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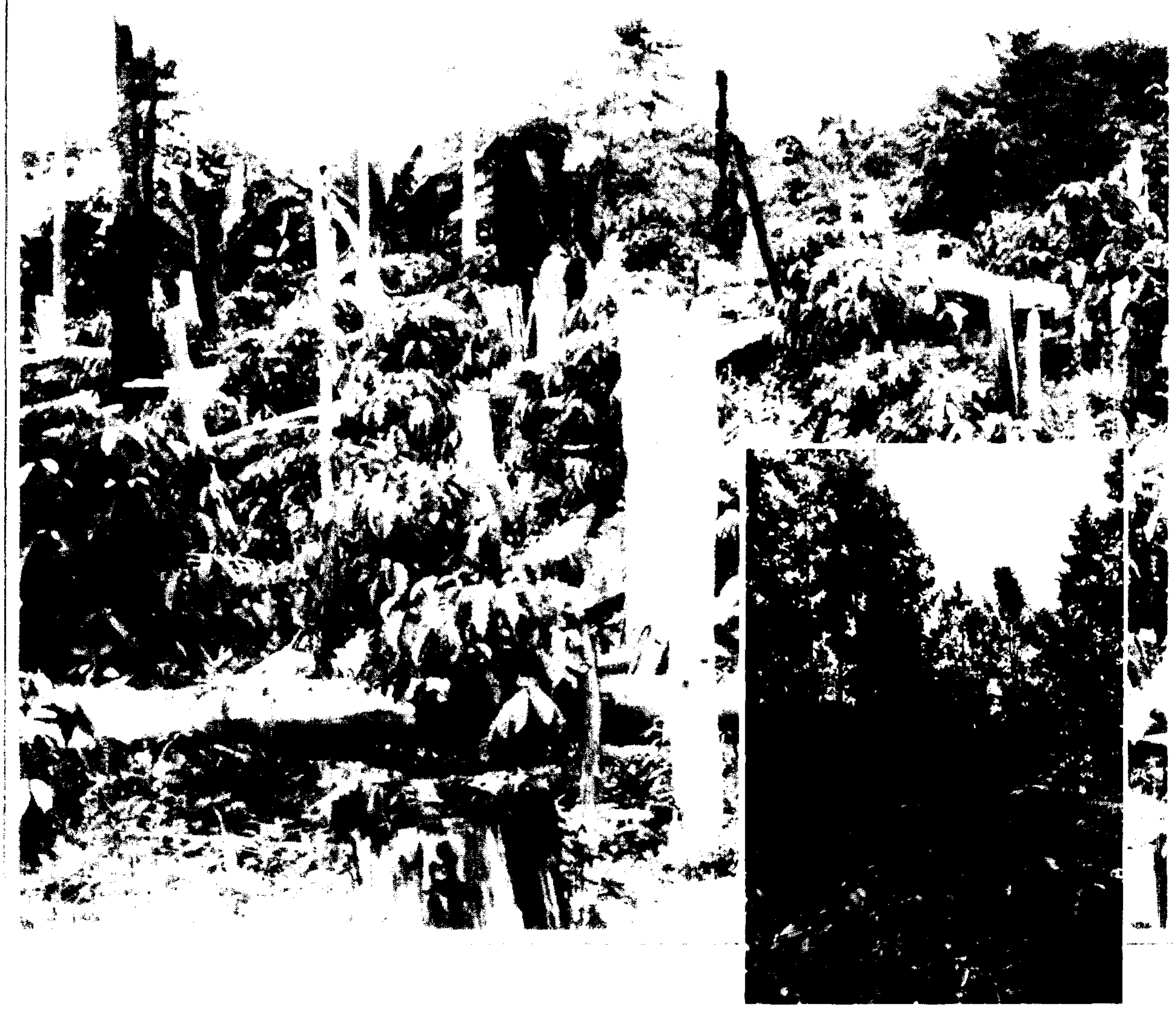
Rehabilitation of Degraded Forests in Asia

Ajit K. Banerjee



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Ajit K. Banerjee is a senior forestry specialist in the Environment and Natural Resources Division of the Asia Technical Department of the World Bank.

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FOREWORD

The rapid pace of worldwide deforestation disturbs the global ecology and hence attracts much attention. What does not catch people's notice so quickly is forest degradation. The process of degradation is often gradual, over a few years or a dozen, and people are likely to miss the change. But the change does take place. Over time, biodiversity is lost and vegetation density and soil cover decrease, and these losses culminate in soil erosion, reduction in agricultural productivity, and ultimately loss of productive land that may have taken thousands of years to build. As productivity disappears, the people living on the forest fringe, or inside its boundary, and subsisting on its products and their labor are made destitute and are forced to join the unemployed in nearby villages or townships to eke out a meager existence. A large proportion of the poor in most cosmopolitan areas of developing countries are those deprived of their land in this manner. Rehabilitation of degraded forests is thus a task that cannot be put off.

The extent of forests that have been degraded is not well documented because the definition of degradation is not very specific. However, many observers estimate that degraded forests cover millions of hectares and are spread throughout all of the Asian developing countries, with most in the tropical and subtropical belts. The task of rehabilitation therefore is not only urgent, it is also colossal.

There are other important reasons for timeliness. Taking on the challenge now rather than later would not only save the land from further degradation, increase forest benefits, and improve the economic status of the people living in or near the forest, it would also cost less than if the work were delayed. Therefore, international development agencies and national policymakers would do well to give priority to the job and allocate appropriate resources for it.

In Asia, a working definition of degraded forest areas is: shifting cultivation areas, *Imperata* grasslands, low-profile hacked forests, and overlogged forests. The success of rehabilitating these areas depends both on enactment and execution of appropriate policies and on application of correct technology.

The most important national policy would be to introduce measures that neutralize the causes leading to degradation. Another step could be to promote participatory forestry by which the population adjoining forests are given usufruct to the forests in exchange for managing and protecting them according to management plans drawn up with the government. This strategy would not only save forests from destruction but would also alleviate local poverty. Other efforts could include introducing policies that encourage low-impact harvesting and that generate higher forest rents and timber prices than those generally obtained by forest owners (primarily governments). In addition to these and other policy introductions, however, corrective technology must be applied.

This paper refers to but does not deal in depth with policy issues, except where policy and technical aspects cannot be distinguished —as in *taungya* cultivation or participatory forestry. A number of thought-provoking papers have been written on these policy issues, but there is not enough documentation on the technology needed for rehabilitating degraded forests and, particularly, on the different manifestations of degradation in one place.

This paper, therefore, focuses on technologies that have proven effective in some areas of Asia, on the expectation that, with site-specific modification, they can be replicated in other areas. The paper is intended to be of general use to project managers during project preparation and supervision of forest rehabilitation projects.

Harold W. Messenger
Director
Asia Technical Department

ABSTRACT

The degraded forests discussed in this paper are those that have been so badly damaged they have completely lost their protective or productive functions—but still retain their potential to revive. The paper focusses on the major areas in Asia fitting this description: swidden agriculture areas in moist forests; human-induced extensive *Imperata* grasslands; repeatedly hacked, low-profile hardwood forests; and overlogged forests. The areas are defined carefully to determine their extent in Asia; key characteristics are described; their impacts on the local ecology are evaluated; the social and economic pressures that prolong the degradation are analyzed; and technical methods for rehabilitating the damaged areas are proposed. Although the paper recognizes that policy interventions are also crucial, it targets a specific audience: governments and agencies that plan and prepare the technical aspects of projects for restoring these important natural resource areas in Asia.

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ABBREVIATIONS AND ACRONYMS

DBH	Diameter breast height
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	United Nations Food and Agricultural Organization
ha	Hectare
ISLS	Indonesian Selective Logging System
MAI	Mean annual increment
MUS	Malaysian Uniform System
NTFP	Nontimber forest products
SMS	Selective Management System
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

1 INTRODUCTION

At the outset it is necessary to know what is meant by the term "degraded forests." A dictionary meaning would be "forests that are characterized by degeneration of structure or function." This is too broad a definition to be workable, however, as it would encompass almost all the forests that are not pristine. Barring a few spots in the world, all forests have been disturbed in some way or the other. Forests where swidden agriculture (defined on page 3) is practiced, where trees are logged or planted, or where local people gather products are degenerating or are at least losing their original character. At the other extreme, mismanagement and maltreatment have turned some forests into wastelands—little more than gullied hill slopes with sparse vegetation or badlands with grasses predominant. Much of the primary forests have thus been converted into secondary forests or other vegetative forms. The question therefore arises whether all of these should be considered degraded forests.

Another vegetation form that should be considered in defining degraded forest is the extensive grasslands of Southeast Asia. In the recent past, most of these grasslands were forests that have changed radically as a result of mismanagement. Should these grasslands be considered degraded forests?

Strictly speaking, most of these conversion processes should be considered as forest degradation and the resultant land as degraded forests. But again, this definition is too wide in that it ignores the difference between the small degenerative changes that accompany forest use in a restrained manner and at the other extreme the large-scale ongoing forest degeneration that results in unrehabilitable wastelands.

For this paper, degraded forests are defined as follows: forests with grossly understocked tree, shrub, grass or cultivation formations that, due to ongoing or comparatively recent biotic interference, have either degenerated or are progressively degenerating in their protective or productive functions but that still retain the potential to revive to become a sustainable economic forest formation.

This definition would include the following major categories of land uses in Asia, which will be the focus of this paper:

- Swidden agriculture areas in moist forests;
- Human-induced extensive *Imperata* grasslands of Southeast Asia;
- Repeatedly hacked, low-profile hardwood forests of, for example, Bangladesh, China, India, and Nepal; and
- Overlogged forests of South and Southeast Asia.

The objectives of this paper are to define and describe each of the above forest categories, determine its extent in Asia, describe key characteristics, evaluate its impact on the local ecology, analyze why over time more area is added to each category, and to propose economic rehabilitation methods. The rehabilitation methods include: (a) policy interventions to prevent the causes that lead to degraded forests; and (b) technical interventions to rehabilitate the areas already degraded. Emerging evidence indicates that forest degradation is often driven by social and political forces that must be dealt with prior to the application of technical strategies. However, although policy interventions are imperative and will be referred to where appropriate, the paper focusses on technologies for rehabilitation.

The target audience of the paper are those who are involved in the preparation and management of projects dealing with rehabilitation of degraded forests of Asia and elsewhere.

2 SWIDDEN AGRICULTURAL AREAS

Introduction

Swidden cultivation is an age-old agricultural system that involves clearing a site of vegetation by slash and burn methods, cultivating it for a short period, and then letting it lie fallow for a longer period to restore the natural vegetation. During the fallow period, the cultivator repeats the same process on other sites until the vegetation of the first site is restored and is ready to be cultivated again. Then the cultivator returns to the first site and starts the cycle over again. Slashing and burning not only clears the area but also adds mineral vegetation ash as fertilizer to the soil. The system is also characterized by some or all of these features: absence of soil manipulation (except sometimes hoeing); use of simple planting methods such as seed broadcasting and, at most, some seed dibbling; the growing of a mixture of many crops (in contrast to the monoculture or simple species mixture of sedentary agriculture); and management of the system as a family operation without engaging wage labor.

Types of swidden

Authors describe swidden cultivation according to movement of the cultivator with respect to the swidden area, length of fallow, economic dependency, or vegetation type.

Based on the criteria of movement of the swiddeners, Greenland (1974) classifies swidden cultivation into four types, the two more common of which are: *simple shifting cultivation* where dwellings of the cultivators shift along with the shifting of the site and *recurrent cultivation* where cultivation sites shift more frequently than the dwellings.

Swidden cultivation is also classified according to the length of the fallow period: short cultivation–short fallow, short cultivation–long fallow, long cultivation–long fallow, and permanent field crops with swidden. Although there are no fast rules about the period of time involved, fewer than eight years is considered short fallow.

Depending on the degree of economic dependency of the cultivators on swidden cultivation, the following variations have been noted: exclusive dependence, major dependence, and contingent dependence (UNESCO 1983). The third refers to displaced communities or individuals who, having no other options, practice swidden cultivation temporarily until new innovations are introduced. For example, three categories of *jhumias* (Indian word for swiddeners) have been recorded in Tripura state of India: pure *jhumias* (exclusive dependence type), *jhumias* by choice (major dependence type) and incipient sedentary farmers (contingent dependence type). Similarly in Thailand, it has been observed that there are established swiddeners, pioneers and incipient swiddeners (UNESCO 1983).

Another classification has been based on whether the cultivators are born into the system, practice it by choice, or are forced to practice it for subsistence. For example, in the Philippines, the categories observed are: born *kaingineros* (Tayalog word for swiddeners), forced *kaingineros*, and speculative *kaingineros* (UNESCO 1983).

Classification has also been based on the type of vegetation the swiddeners remove. Vegetation may be primary forests, as removed by the Hmong (pioneers) of the Thailand highlands, for instance; secondary forests, by the Karen of Northern Thailand (Grandstaff 1980) or the Dyak of Kalimantan (Hurst 1990); savannahs or grasslands, by the Benjarese of South Kalimantan (Dove 1984); and shrub or scrubland (UNESCO 1983).

To summarize, swiddeners in Asia are born into or forced into the practice of swidden cultivation, are exclusively or partially dependent economically on it, and use various types of vegetative formations in the system.

Special features of swidden in countries where this form of cultivation is significant are discussed below.

Bhutan. Bush-fallow shifting cultivation (called *tsheri*) is carried out mainly in the eastern zone. In other zones, particularly at higher elevations, grass-fallow shifting cultivation (*pangshing*) is also practiced. The area of *tsheri* or *pangshing* is not accurately known; however, the shifting cultivation area is estimated at 141,000 hectares, or about 1 percent of the total land and 6.5 percent of the forest area in the country. *Tsheri* is carried out on slopes of 25 degrees to over 45 degrees, but usually below 35 degrees. Barring a few landslips, the *tsheri* areas do not show much erosion. The rotation cycle is about 8–10 years. Cropping patterns vary but usually involve only one crop in one cycle. The crops are maize, foxtail millet (*Setaria*) and common millet (*Panicum milaceum*).

