rising recurrent costs have limited Mweka's development. Costs have increased threefold since the mid-1970s, forcing student fees up from US$2,200 to US$6,000 annually. The fee does not pay for all operating expenses, and, to keep tuition affordable, Tanzania subsidizes the remaining expenses. Tanzania's annual contribution to Mweka has increased from US$15,000 in 1963 to US$134,000 in 1980-81. The need for securing adequate and reliable funding to cover operating expenses and capital improvements will have to be met. For Mweka to continue to serve countries that lack their own training facilities, scholarships will have to be provided to many students.

Mweka can continue to serve countries with newly established technician-level facilities by—

- Increasing the number of postgraduate students
- Offering inexpensive short courses, workshops, and seminars to mid- and upper-level personnel.

The demand already exists. Graduates have recommended that Mweka offer refresher courses at least yearly and upgrade the diploma to an advanced diploma or degree program.

International parks and forestry seminars, U.S.A.

The University of Michigan hosts two major natural resource management seminars each year:

- The International Seminar on National Parks and Other Protected Areas
- The International Seminar on Forest Administration and Management.

The Parks Seminar, administered jointly by the U.S. National Park Service and Parks Canada, now is in its 19th year. The Forestry Seminar, administered through a cooperative agreement between the U.S. Forest Service, the University of Michigan, and USAID, will convene for the second time in 1985. Both seminars offer unique opportunities for senior natural resource professionals from all countries to observe North American land management techniques and to discuss applying these practices in their own countries.

Parks seminar

The Parks Seminar developed in response to requests from managers of new national parks worldwide for tours and information about the U.S. parks system. The first seminar was organized in 1965 by the International Park Affairs Office of the U.S. National Park Service and the Department of Natural Resources at the University of Michigan. Since 1970, Parks Canada has cosponsored the seminar, provided a staff officer and resource specialists, assisted in curriculum design, and arranged visits to parks, a World Heritage Site, and Biosphere Reserves in western Canada.

Originally a 2-week classroom course, the Parks Seminar evolved into a 4-week study tour with morning lectures and afternoon field visits. Typically it begins in western Canada at Jasper National Park and after 10 days in Canada moves on to the western United States.

The curriculum has been broadened from the original focus on protection and interpretative strategies to include policies and management philosophies. Evaluations by the visiting resource managers and feedback from former participants have helped adjust the curriculum to meet participants' needs. The program has five major themes:

- Global perspective: The worldwide significance of protected parks and wildlands, and international programs, treaties, and conventions applicable to their management
- Diversity of habitat: Comparison of international management techniques for conservation of habitats, including alpine ecosystems, grasslands, tropical forests, islands, and deserts
- Resource protection: Processes and procedures to optimize use and protection of natural resources
- Interpretation and environmental education: Analysis of methods for communicating values, concepts, and a conservation ethic to the public
- Staff development: Processes for developing a qualified staff to implement the mission and goals of the organization.

The cultural exchange that occurs between participants is perhaps as valuable as the academic portions of the seminar. Planned social events help build friendships, create personal bonds which lead to future cooperation, and provide new ideas on styles of communication, decisionmaking, and compromise. Former participants maintain contact through alumni groups.

Since 1965 the seminar has graduated 595 park executives and conservation leaders from 103 countries. Annual attendance averages 35 people. Each year the list of applications grows longer as the seminar's reputation spreads. In 1984, for example, 160 applications were received.

The professional level of the seminar's participants generally is very high and, for some, completing the course has resulted in advancement within their own agencies. Dozens of alumni hold high positions in their natural resource administrations as planners, policymakers, or ministers of agriculture or natural resources.

From the beginning, the costs of the seminar have been borne by the participants, either through sponsorship by their home governments or by donations from universities, international conservation groups, private foundations, zoological societies, or bilateral or multilateral development assistance agencies. In recent years half of the participants have been fully supported financially by their home governments. The fee (US$3,000 in 1984) is based on actual operating costs, including tuition, materials, food, lodging, and travel.

Forestry seminar

The success of the parks seminar led to development of a parallel seminar for forest managers. In early 1984 the U.S. Forest Service, USAID, and the Office of International Cooperation and Development of the U.S. Department of Agriculture agreed to support the University of Michigan in organizing a forest management seminar for developing country foresters. USAID committed financial support through 1986.

This seminar arose from growing concern about deforestation in the humid tropics. Because the United States has long dealt with problems arising from deforestation and soil erosion, it was recognized that the U.S. experience might serve as a model for exploring forest policy issues, problems, and solutions in developing countries. It was recognized, at the same time however, that many tropical forest management problems are unique to the tropics and that much temperate forest experience simply is not applicable elsewhere.

The first session of the forestry seminar included 23 participants from 21 countries: 5 from Latin America, 4 from the Caribbean, 9 from Africa, and 5 from Asia. All were experienced, professional resource managers who were highly committed to improving their organizations and the natural resources under their management.

The design of this seminar was heavily influenced by successful elements in the Parks Seminar. The 30-day course period, traveling structure, and daily routine of morning lectures and afternoon field visits were adopted.

The seminar focuses on sustainable resource use. Unlike the parks seminar, it concentrates less on management of public lands and more on private or communally owned lands. It examines how public institutions, through education or regulation, can affect forestry efforts to maximize public benefits. Strong emphasis is placed on resolving conflicts through public participation. Participants are exposed to a broad range of perspectives on forestry priorities and practices in the United States. They speak with representatives of federal and state governments, private industry, farmers, universities, professional societies, conservation organizations, and farm interests. They are divided into groups by region and given time to talk about their own forest management programs.

Strengths and significance

Both the parks and forestry seminars have been received with enthusiasm. Several factors contribute to their strengths and significance:

- Cultural exchange through formal presentations and discussions of the participants' experiences. Planned social gatherings and group events help build personal relationships and professional camaraderie.
- Shifts from one location to another allowing visitors to compare different environmental and administrative conditions.
- Exposure to a variety of management systems. Participants determine for themselves if components of these systems can be translated to their own cultural environments.
- Small group exercises and problem solving situations that encourage active participation and effectively teach the principles of group process and decisionmaking.

Tropical Agricultural Research and Training Center in Costa Rica

The development of CATIE, the Tropical Agricultural Research and Training Center, is the story of an international research and educational institution that has evolved in form and function to better meet national needs within its region. This story demonstrates the dynamic between regional and national institutions and, in describing CATIE's role in the AID-funded Regional Fuelwood and Alternative Energy Sources Project, illustrates how a regional institution can serve to strengthen national institutions through collaborative efforts and information sharing.

CATIE's history begins with the Inter-American Institute of Agricultural Sciences (IICA). The institute was created in 1942 as an agency of the Organization of American States to develop agriculture throughout the Americas by strengthening research, training, and extension. During the early years, IICA established several research centers. One of them was CEI (Centro de Ensenanza y Investigacion), located at IICA headquarters in Turrialba, Costa Rica. CEI launched an agricultural research program in 1943 and graduate training in 1946. For the next 11 years it was the only graduate agricultural school in Latin America.

The center gained steadily in size and reputation. By the late 1960s there were more than 50 staff members, more than half with Ph.D. degrees. The school had awarded more than 270 master's degrees to students from all over Latin America, and enrollments were predicted soon to reach 300. The center was making a significant contribution to Latin American agriculture through professional development; 43% of its graduates were working with national ministries, agricultural development institutions, and agricultural experiment stations. Another 27% were university professors, and 8% were working in international institutions.

Despite its achievements, CEI fell under attack in the late 1960. Activities at the Turrialba research and training center were held to be too heavily oriented to conditions of the humid tropics to represent adequately the regional and national interests of those in the temperate and highland zones. Moreover, social and institutional development in Latin American agriculture were said not to be getting the kind of attention and support needed, particularly at the national level.

A special advisory committee concluded that it was not in the best interests of the American States for IICA to continue to support a graduate and research center serving all of Latin America. Their argument was that "an international institution should help member countries only in those things which they cannot do by themselves." The task, they held, "is to provide assistance to the countries to make them capable of [doing] what they cannot adequately do. The primary preoccupation of IICA should be the development of national institutes." It was determined that IICA would divest itself of CEI, thus freeing funds for support of national and regional graduate schools and related institutions.

In 1970 the organization's name changed from CEI to CTEI (Centro Tropico de Ensenanza y Investigacion), serving to emphasize its orientation toward the humid tropics. Later, IICA entered into negotiations with the Government of Costa Rica, which culminated in mid-1973 in the creation of the autonomous, nonprofit, civil association now known as CATIE.

With a narrowed regional focus and redefined objectives, CATIE is dedicated "to supporting the countries in Central America and the Caribbean in their agricultural, animal, and forestry development programs in order to increase food production and the average income per unit area of land in the rural sector." Special attention is given to helping the rural poor.

To meet this objective, CATIE's research has been aimed principally at developing integrated crop, cattle and forest production systems suited to tropical conditions. Graduate training is provided in the three research fields. Short courses, seminars, technical meetings, and in-service training serve to update professionals. Cooperative agreements with governments, national institutions, and foreign donor agencies help channel technical support where most needed.

Core financial support now derives from IICA, annual contributions by participating governments, profits from the center's commercial farm operations, and income from institutional services, such as consulting. Money and staff support also derive from specific contracts and agreements with international donors. The annual budget recently exceeded US$8 million.

Growing regional interest in the school is reflected in several ways. Panama, Nicaragua, Honduras, Guatemala, and the Dominican Republic have joined Costa Rica as contributing members and other memberships are pending. Regional research is in progress under the terms of ten international agreements. More than 275 students have received the master's degree under a joint agreement between CATIE and the University of Costa Rica. Further, 170 technical staff members are at work, one-fourth of them in member countries.

One of CATIE's current research projects can be used to illustrate how it contributes to national development within the region. The Regional Fuelwood and Alternative Energy Sources Project was initiated in 1980 in response to a proposal by the USAID Regional Office for Central America and Panama. The purpose is to improve the welfare and productivity of low-income groups by alleviating the current shortage of low-cost energy.

The strategy was to develop locally efficient technologies for producing wood fuel and to teach poeple how to apply them. The project has research, training, and extension components. The Natural Renewable Resources Division was to identify zones of relative fuelwood scarcity in six countries, determine what tree species would grow best in these areas, and develop planting and management techniques to accelerate fuelwood production from the more promising species. Practitioners within national cooperating institutions would then be trained in the use of these techniques. In turn, they would transfer what they learned to potential tree growers.

Implementation required three steps:

- First was international cooperation and planning. Working arrangements had to be established with national coordinating agencies in each of the six countries with lines of communication to national agricultural and forestry institutions, nongovernmental organizations, community leaders, industry, and small land owners. Mutual agreement had to be reached on program plans, particularly as to the participatory role of each interest group.
- Second, standardized field techniques and research procedures had to be developed for gathering, aggregating, organizing, and interpreting field data efficiently and accurately.
- Third, procedures had to be developed for disseminating research findings to practitioners, interpreting the findings, and showing how to apply them at the local level.

