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# Introduction

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Each year, 11.3 million hectares of the Earth's remaining tropical forests (an area roughly the size of Pennsylvania) are cleared and converted to other land uses or to unproductive land. Where the land can support sustainable agriculture, deforestation may be beneficial. But most of the Tropics' remaining forest land cannot sustain continuous farming or grazing using current practices and so is soon abandoned. The abandoned land has lost much of its inherent productivity—a loss the tropical nations and the world can ill afford. The United States, however, can contribute expertise to develop and disseminate technologies that could reduce the need to convert forests to unsustainable land uses.

Forest land and former forest land in tropical areas can be classified as undisturbed forest, disturbed forest (secondary forest and man-made forest), converted land (cropland and grazing land), and unproductive land.\* The products from these lands differ, with the most actively managed lands—cropland and man-made forest—generally yielding the highest economic value. Secondary forest is often perceived as relatively unproductive. Yet all forested land provides important services including climate and runoff regulation, water retention, and maintenance of an enormous, still-uncataloged stock of species.

**\*Undisturbed forest**—natural tropical forest with at most a few small areas cleared by natural or human-induced events, regenerating by natural stages of succession.

**Disturbed forest**—includes:

*Secondary forest* or forested land that has been cleared in large areas within the last 60 years, commonly for crops or pasture. Usually it is sufficiently degraded or harvested so often that it does not return to its original state. Trees may be managed or left to natural succession, and

*Manmade forest* planted and maintained in trees, often in exotic species, often a tree monoculture and sometimes also with a useful understory.

**Converted Land**—includes:

*Cropland* planted annually or every few years with food or fiber crops, and

*Grazing land* covered permanently with grasses, legumes, and/or herbaceous species, harvested by grazing animals.

**Unproductive land**—land that has been so degraded that it produces few useful products and provides minimal environmental services (e.g., erosion and flood control). It usually supports very little growth of useful species and does not return naturally to any of the previous categories.

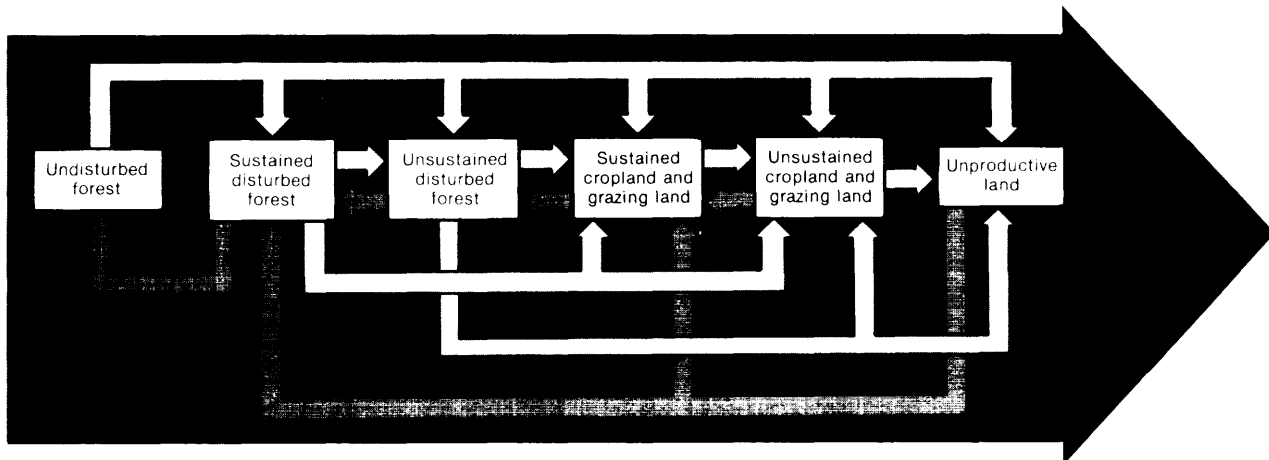
Depending on the methods of management, these natural resources may be sustained or unsustained. Sustained resources are those in which the inherent productivity is not diminished over time. Conversely, unsustained resources suffer declining or degraded productivity. Productivity of almost any land can be sustained by applying substantial inputs (e.g., fertilizer, water), but this is not the general practice on tropical lands.

Undisturbed forest is the only productive form that maintains itself without human management. Four of the land types—cropland, grazing land, secondary forest, and manmade forest—potentially are interchangeable. For example, cropland can be fallowed into grazing land, which can be planted with trees. In some cases, several land uses can be realized simultaneously—e.g., agroforestry can combine agriculture, forestry, and grazing. Little, if any, land changes back into undisturbed forest or out of unproductive land, although in theory undisturbed forest might be regenerated from other land types or unproductive land might be made productive if given enough investment or time to recuperate (fig. 1).