Area in Asia under swidden

The total area in Asia under swidden is not accurately known. Le Trong Cuc (1988) indicates that in Asia about 24.5 million families employ some form of shifting cultivation on 8.5 million hectares annually. He estimated the total area under swidden at 103 million hectares. FAO estimates that 30–80 million people are involved and that 75–120 million hectares of land are affected. Data on the extent of swidden cultivation for selected Asian countries are provided in table 2.1.

Tsheri (shifting cultivation) in the eastern zone of Bhutan. At the background is the old fallow. *(photo Banerjee)*

India. Swidden cultivation (called *jhum* in northeastern India, *bewar* or *penda* in central India, and *podu* in southern India) is most prevalent in the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, and Tripura, and occurs only to a small extent in a few states of central and southern India. The nature of swidden cultivation varies from region to region and even within the same region. Some cultivators are totally dependent while others are partially or marginally dependent on swidden. Vegetation affected are the secondary forests of Arunachal Pradesh, the bamboo forests of Mizoram and Nagaland, the pine and subtropical forests of Meghalaya, Manipur and Tripura, the moist and dry subtropical forests of central India, and the wet forests of southern India.

Studying the *jhum* of Meghalaya, Ramakrishna and Mishra (1981) report that it involves growing 30-35 crop species on one site and is based on the recycling of resources. Shortening the *jhum* cycle to the current 5-30 years is resulting in colonization by weeds (many exotic) and desertification (despite high rainfall).

The total area under shifting cultivation is estimated at 0.94 million hectares, and in 1956 involved 2.6 million people (Atal 1984).

Indonesia. In Indonesia, all major islands have forest areas cultivated by the swidden method (called *ladang*). The forests involved are *Imperata* grass areas, tidal swamps, upland forests and savannahs.

An estimated 1 million families are involved. Estimates of the area cultivated vary widely, from 33 million hectares (Atal 1984) to 11 million hectares (World Bank data). Inoue and Lahjie (1990), discussing the dynamics of swidden agriculture in East Kalimanthan, describe three systems of swidden that have varying sustainability. The first is the fully sustainable, rice-rattan forest swidden that is practiced by the Benuaq-dayak people. The second is the least sustainable, paddy-pepper swidden of the Buginese villages. The third is the (as yet) untested fruit tree-vegetable agroforestry system developed by the transmigrants.

Malaysia. There are both migratory and settled swidden cultivators throughout Malaysia. In Peninsular Malaysia, only 0.1 percent of the total land area is under this form of cultivation. In Sabah, 13 percent (43,130 hectares) of agricultural land comes under this category. Figures for Sarawak vary widely. One source suggests 0.5 percent (60,463 hectares), while another, using aerial photos, estimates 23.5

Table 2.1 Estimated extent of land under shifting cultivation in selected Asian countries

Country	Total land area ('000 ha)	Total forest area[a] ('000 ha)	Area under shifting cultivation ('000 ha)	Percentage forest under shifting cultivation
Bangladesh	13,391	927	315	33.9
Bhutan	4,700	2,140	141[b]	6.5
China (tropical)	46,000[c]	920[c]	130[c]	14.1[d]
India	297,319	74,200	947	1.2
Indonesia	181,157	116,895	11,700[e]	10.0
Malaysia	32,855	20,996	2,894	13.7
Papua New Guinea	45,286	38,175	200[f]	0.5[g]
Philippines	29,817	9,510	331[h]	3.5
Thailand	51,089	15,675	400	2.5

Note: Data on shifting cultivation varies tremendously from author to author, therefore the following qualifications should be noted. a. Total forest area includes both closed and open forests. b. Upadhyay 1988. c. FAO 1986. d. Percentage of tropical forest. e. World Bank data. f. Saulei 1990. g. Hurst 1990 (25 percent of forest area). h. Bee 1987.
Source: WRI 1991, except where noted.

percent of all land or 2,894,537 hectares (Atal 1984). ESCAP (1990) estimates that 4.7 million hectares have been affected by swidden cultivation.

In Peninsular Malaysia, there are both migratory and settled swiddeners. The former usually prefer cutting primary forests, though the government does not allow the cutting of trees older than seven years in swidden cultivation. In Sarawak, swidden was practiced by the Ibans, who migrated to this area more than four centuries ago. Although they cut primary forests at the beginning, the government encouraged them toward secondary forests until they finally developed as settled agriculturists.

Myanmar. People living in the hilly areas that cover about 50 percent of the country continue to practice shifting cultivation. They usually do so in the subtropical wet hill, subtropical moist hill, and subtropical hill savannah forests, and the pine forests of the Shan and Chin states. All of these areas cover an estimated 181,000 hectares (Blower 1985).

Papua New Guinea. Large parts of the secondary forests of Papua New Guinea are under shifting cultivation. A typical swidden farm (called *ganden*) has fruit plants such as *Pometia pinnata* and *Artocarpus atilis* in the top canopy; food crops such as cane sugar, bananas, and taro in the middle canopy; and yam as the undercover (Allen 1985). Usually the cultivation period is 18 months for yams and a few years for bananas, after which the land lies fallow for 30 years. The total area involved is about 200,000 hectares (Saulei 1990). ESCAP (1990) estimates the total area involved at 400,000 hectares.

Philippines. Swidden farming is concentrated in northern Luzon and Mindanao, where 64 percent of the total swiddening families are located. Cultivation is divided into two subtypes: partial and integral systems. The former can be incipient or supplementary, while the integral system may be pioneer and established swiddeners. The total area involved is estimated from 200,000 hectares (ESCAP 1990) to 331,000 hectares or about 3.5 percent of the forest area (Saulei 1990).

Thailand. Swidden is practiced in northern and in central Thailand, by groups of three basic types. The first are the pioneer swiddeners who affect a substantial portion of primary forests and cultivate poppy as a cash crop in addition to their subsistence dry rice crop, which is planted on rugged slopes above 1,200 meters elevation. These pioneers do not cut big trees but often lop them to allow more sunlight to reach the forest floor. Cultivators include Chinese immigrants (the Yeo and the Meo) and the Tibeto-Burman speaking groups (Lahu, Lisu and Aka). The second are the established swiddeners who include the Austroasiatic-speaking Lua, Khmu, Htin, and Karen. They farm on gentler slopes at low elevations. The third are the incipient swiddeners who have recently moved in close to permanent lowland villages and who practice swidden of a very destructive nature. The total area under shifting cultivation has been estimated at 400,000 hectares (ESCAP 1990).

Summary. It is obvious from the above discussion that the total number of cultivators in Asia—while not accurately known—is large, that the area under this form of agriculture is significant, and that the nature of swidden varies from site to site.

Impacts of swidden on forests

Swidden cultivation has variable impacts on forests and on the surrounding land, depending on the length of the fallow period. The main impacts from long- and short-fallow swidden are described below.

Long-fallow system

When long-fallow swidden is practiced, the primary forests will change over time to secondary formation. A few specific examples of conversion to secondary forests are presented in the following discussion.

The established swiddeners of North Thailand practice a short-cultivation long-fallow system in tropical evergreen forests and, with increasing population, also enter the hill evergreen forests (Grandstaff 1980). Dominant species in tropical evergreen forests are *Dipterocarpus costatus* and *Dipterocarpus alatus*. The hill evergreen forests are semi-temperate and are characterized by *Quercus*, *Lithocarpus*, and *Castanopsis* species. Cutting and burning of the primary forests quickly produce a host of weeds. In due course, stumps of cut trees coppice, the reserve of seeds in the forest floor germinate, and climbers (aggressive vines) also appear. If the fallow period is more than five years, pioneer species follow. The most conspicuous are *Trema* spp., *Macaranga* sp., and *Musanga cecropioides*. The pioneers in due course recover to a secondary forest formation.

Vegetational changes subsequent to swidden cultivation have been studied in a swidden farm in Burnihat of the Meghalaya state of India (Ramakrishnan and Mishra 1981). The first species to appear are a host of weeds that include *Eupatorium odoratum* (also found in the Thailand highlands); grasses such as *Imperata cylindrica, Sacharum spontaneum, Thysanolaena maxima*; and climbers such as *Mikenia* sp. If the area continues to remain fallow and is not burned, the grasses are replaced by bamboos such as *Melocanna babusioides, Bambusa tulda, Dendrocalamus longispathus*, and *D. hamiltonii*. If this vegetation remains undisturbed, secondary forests develop that include *Schima wallichii, Pinus roxburghii, Shorea robusta, Terminalia bellerica*, and so forth. The vegetation formation following swidden cultivation would thus be weedy shrubs, bamboos or secondary seral trees, depending on the length of fallow.

In Indonesia, upon forest felling, two stages of succession take place. At first, short-lived herbs such as *Trema-Blumea balsamifera-Abroma angustum* establish; then, they are followed by secondary trees such as *Trema* spp., *Macaranga tanarius, M. denticulata, Callicarpa tomentosa* and *Melochia umbellata*. Abandoned cultivated land in south Banten and Western Java is invaded first by *Imperata*, later by shrubs such as *Melastoma malabaricum, Lantana* sp., and then by *Vitex, Grewia*, and *Dillenia*.

Whitmore (1975) describes the succession in parts of Malaysia. On clearing, *Paspalum conjugatum* grass association invades. This takes two different successional paths, depending on the treatment the site goes through. If the site is burned, *Imperata cylindrica* appears and with continued burning becomes a permanent feature. If the site is not burned, secondary growth takes place. Giant herbs such as banana and ginger and pioneer trees such as *Trema* spp. and *Macaranga* come along. On further protection, secondary species would appear. In about 30 years, a mixture of pioneer and successional species build up a mosaic of tree associations.

In Kepong, Peninsular Malaysia, a 0.9-acre plot laid out in 1947, has been studied for 30 years. The plot was intensively farmed for a period and then left fallow. The weed species that appeared were (first) *Melastoma malabathricum*, which was replaced by the fern *Gleichenia linearis*. The latter did not allow any other crop to grow for a while, but after 15 years about 15 other species overtopped the *Gleichenia*. By 1976 the number had grown to 51 species in the site (Kochummen and Ng 1977).

Therefore, in a long-fallow swidden system, secondary forests grow during the fallow if it is of adequate duration. Although the initial forest structure is altered, the ecosystem may still function satisfactorily. If swidden is discontinued, even the climax forest is likely to grow in the long run.

Short-fallow system

It has been proved beyond doubt that forests are affected adversely in a variety of ways by short-fallow swidden (Inoue and Labjie 1990).

In the initial stages, the forest composition changes from a high forest to a low-profile secondary forest, as in the long-fallow system. Because of continued more-intense disturbance, however, ultimately it changes to a different vegetative form altogether (such as grassland in Thailand and Sarawak or bamboo forest in India). The number of species and the number of trees in an unit area also fall drastically. Finally, the land is eroded and shifting cultivation is abandoned.

Comparison of impacts in long and short fallow

In long-fallow systems, there is loss of soil nutrients in the burning and cultivation. But, one year after the clearing, some nutrients will be returned by the quick growth of weeds, most of which are either plowed back by swiddeners or retained for use. Ramakrishnan (1991) reports that nutrient recovery starts from the 10th year of continuous fallow. The aboveground biomass increases linearly up to 20 years. The annual rate of accumulation in the aboveground living biomass is maximal after 10–20 years for nitrogen, 10–15 years for potassium, and 5 years for phosphorus.

Soil loss through erosion also takes place following burning, but it is dramatically reduced under fallow. In fact, the total loss is much less than in an agroforestry system. Ramakrishnan (1991) reports that in Burnihat, Meghalaya (India), particulate sediment loss dropped from 31 tons per hectare in the agroecosystem to 1.13 tons per hectare in the 5-year fallow and 0.076 tons per hectare in the 10-year fallow.

In the short-fallow system, nutrient and soil losses are quite different. Many of the soils underlying tropical forests have been described as fragile and containing little organic matter. Increased soil temperature from repeated exposure after slashing and burning hastens decomposition of the remaining soil organic matter. As the content of the organic matter decreases, phosphorous and nitrogen content also decreases. Nutrient loss takes place due to ash blowoff after burning and to leaching and volatilization of nitrogen, carbon and sulphur (UNESCO, UNEP and FAO 1978). Adverse changes take place in the hydrology through increased runoff. Repeated burning also fixes phosphorus with aluminum and silicon in an insoluble form. The pH of the soil increases due to the addition of carbonates in the conversion of nutrients by burning.

The physical characteristics of the soil is also adversely affected. As the soil is exposed, soil particles are easily detached and are moved out by sheet erosion. The intensity of erosion has been reported to vary according to the length of the fallow periods.

The absorption capacity of the soil is reduced drastically under the new vegetative formations that follow short-fallow swidden. Grassland or low-density secondary forests have more throughfall and soils have less infiltration capacity. This increases the runoff that increases soil loss significantly.

The seed stock of the soil, which is the potential future crop of a forest, may be washed out permanently. Where they are retained, seeds of primary species may have difficulty germinating under the higher temperatures that result from removal of the overhead canopy. Even if they manage to germinate, they will be killed if burning is continued.

Short-fallow cultivation reduces wild life, microorganisms, beneficial soil fauna, and in particular the mycorrhizal fungi and other nitrogen-fixing bacteria. This further decreases organic matter in the soil and reduces nutrient transfer. Unlike the long-fallow system, land under short fallow does not recuperate nutrient losses.

The general conclusion from the above discussion is that long- and short-fallow systems reduce biodiversity to a large degree but less so in the former system. In the long-fallow system, the land is less degraded and on total discontinuance of swiddening, the original biodiversity is likely to come back. By contrast, in the short-fallow system (as it is practiced now), the original forest crop is less likely to reappear. Under the short-fallow system, not only does biodiversity decrease, but soil characteristics deteriorate and finally the land is degraded to such an extent that production does not justify swiddening.