The project is now in its sixth year. Close collaboration has been achieved with the national forestry departments of member countries. Ninety-three professionals and technical and administrative assistants, more than half supported by their country governments, are receiving some specialized education and training while working on the project. Trials of more than 120 tree species have selected three to five species which do well under the wide range of conditions normally found in areas of critical fuelwood shortage. Dozens of tree nurseries have been established, and more than 700 demonstration plantings have been made on farms, village woodlots, and industrial lands; in natural forests; and mixed with agricultrual crops.

Training efforts at CATIE have included sponsorship of nine master's candidates and one fellowship for doctoral study overseas; 45 short courses, workshops, and seminars have been organized or are planned as a means of bringing research findings to implementing groups; and 30 manuscripts have been published. A computerized, regional database is being assembled. This, and manuals describing research techniques and improved silvicultural practices, will be distributed to national practitioners.

These practical achievements should not obscure more fundamental contributions. CATIE has helped develop a cadre of trained professionals for staffing national institutions. It has operated efficiently to maximize benefits from scarce financial resources while providing services for member nations. It has helped to ensure continuity and increasing quality of research and training, particularly in times of financial retrenchment. And it has acted as a clearinghouse for donor funds to be applied nationally and regionally.

Today, because of its narrowed yet still regional perspective, the center is able to do even more than before by creating a stronger sense of community among the countries of the humid tropics and by developing communication links between Central American public and private natural resource institutions.

Forestry research at Aracruz Florestal in Brazil

Aracruz Florestal, S.A., is a private forest company that manages 85,000 hectares in northern Espirito Santo and southern Bahia states of Brazil. In less than 20 years the company transformed badly degraded forest lands containing excessive scrub vegetation into more than 60,000 hectares of highly productive eucalyptus plantations. These plantations furnish the raw material for Aracruz's pulp mill, one of the largest in South America. The company's innovative research team has more than doubled plantation yields by successfully cloning eucalyptus on a large scale. In recognition of its work, the team was awarded the prestigious Marcus Wallenberg Prize for pioneering work in industrial forestry research.

The company was started and the first plantations were established in 1967, stimulated by Brazil's Forestry Incentive Program. This program allows a portion of federal income tax to be used directly for establishing plantations and other forestry programs, and it has stimulated much of the development of Brazil's forest industry.

Aracruz was a pioneer in large-scale plantation forestry in the region. The information needed to select plantation species did not exist, and silvicultural information was limited to eucalyptus research in Sao Paulo state that was performed by government agencies and private companies. Spacing, fertilization, and weed control technologies developed in Sao Paulo, however, were not directly applicable because of different ecological conditions at Aracruz. In addition, the plant material brought from Sao Paulo was not well adapted to the area. Survival and growth rates were low. The trees were also highly susceptible to an introduced canker, other diseases, and insects—all of which caused significant mortality.

To find solutions to these and other problems, in 1972 Aracruz formed a research team that placed emphasis on tree improvement, soils and plant nutrition, and pathology. Today this team consists of six professionals. They are supported by 70 technicians, aides, and field workers. Approximately 4.3% of the budget is committed to research.

The Aracruz research team has solved many of the company's management and technical problems. Much of this success has been due to the company's commitment to the research program. At Aracruz, operations and research are intimately related. The research program is aimed toward obtaining practical results, and the success of the program can also be attributed to the selection of dedicated, competent researchers who are all Brazilian nationals. Some of them have been with the company from the beginning. Continuity of staff has been due largely to competitive salaries and adequate funds and facilities to carry out the program. Members of the research team are encouraged to participate in national and international meetings and to obtain additional training both locally and outside Brazil.

In addition to its own research program, Aracruz participates in two research cooperatives organized by major forestry schools and including other Brazilian forestry companies. It supports basic research by these cooperatives and uses the results in its own programs. It also collaborates with several national and international forestry research organizations and frequently uses consultants to assist with special problems or projects.

The research program at Aracruz has been responsible for major changes in forestry operations on company lands, including changes in species planted, disease and insect control, harvesting methods, silvicultural practices, weed control, fertilization, and clonal propagation of eucalyptus. Aracruz has presented its research findings at national and international meetings and disseminated them in publications issued by the company. Some of the technologies have been adopted by other forest companies and government organizations in Brazil and elsewhere.

Perhaps most significant is the development of a large-scale vegetative propagation system for eucalyptus. Many of the early plantings at Aracruz originated from Brazilian seed from hybrids of *Eucalyptus grandis*, *E. saligna*, and *E. urophylla*. These plantings were extremely heterogeneous and had relatively low yields and high susceptibility to certain diseases. The yields averaged 22 cubic meters per year, and 80% of the trees were infected with canker. Later plantings of *E. grandis* with seed collected from South Africa and Zimbabwe had higher yields and greater disease resistance, but production was still below company expectations.

Aracruz began research on vegetative propagation of eucalyptus in 1974 as part of a tree improvement program to increase yields and produce more homogeneous

planting material. Initial studies were successful, and by 1975 the first clonal material was planted in the field. Work began on selection of superior trees, and, eventually, 4,600 of the best individuals were selected from existing plantations. During the next 5 years, studies were conducted on how to efficiently collect and process large numbers of cuttings, and additional clonal material was field tested. Clonal orchards were established and processing facilities for the seedlings were built. From the original 4,600 selections, 38 clones were selected for large-scale planting. In 1979, the first commercial planting of 1 million rooted cuttings was made. Planting increased to 3.5 million cuttings in 1980, to 10 million in 1983, and to 15 million in 1984. In 1984 the company's entire planting program used cuttings developed by its research program. To avoid dangers associated with extensive monoclonal plantations, a maximum of 100 hectares of any one clone is planted in an area.

Gains made through the use of clonal material have been spectacular. Average annual growth has increased 112%, from 33 to 70 cubic meters per hectare. Average wood density has increased by 25% and cellulose content, by 23%. All clones currently in use are resistant to the major diseases affecting eucalyptus in the area. The plantings of individual clones are extremely homogeneous in growth rate. Mortality caused by overtopping of slower growing trees does not occur as in plantations established from seedlings. Because clones were selected partly for their ability to coppice, the proportion of stumps that coppice after the first and subsequent harvests approaches 100%.

Clonal material has been furnished to other Brazilian forestry companies and to the U.S. Forest Service for testing in Hawaii. Other Brazilian companies are initiating their own programs of vegetative propagation using the methodology pioneered by Aracruz.

Central Soil and Water Conservation Research and Training Institute in India

India faces an enormous task in watershed management: an estimated 145 million of 328 million hectares of total land area need soil and water conservation measures—and soon.

The focus for watershed management research and training is the Central Soil and Water Conservation Research and Training Institute, in Dehradun. The institute has developed soil and water conservation techniques and trained personnel in soil conservation, water management, and land reclamation. It is a strong national institution that effectively meets state needs for research and training.

After independence, the Government of India reaffirmed the importance of soil and water conservation. In 1954, under the first 5-year plan, Soil and Water Conservation Research and Training Centers were established at Dehradun, Chandigarh, Ootacamund, Bellary, Kota, and Chantra. Two more, at Vasad and Agra, were set up the following year and another at Hyderabad in 1961. The centers were independent until 1975, when they were redesignated as regional centers of the Central Soil and Water Conservation Resarch and Training Institute. This administrative structure has helped coordinate research over a wide range of ecological and social conditions and has provided the flexibility to adjust research and training to local conditions.

The centers have several common objectives:

- To develop mechanical and biological methods of erosion control
- To reclaim gullies and ravines, and to stabilize slopes to reduce landslides and water torrents
- To develop watershed management techniques
- To set up demonstration projects to show soil and water conservation measures
- To provide specialized training in soil and water conservation to officers of state governments.

The centers are distributed throughout various ecological zones with different watershed treatment requirements: sub-Himalayan and Himalayan watersheds (Dehradun); Siwalik hill ranges (Chandigarh); ravine reclamation on the banks of the Chambal River (Kota), Mahi River (Vasad), and Yamuna River (Agra); southern hilly high

rainfall region (Ootacamund); semiarid, black soil region (Bellary); and semiarid, red soil region (Hyderabad).

Each year the divisions meet to plan the following year's program. The Staff Research Council, acting on recommendations from the division meetings, then formulates the research program for the entire institute.

The center's research over the past two decades has included collection of baseline data on climate and soil characteristics; studies and trials of various agronomic measures (contour farming, mulching, choice of species to reduce erosion) and mechanical measures (bunds, terraces) for soil and water conservation; methods for estimating runoff; and studies of various grass and tree species for fuel, fodder, and/or fiber production on degraded lands.

The center has also classified India into land resource regions according to physiography, vegetation and soil groups, land use, and rainfall. This has helped determine national soil and water conservation needs, organize soil and water conservation research, and distribute technical information to appropriate areas. The institute disseminates the results of its research activities through its "Indian Journal of Soil Conservation" which is published twice each year.

Perhaps the most successful work of the institute has been three integrated watershed management demonstration and research projects to apply research findings to local farming systems. Programs have been carried out in the Himalayan region, Shiwaliks in northern India, and the semiarid, red soil region in south-central India.

The Himalayan watershed management project began in 1974. It includes soil surveys; hydrological monitoring; construction of bench terraces; experiments in fuel, fruit, and fodder production; and stabilization of eroded slopes with grasses and trees. High-yield crop varieties tested and introduced by the program have increased yields by 150-200% per hectare. The government has adopted this watershed management model and it is being used elsewhere, for example, in two projects in the Himalayas.

In the Shiwaliks, where the people have identified dependable water supply as their highest priority, the watershed management project involves sedimentation control, flood control, and water resource development. The emphasis is on producing small ponds for agricultural irrigation systems. This management system has been very successful, gaining considerable acceptance locally and being hailed internationally as a model for watershed management.

The program in Hyderabad, in the semiarid, red soil region, includes afforestation, grassland management, water conservation (mainly check dams for underground water recharge), and soil conservation on agricultural lands. This model is being adopted elsewhere in India, including the states of Karnataka, Andhra Pradesh, Madhya Pradesh, and Maharashtra.

The training function of the institute dates back to the mid-1950, and since being established some of the centers have offered training. Today, training of supervisory-level soil and water officers for state departments of agriculture, forestry, and soil conservation is offered at Dehradun in a 22-week course. Kota, Ootacamund, and Bellary are responsible for training mid-level technicians. The emphasis is on practical training, combining classwork with field studies. The syllabus is interdisciplinary. It includes soil and water conservation engineering, soil-plant-water relationships, soil conservation agronomy, soil conservation forestry, and soil conservation planning and application. Between 1954 and 1979, 1148 officers and 2628 assistants were trained in regular courses by the institute's centers. The institute also offers special short courses for continuing education, and in the 1970s it held 10 such courses for 239 trainees.