Because this process moves tropical land from forest to unproductive land rapidly and from unproductive land back to forest more slowly, the area of unproductive land is growing steadily. Thus, serious land degradation is taking place, but the change may not be felt immediately in terms of price or availability of products. This is because the intermediate levels of land use are being maintained by continually clearing undisturbed forest to replace land that becomes unproductive. Figure 2 depicts the trend of land-use changes over time typical of tropical areas.\*

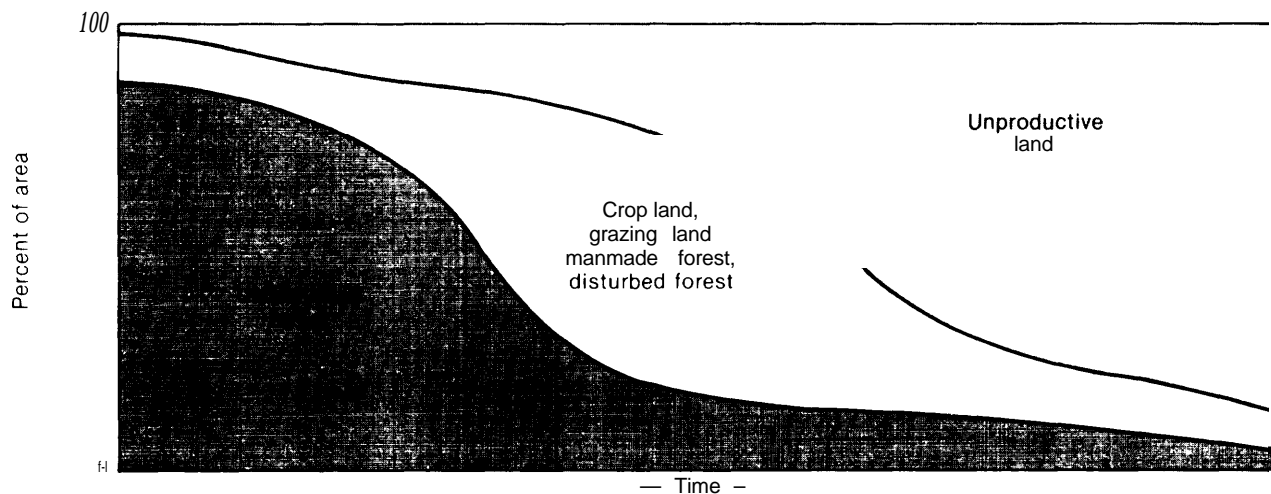
\*This discussion does not present documented trends in land class but provides a general discussion of concepts. The interactions implied by the diagrams are derived from the principles and experience of members of the Advisory Panel and of a workshop attended by Dr. Donella Meadows, Dr. Jeff Gritzner, Dr. Frank Wadsworth, Dr. Jeff Romm, Dr. John Terborgh, and the OTA project staff. Thus, figures 2 and 3 present no scales, nor are specific countries or regions classified by position on the curves.

Figure 1.—Trend of Change Among Tropical Forest Land Uses



SOURCE: Office of Technology Assessment

Figure 2.—Conceptual Diagram indicating Land Use Changes Typical of Tropical Asia



SOURCE: Office of Technology Assessment.

If nothing were done to change the system, the point at which the amount of undisturbed forest land and unproductive land stabilize for a given region would be, in theory, where the cost of clearing the next acre of undisturbed forest equals the cost of reclaiming an acre of unproductive land. Since that cost is high for known technologies, this equilibrium implies little accessible undisturbed forest, a great deal of unproductive land, and extremely low levels

of production. The actual equilibrium maybe delayed until even more undisturbed forest is cleared because costs and benefits accrue to different groups of people, skewing both motivations to invest and to exploit.

Many technologies exist but are not fully used to prevent conversion of productive land to unproductive land, to increase yields on intermediate lands, or to harvest from undis-

turbed forest without converting it to a less sustainable land type. There are also social changes both possible and desirable to reduce the driving forces behind conversion to unsustainable uses.

