Chapter 1

Introduction and Background

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Chapter 1

Introduction and Background

INTRODUCTION

Eleven million hectares (ha) of the world's remaining tropical forests are converted to other land uses or to wasteland each year (33). About half of the Earth's original tropical forest land has thus been altered. Deforestation can be beneficial where cleared tropical land can sustain agriculture. Under available farming technologies, however, many remaining tropical lands cannot sustain agriculture and are soon abandoned or converted to less productive uses. Often, forests cannot regrow naturally on these degraded lands.

Tropical nations* (fig. 1) have about 650 million ha of cropland and nearly 2 billion ha of land in various stages of degradation (33,114). Those regions with rapidly growing populations—Asia, Central America, North Africa, and the heavily populated parts of East and West Africa—need productive land most desperately, yet have the most rapid deforestation and extensive areas of degraded land. In many of these places, firewood has become so scarce that certain foods requiring cooking have been eliminated from the diet. People must use crop residues and dried dung for fuel, which robs the soil of organic matter and nutrients and accelerates erosion. Soil eroded from degraded lands fills riverbeds and reservoirs, increasing the severity of floods and causing water scarcities.

The best solution for stopping this trend of land degradation is to prevent inappropriate land-use practices on forested lands. Where this is not possible, reforestation is one way to improve the productivity of many degraded lands and provide useful products for the people. Trees provide wood, fuel, food, fodder, and other uses. Trees protect soil from the effects of tropical heat, rain, and wind. Soil temperatures are lower under tree canopies, permitting reaccumulation of organic matter that restores soil structure and microbiota and enhances moisture- and nutrient-holding abilities. Bacteria on the roots of some trees produce nitrogen fertilizer, while fungi on tree roots can convert soil minerals to useful forms. In dry areas, trees can help to prevent the rise of saline ground water *(92).* Where surface soils are dry or infertile, deep tree roots can tap underground reservoirs of nutrients and water and bring them to the surface.

In recent years, reforestation efforts have increased. Of the approximately *11.5* million ha of planted forest in 1980 in the tropical nations, some 40 percent have been planted since 1976 (33). About 60 percent of this was planted for industrial purposes (lumber, veneer, pulpwood, etc.). The other 40 percent was nonindustrial (fuelwood, watershed protection, etc.). While it is not known how much of this planting occurred on degraded land and how much occurred on recently cleared primary forests, it is probable that a 1arge and increasing proportion of the reforestation, especially nonindustrial planting, is occurring on degraded sites (37).

This background paper discusses techniques to reforest tropical lands and gives special emphasis to degraded lands and community-oriented forestry. It does not address methods to manage existing forests, nor does it focus on public policies or institutional mechanisms to sustain tropical forests. Those issues are covered in a forthcoming OTA report, *Technologies To Sustain Tropical Forest Resources,* and in another background paper, U.S. *and international Institutions.*

*In this background paper, tropical lands include all lands located at latitudes south of 23.5 N and north of 23.5S.