The institute clearly has played an important role in the management of India's natural resources. Not only has it been an important center for carrying out and disseminating research, but it has trained a cadre of middle- and upper-level officials in water and soil conservation. Today, graduates of the institute are in positions of authority throughout India, including Chief Conservators of Forests and State Directors of Soil Conservation. The institute is widely recognized and respected in India and internationally.

Community forestry extension in Nepal

Extension is an essential component of Nepal's Community Forestry Development Program, supported by the World Bank, United Nations Development Programme, and FAO. Before 1978, forestry extension efforts in Nepal had been very limited. With adoption of the new forestry policy encouraging active local participation in reforestation, the need for a strong extension effort became obvious. Success of the program depended on dissemination of technical information to the villages and promotion of the new community forestry approach. The UNDP Asia and Pacific Program for Development Training and Community Planning in Bangkok, a regional project aimed at improving rural development programs at the village level, assisted Nepal in setting up its forestry extension system.

The Community Forestry and Afforestation Division of Nepal's Department of Forests was established in 1978 to implement the new forest policy. It is divided into five national units: Community Forestry, Afforestation, Motivation and Education (responsible for training and extension), Stove Improvement, and Monitoring and Evaluation. These centralized national units are linked to a network of division and local staffs.

Field activities are carried out by Divisional Forest Officers, Community Forestry Assistants, Panchayat Forest Foremen, and Panchayat Forest Watchers. Forest officers and assistants explain the community forestry system to panchayat and community leaders and advise on nursery sites and forest management plans. The community forestry assistants, a new cadre of forest department staff trained to carry out community forestry activities, have the closest contact with local leaders, school teachers, and village groups. Forest foreman and forest watchers are villagers employed by the panchayats to tend nurseries and manage forests as part of the community forestry program. They work directly with village leaders, forest committees, and other villagers to implement the program locally.

The absence of an extension service, the need to implement field activities immediately, and the forest department staff's inexperience with participatory village forestry activities required that in-service training be provided to staff at all levels. A variety of training activities, from seminars through study tours and workshops, have been carried out for high- and middle-level officials in the central units of the division. Field officers have attended 3-week workshops on extension, communication skills, and training methods. Each year, forest assistants attend a 2-week refresher training course that introduces them to new information and extension materials. They in turn train forest foremen and watchers.

The Motivation and Education Unit has developed training aids and extension materials (flipcharts, booklets, filmstrips, posters, publications) for forest officers and assistants. Local extension programs are complemented by district and national activities to create an awareness of the role of forestry and to inform the public about the community forestry program's activities and accomplishments. These include distributing a publication on deforestation and forest protection to schools, a weekly radio program on community forestry activities, stickers, calendars, and films. A logo for the Community Forestry Development Programme, printed on all written materials and teeshirts, immediately identifies the program visually.

Annual workshops held in district headquarters allow panchayat leaders or other local officials to ask questions of the forestry officers and representatives of the central division. This 3-day meeting normally includes a 1-day visit to a nursery or plantation. National study tours are also organized for village leaders to show them successful program sites. The demonstration effect of such activities has stimulated interest and participation in the forestry program.

Communication between the implementors and recipients of an extension system is essential. The information from the local level must filter back to central decision-makers. Community forestry extension provides for the upward movement of information by use of seminars, questionnaires, field reporting forms, and visits by central program staff to project divisions.

By September 1984, 400 nurseries and 7500 hectares of plantations had been established, 1.8 million seedlings distributed for individual planting, and 6000 improved stoves installed. Although the program has been in full operation only since 1980, it is gaining widespread participation.

The effectiveness of Nepal's forestry extension system can be attributed to these factors:

- A central forestry system closely linked to a decentralized network of field extension representatives

A combination of training of central and field staff and communication and extension at the village, national, and district levels

- Development of training and extension materials
- Good communication between the field and central office.

Department of Forest Resources Management of the University of Ibadan in Nigeria

The department was established in 1963 to provide professional level forestry training in Nigeria and other African countries. Since then, it has grown from three small rooms that had access to water only 4 hours a day to a well developed and well equipped facility. It consists of administrative offices, lecture rooms, laboratories, a library, workshop, and wildlife domestication research center. An area 40 kilometers from the school is managed as a university forest. The department is one of the few institutions in west Africa offering high-quality postgraduate training in forestry.

The establishment and development of the department was possible because of financial support from the United Nations Development Programme and provision of FAO staff for teaching. Close links have been developed with the Department of Forestry at Oxford for training and library exchange.

The department's course and degree offerings have expanded over the past 20 years. Originally providing only a 3-year bachelor's level course, the department began to offer the master's degree in 1969 and Ph.D. degree in 1965. The 3-year B.Sc. degree course was replaced by a 4-year course in 1977 to provide more practical training. Three B.Sc. degrees are offered: Forestry, Wildlife and Rangeland Management, and Fisheries Management. The same programs are offered on the M.Sc level, but with further specialization available in forestry. A student choosing to study forestry can focus on silviculture and forest biology, forest economics and forest management, forest biometrics and remote sensing, or wood science.

Enrollment has increased steadily. There were 13 students the first year, 71 in 1969, and 146 in 1979. By 1979 the department had graduated 223 students with a B.Sc., 15 with an M.Sc., and 13 with a Ph.D. Recently, women have sought admission to the forestry and wildlife courses, and, in 1979, four women were enrolled in the B.Sc. course.

Ibadan has offered training to students from other African countries. Between 1963 and 1979, it graduated 30 students from outside Nigeria. Nigeria's need for

trained personnel is so high, however, that recently the school has admitted only Nigerian students. Graduates have easily found jobs in forestry, usually with State Forest Services or the forest industry.

The school offers both practical field training and exposure to research. Students are required to do a specified amount of fieldwork to complete their degrees. All teaching staff must carry out research.

Research and training are coordinated with other national and state forestry bodies. The National Forestry Development Committee, made up of representatives from the university department, the Forestry Research Institute of Nigeria, the Federal Department of Forestry, and the Chief Conservators of Forests of all Nigerian states, coordinates research and identifies training needs.

Because demand for foresters in Nigeria is so high, Ibadan cannot meet all the training needs. Other Nigerian universities have been considering establishing forestry departments. Ibadan has encouraged this, to have more freedom to develop advanced educational programs and technical research.

Despite its rapid and successful development, the department faces a number of problems, some of which are common to many forestry training facilities in developing countries. These include shortages of teachers, equipment, and funds to cover operating costs and research. At the same time that Nigeria is confronted with severe shortages of trained forestry personnel, the department at Ibadan is having difficulty maintaining its high quality of training. It has a well developed infrastructure and a good reputation for training, but it needs additional financial support to build on the foundation it has established.

National School of Forest Sciences in Honduras

The school is the only institution in Central America providing forestry training at the advanced technical level. It was established in 1969 at Siguatepeque. By 1982 it had graduated 428 students, 55 of them from other Central American countries and the Dominican Republic. It has excellent physical facilities for instruction, fieldwork, and applied research, and it now has a reputation for academic excellence.

With UNDP/FAO assistance, the school was established to offer a 1-year course for forest guards. It has progressively raised its entrance requirements and improved its curriculum. It started a 2-year forest technician program in 1972 and a more advanced 3-year program in 1974, which all students now follow. It also provides in-service training to forestry personnel through seminars and short courses. Between 1978 and 1981, the school offered 74 training courses for 1206 participants, many from other countries in Central America.

The physical facilities of the school are extensive. They include administrative offices, an auditorium, laboratories, new library and research facilities, classrooms, and dormitories for 240 students. The school manages 5000 hectares of forest lands for research and practical training in forest management. When the school was established, much of this forest land was seriously degraded. Under intensive management, the condition of the forest has improved greatly, and it now generates a small income for the school. A nursery provides seedlings for its reforestation work and serves to train students in nursery management. The school also uses the Wilson Popenoe Botanic Garden in the Lancetilla Research Station. The garden has a valuable collection and represents an important research and training facility for Central America.

Besides training, the school is developing a strong capability in applied research. There is a new building with facilities for research in genetics, pathology, seed improvement, and nursery and plantation techniques. The research staff of 14 professionals carries out nine research projects, and research publications are being produced.

A renowned seed bank is located at the school. It was created in 1976 with assistance from Great Britain. Seeds come from various parts of the country, and technicians collect, test, store, and distribute seeds worldwide. Pines indigenous to Honduras have been found to grow well in other countries, and the demand for pine seed has increased rapidly. Seeds have been sold to public and private entities in more than 32 countries since 1978. The seed bank now generates an annual profit of US$400,000 from the sale of *Pinus oocarpa* and *P. caribaea.*

The school was established as a national facility, but since 1977 efforts have been made to expand its regional function. In 1974 it became an operating unit of the Honduran Corporation for Forestry Development, the national agency charged with forest management. The agency contributed US$1.1 million to the school's operation in 1983, including funds for full scholarships for qualified Honduran students. The school was also given the responsibility to carry out and direct forestry research for the country.

The school graduated its first non-Honduran students in 1974 and since then the number of students attending from the region has increased. In 1977, the countries of the region agreed to strengthen the school as a regional facility. With UNDP/FAO assistance during 1978-81, Central American governments increased their scholarships for students, and the school expanded its curriculum to offer more in-service training. By 1981, about half the students were from outside Honduras.

Since 1981, however, total enrollment has dropped. The decline is attributed to many factors: the regional economic recession which limits the ability of all Central American governments to provide scholarships; political factors affecting the school; and the cost and duration of the school's program.

This decline in enrollment is not due to a lower demand for forest technicians. FAO projections indicate a substantial and increasing need for both forest engineers and technicians in the region. Other Central American countries are proposing to establish 2-year technician schools of their own. The Honduran school, with its capacity for 240 students, however, could accommodate a large portion of the regional demand for forest technicians. Probably, the most reasonable strategy to meet the need is to strengthen the school as a regional institution. It is the most tested and established institution in the region providing this level of training. It has developed an excellent physical facility worth more than US$6 million and has built a strong reputation for its training programs. To replicate this elsewhere would be costly and time-consuming.

Increasing the school's ability to meet regional needs may require further restructuring of its training program. Recognized needs in forestry are increasing the emphasis on applied techniques and fieldwork and making it possible to complete the program in 2 years. To become more regional, the school may also have to become financially and administratively independent to be free of political forces affecting it.