Because different countries or regions of countries fall at different points along the curves in figure 2, the actions needed to halt this degradation would be most effective if designed for the urgency of the situation in each country. For example, regions with low rainfall and/or dense populations probably follow this process more rapidly than countries with moist forest and large areas of currently inaccessible land. Categorization of countries or major regions to indicate the urgency for actions to address loss of tropical forest resources and degradation of land productivity might take the form indicated in figure 3:

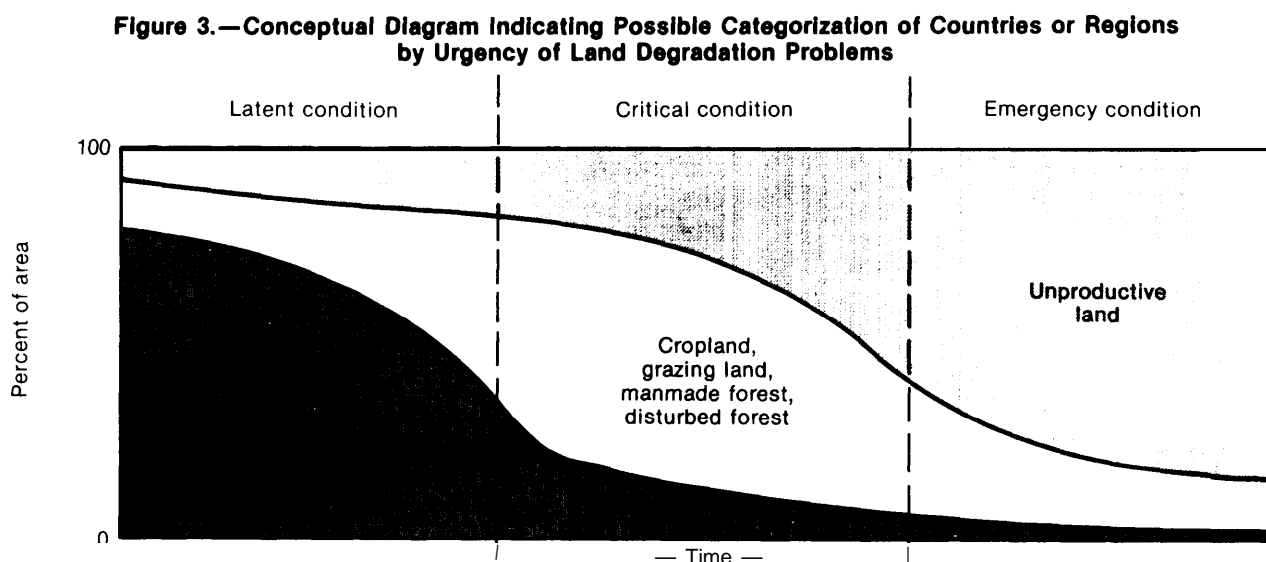
- Countries where the problem is latent but not compelling: A considerable amount of original forest land remains, but without appropriate measures, population pressures and development needs can be expected eventually to propel these countries into the next categories.
- Countries where the problem is critical: Much original forest land has been converted into the four intermediate uses, in-

cluding most of the land capable of sustaining continuous agriculture. Further clearing is occurring and technologies to sustain productivity on these lands generally are not applied.

- Countries where emergency measures are required—the ratio of unproductive land to original undisturbed forest is high and increasing, severe shortages of locally produced forest products are occurring, and the amount of intermediate land types is declining rapidly because technologies are not adequately used to sustain land productivity.

An improved division of countries into categories might account separately for urgency of human needs (e.g., food, fuelwood, materials for shelter, fodder, etc.) and urgency of ecological need (e.g., loss of genetic diversity). The Food and Agriculture Organization has categorized countries by need for action to ameliorate fuelwood deficiencies, but scales to measure other dimensions of forest resource value have not been created.

The loss of tropical forest resources is not new, and its effects are not restricted to those who live within the forests. Part I of this report describes the Background of tropical forest resource changes, including who is affected,



SOURCE: Office of Technology Assessment.

the current status, the visible agents and underlying causes of change, and the organizations—United States, national and international—involved. This section also describes the tropical lands of most direct concern to the U.S. Congress: the U.S. tropical territories.

Part H of this report, Technology Assessment, discusses various technologies for resource-sustaining development of tropical forest lands. The technologies considered cover a broad range. Some are techniques to manage the forests—undisturbed and disturbed—and some are technologies to use forests to protect related resources such as agriculture and water. Others are techniques to prepare people for the various tasks involved in sustaining tropical forest resources, such as resource development planning, education, research, and technology transfer.

- Within each technology discussion, actions are suggested to promote development of sustainable tropical forest use. In general, actions can enhance the stability and productivity of tropical lands if they:

- reduce degradation of the resource base,
- reduce demand on the ecosystems,
- provide more timely and accurate information to decisionmakers or reduce the time necessary to implement decisions.

A final chapter in this section discusses application of the various kinds of technologies to the U.S. tropical forests.

Part 111 describes Issues and Options for Congress to promote development and use of technologies that can sustain tropical forest resources globally and within U.S. tropical territories. The organization of options for the Congress does not indicate the relative importance of the various measures. If long-term actions are not taken to build institutions concerned with the sustainable use of tropical forests, short-term actions will be overwhelmed. And conversely, if short-term measures are not taken, development of institutions to manage the forest resources in the long term may be pointless.