Rehabilitation

Swidden cultivation remains a widely practiced agricultural system for the following reasons:

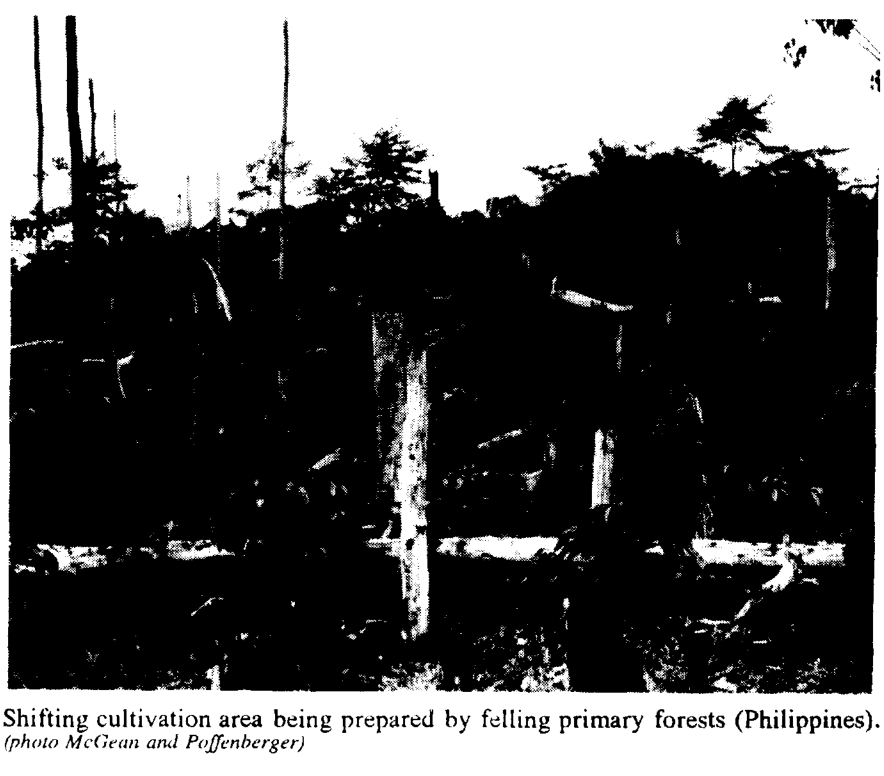
• This is an age-old tradition of some tribal and indigenous people that has evolved into an integral part of their culture and lifestyle. Usually, they practice a short-cultivation long-fallow system.

Originally, shifting cultivation in its pure form was an agricultural practice associated with certain tribal patterns of behavior responding to the natural ecological situations. The practice generally originated in areas where the land/man ratio was low, where land was not suited for continuous agricultural cropping, or where subsistence could be only partially satisfied by gathering, hunting and fishing, hence requiring swidden cultivation for survival. In this form of swidden, people would cut primary forests, burn them, sow, and harvest. After cultivating the area for a year or two, the cultivator would move into another area that had not been cultivated for some time (8-20 years). This form of swidden is a part of the cultural part of the tribal life and is also the only means of subsistence, besides hunting and gathering.

Hence, this age-old form of shifting cultivation continues, though changes are apparent in some parts of Asia. It is still prevalent in the highlands of Papua New Guinea, Myanmar and Thailand; in parts of Sarawak, Kalimantan; in northeast India; and so on.

• A growing number of landless and unemployed people, having no other means of subsistence, are taking to this form of agriculture and usually practice short-fallow swidden.

The increasing number of landless people in many of the developing countries of Asia is an important reason for the continuation of swidden. These people who have no land basically subsist on wage labor in agricultural work or, in some cases, travel to town and make a living out of whatever employment comes their way. Such people do not have an appropriate means of living and are forced to take whatever land they can and begin practicing swidden—without adequate resources. These people are also known to occupy the logged forests when the concessionaires move on. As their knowledge of swidden is limited, they often cultivate without the usual safeguards in the system. For example, groups classified as pioneers working in northern Thailand, cut climax forest only, practice the long-cultivation short-fallow system and in the



Shifting cultivation area being prepared by felling primary forests (Philippines). *(photo McGean and Poffenberger)* process cause enormous ecological damage. In Thailand today, the largest number of swiddeners come from the rural poor of the lowlands who were previously engaged in settled agriculture. The number of such swiddeners swelled from 300,000 to 700,000 between 1969 to 1984 because of the addition of landless, unemployed farmers (Boonkird, Fernandez and Nair 1984).

A similar situation is found among the lowland plains farmers of the Philippines. In Mindanao where the largest number of swiddeners live, there is an increasing number of forced *kaingineros*. They are in fact landless, unemployed people forced to carry out swidden, and they damage both the land and the environment because of their large numbers and lack of experience.

- Richer farmers promote swiddening in order to secure tenure on cultivable land or use the practice to make a quick profit. For example, in Orissa, India, prosperous farmers that have land in the valleys or the plains encroach forests, on their own or through unemployed labor, and claim lands through swidden for future ownership. Often, people with similar expectations follow into areas worked by pioneer swiddeners (as in Thailand) or logged by concessionaires. They carry out short-fallow cultivation, monoculture and so on—practices that are not compatible with good land husbandry.
- Transmigration policies of some governments encourage population growth in areas adjacent to forests. The selected sites for resettlement are often marginal for agriculture and need adequate development that is not systemically provided. The resettled people then take up shifting cultivation by necessity.

For various reasons, mostly developmental policy, people are moved by governments from their own homes to new places, and quite often transmigrants or newly settled people find permanent agriculture on their designated plots difficult. One example is the transmigration of people from Java and other islands to Irian Jaya. Approximately 170,000 families have moved voluntarily, hoping to make a profit from cash crops. But 20 of the 46 sites chosen for resettlement are considered unsuitable for sedentary agriculture. Shifting cultivation is more profitable than investing in terracing for permanent agriculture (Hurst 1990). Although most of these people were sedentary agriculturists earlier, they now have resorted to shifting cultivation, causing enormous damage to the forests. On Kalimantan, Indonesia, it has been estimated that only 75,000 hectares of forest land are suitable for agriculture and yet the Transmigration Department wants 17 times that area for the program.

These examples show that the pressures for continuation of shifting cultivation arise from many different sources: the traditions of indigenous people, poverty, greed of richer farmers, and inadequate government policies to settle the unemployed. Effective rehabilitation methods will consequently have to address these causes. Several proposals for rehabilitating various categories of swidden cultivation are discussed below.

Rehabilitation of long-fallow areas

As has already been noted, pure swidden of short cultivation periods and long fallow causes relatively little damage to land. Affected forests restore ground vegetation in a short period and thereafter go through stages of vegetation succession during the fallow period that protect the soil, restore soil nutrient losses and biodiversity, and build reserves for the next swidden cycle. In fact, from the ecological point of view, swidden cultivation as a form of land management might be more appropriate for tropical forests than conversion of those lands to agriculture or for management for commercial logging (Dove 1984).

For example, the energy output/input ratio is arguably higher in swidden cultivation than in other forms of agriculture. Data supporting this argument is presented in table 2.2, which indicates that the *jhum* systems have ratios far higher than the terrace and valley agricultural systems.

Toky and Ramakrishnan (1982) found that

Table 2.2 Comparison of energy input/output ratio in *jhum*, terrace and valley cultivation systems

	Energy (MJ/hectare/year)		
System	Input	Output	Output/input ratio
Jhum 30-yr cycle	1,665	56,766	34.1
Jhum 10-yr cycle	1,181	56,601	47.9
Jhum 5-yr cycle	510	23,858	46.7
Terrace	6,509	43,602	6.7
	(8,003)		(5.4)
Valley			
(I and II crops)[a]	2,843	50,596	17.8

a. See table 2.3.
Source: Toky and Ramakrishnan 1982.

the monetary output/input ratio in swidden also is more favorable than that of terrace and valley cultivation in Mehghalaya, India. In 30-year swidden cultivation, the ratio is 2.13:1, in comparison to 1.43:1 for the terrace system, which is the best among all sedentary systems (see table 2.3).

Dove (1984) has compared the monetary output of and the number of people supported by 1 square kilometer of shifting cultivation by Mantu tribesmen of West Kalimantan with that of modern logging. For 1981 he recorded the value of rice and other crops that the tribesmen had grown on 1-hectare plots over the past 10 years (assuming 1 year of cropping followed by 9 years of fallowing). For the same year, Dove also recorded the gross returns over the past 10 years from commercial logging of 1 hectare of secondary forests under sustained-yield management. He then calculated the per capita subsistence needs of the shifting cultivator and the commercial logger. Table 2.4 incorporates these data and indicates how much is earned and how many people earn subsistence from the two activities. The table shows that monetary returns are much higher with commercial logging, but shifting cultivation supports more than three times as many people. For a developing economy, larger subsistence support may be a more important criteria for land use choice.

However, there is a large body of opinion opposed to swidden agriculture in any form on the grounds that, in due course, such long fallow is changed to a short-fallow system, with consequent degradation. It is further argued that the long-fallow system also reduces biodiversity, reduces forest stocking, generates less product per unit of land, and is wasteful (in the burning process). If on the strength of this argument, swidden by traditional swiddeners is totally discouraged, however, a number of problems can be expected.

The first is a cultural consideration. Pure swiddeners practice this form of cultivation that allows them more time for hunting, cultural occupation or leisure. Even when incentives are offered, traditional swiddeners are reluctant to relinquish their rights or change their practices. In northeast India, 150 tribes practice swidden and have their own festivals associated with the cultivation. Any drastic change in their traditional habits would upset their cultural life (Ramakrishnan and Mishra 1981).

Second, some of the lands where swidden is practiced are marginal and are more suitable for short-cultivation long-fallow agriculture than for conventional agricultural systems. Third, it would be an environmental step backward to change a system that has the highest energy output/input ratio of all the agricultural systems of the world and, if properly practiced, does less damage to the land than modern agriculture.

Fourth, crops are mixed in swidden, providing a range of dietary, medicinal, construction and fuel products. If the proposed change is to monoculture, which is likely if sedentary agriculture is considered, the croppers would have to buy most of their needs. This would mean a total change in their economy from subsistence to cash, a change that increases risks and subjects the population, as yet not properly initiated to the modern world, to market forces.

Fifth, in some developing economies, contribution by shifting cultivators to the total

Table 2.3 Monetary input/output ratio in *jhum*, terrace and valley agriculture systems (Rupees per hectare per year)

	Jhum				Valley		
Indicator	30 years	10 years	5 years	Terrace[a]	Crop I	Crop II	Crop I and II
Input	2,616	1,830	896	2,542 (4,544)	2,602	2,241	4,843
Output	5,586	3,354	1,690	3,658	2,820	2,745	5,565
Net gain/loss	2,970	1,524	794	1,116 (-886)	218	504	722
Output/input	2.13	1.83	1.88	1.43	1.08	1.22	1.14

a. Values in parentheses indicate values for the first year of terrace cultivation.
Source: Toky and Ramakrishnan 1982.

production of agricultural products is very high and cannot be quickly substituted. For example, in 1982 in Indonesia, all of the pepper, coffee, coconut, and tobacco, and 80 percent of the rubber were grown by swidden cultivators. Rubber smallholders were found to be more competitive than commercial plantations because the former were less capitalized. The investments needed to change from swidden to sedentary agriculture or to any other form of production for such large quantities of goods therefore would be high, and it is questionable whether the opportunity cost of the money is justifiable.

This paper therefore argues that traditional swiddening should be allowed to continue without interruption. It would be necessary, however, to distinguish the traditional practice from the destructive methods of swidden cultivation. It would also be necessary to ensure that the area available to the group not be further reduced by conversion to other uses, including development. Monitoring is also necessary so that the number of swiddeners does not increase. The additional population to traditional swiddeners above the optimal level should be provided with opportunities to earn a living in some other way besides swidden cultivation. This would mean training the young people in new skills.

Rehabilitation of degenerated short-fallow areas

Some areas where short-fallow swidden has been practiced have degenerated to such an extent that restoration to reproductive forest use would be prohibitively expensive. The rehabilitation proposals, discussed later in this section, do not apply to those areas. They apply only to areas that have the potential to recuperate.

Governments have taken action in various ways to contain swidden cultivation. Before 1950 most action was toward eliminating swidden by policing. This approach has, to a great extent, changed in favor of more socio-economic, ecological and legal measures. Before describing some of the technical rehabilitation methods, several policy measures that are necessary for making the technology effective will be discussed:

- Appropriate action has to be taken to keep the urban unemployed and destitute sedentary farmers from swelling the number of swiddeners. This is a very tall order, but it is an essential step in stemming the increase in degenerative swidden cultivation. The movement can be contained only if national economic development is targeted to the poorer sections of the population in the towns and

Table 2.4 Comparison of profit earned and numbers supported by commercial logging and swidden

Agent	Product	Profit per square kilometer for 10 years (US$)	Per capita subsistence needed for 1 year (US$)	Number people supported
Mantu tribe	Rice, etc.	2,680	118	23
Commercial logging	Timber	10,540	1,150	9

Source: Calculated from Dove 1984.

villages, land reforms in favor of landless and agriculturists are carried out, and opportunities for employment and for grants and credits are provided to private entrepreneurs. Land reform should include provision of clear land titles to swiddeners. Extension services for increasing agricultural productivity through technology—and thus improving the economic status of the farmers—should go hand-in-hand with land reforms.

• Where suitable land is available, swiddeners should be encouraged away from the short-fallow system and toward sedentary agriculture.

• Experience shows that swiddeners who have been weaned away from swiddening do not revert to the process again of their own accord. Reversion takes place because of lack of other suitable land, distress sale, destitution, or relocation to new areas without training or funds for utilizing the natural resources of the new area.

• Legal measures must be set in place to prevent the employment of landless people or other agents for the specific purpose of using swidden cultivation to claim ownership to land.

• In-situ technological development of swidden methods and improvement of swidden land should be promoted, particularly where the land/man ratio is low or the land is rehabilitable. Technologies that (possibly) could replace swiddening and rehabilitate the land, while not displacing the swiddeners, are described below.

Rehabilitation by *taungya* system of cultivation. *Taungya* is a system of plantation forestry and agroforestry with a long history of practice: in Myanmar from the mid-1800s, in India from the early-1890s, and in Thailand for a similarly long time. In government-owned forest land under *taungya*, forest tree seedlings are planted together with agriculture crops of various types, the latter between the tree rows. The areas between the tree rows are cultivated by private farmers in exchange for protecting and maintaining the tree seedlings during the time they cultivate the area.