The school could be self-supporting financially, but it will need donor support while it lessens its dependence on Honduran government agencies. It could cover a large portion of its operating budget with more students, more sales by the seed bank, and greater income from its other services and activities (lumber sales, research contracts, short courses). The remaining income would be from student scholarships but, given current economic conditions in the region, donor support will be needed to provide scholarship funding over the near term.

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The World Resources Institute is a policy research center created in late 1982 with a grant from the John D. and Catherine T. MacArthur Foundation to help governments, international organizations, the private sector, and others address a fundamental question: How can we meet basic human needs and nurture economic growth without undermining the natural resources and environmental integrity on which life, economic vitality, and international security depend?

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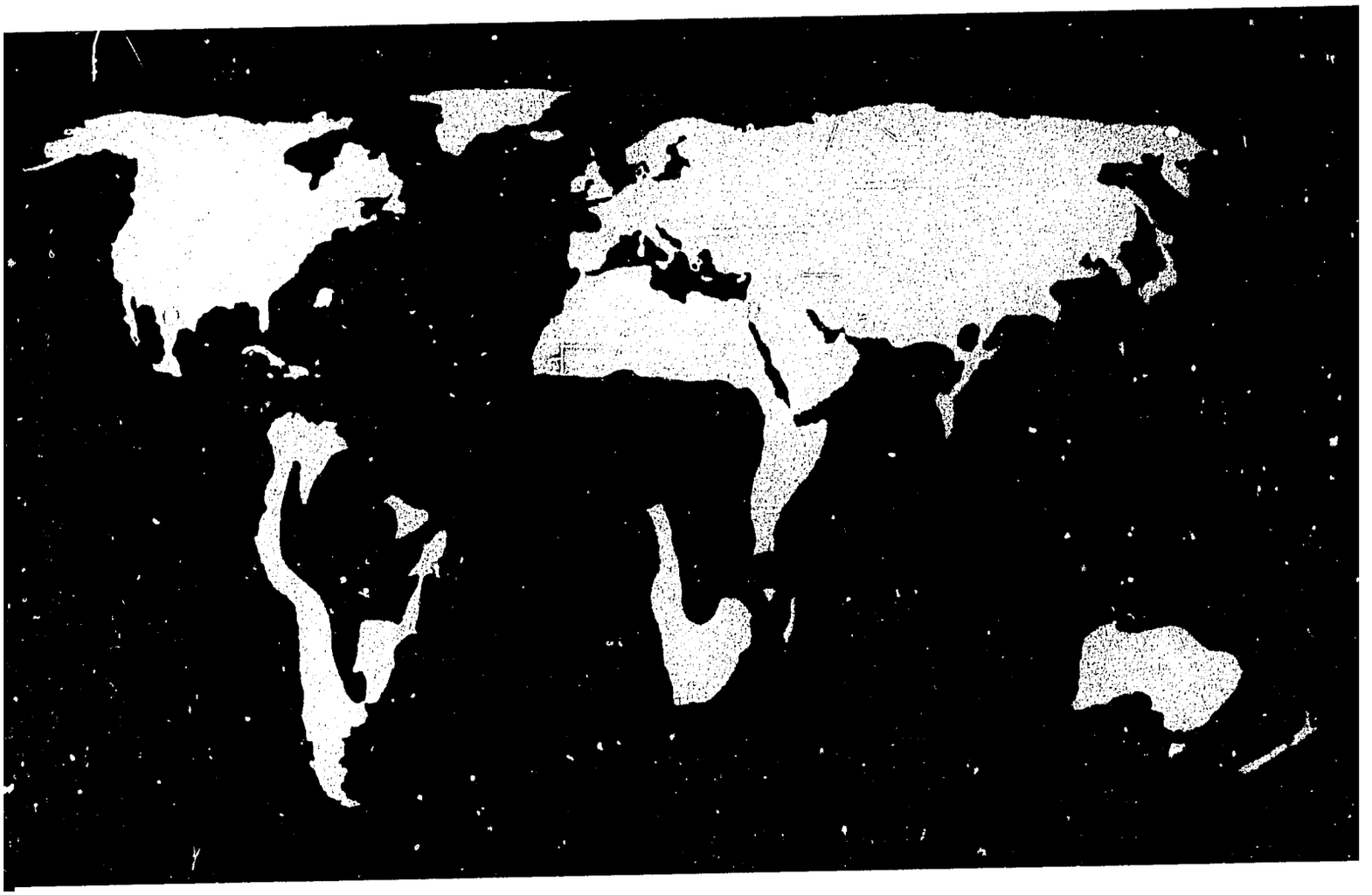
Part III Country Investment Profiles

Tropical Forests: A Call for Action



Report of an International Task Force convened
by the World Resources Institute, The World Bank,
and the United Nations Development Programme

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Tropical Forests: A Call for Action

Part III
Country Investment Profiles

Report of an International Task Force convened by the World Resources Institute, The World Bank, and the United Nations Development Programme

World Resources Institute

October 1985

Each World Resources Institute study represents a significant and timely treatment of a subject of public concern. WRI takes responsibility for choosing the study topics and guaranteeing its authors and researchers freedom of inquiry. It also solicits and responds to the guidance of advisory panels and expert reviewers. Unless otherwise stated, however, all the interpretations and findings set forth in WRI publications are those of the authors.

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Introduction

This report presents a country-by-country analysis of the five-year program of accelerated action outlined in Part I. The country investment profiles propose specific actions and estimate investment needs for 56 countries. Detailed investment needs could not be prepared for all countries affected by deforestation because of constraints of time and available information.

In preparing the country profiles, the Task Force adopted these guiding principles:

- The list of high-priority countries is based on studies by the U.N. Food and Agriculture Organization, leading multilateral and bilateral aid agencies, and nongovernmental organizations such as the International Union for Conservation of Nature and Natural Resources.
- Investment needs were treated in the broadest sense to include support for institution-strengthening activities, including research, training, and extension which, by past experience, are likely to account for between 15 and 25% of total investment requirements.
- In estimating accelerated investment requirements for the years 1987–91, special account was taken of each country's likely absorptive capacity for new investment.

The Task Force estimates the level of public and private investment needed to make an impact on tropical deforestation over the next 5 years to be US$8 billion. About US$5.3 billion (two-thirds of the total) would be needed for the 56 most seriously affected countries reviewed in this report. At least 30% of the proposed investment would be agriculture-related.

It is anticipated that close to half of the total of US$8 billion, or US$800 million annually for 5 years, would need to be mobilized by the development assistance agencies and international lending institutions, with the remainder provided by the private sector and national governments.

Investment of US$800 million a year in forestry and related agricultural development would double the present levels of external aid to combat deforestation.

Fuelwood and agroforestry

Introduction

The list of 32 countries in this section is based on the analysis of developing country fuelwood supplies completed in 1981 by the U.N. Food and Agriculture Organization for the U.N. Conference on Renewable Energy. It includes countries with acute scarcity or deficits of fuelwood that affect large numbers of people and where the problem of fuelwood shortages is compounded by threats of desertification and declining food production.

The proposed actions and investment needs incorporate recommendations of the joint U.N. Development Programme/World Bank Energy Sector Assessments and related studies where available. They also reflect priorities outlined in national government forestry development plans as described in World Bank staff appraisal reports, U.S. Agency for International Development project papers, and other reports.

The program is based on research and analysis of the most urgent problems in the fuelwood and agroforestry sector in each country. The relative success of current programs and limitations in absorptive capacity both were examined to identify high-priority areas for action and needed levels of investment.

Unit costs for reforestation and other proposed investments are based on previous experience in the region concerned, and they vary among countries.

Bangladesh[1]

1. Improve recovery of logging residues from agricultural settlement schemes and commercial logging operations.
2. Continue to work on improved energy end-use efficiency, particularly through use of improved stoves.
3. Provide incentives for use of substitute fuels (solar and wind), particularly solar drying of grain crops.
4. Increase the productivity of logged-over natural forests by conversion to fuelwood plantations of fast-growing species.
5. Encourage reforestation with multipurpose trees around villages, homesteads, and along irrigation dikes.
6. Strengthen forestry extension capabilities.
7. Expand research, with special emphasis on intensive biomass production technologies such as tree breeding and closer spaced planting.

Estimated investments: US$ 52 million

Bolivia

1. Improve the efficiency of charcoal production and transport systems in the Santa Cruz region.
2. Initiate reforestation for charcoal production in the Oruro area.
3. Accelerate tree planting in the Cordech area as part of a broadly based social and industrial forestry program.
4. Expand the forestry component of the Omasuyos-Los Andes rural development project.
5. Intensify agroforestry research with special emphasis on high-protein crops and other leguminous plants.
6. S engthen forestry education

Estimated investments: US$ 25 million

[1]Afghanistan should be included as a priority country, but recent information on investment requirements is not available.

Botswana

1. Improve efficiency of fuelwood use and give appropriate support to use of improved woodstoves such as the Louga metal model.
2. Strengthen the extension capability of the Forest Department.
3. Encourage decentralized seedling production.
4. Focus reforestation program around population centers (Gaborone, Lobatse, and major villages of eastern Botswana).
5. Improve the recovery of logging wastes in forest reserves.
6. Implement recommendations of the Rural Energy Survey.

Estimated investments: US$ 15 million

Brazil

1. Support the Government's National Energy and Forestry Program; aim to replace at least 26% of national fuel-oil demand with fuelwood or charcoal by the mid-1990s.
2. Aim at establishment of 500,000 hectares of energy plantations over the next 5 years and improved management of remaining natural forests.
3. Strengthen rural afforestation activities, particularly in the northeast.
4. Further strengthen the institutional capability of the national (IBDF) and state forest services for managing forestry/energy programs.
5. Extend improved charcoal production techniques used in Minas Gerais to other areas.

Estimated investments: US$ 400 million

Burkina Faso

1. Strengthen extension capabilities to expand rural forestry programs.
2. Decentralize seedling production of multipurpose species.
3. Encourage on-farm reforestation with *Acacia albida* and planting within or around homesteads.
4. Disseminate improved woodstoves and reduce urban fuelwood consumption through use of substitute fuels.
5. Increase stumpage fees.
6. Intensify the management of forest reserves and savanna woodlands with an emphasis on community involvement.
7. Expand the involvement of nongovernmental organizations in farm and community forestry.
8. Increase support for forestry research and training.

Estimated investments: US$ 25 million

Burundi

1. Introduce improved woodstoves and more efficient charcoal production.
2. Decentralize multipurpose seedling production.
3. Expand farmer participation in establishment of peri-urban plantations and farm forestry.
4. Strengthen agroforestry research and forestry extension.

Estimated investments: US$ 20 million

Cape Verde

1. Accelerate the National Afforestation Program and increase protection and management of remaining natural forest areas; aim to reforest 5000 hectares in high-elevation areas and 20,000 hectares at lower elevations within 5 years.
2. Strengthen Forest Service extension capabilities and expand training components of existing projects.
3. Distribute fuel-efficient woodstoves.
4. Provide assistance to update forest legislation, define a comprehensive forest policy, and strengthen the financial base of the Forest Service.