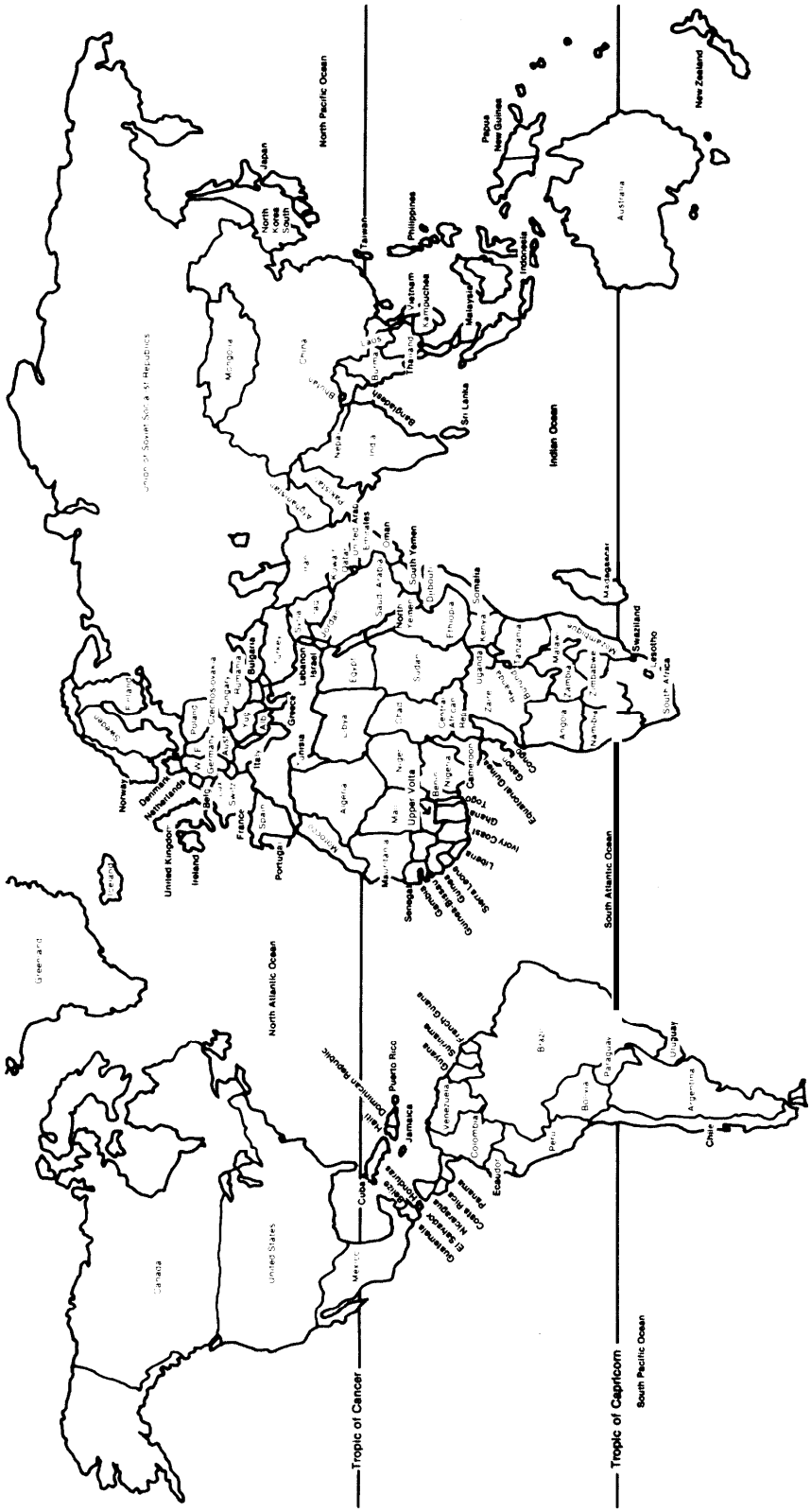


Figure 1.—Tropical Forests and Woodlands, for the Purpose of the Report, Are Located at Latitudes South of 23.5° N and North of 23.5° S, and at Other Frost-Free Localities

BACKGROUND

To understand the constraints on existing reforestation techniques and the potentials of new ones, it is first necessary to define land degradation, briefly describe tropical soils and climates, and discuss the causes of land degradation and benefits of reforestation.

Definition of Degraded Lands

Degradation of tropical land is a physical, chemical, and biological process set in motion by activities that reduce the land's inherent productivity. This process includes accelerated erosion and leaching, decreased soil fertility, diminished natural plant regeneration, disrupted hydrological cycle, and possible salinization, waterlogging, flooding, or increased drought risk, as well as the establishment of weedy plants that displace more desirable plant species, Evidence that the degradation process is advancing includes, for example, a reduction in the water-holding ability of the soil, a decrease in the amount of soil nutrients available to plants, a reduction of the soil's ability to hold nutrients, or soil compaction or surface hardening.

This definition implies a strong interrelationship between inappropriate land-use practices and land degradation. In some places degradation is manifest (e. g., erosion and desertification), whereas in others it is inferred (e.g., declining crop yields).