In the *taungya* system, the forest site is first clearfelled, the saleable wood is extracted, and then the residue is burned. The area is divided into small blocks (in India, it is 0.2–1.0 hectares), each of which is allotted to one cultivator family. The cultivator cultivates the land with crops that (in Eastern India) may include paddy, wheat, millet, maize, cotton, and vegetables. In either the first or second year, the cultivator sows or plants the tree seedlings at a prescribed spacing. In India the Forest Department provides this guidance (Chaturvedi 1991). Representative species previously grown in this manner in the West Bengal state of India were *Chukrassia tabularis* and *Schima wallichii* (by planting in rows 2-3 meters apart) and *Shorea robusta* (by sowing in somewhat closer spacing than the planted rows).

The farmer looks after the tree seedlings along with his cultivation—weeding and spacing them when necessary. As foresters take up new areas for planting every year, the *taungya* cultivator is provided with a new planting site (annually), although he is allowed to farm the older site until the tree canopy closes (in about three years). Subsequently, the government takes over the tree management and marketing.

Taungya cultivation has not been an unmitigated success. In India, this method has been more or less discontinued as the *taungya* cultivators aspired to own the land they were cultivating for practicing sedentary agriculture. In addition, cultivators considered the system to be exploitative, since most of the tree planting work was done free by them while the profits from selling the trees went to the government.

The *taungya* system has however been more successful in Thailand, where the method carries greater benefits for the cultivators. In Thailand the system is now called the Forest Village system. It began in the highlands and has been adopted in the whole country (Boonkird, Fernandez and Nair 1984). The scheme encourages the swidden cultivators to settle down in forest villages (with free medical and educational facilities) that are established for them. They are given land for a homestead and home garden. Farmers are expected to raise and maintain forest plantations where they also raise agricultural crops during the first three years of plantation establishment. Technical advice on agriculture and animal husbandry are provided free of charge—and also a cash reward upon successfully establishing the forest plantation.

Tree crops raised by this system are *Tectona grandis, Eucalyptus camaldulensis*, and *Melia azederach*, and the crops are rice, maize, sesame, sweet potatoes, and cassava. In addition to growing crops between trees, the villagers also grow fruit trees such as *Parkia speciosa* and *P. javanica*, *Anacardium occidentale* (cashew nuts), and in some areas, *Hevea brasiliensis* (rubber tree).

Management consists of clearing the degraded forests (which mostly are short-fallow shifting-cultivation areas); burning and planting the trees (at a spacing of 2x8 meters). The usual rotation period is 40 years. In dry areas, *Eucalyptus camaldulensis* and *Melia azederach* are planted; the rotation period for eucalyptus is 20 years for fuelwood and timber production.

Boonkird, Fernandez and Nair (1984) report that village establishment and planting fell far short of targets, but the system is sustainable. The causes for the shortfall appeared to be implementational and not insurmountable.

This method of cultivation has the attributes of swidden cultivation but simultaneously promotes forest replanting. As the plantation rotation is scientifically established, the land is protected from degradation and the forest is concomitantly upgraded.

Re-orienting the swidden cultivators to this form of occupation could be one of the main strategies for restricting short-fallow swidden. The total number of swidden cultivators who can be accommodated would, however, be restricted by the area that the country can take up for tree planting. For instance, if the country has a program for planting 1,000 hectares each year and if each villager is allocated 0.5 hectares to make it attractive to them, the total number of swiddeners who can be accommodated by the system is only 2,000 families, which may be far less than the number practicing swidden. As noted earlier, the number of swiddeners runs into thousands, if not millions in many countries. Absorbing all by *taungya* would mean much larger programs of planting than hitherto envisaged.

Rehabilitation by fallow-period management. Fallow-period management attempts to derive economic return with fast growing perennial crops during the time gap between the cultivation periods. In classical swidden, the growth of new vegetation is left to nature during the fallow period. In fallow-period management, valuable species are planted to artificially produce products. Products generated in this way can be perennial crops of commercial timber, bamboo and rattan, fuel, fodder, bedding, fruit trees and soil-enriching legumes.

Bamboo and cedar are grown in fallows by the Lingnan Yao of Kwangtung province in China. Rattan is planted by the Luangan dayaks of Borneo with a 7-10 year growth period that fits in well with the fallow period of their swidden system (Raintree and Warner 1986). In the lowlands of Papua New Guinea, shifting cultivators plant yams (*Diascorea sp.*), bananas, taro (*Colocasea esculenta*), and sugarcane for 18 months, followed by a fallow cycle of 30 years. During the cropping cycle, they plant two fruit trees such as *Pometia pinnata* and *Artocarpus atilis*. The leaves of the former are used for mulching and green manure for yam cultivation. Since 1950, robusta coffee has been added as a cash crop.

In India, the swiddeners never fell the *Bassia butyraceae* trees, which supply them with flowers and fruits for food, drinks and fodder even after they have left the area for fallow. Maikhuri and Ramakrishnan (1991) suggest planting *Alnus nepalensis* in the foothills of Arunachal Pradesh of India to improve biomass when the fallow period is shortened to five years or less.

Fujisaka and Wollenbert (1991) evaluated a socio-economic interactive system in two pioneer forest settlement areas in the Luzon islands of the Philippines. Through experimentation, the settlers found perennial crop-based agroforestry (akin to fallow-period management) to be the most sustainable system. This is borne out in the data provided in table 2.5, which shows that home gardens and perennial crop-based agroforestry (among others) achieves the best combination of productivity, stability, equity and sustainability.

Fallow management need not necessarily be centered around tree crops. It can improve the management of cattle raising and grazing. Wildlife hunting may also be the main economic activity during the fallow period.

Some advantages of the fallow-period management are: (a) areas shaded by perennial trees either planted or left uncut produce more woody plants than open land; (b) in contrast to the traditionally abandoned fallow with its depleted root mat, the managed swidden would have more root systems at the end of the cycle and thus more organic matter in the subsoil; (c) the managed fallow might have more canopy cover and thus reduce chances of erosion; and (d) the economic return from fallow management is much more than from the abandoned fallow system (Unruh 1990). The disadvantages are: (a) the fallow period has to be increased if perennial crops are raised, resulting in more land under shifting cultivation or less area cultivated per year (reducing the economic advantage); (b) the fallow must be protected and therefore more manpower is required; and (c) soil nutrition is depleted as products are removed from the site, unlike undisturbed fallow where all products remain in the site. Because of this problem, fallow management may need occasional fertilization or planting of soil-enriching legumes.

Rehabilitation by intensive mixed cropping. A useful alternative method would be intensive

Table 2.5 Sociosystem and ecosystem interactive change over time
(comparison of productivity, stability, equitability and sustainability)

System	Productivity	Stability	Equitability	Sustainability
Primary humid tropical forest	3	3	—	3
Disturbed (logged) forest	1	2	—	2
Forest–annual cropland fallow mosaic	1	1	—	1
Secondary forest and tree plantations	3	3	—	3
Commercial and illegal logging	3	—	1	1
Settler resource extraction	3	—	2	2
Settler home gardens	2	3	3	3
Annual cereal cropping	1	1	3	1
Annual tomato cropping	3	1	2	1
Perennial crop agroforestry	2	3	3	3

Key: 3=high, 2=moderate, 1=low, — not applicable.
Note: These values are a very subjective comparison.
Source: Fujisaka and Wollenbert 1991.

mixed cropping in which trees and cultivated crops are raised simultaneously, if the fallow period is too short to generate economic production by fallow management. In the district of Krui of Lumpung, Sumatra, farmers have planted *Shorea javanica* in the top canopy and a host of fruits and vegetables in the middle and lower canopies. These crops include *Durio, Syzgium, Mangifera, Areca* and so on. Economic gains are made from the resin tapped from the *Shorea* tree and from the sale of fruits, fibers and rattans.

In Western Java, a somewhat similar method but with an important variation from the typical agroforestry has been practiced by farmers (Cuc 1988). The system, tentatively called agro-silviculture, is known locally as the Kebun-Talun system. This system has three stages: kebun, kebun-camparun and talun. In the kebun stage, the degraded forests consisting of shrubs and grasses are cleared and perennials (such as *Albizia falcataria*, several bamboo species, coconut, sugar palm, and fruit trees) and annuals (such as beans, cucumber, tobacco, onion, chili pepper, tomato, and cassava) are planted. The annuals are fertilized with ash and manure. Part of the annuals are consumed and part are marketed. In two years, the next stage of kebun-campuran is reached. The trees will be forming canopies and therefore the crops are changed to pineapple, cassava and so on. After three more years, the annual cropping is abandoned as the crops become almost totally perennial. The farmer begins exploiting the perennials such as bamboo, albizia fruits and other products (Cuc 1988). These perennials are felled in due course when naturally growing forest trees take over again and the cycle is repeated.

Conclusions

There is not just one solution to the problem of shifting cultivation: all have to be adapted to the social, economic and other situations in the concerned country. State interventions may be necessary to tackle the problem.

The first task for each country should be to prepare maps of areas with swidden cultivation. This is not difficult if satellite imageries are taken during the right season and interpreted.

The second step is more laborious. It is necessary to distinguish between traditional swiddening and degenerated swiddening by field visits. The former areas can continue to have the present land use pattern if arrangements are made to ensure that the number of cultivators do not increase. Any normal population increase should be taken care of by redirecting the people toward alternative occupations.

In degenerated swidden areas, the technological options of *taungya* cultivation, fallow-period management, intensive mixed cropping and perennial cropping should be looked into and promoted. Incentives for successful promotion should include land reform to provide clear land title to the swiddeners and marketing arrangements for the products generated in swidden. There should be appropriate policy changes and programs so that the areas are not invaded by outsiders.

3 GRASSLANDS

Introduction

Grasslands in Asia can be classified according to origin:

- Grasslands caused by climatic or edaphic reasons; and
- Grasslands caused by conversion of forests through cutting or burning.

This paper will consider only those grasslands that have been brought about by forest conversion and that can be rehabilitated economically to productive forest.

Extent of human-induced grasslands

The total area of grasslands in Asia is not well documented, but in 1987 FAO estimated it to be 537 million hectares. How much of this is human-induced is not accurately known either, but some indicative figures are available for some countries. Table 3.1 provides data for selected countries where grasslands spread over large areas. These countries include China, India, Indonesia, the Philippines, Sri Lanka, and Thailand.

Origin of grasslands

Although there is continuing controversy about the origin of the grasslands of Asia, most authors consider that—barring all of those in subalpine and alpine zones and some of those in temperate zones—the majority are human-made. According to Numata (1979), most of the grasslands in Borneo, Cambodia, Java, Japan, Korea, Lao People's Democratic Republic (Lao P.D.R.), Myanmar, the Philippines, Sumatra, Selebes, Thailand, and Viet Nam resulted from deforestation and shifting cultivation. Seavoy (1975) also attributes the origin of grasslands in Indonesia to shifting cultivation.

This view is opposed by a few authors. According to Dove (1984), if destructive shifting cultivation had been responsible for grasslands, they would be more concentrated in areas with higher population densities and higher intensity of swidden agriculture. The opposite case seems to be true in Sumbawa, Eastern Indonesia.

Field data from southern Papua New Guinea indicates that derived savanna and grassland observed on aerial photographs develop from cultivated forest land as a result of burning (Eden 1985). It has been found that 22 percent of abandoned shifting cultivator fields sampled regenerated to savanna or grassland.

Lowland grasslands in India are seral in nature and are maintained at various successional stages by grazing and burning. These have been caused by deforestation, and sometimes by abandoned cultivation, and have been further degraded by uncontrolled livestock grazing.

In some countries, the people do not allow

Table 3.1 Extent of grasslands in selected countries in Asia (thousands of hectares)

Country	Total land area[a]	Area under grassland
China	932,641	279,792[b]
India	297,319	30,000[c]
Indonesia	181,157	12,000[c]
Pakistan	77,088	5,000[c]
Philippines	29,817	7,000[d]
Sri Lanka	6,474	64[e]
Thailand	51,089	2,000[f]

Note: It is not known how much of these grasslands is humanmade. a. WRI 1991. b. Forestier 1989. c. World Bank data. d. Revilla, Canonizaddo and Gregario 1987. e. Skerman and Riveros 1990. f. FAO 1981.

the grasslands to revert to forests. In Bhutan grasses under abandoned-pine (*Pinus roxburghii*) forests are burned to promote growth of lemon grass for oil extraction. In the western Himalayas in India, burning is done to get fresh shoots of Bhabar grass (*Eulaliopsis binata*) for making rope or for paper. In the states of Bihar and West Bengal in Eastern India, local tribal groups burn forests and grasslands annually in the summer to flush out animals for hunting. In due course, some of these forests turn into grassland with sparse trees.

In Indonesia, in the districts of Bima and Dompu (Island of Sumbawa) the people perpetuate grasslands to hunt rusa deer (*Cervus timorensis*), which are more prolific in *Imperata cylindrica* grassland niches (Dove 1984).

Imperata cylindrica grassland in East Kalimantan, Indonesia.
(photo McGean and Poffenberger)

These examples and surveys of other literature indicate that the most important factors responsible for humanmade grassland formation are the cutting of forest vegetation followed by repeated burning at frequent intervals for short-fallow swidden cultivation, for generating pasture, or for growing commercial grasses or wild grasses to attract game animals. There may be other reasons for converting forests to grasslands, but they do not involve large areas.

Blasco (1983) describes diagrammatically the evolution of different vegetation forms, including grasslands, for different climatic conditions in Asia. He indicates that grasslands, especially of *Imperata cylindrica*, owe their origin to the practice of burning forests in humid climates (figure 3.1).

Description of human-induced grasslands

Grasslands are dominated by specific communities of species depending on rainfall and temperature gradients as well as on the level of biotic pressure and disturbance.

In Southeast Asia, grasslands are dominated by *Imperata* from sea level to 700 meters above sea level, are found on basaltic soils, and are induced by repeated burning. At altitudes over 700 meters above sea level, *Arundo madagascariensis* replaces *Imperata*.