Estimated investments: US$ 15 million

Chad

1. Strengthen forestry sector planning.
2. Accelerate training of forestry extension agents.
3. Decentralize seedling production and increase incentives for on-farm tree planting.
4. Intensify management of existing forests.
5. Increase gum arabic production.
6. Improve the efficiency of charcoal production.

Estimated investments: US$ 14 million

China

1. Increase efficiency of wood use by improved recovery of logging and mill wastes; investigate potential for increased use of briquetted wastes from large-scale farms as a substitute for fuelwood used by small industries.
2. Improve management of existing fuelwood plantations and forests by increased stocking, more regular thinnings and harvestings, and adequate regeneration; experiment with use of management contracts and other alternatives to collective or communal management.
3. Accelerate reforestation to achieve a national target of 6 million hectares per year.
4. Examine tree tenure and wood pricing policies to increase incentives for investment in tree planting and forest management, especially in private woodlots and around households.
5. Increase the number of forestry extension centers to promote local participation in the management of forest resources, to reduce illegal cutting, and to increase tree survival rates in reforestation programs.
6. Strengthen agroforestry and silviculture research, focusing on fast-growing, multipurpose species suitable for farm forestry, border plantings, intercropping, and improved techniques for reforestation of degraded lands.

Estimated investments: US$ 250 million

Costa Rica

1. Strengthen the rural forestry capabilities of the Forest Service with a planting target of 10,000 hectares a year within 5 years.
2. Support forestry extension programs to organize communities and landowners to improve the management of remaining unreserved forests, with emphasis on protecting natural regeneration.
3. Assist in translating recommendations of existing fuelwood and forestry sector studies into new rural development and forest policies.
4. Explore potential fuelwood substitutes for large-scale industrial users.
5. Improve recovery of fuelwood from land clearing operations.

Estimated investments: US$ 15 million

El Salvador

1. Strengthen the Forest Service to accelerate reforestation programs and to improve management of remaining forests.
2. Provide assistance for briquetting residues from coffee and banana crops to substitute for fuelwood.

Estimated investments: US$ 10 million

Ethiopia

1. Make more effective use of agricultural residues and improve the recovery of logging and sawmill wastes.
2. Distribute fuel-efficient woodstoves.
3. Protect natural woodlands and improve the management of existing fuelwood plantations.
4. Strengthen extension and promote participation of Peasant Associations and nongovernmental organizations in reforestation.
5. Increase support for training and research.

Estimated investments: US$ 40 million

Haiti

1. Continue to support decentralized seedling production in areas not already covered by the current USAID-funded project.
2. Continue to emphasize the involvement of non-governmental organizations and communities in seedling production.
3. Aim at a target of 100 million seedlings a year within 5 years.
4. Expand training programs for forestry extension agents to form a "community forestry division" within the Forestry Department.
5. Accelerate applied research in agroforestry and low-cost seedling production techniques.
6. Work with farmers to increase the survival rate and productivity of planted trees.
7. Increase the efficiency of charcoal production to at least that of the Casamance Kiln.
8. Develop audiovisual aids and other extension material to promote rural tree planting.
9. Strengthen the land-use planning capability of the Forestry Department and coordinate with energy and agricultural planning.

Estimated investments: US$ 15 million

India

1. Expand the social forestry program to double the number of seedlings planted, with an annual target of 3 billion trees for the next 5 years.
2. Strengthen the new Forestry Department created within the Ministry of Environment.
3. Continue to give strong support to multipurpose farm forestry, particularly involving the landless in tree-crop farming as was done in West Bengal.
4. Intensify efforts to initiate tree farming on degraded forest lands and agricultural wastelands.
5. Strengthen forestry extension and research, concentrating research on technologies that can help improve biomass productivity.
6. Support the newly planned Coordinated Forestry Research and Extension Program.
7. Continue to support fuelwood conservation programs, particularly improved production of charcoal, introduction of improved stoves, and more efficient woodburning crematoria.

Estimated investments: US$ 500 million

Kenya

1. Continue to decentralize seedling production through expanded extension programs and mass media campaigns.
2. Improve charcoal production techniques, improve efficiency of wood use, and introduce solar technology for tobacco curing.
3. Expand fuelwood planting for tea drying.
4. Intensify management and increase productivity of natural forests.
5. Encourage farmer and private sector establishment of peri-urban fuelwood plantations as a component of a broadly based rural forestry program.
6. Strengthen forestry research, particularly on tree improvement and on training.

Estimated investments: US$ 48 million

Lesotho

1. Accelerate training programs, with emphasis on agroforestry and extension techniques.
2. Strengthen the extension capability of the Forest Division.
3. Conduct socioeconomic surveys designed to identify major constraints and potential incentives to tree planting.
4. Expand reforestation programs emphasizing planting of multipurpose trees by individual families.
5. Increase use of fuel substitutes, particularly biogas produced from dung.

Estimated investments: US$ 10 million

Madagascar

1. Make more effective use of logging wastes and crop residues.
2. Support increased substitution of electricity and briquetted crop residues for fuelwood in urban areas.
3. Intensify management of existing plantations, particularly mature eucalyptus stands under private control.
4. Accelerate establishment of peri-urban plantations and promote farm forestry.
5. Expand development and marketing of minor forest products.

Estimated investments: US$ 30 million

Malawi

1. Improve efficiency of wood use for tobacco curing.
2. Provide local incentives to promote farm and community forestry.
3. Strengthen sociological and agroforestry research.
4. Expand seedling production and extension support for tree planting.
5. Strengthen forestry sector monitoring, evaluation, and planning.

Estimated investments: US$ 24 million

Mali

1. Strengthen forestry training and extension to promote rural forestry with an emphasis on soil and water conservation.
2. Promote community involvement in management of natural vegetation outside reserves.
3. Increase fuelwood substitution and use of improved woodstoves in urban areas.
4. Intensify management of forest reserves.

Estimated investments: US$ 30 million

Mauritania

1. Intensify management of forests in the Senegal River basin.
2. Expand tree planting to combat desertification, particularly on borders of irrigated areas in drylands.
3. Increase seedling production and forestry extension.
4. Provide technical assistance and training for planning.

Estimated investments: US$ 16 million

Nepal

1. Encourage involvement of local panchayats in community management and protection of forests, particularly in the Hills.
2. Prepare management plans for existing forests.
3. Continue to increase forest productivity by introducing fast-growing species on 25,000 hectares over the next 5 years.
4. Aim to distribute 10 million seedlings over the next 5 years for multipurpose farm forestry and planting on agricultural wasteland.
5. Aim to distribute 30,000 improved woodstoves.
6. Strengthen and expand the Community Forestry Division forestry survey and forest inventory activities.
7. Strengthen forestry research, training, and extension, particularly in farm forestry.

Estimated investments: US$ 30 million

Niger

1. Increase use of substitute fuels in urban areas.
2. Promote local participation in management of natural forests.
3. Support agrosylvopastoral activities on family farms.
4. Continue trials with irrigated plantations.
5. Intensify management of gum arabic.
6. Strengthen forestry training and research.

Estimated investments: US$ 20 million

Nigeria

1. Make more effective use of logging wastes.
2. Continue to decentralize seedling production of multipurpose trees in priority areas, particularly in the north.
3. Convert degraded forests close to urban centers to energy plantations.
4. Further strengthen forestry extension and research.

Estimated investments: US$ 50 million

Pakistan

1. Continue efforts to introduce rural electrification into villages and further improve the efficiency of charcoal production.
2. Increase support for social forestry with a strong emphasis on meeting energy needs.
3. Accelerate the current rate of rural afforestation at least fivefold through multipurpose farm forestry and reclamation of wastelands and ravines.
4. Intensify planting of trees around irrigated perimeters.
5. Further strengthen forestry extension and research, with a strong emphasis on meeting energy needs.
6. Strengthen forestry and energy sectoral planning.

Estimated investments: US$ 40 million

Peru

1. Expand sociological research on people's attitudes toward fuelwood planting.
2. Expand rural forestry programs by involving farmers and local communities in raising tree seedlings, particularly in the altiplano and northern coastal regions.
3. Strengthen forestry training and increase support for extension.
4. Expand forestry research, particularly on increasing biomass productivity.
5. Intensify the promotion of fuelwood substitution.
6. Continue to examine the feasibility of developing charcoal production in the Selva region to supply deficit areas.
7. Strengthen forestry training.

Estimated investments: US$ 25 million

Rwanda

1. Develop management plans for existing plantations.
2. Improve the efficiency of charcoal production.
3. Encourage the use of substitute fuels, including peat.
4. Emphasize participation of farmers in establishment of peri-urban plantations.
5. Increase forestry extension efforts to support farm forestry and decentralized seedling production.

Estimated investments: US$ 30 million

Senegal

1. Establish a Community Forestry Department and increase extension support for rural reforestation with emphasis on agroforestry on farmfields.
2. Plant windbreaks using multipurpose trees.
3. Intensify management of reserve and nonreserve forests.
4. Reduce fuelwood consumption through use of substitute fuels, particularly peat.
5. Strengthen forestry research.

Estimated investments: US$ 25 million

Somalia

1. Continue strengthening extension capabilities for farm forestry.
2. Strengthen technical capabilities of the Forestry Department and continue support to the Afgoi School.
3. Continue to improve charcoal production methods.
4. Strengthen forestry research and wood-based energy planning.

Estimated investments: US$ 15 million

Sri Lanka

1. Improve the recovery of wood residues from land-clearing operations, especially areas within the Mahaweli Development Project.
2. Expand reforestation and fuelwood production program to achieve an annual planting target of 30,000 hectares within 5 years, particularly on degraded lands closest to centers of fuelwood demand.
3. Strengthen the agroforestry and tree planting components of agricultural sector programs by encouraging boundary plantings and strip plantations along canals and roads.
4. Increase the outreach capability of the Community Forestry Division.

Estimated investments: US$ 30 million

Sudan

1. Strengthen extension capabilities to expand farm and community forestry, with major emphasis on soil and water conservation.
2. Improve charcoal production techniques.
3. Promote involvement of rural communities in management of savanna woodlands.
4. Establish 7,500 hectares of fuelwood plantations on mechanized farms.
5. Review pricing policies for gum arabic.

Estimated investments: US$ 35 million

Tanzania

1. Improve the productivity of miombo woodlands through cooperative programs with rural communities.
2. Expand afforestation programs based on tree planting by individual farmers.
3. Encourage farmers' involvement in establishment of multipurpose, peri-urban plantations.
4. Improve the efficiency of charcoal production and tobacco curing barns.
5. Strengthen forestry extension and research.