Tropical Soils and Climates

Although the chemical, physical, and biological processes that occur in the tropics are the same as those elsewhere in the world, the rates often are accelerated. Tropical air, soil, and water temperatures are higher; rainfall is more intense and erratic; and the growing season is longer than in temperate parts of the world. These factors affect tropical forests and their soils. Further, they can place severe constraints on certain land uses. Although detailed soil descriptions are beyond the scope of this report, * a simple but useful breakdown of tropical areas divides it into three types: 1) hot, wet lands, 2) arid/semiarid lands, and 3) mountainous lands.

Most tropical soils on hot, wet lands have significant fertility problems. Year-long high temperatures and high rainfall combine to accelerate the removal of nutrients needed by plants from rock materials and soil mineral particles. The residual minerals tend to be composed mostly of aluminum, silicon, iron, oxygen, and water—a chemical composition so restricted that many food or tree crops will have stunted growth or will not survive. An estimated 2 percent of the soils of hot, wet lands, if cleared of vegetation, will irreversibly harden on drying *(119),* severely limiting reestablishment of any vegetation *(67).*

In arid/semiarid lands, soil nutrients needed by many plants become available to plants with sufficient water (16). However, if most of the water evaporates from the soil surface rather than percolating down, dissolved solids or salts can accumulate at or near the land surface in concentrations that many plants will not tolerate (43).

Mountainous lands** are cooler than the other two categories and exist in both wet and dry climates. Because they have steep slopes, their soils are easily eroded. Much of the rainfall in the wetter regions runs off the land surface rather than percolating into the ground. Consequently, soils in mountainous lands are likely to be rocky and thin, except perhaps on the lower slopes (16),

*See Van Wambeke (1 19) and Fripiat and Herbillon (36) for more detailed information. These are good references on soils of the hot wet tropics. They not only contain the commonly cited information on agriculture, soil names, etc., but also provide discussions of mineralogical and chemical processes.

* *Elevated areas throughout the tropics typically from 750 meters and abet'e.

Photo credit. B C Stone *for the* National Academy of Sciences

Severely degraded lands on Guam which were once covered by tropical forests
Erosion has uncovered large expanses of infertile soil

Photo credit OTA staff

Barren landscapes on islands along the south coast of China reflect deforestation
that occurred hundreds of years ago

Scope and Causes of Land Degradation

In much of the open woodlands of arid and semiarid areas, overgrazing and repeated fires have converted the vegetation to a degraded fire climax stage. Consequently, soils become dry and little woody regeneration occurs. Fire-tolerant vegetation—often unpalatable to animals—persists, leading to a desert-like state. Today, there are few undisturbed woodlands or savannas in these regions. An estimated 20.5 million hectares (ha) of tropical arid lands, an area about the size of South Dakota, become decertified every year. To date, an estimated 1.56 billion ha of tropical land have undergone desertification (table I).

Desertification occurs in the savanna region of North Africa as well as in the savannas of southern tropical Africa and northeast Brazil. In the Sudan and elsewhere in North Africa, the populations of grazing animals—including goats, sheep, cattle, and camels—number in the millions and their grazing intensity has severely impaired natural regeneration of forests and forage (28), Consequently, people have had to range farther in search of fodder for their animals and wood for cooking and heating (131).

Forest degradation and loss under the rainy and seasonal environments may not be so severe as under the arid and semiarid environments, but the effects on people are similar. There are approximately 156 million ha of tropical moist forest, 181 million ha of forest fallow, and 84 million ha of deforested watersheds available for reforestation (131). When areas cleared by agriculturalists are exposed to abundant rainfall, erosion, and leaching, soil productivity is greatly decreased. After 1 to 5 years, the land typically is abandoned by farmers who move on to other areas. The land then reverts to secondary forest, vines, brush, or grasses of low nutritive value. Land abandonment is caused by decreasing crop yields and increasing weed control problems (57). Normally, these farmers (shifting cultivators) allow fallow periods of 10 to 15 years, thus giving enough time for soils to recuperate some productivity, However, in a growing number of places, increased population pressures lead to shortening of these periods. Food production is then greatly decreased, leading to even stronger pressures to clear more forest. Such effects of acute population pressure are evident in Haiti, El Salvador, and parts of the Philippines and Indonesia (131). Detailed descriptions of tropical agriculture and its effect on soils include: Laudelout (71); Nye and Greenland (88); Jurien and Henry (60); Watters (123); Sanchez (104); Lal and Greenland (69].