In the Philippines, four vegetative associations have been recognized (Singh, Hanxi and Sajise 1985). These are: (a) *Imperata cylindrica* community with *Heteropogon contortus, Chrysopogon aciculatus, Manisuris clarkei, Paspalum dilatatum*, and *Capillipedium parviflorum* as the main associates; (b) *Themeda tirandra* community with *C. aciculatus, P. dilatatum, I. cylindrica, C. parviflorum and Coelorachis glandulosa* as the main associates; (c) *Chysopogon aciculatus* community with *T.triandra, I. cylindrica, P.dilatatum, Alysicapus vaginalis* and *Fimbrisylis monostachya* as important species; and (d) *Capillipedium parviflorum* community with *I. cylindrica, P. dilatatum, Heteropogon contortus, F. monostachya* and *C. aciculatus* as main associates. This last community is associated with overgrazing.

In India, five major types of grass cover have been found: (a) *Schima-Dicanthium* type; (b) *Dicanthium-Cenchrus-Lasiurus* type; (c) *Phragmites-Saccharum-Imperata* type; (d) *Themeda-Arundinella* type; and (e) temperate-alpine type. The first is tropical and is less extensive. The second, third and fourth are subtropical. The *Themeda-Saccharum-Imperata* type, which is akin to the *Imperata* grasslands, is found in the moist and wet habitats (Singh, Lauenroth and Milchunas 1983).

In China, seminatural grasslands are predominantly *Imperata cylindrica, Paspalum scorbiculatum, Cymbopogon caesius* and species of *Aristida, Ischaemum, Heteropogon, Eulalia, Digitaria, Eragrostis*, and *Arundinella* (Singh, Lauenroth and Milchunas 1983).

Apart from the species composition, other characteristics of the extensive grasslands (especially of *Imperata cylindrica*) are: shallow mat-like root system, tolerance to drought and harvivory, production of excessive seeds, and easy propagation.

Impact of grasslands on local ecology

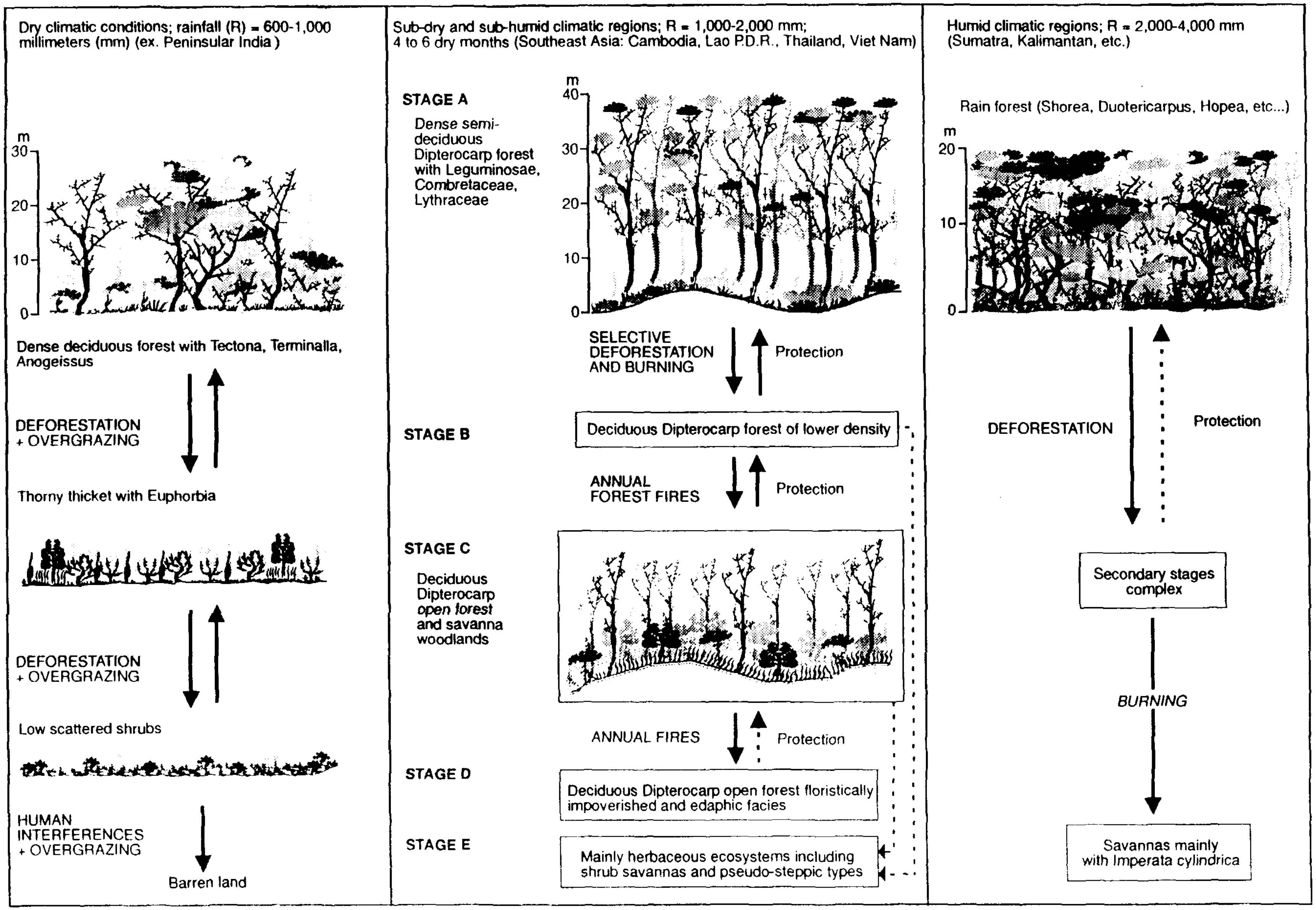
In certain cases grasslands can be very productive ecosystems. Yadava and Singh (1977) found that the total Net Primary Production (NPP), both above and below ground, of grasslands in India ranged from 278 grams per square meter (for the grassland at Pilani) to 4,558 grams per square meter (for the *Eragrostis* grassland near Varanasi). In general, dry subhumid grasslands support greater biomass, but this decreases in semi-arid to arid and in moist subhumid regions.

The NPP of grasslands will also depend on the original vegetation form. In a three-year study of pastures converted from primary and secondary forests, the total aboveground NPP of the pasture formed from clearing primary forest was found to be very close to that of the undisturbed rain forest—approximately 10 tons per hectare per year. This yield suggests an efficient use of nutrients by the pasture grass *Brachiaria decumbens*. The NPP of pastures formed after clearing secondary forest, however, was only 50–60 percent of the amount derived from primary forest.

In addition to having high NPPs, grasslands can support a large number of primary and secondary consumers. Primary consumers include ungulates, ruminants, rodents, frugivorous birds, grasshoppers, termites, seed eating ants, actinomycetes, fungi and viruses. Secondary consumers are carnivores, dung-feeding arthropods, invertebrate detritus feeders, and bacterial decomposers. Depending on the rainfall and soil types, aboveground herbaceous production may be as much as 20–25 tons per hectare per year. It may occasionally exceed the production of a high forest in similar ecological conditions and may be as low as zero at the edge of the desert (Lamotte and Bouliere 1983).

Under certain circumstances, well-stocked grasslands are also better soil conservers than agriculture. In one area in Java, Indonesia, erosion increased 100-fold when *Imperata* was converted to agriculture. Thus, it appears that grasslands, even if human-induced, are quite

Figure 3.1 Examples of evolution of vegetation in Asia



Source: Blasco 1983.

often highly productive, economic, socially useful, and ecologically desired.

The impact of grasslands therefore seem to be more beneficial than adverse. As seen above, some of the human-induced grasslands are required for local and commercial uses, are intentionally perpetuated as grassland, and should be retained as such.

Where grasslands are not playing an ecological, social or economic role, however, they need to be rehabilitated. *Imperata cylindrica*, the species most common in the grasslands of Indonesia, Malaysia, and Thailand, is a menace to shifting cultivation, agricultural fields and cash crops. The grass encroaches on the shifting cultivation areas and cause them to be abandoned. Two million hectares of rubber plantation have been affected by this species. Twelve million hectares are covered by this species in Indonesia, with 150,000 hectares being added annually (Holm and others 1977). *Imperata cylindrica* reduces the growth of rubber plantations by 50 percent in the first five years in Malaysia. The yields in *Tectona grandis* plantations is similarly affected: the first year's growth of the tree with *Imperata* was measured at only 13 centimeters compared to 100 centimeters without the grass (Holm and others 1977).

Rehabilitation of *Imperata* grassland

Ivens (1983) lists a number of weaknesses of the *Imperata* grass that can be used in eradication methods. The weaknesses include low viability of the seeds, slow seedling growth at the outset, and vulnerability to competition. The grass is light-demanding and thus cannot withstand prolonged shade. Although, like other rhizomatous systems, the roots of this grass are matty, they are shallow and are mostly concentrated at about 15-40 centimeters from the surface of the soil. They are also killed by overgrazing as the area is then visited by weeds that sheds off the grass. Possible methods of eradication should therefore focus on resisting invasion and, if already invaded, on exposing the rhizome to sunlight to bake them or on shading them with cover crops to kill them. It has also been proposed that the sequence for eradication could be overgrazing and sowing of leguminous fodder, followed by the growing of shade trees.

The following rehabilitation methods are discussed below: (a) natural succession of grasslands to forest formation; (b) use of hedgerowing to kill grasses and replacement with trees; and (c) mechanical removal of the grasses followed by artificial regeneration.

Natural succession of grasslands to forest formation

"Vegetation potential, which is a time dependant function of climate, soil, topography and floristic material available in an area, can be modified considerably by fire, grazing...." (Muellar-Dumbois 1981). Another method is logging with machines. Whitmore (1975) observes that if a site is cut, burned and cultivated once, revegetation occurs without any problem. On the other hand, if the cutting, burning, cultivation, logging and so forth continues a number of times and is repeated within a short time, the resulting grassland is often difficult to eradicate. This is so because the dense root mat of the grass does not allow penetration of the root system of most tree species. Quite often in overgrazed *Imperata* grasslands, the disintegration of humus and organic matter and the change in the mechanical composition of the soils by constant animal trampling produces soils with a high-bulk density, a lower infiltration rate, high runoff, and high soil loss. These soils are thus more arid and are unsuitable for tree growing (Senaratna 1958). It is also possible that the site would have hardly any trees for seed dispersal.

In contrast to these observations, there are other opinions that there is no evidence for believing that soils in tropical regions can become too poor to support forest growth. Muellar Dumbois (1981) distinguishes between large gaps and small gaps of grasslands. A large grassland may be returned to forest only with difficulty, while small gaps that simulate small natural perturbations can be returned.

Grassland in a moist tropical-subtropical area will revert to forest, provided the conditions that perpetuate the grassland are eliminated from the site. The adverse conditions are fire, grazing and hacking of tree seedlings. If the soil has reached low fertility and high soil-bulk density and the grazing continues, it is likely that some weed species such as tall herbaceous flora (for example, banana), shrubs (such as *Eupatorium* and *Lantana*), ferns, and spiny shrubs (such as *Carissa* and *Flacourtia*) would germinate and thrive indefinitely. They would eliminate by competition the more desirable species, thus establishing a deflected succession.

If there is no grazing, pioneer species would appear. These may include *Macaranga, Mussaenga, Acacia, Dalbergia, Salmalia, Premna, Trema*, and *Melastoma*. Their efficiency relates to wind pollination and prolific seed sets, with small numerous viable seeds. If the forest continues to be undisturbed, it would finally become a fully stocked secondary forest, characterized by species that are light-demanding, fast growing, and short lived. Secondary forests in due course would encourage the primary forest species, provided the secondary forests have some representative of the primary species, are near seed sources, or are visited by forest dispersal agents such as bats or rodents. The succession of vegetation in forests of Bombay (now Maharashtra) was studied by Bharucha and Sankarnarayana (1958) and indicated the conditions under which the primary species are lost to grasslands and then return (table 3.2).

It appears that manipulation of grazing, burning and protection can promote succession of grassland to forests. This takes time and it will be a few decades before the grassland can be effectively rehabilitated to productive forest formation.

Hedgerowing to kill grasses

One of the methods of replacing grass is by planting desired species and then to keep the grasses down by repeated weeding and slashing. This is expensive however and also is not possible where labor is in short supply.

The most important factor governing *Imperata* grass growth is light. Anoka, Akobundu and Okonwo (1991) studied the effects of *Gliricidia sepium* and *Leucaena leucocephala* on the growth and development of *Imperata cylindrica*. Shading by *Gliricidia* and *Leucaena* caused a reduction in grass density of 67 percent and 51 percent (respectively) during the rainy season despite the more favorable moisture conditions. Twelve months later, the *Imperata* grass rhizome biomass was further reduced by 96 percent and 90 percent (respectively) of the original density. This reduction was most pronounced during the growing season, implying that *Imperata* is most vulnerable to control measures at the onset of rains before it can replenish its carbohydrate reserve with new growth.

Shading with hedgerow species offers an alternative to the usual practices of hand weeding, tillage and slashing that are labor intensive. To establish tree species requires burning off the grass, sowing or planting the species at close spacing, and then weeding between the lines until the seedlings overcome the grass. This may take less than a year. However, establishment can be very difficult at times and may not be successful over large areas.

Removal of grasses followed by artificial regeneration

Manual Method. The traditional method of removing grasses in agriculture, and sometimes in rehabilitating grassland, is burning and mechanical removal. Burning is usually the method for shifting cultivation. The grass is removed only temporarily by burning alone, as the grasses regenerate during the fallow period.