Estimated investments: US$ 30 million

Uganda

1. Conduct surveys of fuelwood consumption and an inventory of tree cover outside forest reserves.
2. Reorganize the extension unit of the Forest Service and expand its field capabilities, particularly in areas of low agricultural productivity.
3. Promote private sector involvement in fuelwood planting by provision of seedlings and technical assistance.
4. Improve recovery of logging wastes from existing plantations.
5. Revise curriculums at agricultural and forestry colleges to place greater emphasis on agroforestry and extension.

Estimated investments: US$ 15 million

Fuelwood and agroforestry

Summary of needed investments, 1987–91

Africa	***Million US$***
Botswana	15
Burkina Faso	25
Burundi	20
Cape Verde	15
Chad	14
Ethiopia	40
Kenya	48
Lesotho	10
Madagascar	30
Malawi	24
Mali	30
Mauritania	16
Niger	20
Nigeria	50
Rwanda	30
Senegal	25
Somalia	15
Sudan	35
Tanzania	30
Uganda	15
Asia	
Bangladesh	52
China	250
India	500
Nepal	30
Pakistan	40
Sri Lanka	30
Latin America	
Bolivia	25
Brazil	400
Costa Rica	15
El Salvador	10
Haiti	15
Peru	25
Total (32 countries)	1899

Land use on upland watersheds

Introduction

The total area of degraded watersheds is not known. Worldwide data, such as that collected on fuelwood supplies by the U.N. Food and Agriculture Organization (FAO), are not available on degraded watersheds.

The recommendations presented here for accelerated action over the next 5 years are based on experiences of 11 countries that have applied corrective measures known to have achieved success. The 11 countries are among those that have seen the need to correct the current misuse of their uplands and have begun practical rehabilitation of their degraded watersheds with the support of external aid.

This list will need to be expanded as other countries take up the challenge of their rural watershed problems and seek help in solving them. No developing countries can afford to ignore the dangers to their soil and water resources as populations increase or to ignore the capacity of their lands to sustain future population growth.

The profiles are based on research and analysis of the most urgent needs in each country for upland watershed rehabilitation and management. Both relative success of current programs and limitations on absorptive capacity were examined in identifying priority areas for action and needed levels of investment.

China

South China: Rehabilitate watersheds in 12 southern provinces with a target of 20,000 hectares per year in each province at a cost of US$100 per hectare by—

1. Communal reforestation through the planting of steep slopes on handmade contour furrows and of mild slopes on bench terraces.
2. Providing seed, establishing tree nurseries, improving transport, and providing technical assistance (particularly in setting out conservation works).

Loess Plateau: Expand the pioneer work in aerial seeding of the Northwest Institute for Water and Soil Conservation by—

1. Extending aerial seeding with legumes to 300,000 hectares of bare hills that are inaccessible.
2. Following up by reforesting stabilized steep slopes through establishment of three 5000-hectare plantations.

Estimated investments: US$ 135 million

Colombia

Expand technical assistance, primarily training of management and extension staff, for watershed rehabilitation to protect hydropower, irrigation, and drinking water investments and to increase agricultural productivity.

Estimated investments: US$ 50 million

Ethiopia

1. Provide technical assistance in training and in preparing and organizing watershed rehabilitation projects in the Central Highlands Plateau region over a 5-year period—including soil conservation, provision of inputs (such as simple hand tools, fertilizers, and improved seeds) to improve agricultural yields, planting of shelterbelts, on-farm tree planting on denuded areas, and training of field staff (particularly junior technicians).
2. Examine incentives for farmers to invest in raising agricultural productivity.

Estimated investments: US$ 100 million

India

Expand upland watershed rehabilitation and management as part of a 15-year program to cover 45 million hectares needing treatment to protect the 18 flood-control reservoirs identified as most urgently in danger of destruction by sedimentation:

1. Rehabilitate agricultural land through land closure, tree planting, stall-feeding of livestock, and provision of inputs such as improved seed at a cost of US$250 per hectare.
2. Expand and improve extension.

Estimated investments: US$ 500 million

Indonesia

Provide technical assistance for expanding the government watershed rehabilitation and management program at the rate of 50,000 hectares per year at a cost of US$400 per hectare by—

1. Improving agricultural productivity through agroforestry, emphasizing tree crops.
2. Replanting denuded areas of protective forest on steep slopes.
3. Developing productive agricultural settlement on Sumatra, Kalimantan, and other islands.

Estimated investments: US$ 100 million

Kenya

1. Upper Tana River watershed: Rehabilitate 200,000 hectares of upland areas through soil conservation, agricultural improvement, and tree planting activities, including: (a) 50,000 hectares of densely settled hills at a cost of US$300 per hectare; (b) 150,000 hectares of forest and sparsely settled hills at a cost of US$100 per hectare.
2. Lower Tana River watershed: Sediment control in semiarid areas through improved grazing and tree planting, including 100,000 hectares of selected subcatchments at a cost of US$50 per hectare.

Estimated investments: US$ 35 million

Madagascar

Provide technical assistance for rehabilitation of degraded watersheds, including reforestation, soil conservation, and agricultural improvement, at a cost of US$2 million a year.

Estimated investments: US$ 10 million

Nepal

Provide technical assistance for Panchayat Forest development on 75 watersheds in the Middle Mountains covering 375,000 hectares:

1. Continue to expand stall-feeding of livestock from planted fodder grasses and trees.
2. Following the establishment of stall-feeding, plant the denuded slopes with fast-growing fuelwood and fodder trees.

Estimated investments: US$ 15 million

Pakistan

Reorganize and control land use and rehabilitate the watersheds above the Mangla and Tarbella Dams by—

1. Reforesting critical slopes with forage and fuelwood trees.
2. Terracing and improvement of permanent agriculture.
3. Protecting forests from encroachment.

Estimated investments: US$ 45 million

Philippines

Rehabilitate and protect the 200,000 hectares of annually logged virgin forest to ensure regeneration of forest cover at a cost of US$120 per hectare.

Estimated investments: US$ 120 million

Zimbabwe

Reorganize and improve land use in Communal Areas:

1. Organize and manage grazing in Communal Areas. Five pilot schemes of 100,000 hectares each at a cost of US$20 per hectare.

2. Intensify agriculture and tree planting in Communal Areas. Five pilot schemes of 20,000 hectares each at a cost of US$200 per hectare.

3. Develop irrigation schemes in Communal Areas. Three pilot schemes of 1000 hectares each at a cost of US$5000 per hectare.

4. Manage watersheds to protect irrigation schemes. Control of runoff from 20,000 hectares of grazing lands at a cost of US$50 per hectare.

Estimated investments: US$ 46 million

Land use on upland watersheds

Summary of needed investments, 1987–91

	Million US$
Africa	
Ethiopia	100
Kenya	35
Madagascar	10
Zimbabwe	46
Asia	
China	135
India	500
Indonesia	100
Nepal	15
Pakistan	45
Philippines	120
Latin America	
Brazil	10*
Colombia	50
Ecuador	15*
Jamaica	10*
Panama	20*
Peru	20*
Total (16 countries)	1231

*Preliminary estimate

Forest management for industrial uses

Introduction

Most of the 28 countries in this section depend on large exports of forest products (exceeding US$40 million annually) or are experiencing a rapid rise in imports of forest products. In 14 of these countries, forest product imports now exceed US$75 million per year.

Several additional countries are included as being representative of those where forest product exports have already declined because industrial forest resources have not been adequately managed and where additional investment is needed to realize their full potential.

The profiles are based on an analysis of global supply and demand for industrial roundwood and the specific needs of the tropical developing countries. The current state of forest land use and reforestation efforts in each country, as well as the chief obstacles to improved management of forests and plantations, were examined, and strategies for the development of industrial forest resources were outlined. The investment needs for forestry operations were determined after consideration of current and projected targets for annual reforestation and forest management. Unit costs for industrial plantation establishment were assumed to average US$500 per hectare. Preliminary planning and inventory operations for the improved protection and management of natural forests were estimated to average US$5 per hectare.

Argentina

1. Intensify management of existing industrial plantations.
2. Develop an additional 150,000 hectares of fast-growing pulpwood and lumber plantations and aim to reduce the rapidly rising import bill from manufactured forest products.

Estimated investments: US$ 100 million

Brazil

1. Double the annual rate of industrial plantation establishment from 160,000 to 320,000 hectares over a 5-year period.
2. Define a forest resource management policy for the Amazon region.
3. Expand industrial forestry activities into northeast Brazil and other wood-deficient areas.
4. Bring under control and management 5 million hectares of Amazon forest.
5. Intensify trials with selected, high-value peeler species in areas close to industrial centers such as Manaus.

Estimated investments: US$ 325 million

Burma

1. Bring 400,000 hectares of teak forest under improved management.
2. Continue to expand the teak planting program by an additional 40,000 hectares over the next 5 years.
3. Further strengthen the Forestry Department capability to manage remaining natural forests.

Estimated investments: US$ 30 million

Cameroon

1. Increase the annual rate of industrial plantation establishment from 1,000 to 5,000 hectares, concentrating on higher-valued peeler species and sites close to export ports.
2. Bring under more intensive management 1 million hectares of natural forest.
3. Intensify the use of existing species and strengthen the Forestry Department's capability for effective control of concession licenses.

Estimated investments: US$ 20 million

Chile

1. Revise forest policies to encourage intensive management of existing plantations.
2. Establish an additional 100,000 hectares of fast-growing *Pinus radiata*.

Estimated investments: US$ 50 million

China

1. Maintain the current rate of industrial plantation establishment of 50,000 hectares per year.
2. Bring an additional 20 million hectares of natural forest under protection and management.
3. Develop a comprehensive forestry sector strategy and related policies.

Estimated investments: US$ 285 million

Colombia

1. Evaluate the achievements under the National Reforestation Plan.
2. Identify the institutional, financial, and other constraints to meeting planting targets and develop appropriate solutions.
3. Rapidly expand the annual rate of industrial plantation establishment from 8,000 to 35,000 hectares per year over a 5-year period, with an emphasis on pulpwood for a new mill to reduce the forest products deficit.

Estimated investments: US$ 45 million

Congo

1. Establish management of natural forests in north Congo with a target of 1.5 million hectares.
2. Accelerate industrial plantation establishment in the Dolisie region and around Point Noir with a target of 30,000 hectares over a 5-year period.
3. Strengthen management and control of logging operations in natural forests.

Estimated investments: US$ 20 million

Costa Rica

1. Establish 15,000 hectares of fast-growing industrial plantations.
2. Strengthen the institutional management and protection of remaining natural forest reserves.

Estimated investments: US$ 15 million

Ecuador

1. Establish 10,000 hectares of fast-growing industrial plantations in the Sierra region.
2. Bring under management about 1 million hectares of natural forest in the Esmeraldas region.
3. Continue forest inventory work in the more accessible Amazonian forest areas.