Table 1 .—Tropical Lands Recently Undergoing Severe Desertification (million **hectares)**

Region	Total decertified area
Latin America. . . .	701,8
Africa, ...	685.0
India and Pakistan .	170.0
Total	1,556.8

SOURCE United Natlons, UN Conference on Desertification: Round-Up, Plan of *Action and* Resolutions (New York United Nat Ions, 1978)

Population growth rates in tropical countries are the world's highest. Growing numbers and rising aspirations lead to more than proportional increases in the demand for food, fuel, fodder, and building materials (15). Population growth also requires increased land for urbanization and village expansion, energy production, and transportation (14).

With few exceptions, such as the river valleys of West Africa where river blindness is being eradicated, most of those lands that can sustain stable agriculture probably have been cultivated. Remaining unused lands are those already degraded, or those too infertile for continuous farming without constant infusion of high-cost inputs such as commercial fertilizer. Without these inputs, the land becomes susceptible to degradation, thus reducing the standard of living (49,108).

In recent years, some developing countries have been planning and encouraging movement of people, usually into sparsely occupied Virgin tropical forests, Two examples are Brazil's planned colonization of the Amazon Basin via the Transamazon highway and Indonesia's colonization of its outer islands (49,108).

In both cases, people are moved between regions that are geographically and geologically different and thus they are ill-equipped to cope with the new environment. Consequently, inappropriate land use practices have led to decreased crop yields. Forest clearing exposed the lands to heavy erosion and depleted the soil's nutrient supply, leading to land degradation and to indebtedness and landlessness for the people.

The expansion of lands under cultivation will continue, given the rising pressures. More lands will become degraded and subsequently abandoned. To break this cycle, some of these degraded lands can be reclaimed via reforestation. Tree planting of degraded lands is not a panacea to deforestation or inappropriate land uses. Some degraded lands will be difficult and some may be impossible to reclaim. In addition, reforestation of degraded lands may not be so profitable, in financial terms, as reforestation of rich, fertile lands. However, in many countries, fertile sites are reserved for agricultural activities. Given the dwindling amount of good lands and the increasing demands for forest products, it is necessary to consider all alternatives. Reforestation is an alternative that has the potential to rehabilitate the degraded soils and provide many goods and services for industrial and local needs.

Reclamation Using Trees

For degraded sites it is often advantageous to plant trees because of their ability to use water and nutrients inaccessible to plants with

shallow roots and because they supply a multitude of products: wood, fuel, fodder, and others. Moreover, a tree canopy acts as a buffer against the direct impact of raindrops on the soil. The litter and humus layers underlying the forest absorb moisture, allowing water to infiltrate the ground and recharge the ground water supply (92). Trees, by shading the soil, reduce soil temperatures and thus promote accumulation of organic matter and retard possible soil hardening,

The presence or absence of organic matter in any soil is an important factor in the soil's productivity. Soil organic matter is important to soil productivity because it:

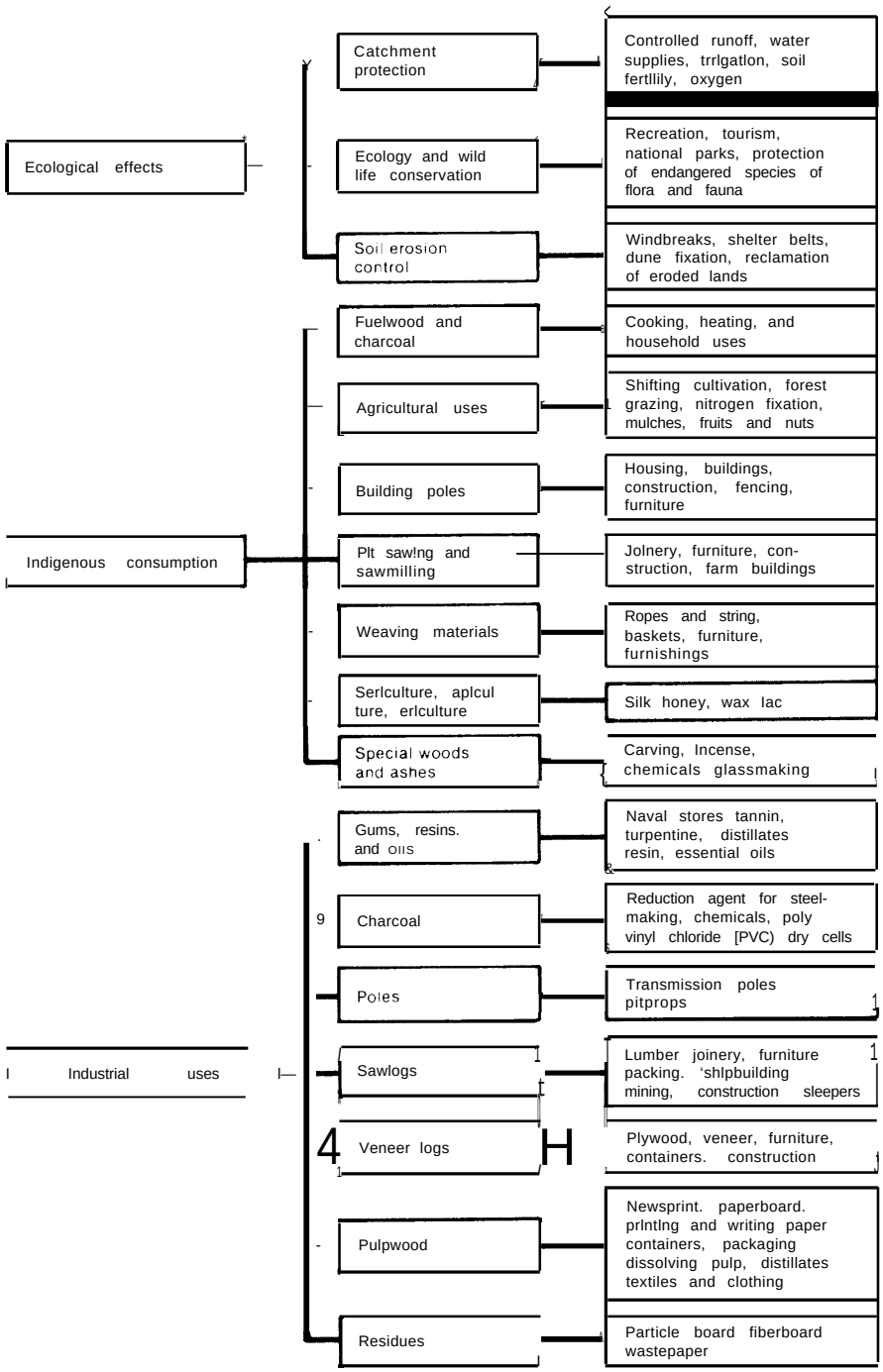
- contributes to the development of soil aggregates, which enhance root development and reduce the energy needed to work the soil;
- increases the air- and water-holding capacity of the soil, which is necessary for plant growth and helps to reduce erosion;
- releases essential plant nutrients as it decays;
- holds nutrients from fertilizer in storage until the plants need them; and
- enhances the abundance and distribution of vital soil biota (90).

Soils under forest cover often have high organic matter content. Land-use practices that jeopardize the soil's organic content therefore can have adverse effects on successful}' reforesting degraded lands.

The living network of roots near the surface of forest soils provides mechanical support for steep slopes; this root network is the main contribution to slope strength and prevention of landslides (100). Consequently, trees are particularly valuable for watershed protection and for arresting desertification in areas of moving soils (e. g., sand dunes). Some trees act as soil improvers as well as soil protectors. Leguminous trees and forbs have the capacity to enrich soil with nitrogen. Legume trees have nutrient-rich leaves which can be used as fodder or mulch *(80,81)*.

There are many reasons for planting trees. Provision of goods for household and industrial use (see fig. 2) is equally as important as rehabilitative factors. For local needs, a tree species with several attributes or a mixture of tree species can be planted to obtain multiple benefits —e. g., ability to enrich soil fertility, wood suitable for fuel and poles, and nutritious leaves for fodder.

Figure 2.—The Role of Forests



SOURCE World Bank 1978