One method of manual removal described by Sherman (1987) is successful in the Huta-Ginjang area of the Tapanuli region of Sumatra. In this system, most of the work of opening the *Imperata* grassland is done in April and

Table 3.2 Succession of vegetation at Bombay

Form of interference	Vegetation
Pre-existing vegetation	Moist mixed deciduous forest of *Tectona grandis* and *Terminalia tomentosa*
Cutting	*Tectona grandis* and *Lagerstroemia parviflora*
Cutting	*Lagerstroemia-Holarrhena antidysenterica*
Cutting	*Holarrhena-Themeda triandra*
	Pseudanthistiria-tschaemum ciliaris
Cutting and grazing	*Themeda-Pseudanthistiria-Ischaemum*
Further grazing	*Pseudanthstiria-Eulalia fimbriata*
Further grazing	*Eulalia-Eragrostis unioloides*
Overgrazing	*Eragrostis-Blumea eriantha*
Burning	
Maximum regression	*Blumea-Eragrostis unioloides*
	Pogostemon parviflorus
Closure to grazing	*Eragrostis-Blumea eriantha*
Closure to grazing	*Eulalia-Eragrostis unioloides*
Closure to grazing	*Pseudanthistiria-Eulalia fimbriata*
Closure to grazing	*Themeda-Pseudanthitiria*
Closure to grazing	*Holarrhena-Themeda-Pseudanthistiria*
Closure to grazing and cutting	*Lagerstroemia-Holarrhena antidysenterica*
Closure to grazing and cutting	*Tectona grandis-Lagerstroemia*
Closure to grazing and cutting	Mixed deciduous forest of *Tectona grandis* and *Terminalia tomentosa*

early July when the ground is broken up and turned. The usual method is for four or five workers to drive their mattocks in unison down into the sod, section by section, and then to heave and pull a section of sod over. Each sod pellet is about 3 feet long, 1 foot wide, and 8 inches deep. Approximately 82 manual work days are required to turn over 1 hectare. The field is exposed to bake in the hot sun so that the rhizomes of the *Imperata* lose their resilience. The size of the overturned sod pellets allow regrowing of new shoots only from the edge of the pellets. After four to six weeks the pellets are further broken up into large chunks and left again to dry. After another month, a third working completely breaks up the chunks. Then the dry rhizomes and shoots are collected and burned or arranged perpendicular to the slope to prevent erosion. Planting or sowing of the desired species can then be carried out with satisfactory results.

Mechanical Method. Plowing may not always reach the bottom part of the root system, in which case, the grass would not be eliminated. Plowing with heavy machines may be more effective.

Plowing should be in the dry season when high temperatures have a better chance of killing the rhizomes by reducing the moisture content to below 70 percent (Holms and others 1977). Heavy tractors are used to uproot the grass rhizome and to till the land. Tillage should plow at least 30 centimeters deep and chop the rhizomes into small pieces. Once the grass has been removed by machine, the area should be planted with appropriate species. The area between the planting lines can be cultivated with agricultural crops. Tree species should be selected that can compete with the grasses that are bound to grow back.

Besides *Leucaena* and *Gliricidia, Acacia mangium* is another species found to overtop the grasses and kill them. *Acacia mangium* is a fast-growing leguminous species, which in South and Southeast Asia can be managed at a rotation of 7–8 years for producing raw material for making paper pulp. In 1992 the area under *A. mangium* plantation in Malaysia was about 100,000 hectares. In Indonesia, about 50 million seedlings of *A. mangium* are being planted annually. At the end of the first rotation, the soil is likely to be ready to be planted with indigenous species of wet evergreen or deciduous trees. It is necessary to ensure that after cutting Acacia trees, the area not be allowed to remain fallow or it will be re-invaded by *Imperata*.

Conclusions

Grasslands, particularly those of *Imperata cylindrica*, are spread over large areas of Southeast Asia, most of which have been caused by humanmade repeated fire. Grasslands that are extensively used by the local people for long fallow-shifting cultivation, thatch, grazing and hunting should not be reforested. Grasslands, except when they are burned, retain soil very well, hence their continuation does not lead to erosion. However, grasslands other than those now extensively used, should be rehabilitated by reforestation. In Asia, where land is so scarce, the vast areas of grassland, particularly of grass weed *Imperata* should not be left below its potential productivity.

Rehabilitation of the grassland may be done by stopping the practice of burning and allowing natural succession to lead the forest back to seral and finally to climax forest types. Such successional processes would take not less than 30 years, to be covered first by the pioneers. A return to the seral and the climax stage would take a much larger time.

An alternative method is to grow suitable tree species in close hedgerow fashion to shed out the grasses. This method, however, is not always successful, requires intensive care, and is expensive.

Another method to rehabilitate is by uprooting the grass by machinery or manually, baking the sods in the sun, and then planting the area with leguminous fast-growing trees such as *Gliricidia, Leucaena* and *Acacia mangium*. These species will kill the grass by overtopping. The tree roots would recover soil minerals from depth and build up on the forest floor an organic pool with appropriate microbial composition. At the end of a 15-year rotation felling, species of seral and climax stages can be planted to rebuild indigenous forests.

4 LOW-PROFILE HACKED FORESTS

The low-profile hacked forests of Asia are characterized by live tree stumps, tree species in shrub form (hereafter referred to as the tree-shrub layer), poles, a few odd trees, and thickets of shrubs and climbers. These forests are often dense, have low height and bad forms of poles, and are affected by pathogens. The soil is hard, is often sheet- or gully-eroded, is usually of low fertility with limited organic matter, and is frequently subjected to overgrazing and burning.

Some of these forests were climax or seral-stage high forests that were managed for commercial purposes. Following the commercial operations, the local people gained *de facto* control of the forests. The present forest composition and physiognomy are the outcome of repeated hacking for fuelwood, fodder, poles and small timber. Some of these products are for local use, others are sold for subsistence. Because of repeated use, the forest does not recover. Yet, the live roots and stumps retain their coppicing ability so that innumerable shoots grow annually to reach the appearance described earlier. But the roots may be diseased and the fungus moving up the stem spoils quality and reduces the rate of growth.

An interesting characteristic of these forests is that they can grow back into secondary forests of high value if overexploitation is stopped. Pathogens continue to take their toll on the old stumps, but new trees take their place through regeneration by seeds, root-suckers, or coppicing of the healthy stumps.

Such forests are found in various parts of the tropical wet evergreen, moist, dry, and tropical montane hardwood forests. They are very common in Bangladesh, India, Nepal, and Sri Lanka—in fact, in all parts of South and Southeast Asia wherever large populations coexist with forests. There is no precise estimate of the areas under this category, but in India alone there are an estimated 32 million hectares of forests with only 10–40 percent crown cover (Chaturvedi 1991). This is about 50 percent of all the identified forest land in India. In Nepal, 12 percent of all land is degraded forest.

Description

In eastern India, hacked low-profile forests of moist deciduous type are common. They are composed of one- or two-year old coppice growth in shrub form of *Shorea robusta, Terminalia tomentosa, Buchanania latifolia, Anogeissus latifolia* and many others. The shrubs include *Hollarhena antidysenterica, Adathoda vasica, Vitex negundo* and so forth, and grasses and forbs. The height of the tree shrub layer varies between 2 and 3 meters, with an occasional pole of 5–7 meters. The forests are deciduous during part of winter and spring and leaf profusely in summer, when it rains. The number of stumps varies but an average of 100–150 per hectare is common.

Besides sharing in the harvest, the local people collect fuelwood (above), dry leaves (below), and green leaves (opposite) (West Bengal, India). *(photos Banerjee)*

Their leafy shoot growth provides a dense thicket appearance for at least six months of the year. The biomass growth of such forests is up to about 6–8 cubic meters per hectare per year.

The area of such forests may vary from a few hectares to thousands of hectares. Frequently, surrounding a forest will be villages with high populations of low-income people that subsist partially on products from it.

In Nepal, low-profile hacked forests are numerous in the middle hills of the Central Himalaya, in the siwaliks, and in the terai plains. In fact, all the forests in the middle hills are of this category. People harvest the green leaves for bedding for their cattle, for fodder, and for composting to fertilize cultivated fields. They collect the twigs and branches for fuel.

The main forest species in Nepal are *Castanopsis sp.* and *Quercus sp. Schima wallichi*. Typically, there also are a shrub layer, grasses and herbs. The density is variable but often better than that found in eastern India. The area of these forests are generally less than 100 hectares and are used by a specific group of people living in a few nearby hamlets or a close village.

Practices causing low-profile hacked forests

The composition and physiognomy of these forests has been brought about by biotic interference such as unplanned fuelwood collection, overgrazing, overlopping, and burning. The enormity of the problem can be realized from the examples that are discussed below.

Fuelwood collecting

It is said that by the end of the century much of the world will have enough food to eat—but no fuel to cook it with. ESCAP (1991) records fuelwood and charcoal production in most of the ESCAP countries at 767.6 million cubic meters, at an annual rate of increase of 2 percent. Projections for the end of the twentieth century indicate that the problem of fuelwood shortages is likely to reach alarming proportions in many states of India (Muranjan 1987), where 80 percent of the rural population relies on fuelwood for cooking (Hegde 1991). It is estimated that by the turn of this century, the annual demand for fuelwood in India alone will be 313 million tons, which is equivalent to the harvest from 20–25 million hectares of forest. Given the current rates of demand, supply and afforestation, India would not be able to meet even 50 percent of this future need.

Some studies in India have indicated that the demand on forests for fuelwood decreases with the distance from the forest. For example, people living near the forests get all of their fuelwood from the forest. People living within 10 kilometers of the forest get 70 percent of their firewood there; beyond 10 kilometers, the demand for firewood from the forest decreases quickly. At distances of 15 kilometers firewood from the forest is no longer used (Myers 1989).

This paper contends that, on the contrary, a part of this seeming decrease in use can be attributed to a transition from subsistence collecting to more organized groups or individuals making the trip (including by bus and train) over distances much more than 15 kilometers. These groups extract the wood and market it in local townships, until the transportation costs or time become so large that they cannot recover them in sales.

Nepal's per capita annual energy consumption may be the lowest in the world. Nevertheless, fuelwood is the principal energy source, accounting for more than 78 percent of domestic energy consumption. Fuelwood is not growing as fast as the country's population, however, and is becoming scarce and more difficult to obtain. Per capita use of fuelwood is probably decreasing, but overall consumption is increasing (Wallace 1988).

In Sri Lanka, an estimated 90 percent or more of Sri Lankan households depend on fuelwood for cooking.

In many countries firewood is extracted from savanna woodlands, scrub brush patches and local woodlots. One person can obtain an adequate supply of firewood for the whole year from one-half of a hectare of average forest, woodland or scrub, without causing damage to the forest. However, as populations increase and people try to find fuelwood as close by as possible, often many more people will harvest from the same area and the forest will be degraded (Myers 1989).

As there currently are no substitutes for fuelwood and since populations continue to increase, removing fuelwood from the forests is likely to continue and likely to result in creation of more of hacked forests.

Overgrazing and lopping for fodder

Provision of fodder is another critical issue. In India, livestock numbered at 402.6 million head in 1982 and is expected to exceed 500 million by the end of the century. Fodder supply in the year 2000 would have to be 2,065 million tons, but only 925 million tons are anticipated. This means a shortage of 1,152 million tons (Hegde 1991).

In the villages of Patwadh, Senduria and Chakari in Uttar Pradesh (India), villagers obtain 80-87 percent of their fodder requirements from the surrounding forest and savanna ecosystems. Crop residues supply the remaining 11-20 percent (Singh and Singh 1991).

In Nepal, the demand for fodder is probably the greatest pressure on the forest. Almost every household in Nepal raises animals, and control of the cattle population is limited for spiritual reasons. In 1981, there were 8.9 million cattle and buffalo and 3.6 million goats. The number of goats is now increasing faster than the human population. Overgrazing by livestock, along with trampling, contributes greatly to forest degradation and erosion. People also overharvest fodder, preventing the trees from flowering, producing seed, and regenerating (Wallace 1988).

Overlopping, particularly during the dormant season, kills the trees after a while. Overgrazing compacts the soil and inhibits water penetration and aeration, and more importantly prevents the seeds from germinating. The seedlings that do manage to grow despite this are then destroyed by grazing. In the course of time only coarse grasses of nongrazeable and nonbrowsable species take over.

Burning

Burning of these forests is often resorted to by the local people to promote grasses and sometimes to flush out animals for hunting. In the summer, thousands of hectares of the forests of eastern India are purposely burned for hunting. These fires are not scorching but repeated fire destroys fire-tender species. The fires kill many live stumps as well. Although fire-hardy tree and shrub species are not killed, they are adversely affected. As a result of the passing fire, the spring leaves of the fire-hardy trees dry up and are shed. The trees then have to expend additional energy in the rains to bring out a new leaf flush. This process retards the forest growth.

In the *teral* of Nepal and in Bangladesh, as in many other countries of Asia, burning of hacked forests is carried out in the spring to promote grass production. With repeated burning, coarse grasses with low nutritional value succeed more nutritive palatable grasses. These coarse grasses, when mature, are not palatable. This means that burning becomes an essential annual operation to kill coarse grasses and promote a fresh flush of young shoots—to the detriment of the forest.

Rehabilitation

There are two basic causes that lead to repeated hacking of forests—namely, the rising demand of fuelwood and fodder and the necessity for the local poor people to make even a meager living by collecting fuelwood and other forest products. Rehabilitation methods therefore would have to eliminate these factors, if it is to be successful.

At present, most of these forests are owned and managed by the forestry departments (FDs) of the state. The major element of the management is total protection of the forests by policing. Because of the miles of forest boundary (including habitations) abutting the nonforest areas, no amount of policing can keep the people out—especially when the forest provides the only fuel and fodder and subsistence for the people. These conflicting needs of the FDs and the users cause continual confrontation between the two parties, with forests degrading to a hacked forest in a short time.

To answer these conflicting needs and to rehabilitate these forests, this paper proposes the following three steps (see discussion in the following sections). First, participatory forestry should be introduced, where users are allowed to take over the tenure, planning, management and exploitation of these forests. Second, the role of the FDs should be changed from that of forest custodian to that of facilitator (to assist the users with technical know-how for preparing and carrying out management plans) and later to that of monitor (to assess the performance of the users). The management plan should try to maximize sustained production from the forests. It should also be kept in mind that the users would not only manage the forest for subsistence but, when possible, for commercial gain as well. Third, substitutes should be found for fuel, fodder, and small timber if the forests have to be closed for a few years to recuperate. If the users are dependent on the forest for their livelihood and the forest has to be closed, alternative sources of income or compensation for the lost income also should be arranged.

Management by participatory forestry

Improvement of the hacked forests by technology alone is not possible. Unless the incremental products are shared, poor people living near the forests who have used the forests for subsistence would continue to use them in an unplanned manner, no matter what technology is adopted. The only way to make developmental activities in these forests successful is to involve the people in their planning and execution and in sharing the benefits that the activity would generate. Further, the generated benefits offered the people should exceed what the users are already getting from the forests. This generally would mean changes in policy on tenure and on sharing the products from government forest land.