Estimated investments: US$ 20 million

Ghana

1. Strengthen the Forest Department to restore protection and management to 1.2 million hectares of natural forest.
2. Intensify the use of secondary species.
3. Increase the rate of industrial plantation establishment from 3,000 to 5,000 hectares per year, particularly on degraded lands.

Estimated investments: US$ 10 million

Guatemala

1. Establish 15,000 hectares of fast-growing industrial plantations.
2. Strengthen the Forestry Department's ability to protect and manage existing industrial forest areas.

Estimated investments: US$ 15 million

India

1. Bring an additional 30 million hectares of natural forest under management.
2. Double the rate of industrial plantation establishment from 120,000 to 240,000 hectares per year over a 5-year period.

Estimated investments: US$ 190 million

Indonesia

1. Expand the area of intensively managed forest by 1 million hectares over the next 5 years.
2. Increase the use of secondary species.
3. Increase the rate of industrial plantation establishment from 78,000 to 100,000 hectares per year over 5 years.
4. Expand forestry research and training, emphasizing management techniques for logged forests.

Estimated investments: US$ 50 million

Ivory Coast

1. Place 3 million hectares of natural forest under better management and protection.
2. Complete forest inventories.
3. Intensify use of secondary species.
4. Increase the rate of industrial plantation establishment from 5,000 to 25,000 hectares per year over a 5-year period.
5. Provide technical assistance to identify measures needed to limit log imports to 1.5 million cubic meters per year.

Estimated investments: US$ 75 million

Jamaica

1. Intensify management of the existing pine plantations.
2. Establish an additional 10,000 hectares of fast-growing plantations.

Estimated investments: US$ 10 million

Liberia

1. Bring an additional 300,000 hectares of logged-over forests under improved management and protection.
2. Continue expanding the Bomi Hills plantation project to about 3,000 additional hectares per year, shifting the emphasis to hardwoods.
3. Strengthen forestry institutions to control logging concession operations.

Estimated investments: US$ 15 million

Malaysia

1. Conduct analysis of achievements to date in managing logged-over forest areas.
2. Improve the protection and management of 2.5 million hectares of natural forest.
3. Continue with enrichment planting and intensified use of secondary hardwoods.
4. Increase the rate of industrial plantation establishment from 4,000 to 30,000 hectares per year over a 5-year period.

Estimated investments: US$ 40 million

Mexico

1. Accelerate current efforts to organize and assist forest owners to intensify management on 1 million hectares of natural forest.
2. Conduct forestry sector analysis and recommend changes in forest policy, particularly regarding forest management guidelines and incentives to expand the development of forest industries.
3. Increase the rate of industrial reforestation from 2,000 to 50,000 hectares per year over a 5-year period.
4. Prepare feasibility studies for development of small-scale pulp mills to improve use of small dimension trees and wood residues left behind in logging operations.

Estimated investments: US$ 90 million

Nigeria

1. Accelerate industrial plantation establishment to about 20,000 hectares per year over a 5-year period.
2. Intensify management of existing plantations.

Estimated investments: US$ 35 million

Pakistan

1. Bring 100,000 hectares of conifer forests under management and control.
2. Establish an additional 25,000 hectares of industrial plantations.
3. Strengthen the Forestry Department's administrative capability to control management in remote hill forests.

Estimated investments: US$ 20 million

Papua New Guinea

1. Bring 250,000 hectares under improved management and protection.
2. Expand training and strengthen the Forestry Department's capability for supervising concession licenses and for carrying out enrichment planting in cutover areas.

Estimated investments: US$ 15 million

Peru

1. Complete the inventory of and intensify protection and management on 6 million hectares of the more accessible forests in the Amazon region, with special emphasis on securing future supplies for the existing milling industry.
2. Initiate reforestation with faster-growing, more valuable peeler species in accessible areas close to industrial sites.

Estimated investments: US$ 30 million

Philippines

1. Conduct forest survey and place 1 million hectares of natural forest under protection and management.
2. Intensify the use of secondary species.
3. Increase the rate of industrial reforestation from 9,000 to 25,000 hectares per year over a 5-year period.
4. Review forest policies with respect to increasing participation of the private sector in industrial reforestation.

Estimated investments: US$ 40 million

Thailand

1. Place 1 million hectares of natural forest under secure forest department control and intensify management of hardwood stands.
2. Accelerate industrial planting from 6,000 to 20,000 hectares per year over a 5-year period.
3. Prepare a long-term development strategy for the forestry sector.

Estimated investments: US$ 35 million

Uganda

1. Place 500,000 hectares of existing natural forest under secure protection and management.
2. Strengthen institutions responsible for management of existing plantations.
3. Increase the rate of industrial reforestation from 1,000 to 5,000 hectares per year over a 5-year period.

Estimated investments: US$ 25 million

Venezuela

Continue with the Orinoco pine planting program, with a target of mechanized reforestation of 50,000 hectares over the next 5 years.

Estimated investments: US$ 25 million

Zaire

1. Intensify management of 100,000 hectares of natural forest.
2. Continue forest inventories in the more accessible areas.
3. Strengthen the Forest Department's capability for administering logging concessions.

Estimated investments: US$ 10 million

Forest management for industrial uses

Summary of needed investments, 1987–91

	Million US$
Africa	
Cameroon	20
Congo	20
Ghana	10
Ivory Coast	75
Liberia	15
Nigeria	35
Uganda	25
Zaire	10
Asia	
Burma	30
China	285
India	190
Indonesia	50
Malaysia	40
Pakistan	20
Papua New Guinea	15
Philippines	40
Thailand	35
Latin America	
Argentina	100
Brazil	325
Chile	50
Colombia	45
Costa Rica	15
Ecuador	20
Guatemala	15
Jamaica	10
Mexico	90
Peru	30
Venezuela	25
Total (28 countries)	1640

Conservation of tropical forest ecosystems

Introduction

Most of the world's tropical moist forests are in the 21 countries listed below. Emphasis has been placed on closed forests, but this does not imply that conservation priorities are less critical in savannas or tropical dry forests. Clear distinctions separate many of the tropical forest types but, for this analysis and the following recommendations, the terms tropical moist forests, closed forests, and rain forests have been used synonymously.

The investments needed for each of the countries have been determined by considering—

- The extent to which parks and other protected areas already represent and adequately conserve forest ecosystems in a particular country, and the level and quality of management of those areas
- Existing or anticipated development pressures on forests and conservation units, especially forest encroachment for agriculture
- The condition of natural resource management agencies in the country, and the need for expanding or improving their capabilities.

Specific costs were calculated for—

Developing sustainable agriculture outside conservation areas, to relieve pressure on the forests

New conservation units

Improving management of conservation areas

National conservation strategies

National conservation data centers

Conservation education and training.

Bolivia

1. Better enforce existing conservation laws and treaties.
2. Strengthen the Centro de Desarrollo Forestal, responsible for parks and protected areas.
3. Fund training for Bolivians in natural resource and park management.
4. Strengthen local nongovernmental organization capability to educate and build public awareness of conservation needs.
5. Expand and strengthen management of the system of protected areas: (a) ensure protection of Isiboro-Secure National Park, which is threatened by encroachment; (b) identify and establish protected areas in Amazonia region.
6. Develop the new natural history museum and the conservation data center.

Estimated investments: US$ 31.3 million

Brazil

1. Expand the system of national parks and biological reserves according to the System Plan for Conservation Units, including the best representative areas of all phytogeographic provinces and major ecosystems.
2. Acquire all nonfederal lands within parks and reserves; develop a management plan for each unit that does not have one.
3. Complete the system of ecological stations, including land acquisition; expand and develop university research and training programs at these stations.
4. Establish conservation units in the remaining Atlantic Coast rain forests and bring all these forests under long-term management; place particular emphasis on preserving populations of endangered primates.
5. Resolve the road construction conflict in Araguaia National Park and the problems being created by an influx of settlers and their livestock.
6. Support research in progress to identify conservation priorities in Amazonia; include research on centers of species endemism, Pleistocene refugia, areas of high species diversity, soil and vegetation types, and distribution and abundance of plant and animal species in general.

Estimated investments: US$ 50 million

Cameroon

1. Expand the protected area system to include (a) proposed Korup National Park; (b) proposed Dja National Park, currently threatened by poaching, cocoa and coffee cash farming, and subsistence farming; (c) proposed Pangar-Djerem National Park; (d) Mt. Cameroon, currently threatened by shifting cultivation, logging, commercial and village plantations, hunting, and firewood collecting.
2. Identify and protect other areas of high species endemism and diversity.

Estimated investments: US$ 30.5 million

Colombia

1. Expand the Cauca Valley Conservation Data Center and establish data exchange with natural resource agencies.
2. Expand natural resources agency efforts to limit trade in endangered and threatened species.
3. Identify and establish protected areas in the Choco region, Sierra Nevada de Santa Marta, and Amazonian Colombia.

Estimated investments: US$ 30 million

Costa Rica

1. Further develop the conservation data center, Programa de Patrimonio Natural de Costa Rica: (a) increase funding for salaries and equipment; (b) improve capacity to disseminate information and improve access to existing information abroad, especially on Costa Rican plants.
2. Increase protection and improve management of (a) La Amistad International Park; (b) Bagaces, Guanacaste Province, (c) Zona Protectora La Selva, (d) Corcovado National Park.
3. Establish new conservation areas being identified by the conservation data center.
4. Provide financial and technical assistance to the new wildlife management graduate training program at the Universidad Nacional Autonoma.
5. Develop an existing conservation unit, such as Palo Verde wildlife refuge, to use as a model and regional center for training in refuge and wildlife management.

Estimated investments: US$ 20.5 million

Ecuador

1. Delimit Indian lands and enforce land tenure laws.
2. Provide training for additional conservation personnel.
3. Conduct regional studies of Amazonian natural resources and their economic benefits.
4. Increase conservation efforts in (a) Cuyabeno and Curaray (inventories); (b) mangrove ecosystems; (c) Pajan and Paute Protection Forests (management plans); (d) Yasuni Scientific Research Station (boundary delineation and long-term management funding); (e) Amazonia (inventories to identify conservation priorities); (f) forests in coastal region.
5. Revise land colonization laws in which undisturbed forest is considered unproductive and, therefore, available for distribution to landless settlers.

Estimated investments: US$ 17.1 million

Gabon

1. Expand protected area coverage to include major parts of the forests in the Gabon-Cameroon border region.
2. Expand and improve protection and management of existing conservation areas; develop management plans for units that do not have them.

Estimated investments: US$ 12.7 million

India

1. Support and expand the National Plant Conservation Action Plan: (a) establish proposed system of Biosphere Reserves; (b) establish plant species sanctuaries; (c) identify management needs for threatened plants; (d) conserve endangered flora of Andaman and Nicobar Islands; (e) prevent overexploitation of herbal drug plants; (f) survey plants used extensively in tribal societies.
2. Improve protection for (a) all mangrove ecosystems; (b) Gir National Park, Silent Valley National Park, and Manas Tiger Reserve.
3. Identify and establish conservation units in the Western Ghats region, especially at lower elevations.
4. Establish reserves for the Indian bustard in Andhra Pradesh.
5. Establish reserves in the bamboo forests of Saranda, Bihar, and the Neora Valley of West Bengal.
6. Identify and establish reserves in northeast India, in Assam, Meghalaya, and Arunachal Pradesh.

Estimated investments: US$ 32.2 million

Indonesia

1. Improve management in all protected areas.
2. Increase financial and technical support for Ciawi training school.
3. Establish additional conservation areas in Irian Jaya where more than 50% of the land area is under proposed timber concession.
4. Establish proposed Kutai National Park.
5. Establish other conservation units in tropical lowland forests in Kalimantan, especially in regions undergoing oil and mineral exploitation and large-scale settlement.
6. Identify additional conservation areas and establish proposed reserves in Siberut.
7. In Sumatra, protect Kerinci-Seblat National Park from logging, illegal land clearing, and two proposed roads that would open the park to further development.
8. Establish reserves to conserve the mangrove forests of Java.
9. Support existing nongovernmental organization efforts to publicize conservation needs and to conserve wildlife and critical ecosystems.

Estimated investments: US$ 42.7 million

Ivory Coast

1. Increase protection and improve management in Tai National Park: add staff to deal with illegal logging, poaching, cash-crop farming, and gold prospecting; evaluate perimeter road which has opened up significant portions of park to spontaneous colonization and logging; reevaluate dam project at Soubre which could severely affect the park by bringing more people into the region.
2. Increase protection of Mt. Nimba (severely affected by iron-ore mining and local poaching).
3. Identify and establish conservation areas in the southwest area adjacent to Liberia.

Estimated investments: US$ 23.7 million

Liberia

1. Conduct a 2-year study of conservation priorities, emphasizing major ecosystem types.
2. Increase protection and further develop park infrastructure in Sapo National Park.
3. Increase protection of Mt. Nimba from iron-ore mining and poaching.
4. Identify and establish conservation areas in the southeast adjacent to Ivory Coast.

Estimated investments: US$ 13.0 million

Madagascar

1. Expand the IUCN/WWF program and its several projects, especially environmental education and training of conservation area managers.
2. Develop new types of protected areas to achieve conservation objectives not possible with traditional national parks or strict nature reserves.
3. Substantially expand the system of conservation areas: along the narrow band of tropical moist forest on the east side of the island; and in dry forest areas of the south and west, especially in the regions now coming under pressure of oil exploration and development.
4. Support inventories of flora and fauna to identify critical species and ecosystems and areas of high endemism.

Estimated investments: US$ 24.9 million

Malaysia

1. Support and expand the biological inventory and database begun by the Malayan Nature Society for Peninsular Malaysia, and identify and establish protected areas in the lowland rain forests of that region, especially along the northwestern and eastern coasts.
2. Reestablish protection of Klias National Park (gazetted in 1978 to protect outstanding mangrove and coastal areas, but redesignated as a forest reserve in 1981 to supply a pulp and paper mill).
3. Work with the Sabah Foundation to designate additional conservation areas in Sabah, in combination with existing forest reserves; place emphasis on limestone forests and heath forests and on the Danum Valley.
4. Improve protection of ecosystems in the Endau Rompin National Park.
5. Establish at least one major conservation area in the Silabukan-Lumerau Forest Reserves block.

Estimated investments: US$ 34.3 million

Nicaragua

1. Increase protection and management of Saslaya National Park.
2. Identify and designate new conservation areas as part of existing system of parks and reserves; place emphasis on lowland areas in the Caribbean drainage and in the Mosquitia region.

Estimated investments: US$ 17.4 million

Panama

1. Evaluate natural resource agency (RENARE) transition to an independent natural resources institute and provide funding either for RENARE or for other groups to aid RENARE in developing integrated management and protection of the system of conservation areas.
2. Develop public awareness of conservation and enlist private sector support for conservation projects.
3. Expand protected areas system to include (a) mangroves; (b) parts of the Darien lowlands and areas adjacent to Colombia, especially Darien National Park.
4. Delineate boundaries for La Amistad International Park and protect from encroachment.
5. Support development of the Kuna Indian Forest Park.

Estimated investments: US$ 20.9

Papua New Guinea

1. Carry out a major study of biological resources to identify conservation priorities; survey traditional conservation practices which may be useful in wildlife management planning.
2. Expand financial and technical support for existing wildlife management areas, and formally designate new areas that have been proposed.
3. Establish a major reserve in the western region between the Fly and Sepik Rivers.
4. Establish a major reserve in the southeast region, including high peaks such as Mt. Suckling, Mt. Victoria, and Mt. Albert-Edward.
5. Establish several reserves on the Huon Peninsula, including low elevation foothills along the north coast and peaks in the Finisterre and Sarnwaged Ranges.
6. Develop a model reserve on private land, emphasizing ways local people can be involved in managing, protecting, and using the biological resources.
7. Support and expand wildlife farming, beginning with existing farming systems for crocodiles and butterflies.

Estimated investments: US$ 10 million

Peru

1. Further develop the Centro de Datos para la Conservacion del Peru (conservation data center).
2. With nongovernmental organizations, develop a conservation public awareness campaign.
3. Consolidate administration of the protected areas system.
4. Increase protection of Manu National Park.
5. Identify and establish protected areas in the Amazon basin, and increase financial and technical support for the new Pacaya-Samiria Reserve.

Estimated investments: US$ 35.6 million

Philippines

1. Evaluate the existing protected areas system to identify conservation priorities, with emphasis on lowland forest ecosystems.
2. Improve management of most protected areas and develop a management plan for each unit.
3. Protect mangrove ecosystems throughout the islands.
4. Protect Mt. Apo National Park from illegal logging, colonization, and agricultural development.

Estimated investments: US$ 30.4 million

Thailand

1. Update and further develop the national conservation plan.
2. Combine the National Parks Division and Wildlife Conservation Division and elevate them to Department status; decentralize operations of the new Department among 5 regional divisions.
3. Expand the protected areas system to include more units of lowland moist forests and freshwater marshes.
4. Develop a management plan and increase protection for Thung Yai and Huai Kha Khaeng Wildlife Sanctuaries (a proposed Biosphere Reserve).

Estimated investments: US$ 27.7 million

Venezuela

1. Restructure and unify protected areas administration.
2. Develop management plans to minimize the adverse impact of illegal settlement in national parks.
3. Improve social and economic incentives for park employees.
4. Expand the protected areas system to include Peninsula de Paria; Sierra de Imataca and Altiplanicie de Nuria; Laguna de Tacarigua National Park; and tropical dry forests south of the Orinoco River.

Estimated investments: US$ 19.6 million

Zaire

1. Conduct a 2-year study of biological conservation priorities, and identify major ecosystems and species needing management.
2. Identify ways to conserve indigenous cultures as an integral component of conservation planning.
3. Support development and management of Garamba National Park, including more trained personnel, equipment, vehicles, supplies.
4. Establish protected areas and forest conservation zones in the forests bordering Rwanda.

Estimated investments: US$ 23.8 million

Conservation of tropical forest ecosystems

Summary of needed investments, 1987–91

	Million US$
Africa	
Cameroon	30.5
Gabon	12.7
Ivory Coast	23.7
Liberia	13.0
Madagascar	24.9
Zaire	23.8
Asia	
India	32.2
Indonesia	42.7
Malaysia	34.3
Papua New Guinea	10.0
Philippines	30.4
Thailand	27.7
Latin America	
Bolivia	31.3
Brazil	50.0
Colombia	30.0
Costa Rica	20.5
Ecuador	17.1
Nicaragua	17.4
Panama	20.9
Peru	35.6
Venezuela	19.6
Total (21 countries)	548.3

Summary of total investment needs

Estimated costs* in million US$ for the period 1987–91

	Fuelwood & agro-forestry	Land use on upland watersheds	Industrial forestry	Ecosystem conservation	5-year totals
Africa					
Botswana	15	—	—	—	15
Burkina Faso	25	—	—	—	25
Burundi	20	—	—	—	20
Cameroon	—	—	20	31	51
Cape Verde	15	—	—	—	15
Chad	14	—	—	—	14
Congo	—	—	20	—	20
Ethiopia	40	100	—	—	140
Gabon	—	—	—	13	13
Ghana	—	—	10	—	10
Ivory Coast	—	—	75	24	99
Kenya	48	35	—	—	83
Lesotho	10	—	—	—	10
Liberia	—	—	15	13	28
Madagascar	30	10	—	25	65
Malawi	24	—	—	—	24
Mali	30	—	—	—	30
Mauritania	16	—	—	—	16
Niger	20	—	—	—	20
Nigeria	50	—	35	—	85
Rwanda	30	—	—	—	30
Senegal	25	—	—	—	25
Somalia	15	—	—	—	15
Sudan	35	—	—	—	35
Tanzania	30	—	—	—	30
Uganda	15	—	25	—	40
Zaire	—	—	10	24	34
Zimbabwe	—	46	—	—	46
Subtotal	507	191	210	130	1038
Asia					
Bangladesh	52	—	—	—	52
Burma	—	—	30	—	30
China	250	135	285	—	670
India	500	500	190	32	1222
Indonesia	—	100	50	43	193
Malaysia	—	—	40	34	74
Nepal	30	15	—	—	45
Pakistan	40	45	20	—	105
Papua New Guinea	—	—	15	10	25
Philippines	—	120	40	30	190
Sri Lanka	30	—	—	—	30
Thailand	—	—	35	28	63
Subtotal	902	915	705	177	2699
Latin America					
Argentina	—	—	100	—	100
Bolivia	25	—	—	31	56
Brazil	400	10**	325	50	785
Chile	—	—	50	—	50
Colombia	—	50	45	30	125
Costa Rica	15	—	15	21	51
Ecuador	—	15**	20	17	52
El Salvador	10	—	—	—	10
Guatemala	—	—	15	—	15
Haiti	15	—	—	—	15
Jamaica	—	10**	10	—	20
Mexico	—	—	90	—	90
Nicaragua	—	—	—	17	17
Panama	—	20**	—	21	41
Peru	25	20**	30	36	111
Venezuela	—	—	25	20	45
Subtotal	490	125	725	243	1585
Total	1899	1231	1640	550	5320***
	36%	23%	31%	10%	100%

*All totals rounded
**Preliminary estimate, pending additional research
***Approximately 20% of this investment would be allocated to research, training, education, and extension.

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