In India, the central government has advised the states to share a part of the products of degraded forests with the fringe people, who agree to protect and manage the forests jointly with the Forest Department. In Nepal, the government ordered that forest

Degraded Sal (*shorea robusta*) and tendu (*Diospyros melanoxylon*) forests of Jamboni Range in West Bengal, India. *(photo McGean and Poffenberger)*

With participatory forestry, degraded forests grow back over 10–12 years through the stages shown in the photo above to the final stage shown at right. *(photos McGean and Poffenberger)*

protect and regenerate forest lands. Assured by the government of exclusive rights to forest access, use of nonwood forest products, and a share of the timber revenue (all of some of the intermediate products and 25 percent of the final products), fringe villages have effectively protected hundreds of hectares of degraded

users be allowed to manage the forests they are using and reap its full benefits. These orders, while a definite improvement on earlier government positions of keeping the people away, do not carry sufficiently lucrative benefits to persuade large numbers of people to opt for them. Degraded forests have low productivity and produce very few products in the first few years of protection. Unless the forests offered for management are sufficiently productive in cash or forest products, people are not likely to want to participate in protection and management.

Case studies from West Bengal and Gujarat, India, bear this out. In the southwestern part of West Bengal, the forests have been degraded, but because of high rainfall and the presence of sufficient root stock in the ground, the potential growth of these forests is high. The per capita production for such forests is also high. Considerable success has been achieved through cooperative action between forest departments and forest communities to

forests and witnessed the dramatic increase in productivity of the degraded forests. Since the first pilot project in Arabari started in 1970, more than 2,500 villages have formed Forest Protection Committees, covering more than 200,000 hectares of degraded forests that are now regenerating. Because the protection was assured by the villagers on a voluntary basis, the cost of regenerating the forest land is very low—about Rs. 250 per hectare, or only 5 percent of the cost of establishing a plantation crop. The village communities earn from the sale of Sal leaves (*Shorea robusta*), which are used for making food plates; mushrooms (from the forest floor); and other nonwood forest products. Table 4.1 shows the estimated income from products in regenerating forests.

The tabulated figures of the two villages at Sitarampur and Arabari show the earnings per family from the sale of nonwood forest products. Besides these, the families would be entitled to a share of the final timber harvest. Timber is harvested in the 10th year after forest protection has been taken over by the villagers and is expected to produce a handsome revenue.

The position in Gujarat is different. The government planted some degraded areas

Table 4.1 Estimated family income from West Bengal forests with community protection

Activity	Rate of earnings (Rs.)	Earnings per city (Rs.) Sitarmpur	Arabari
Fuelwood collection	15/headload	360	180
MSC employment	21.7/day	168	34
Mushrooms (chatu)	20/kg.	800	60
Sal plates (thal)	15/1000	402	282
Medicinals, fruits and seeds	500/tree	750	49
Kendu leaves for bidis	4/1000	360	117
Total average annual FPC household income		2940 (245/month)	722 (60/month)

Source: Malholtra and Poffenberger 1989.

(about 5 hectares each) near the villages and offered the plantations to the peoples' elected organization, called *panchyats*, to manage and enjoy all its benefits. In most cases the *panchayats* refused to do so on the grounds that they would not be able to protect them from the people. This outcome is in sharp contrast to that in West Bengal where the people took over the protection enthusiastically. One of the reasons is that in Gujarat the planted area in each site is small and the benefit per capita therefore is too little to be a sufficient incentive for the people to get involved in protection and management.

It would thus appear that participatory forestry with appropriate incentives might be one of the more promising methods of rehabilitating degraded forests.

Extension of technical know-how by forest departments

With the protection of the forest taken care of by the community, the role of the forest department would be to provide technical know-how about management methods to the community. The focus of management should be on introducing technical applications that would increase sustainable production.

Technical applications would consist of soil and moisture conservation and scientific forest management, together with forest protection through participatory forestry (as discussed earlier).

Soil and moisture conservation. Rainfall in many of the hacked forests is high but is limited to only a part of the year, and the balance of the year is dry. Because the hacked forests have low vegetation cover, the rainwater pools and runs off quickly instead of percolating in the soil, leaving the area dry and arid. Consequently, hacked forests suffer from moisture stress annually, with a resulting loss of production. Soil and moisture conservation would help the land retain part of the rainfall for a longer period and thus would improve land productivity.

The soil and moisture conservation method in the coppice management system and the plantation would be to dig contour V-ditches or contour trenches at specific intervals to trap runoff and soil wash. The size of the trench and the interval would depend on the slope and the rainfall intensity. V-ditching is a mechanized operation carried out by crawler tractors that have rippers and an angle dozer blade. The ripper first makes a rip line on the contour to a depth of 50 centimeters. The angle blade is then used to make a ditch in the rip line and simultaneously forms a ridge on the downhill side of the ditch (Banerjee 1990). If the area has sparse undergrowth, contour close planting of *Vetiveria* grass slips between the trenches would be very useful. Over time, the trenches would be filled up with soil wash, but the *Vetiveria* barriers at intervals would continue to grow to reduce the runoff quantity and velocity, thus conserving soil and moisture and increasing forest growth.

Forest management

With soil and moisture conservation and forest protection in place, the forest productivity should be improved. This is possible through coppice management, artificial plantation, or agroforestry.

Management through coppicing (FAO 1989) relies on natural regeneration of shoots emerging from cut stumps. The emerging shoots are allowed to grow uninterrupted for several years. In some cases, the shoots become too congested and should be thinned.

The coppicing system is widely applied, particularly to dry deciduous forests to produce firewood and small timber to be used for poles, local construction and for pulping. Species selected must have good coppicing ability. The systems are highly flexible and require little investment (FAO 1989). The system, besides producing fuel and poles at the rotation time can also be modified to produce nonwood forest products and intermediate yields of various products for the local people.

Classical coppice systems are divided into three general categories:

- Simple coppice. In India, this system is being applied in the dry deciduous forests of Tamil Nadu for the production of firewood. The yield is regulated by area. Rotation may be 10-40 years for fuel. After felling, the area must be protected from fire and grazing. Unfortunately, over time, coppicing vigor declines and stump mortality increases.
- Coppice with standards (CWS). A fixed number of trees are retained and extracted on a rotation that is normally a multiple of the coppice rotation. Thus there are two tiers: the upper layer consisting of standards that will be used for timber, and the lower coppiced layer for the production of firewood and small timber. The standards also serve as a source of seeds for restocking the coppicing component. Any fruit trees are also retained (FAO 1989). Rotation varies from 30 to 60 years. Standards are usually retained for two coppice cycles. An example is the former *zamindari* forests (forests that belonged to large landholders) in India that have been designated as protected forests, with certain rights retained by the local people.
- Coppice with reserve (CWR). This system has evolved in the former central provinces of India—portions of Maharashtra and Madhya Pradesh. One of the main objectives of the system is prevention of degradation through a combination of treatments. Rotation is from 30 to 60 years. After demarcating the annual cut, a treatment map is made identifying protection areas where no felling is to be carried out, areas requiring enrichment, areas fit for felling (with specification of girth limits), and areas fit for establishing plantations. Each category of area is then managed according to plan.

Plantations

Planting artificial plantations to replace hacked forests can be an alternative to coppice management. However, plantations require investment and may not be justified in countries with capital shortages. Further, the plantations may have a larger gestation period and local people cannot afford to wait before using them. Plantation is justified where economic revival of the hacked forest crop is not possible.

Establishing plantations in hacked forest areas is a tricky job because of the live-root system and large number of live and dead stumps. Unless the area is cleared, newly planted seedlings are overtopped by coppice shoots of the old live stumps and by weeds. On the other hand, if the site is cleared of all stumps and shrubs, the area becomes vulnerable to erosion. Such cleared areas have to be treated with soil and water conservation measures earlier described. Planting should be done in the V-ditches.

Some species cannot grow under weed competition. *Eucalyptus tereticornis*, a commonly planted species in India, is a case in point. With weeds, it becomes lanky and gets totally suppressed. Other species survive and overtop the weeds. *Acacia auraeculiformis* and *Cassia siamea* are two such species. Pine (*Pinus roxburghii*) does very well in degraded sites in Nepal.

Species selection plays an important part in planting success. Besides site suitability, however, the needs of the people would have to be taken into consideration in species selection. Most of the time, these plantations would have to produce fuelwood, fodder and small timber for the local people.

In the moist climatic zones of India, plantations with V-ditches at intervals (depending on the slope), appropriate weed control, protection from biotic interference, site-specific species choice, and vigorous seedlings produced from good seeds, can produce an average mean annual increment MAI of 12 cubic meters. A recent survey indicated that only an average of about 7 cubic meters has been reached in social forestry projects of India due to inappropriate technology (Seebauer 1992).

Where regeneration of natural forest is not possible and the usual plantation model is not satisfactory because of excessive weeds between tree lines, agroforestry may be an appropriate rehabilitation strategy. Agro-silviculture (trees/crops) is common in the tropical humid areas of the *terai* of Nepal, but is not practiced at all, or only negligibly, in the arid and semi-arid hills.

Agroforestry

Agroforestry in areas where water availability is low presents challenges due to competition between the agriculture and tree crops. Thus, agro-silvipastoral systems may be appropriate only in the moister areas in the hills. In this operation, there may be a large number of crop and tree choices. For example, maize, paddy, millet, vegetables, and so forth can be grown in the space between the tree lines of *Eucalyptus, Dalbergias, Acacias, Leucaena, Gliricidia,* and *Shorea*. These agricultural crops keep the weeds down as well as promote agricultural production.

An example of a silvipastoral system in Nepal is the *khar-bari* or "hilltop private farm fodder bank" (Tuladhar 1991). This system is practiced by ethnic groups at 2,000–3,000 meters above sea level. Terraces or sloping grazing lands claimed from the forest are managed to protect and promote the fodder grass as well as the fodder trees such as *Ficus semicordata, Garuga pinnata* and so forth.

Substitutes for forest products and curbing demand for fuelwood

An interesting suggestion for upgrading the degraded forests of the Himalayan areas has been proposed by Singh and Singh (1991). They show that agriculture in the Himalayas is sustained by the forests, in that each energy unit of agronomic yield requires about 12 energy units of forest/grazing land energy, which is not now available, nor likely to be in the future. Given that inorganic fertilizer (to replace organic fertilizer) is hard to ship in and is expensive, agriculture is not an economic land use in the Himalayas. The authors therefore propose that farm forestry replace agriculture in the hills. According to them, food for the hills should come from the plains below.

Another possible way to protect forests

from overuse is to promote agricultural productivity of the areas adjacent so that landowners do not have to partially subsist on the forest income.

In addition to increasing the supply of fuelwood, something must be done to curb the demand. Under favorable circumstances, improved stoves might reduce household fuelwood consumption by as much as half. Based on a survey in Nepal, average savings could amount to 30 percent of average household use. Each improved stove might save 1.5 cubic meters per year of fuelwood—or the amount of fuelwood that can be produced on one-fourth of a hectare of well-managed *panchayat* forest in Nepal (Wallace 1988).

Programs to improve the efficiency of stoves have offered hope for immediate reductions in fuelwood consumption, but villagers have been slow to put them into practice, and so far they have had little impact on overall fuelwood use (Wallace 1988). In Nepal, for example, fewer than 30,000 stoves have been distributed and it is estimated that only 30 percent of those in urban areas and only 10 percent in rural areas are being used.

Use of alternative energy sources can also reduce fuelwood consumption. Gas, electricity and kerosene are some of the feasible energy sources suggested.

Conclusions

Low-profile hacked forests of Asia are a reflection of excessive demand of forest products outstripping supply. The governments who own and manage the forests sell the forest products to whomever pays the highest price. The buyer eventually sells the products in the urban or industrial market and the local needs remain unfulfilled. Being left out of the supply chain, local people exploit the forests to furnish their own needs—setting the process of degradation in motion. Exploitation is also caused by the local unemployed people subsisting on forest property: they surreptitiously cut a few trees a few times a week and sell them in the local market to earn their livelihood and simultaneously fulfill the local requirement.

Strategies for rehabilitating the hacked forests would have to resolve these problems. Increasing the local supply means that outside sale should be forbidden until local needs have been satisfied. Governments therefore would have to change their policy on the disposal of forest products.

Technical measures such as soil and moisture conservation will also have to be taken to improve the productivity of the forests. Possible management technologies are the coppice system, planting and agroforestry. If supply meets or is less than demand, substitutes of forestry products (for example, kerosene for fuelwood) would have to be introduced to reduce the demand. The use of fuel-efficient stoves should be encouraged to replace the existing fuel-guzzling village *chulas*.

The issue of poor people subsisting on the forests has to be looked into. Investments in the forest have to be planned for employing the poor in productive jobs so that they are not forced to fall back on surreptitious exploitation of the forest. Participatory forestry should be accepted by governments as a tool for encouraging people to protect, manage and upgrade forests. In order for productive forests to provide reasonable income to the participants, management must be transferred to the people.

5 OVERLOGGED FORESTS

Overview

Overlogged forests are natural primary or older secondary natural forests that have been badly damaged by overcutting and poor logging methods and have resulted in impoverished and ecologically unstable stands. If left untreated, these forests are unable to restore their original state within a reasonable period of time, or even to recover enough to provide the normal services of a forest. Moreover, landless poor people often use these areas for marginal agriculture, degrading the forest further.

Management systems and methods of logging

Although implementation is weak, the forests of South and Southeast Asia have theoretically been harvested according to the following silvicultural systems:

- Selective felling. This term refers to harvesting commercially acceptable species that have at least the minimum harvestable diameter, that may vary from species to species. This system often encourages the "high grading," "skimming," or "creaming" that results in degraded quality and value of the stand.
- Malaysian Uniform System (MUS). In this system primary lowland rain forest (rich, multi-aged and complex) is converted to a more or less even-aged stand containing a greater proportion of commercial species. MUS is a monocyclic system with a rotation period of 70 years. It includes treatment of a part of the forest once every 70 years, clearfelling of the commercial overhead species, plus systematic poisoning of unwanted species—leading to release of valuable species of varying ages. The system is less successful in hill Dipterocarp forests.
- Modified MUS. The MUS system has been modified particularly in Sabah and Peninsular Malaysia to emphasize post-harvest sampling to determine the appropriate silvicultural treatment. The treatment may include further operations to liberate the wanted regenerating seedlings and the advanced growth.
- Selective Management System (SMS). This system has been developed in Peninsular Malaysia. Based on a pre-harvesting inventory, a decision is made whether selected stands should be clearfelled, selection felled, or treated under the uniform system of management. Climbers are also cut before harvesting to obtain directional felling to minimize logging damage to residual stands.
- Liberation thinnings in selectively logged forests. This system was developed in Sarawak and is applied where a young crop of potentially good trees are overtopped by older, less-desirable ones—usually in forests that have been selectively logged. Removal of competitive trees by poisoning or girdling opens up space around the selected final crop, which are thus allowed to grow.
- Basilian working cycle. This is a selective felling system used in the Philippines where

there are intensive extraction rates. In theory, all mature and overmature trees are selectively felled, and the forest is left for 35-45 years to recover. But this rule is rarely followed in practice (Hurst 1990). There is serious doubt whether this system can sustain production at roughly the level of initial utilization. Lamprecht (1989) reports that harvesting is about 100–120 cubic meters, with a rotation period of 30-40 years, in Mindanao. In fact, the practice seems to degenerate the stands, leaving rotten and poorly formed residual trees, and to cause considerable damage during the felling.

- Indonesian selective felling. This system was designed in 1983 by the Directorate General of Forestry and is based on natural regeneration, for a mixed Dipterocarp forest with a normal diameter distribution (Soerianegara and Kartawinata 1985). Lamprecht (1989) refers to this system as the Indonesian Selective Logging System (ISLS), in which all stock with diameter breast height DBH over 50 centimeters is harvestable. The cutting cycle of 35 years is too short, however, and this system has some of the pitfalls of the Philippine system. Lamprecht (1989) cites Kartawinata and Sukarjo as observing that in 1981, 40 percent of the residual stock in East Kalimantan, or roughly 250 trees per hectare, was seriously damaged during exploitation. The primary advantage of the system is its simplicity.
- Clearfelling with natural regeneration. This system is followed in Indonesia if the forest is dominated by one or two Dipterocarp species and has a specified distribution of trees with diameters greater than the stated limit (Soerianegara and Kartawinata 1985).
- Clearfelling and replanting system (Indonesia). This system was designed to convert a poorly stocked forest or a poor secondary forest into a more productive forest by, for example, establishing industrial forest plantations.

Despite the fact that many of these systems are technically acceptable and many countries have developed management specifications and logging prescriptions, implementation is poor. Cutting more than the prescriptions, damaging residual stands in felling and yarding, failing to monitor regeneration and post-harvest damage by illegal logging, relogging before the next cycle is due, and allowing occupation by poor cultivators cause irretrievable damage to many of these forests supposed to be under proper management.

Poore (1989) estimates that less than 1 percent of tropical rain forest are currently being managed in a sustainable manner. Indeed, there is ample evidence that logging has been damaging and wasteful. For example, 5.6 million cubic meters of timber was wasted in Indonesia during the 1970s from rotting in the depots. Recently, Hurst (1990) found that 23 million hectares of Indonesia's forests have been severely damaged through timber extrac-

Overlogged forest in concession area in East Kalimantan, Indonesia. *(photo McGean and Poffenberger)* tion. Fifty percent of a forest is totally destroyed in selective timber extraction, and 50 percent of the logs felled never reach the sawmill. At one site, 70 percent of the forest canopy was still open—15 years after the extraction.

Indonesia is not alone in allowing harmful logging to be practiced. Similar practices can be found in India, Malaysia, Myanmar, the Philippines, Thailand and elsewhere.

Extent of overlogged forests

Determining the extent of overlogged forests is difficult mainly because it is hard to identify what is being measured. Areas that have been subjected to selective extraction are particularly hard to pick up on the satellite imagery in general use (Brookfield and Byron 1990). However, looking at proxy data such as timber production and exports may show trends over time.

The extent of overlogging is difficult to assess also because of the changes that occur rapidly after logging. FAO has statistics on overlogged forests, but these forests may be logged again, further degrading the stands and the site (Lanly 1985; Joseph 1985). Practically all logged areas in Thailand and Lao P.D.R. are reportedly converted to agricultural purposes immediately, so no significant area of overlogged forests would show at any given time (Lanly 1985).

Table 5.1 provides a summary of estimates of overlogged forests in selected countries, with particular reference to the tropical broadleaved forests of South and Southeast Asia.

According to one source, approximately 1.4 million hectares of forests are being logged annually, of which more than 0.9 million hectares are in Indonesia and Malaysia (Lanly 1985). The World Bank estimate of the total area logged is slightly higher, at 2.1 million hectares (World Bank 1993). This does not include areas of forest that have been disturbed or are managed. Relogging takes place in some forests. Average logging intensity varies from 10–30 cubic meters per hectare in the countries of continental Southeast Asia, to 45–90 cubic meters per hectare in the countries and islands of insular Southeast Asia where Dipterocarps abound (Lanly 1985). The average logging intensity for the entire area of Southeast Asia is 38 cubic meters per hectare, as compared to 12 cubic meters per hectare in tropical Africa and 17 cubic meters per hectare in the United States.

Damage and impacts of logging

Types and causes of damage

The major reason for degradation of logged forests is the use of heavy machinery and poor extraction methods that damage the soil, adjacent trees, water and wildlife. These damaging processes include:

- Non-directional felling, which damages many adjacent trees and understory vegetation. Burgess (1971) reported that 55 percent of the basal area trees over 0.1 meter in diameter in lowland mixed-Dipterocarp rain forests were damaged following the felling of 10 percent of the basal area of timber. Conditions have not improved significantly since then. A 1986 study in Sarawak showed that damages to residual stands ranged from 48 to 72 percent of all trees larger than 30 centimeters in diameter for Dipterocarps and 25 centimeters for non-Dipterocarps.
- Skid trails, which damage vegetation and cause the compaction of soil that leads to erosion. In one Indonesian logging site, erosion has been reported at 12.9 tons of soil per hectare per month.
- Poorly designed roads that cause erosion and methods of construction that can be quite destructive. In East Kalimantan, entire hillsides are blown up and quarried to provide crushed rock for roads.
- Log yards and landings that become areas of soil compaction and erosion.
- High-lead cable yarding that, although it disturbs the soil less than heavy machinery, damages all of the vegetation in the cable path. Cables allow loggers to work on extremely

Overlogged, almost bare watershed at Dipinga, East Luzon, Philippines. *(photo McGean and Poffenberger)*

steep, fragile slopes where bulldozers cannot operate. FAO found in 1981 that, on average, 31 percent of the land surface was stripped of vegetation in the Philippine logging operations that commonly use this technique (Hurst 1990). In East Kalimantan, bare areas caused by the use of cables extended over 30 percent of the logged area (Kartawinata 1981).

Impacts

These damages will in turn have cascading effects on the forest. These impacts are discussed in the following section.

Change in composition. Many forest management plans do not keep biodiversity in mind and prescribe silvicultural treatments that will result in a change in species composition. Selective felling of the most valuable species (for example, of the genera *Shorea, Dipterocarpus* and *Dryobalanops*) can degrade the forest of economic species permanently and forfeit this valuable resource, particularly if parent trees are removed when they are not fruiting or releasing mature seeds (Saulei 1984). This practice leaves undesirable, genetically inferior individuals in the residual stand. It has also been observed that the seedling population in overlogged forest is far less than in primary forest, due to felling, skidding and yarding (Kartawinata 1981). If logged areas are subjected to continued disturbance such as agriculture or are located on slopes or in soil-compacted sites, they become dominated by *Imperata* or *Saccharum* grass (Saulei 1984).

Change in soil physical properties. Compaction by heavy machinery and dragged logs affects the thin organic layer on the surface and destroys the physical structure of the soil, impeding water infiltration, nutrient transfer and so forth; lowering water-holding capacity; and preventing plant growth. Rahim has estimated that as much as 60 percent of the soil surface may become disturbed through such logging operations as the construction of access roads, log landings and tractor paths (Bruijnzeel 1991).

Change in hydrology. Because of soil damage, sometimes the roads, skid trails and so forth have very low infiltration capacity even a decade later (Bruijnzeel 1991). These compacted surfaces generate substantial volumes of overland flow and sediment during rainstorms, causing increased peak flows and stream sediment loads that can lead to flooding.

In addition, removal of the overstory reduces interception and catchment by the canopy. Uptake of water by trees and transpiration also decrease. Overlogging in Sichuan, China, is said to have been the cause of the disastrous 1981 summer floods that killed 1,358 people and left more than 1 million homeless (Delfs 1982).

Change in soil chemistry and site fertility. In general, decreased fertility is considered to be less of a problem than compaction and erosion. Yet, a study by Saulei (1984) in Papua New Guinea showed that removal of forest cover can reduce phosphorous levels by 53 percent and can increase acidity in water-logged areas.

Increased risk and intensification of forest fires. There is increasing evidence that careless logging techniques were responsible for intensifying the great fire that swept East Kalimantan, Indonesia, during 1982 and 1983, destroying 20 million cubic meters of timber from primary forests and 35 million cubic meters from secondary forest. The total export value of this lost timber was US$5.5 billion (Hurst 1990).

Fires are more intense in overlogged areas due to higher windspeed and localized droughts caused from the removal of trees. Fire from adjacent grasslands may not develop enough heat to ignite primary forests but can ignite the debris in the overlogged forests, which in turn develop much higher temperatures—enough to ignite the primary forests.

Rehabilitation

One aspect of rehabilitation would be to prevent adding any more overlogged areas. A number of studies on this subject can be consulted (for example, Chin 1989; Bruijnzeel 1991; Bautista 1990). Migration of local people and outsiders into the logged forest to practice other land uses is another factor that needs to be curtailed.

Depending on the logging intensity, two site and soil conditions may exist in the overlogged areas: a damaged natural stand that is likely to remain impoverished for a long time, or secondary growth. The first condition is particularly unfavorable for timber production. Domesticating and improving the stand will be extremely difficult and expensive. According to Lamprecht (1989), rehabilitating an overlogged stand is the worst task a forester can face. All valuable species have been removed, residual stock has been damaged, and probably little attention has been paid to regeneration. If timber production is an objective, enrichment planting will be needed at the least and perhaps total conversion to plantation or agroforestry. In areas where secondary growth has developed or where regeneration looks promising, management may be possible. This is particularly true where there is a market for the lesser-valued pulpwood and industrial woods or for any nontimber forest products (NTFP) that can be grown in secondary forest.

Technical rehabilitation measures, which will be discussed in the following section, are:

Table 5.1 Extent of overlogged forests in selected countries in Asia

Country	Total land area ('000 ha)	Total forest area ('000 ha)	Total broadleaf 1980 ('000 ha)	Estimated area logged/year 1981–85[a] ('000 ha)	Estimated volume extracted 1981–85[a] (m^3/ha)	Area under concession (1986)[b] (ha)
Bangladesh	13,391	927	315	33	n.a.	n.a.
Indonesia	181,157	116,895	113,575	550	37	53,374
Lao P.D.R.	23,080	13,625	7,560	25	12	n.a.
Malaysia	32,855	20,996	20,995	375	66[c]	7,460
Myanmar	65,754	31,941	31,193	174	15	n.a.
Papua New Guinea	45,286	38,175	33,710	47	30[d]	2,417
Philippines	29,817	9,510	9,320	80	90	5,675
Viet Nam	32,536	10,110	7,400	46	30	n.a.

n.a. Data not available. a. Lanly 1985. b. Johnson and Cabarle 1993. c. Weighted labor values by annually logged area in the various states or islands. d. Selective logging only.
Source: WRI 1991 (except where noted).

- Natural regeneration (requires protection) and management of resultant secondary forests for industrial wood or NTFP;
- Natural regeneration with enrichment planting; and
- Clearfelling and artificial regeneration with or without *taungya*.

Natural regeneration

There is evidence that if degraded forests are left alone for a long enough period of time, they will eventually regenerate (by progressing through seral stages to a climax stage) and will recover their full protective functions.

If the extent of logging damage is not too great, secondary forest may begin to develop. For example, logged land in the Gogol Valley of Papua New Guinea first became semi-derelict, but within a short period sprouting coppice regrowth and seedings led to partial regeneration. This rapid regrowth is characterized by impenetrable thickets and vines (Seddon 1984).

In 1983 a study was begun on natural regeneration following clearcut logging operations in the Gogol Valley. The study area was a 0.2-hectare plot within a 240-hectare village reserve (that had been clearfelled) near the Sapi River. Plants became established within three weeks after logging ceased. Six months later 90 percent of the area was covered by weeds, grasses, climbers and trees, and the other 10 percent was still bare, particularly on soil-compacted and water-logged areas. The new trees were 50–200 centimeters tall; plant density was measured at 40,000 per hectare and consisted of 51 genera and 60 species, 84 percent of which were small secondary trees (Saulei 1984).

As a rule secondary forests growing from the overlogged forests are not adequately suitable for commercially sustained forestry because of the instability of production and the low market value of their wood, except for a few pioneer species such as *Leolamarkia kadamba* (earlier *Anthocephalus chinensis*), *Eucalyptus deglupta, Octomeles sumatrana, Pinus kesiya*, and *Pinus merkusii* (Whitmore 1975). Production instability is caused by the nonuniform distribution of a few high-value species that naturally regenerate with protection. However, where there is a market for pulpwood and industrial woods, natural regeneration in secondary forests could be an option (Lamprecht 1989).

The main constraint to a natural regeneration approach is that the forest may be left without a productive function for a long time. Given the socio-economic setting in Asia, mere protection may prove impractical. Instead, solutions that provide economic benefits during regeneration or that speed up the process are more favorable.

Natural regeneration with enrichment planting

Seedlings for enrichment planting will be needed to complement the natural species distribution. These may be collected from the forest floor in the logged area and raised in a nursery, where they will be protected from predation, competition and deterioration. There are two major opinions about wildling collection. One is that wildlings may be a mixture of genetically superior and inferior species. If the objective is only enrichment planting, seeds from the selected trees only should be collected, raised in the nursery, and used for planting to avoid regeneration of inferior trees. The second opinion is that use of wildlings not only enrich but also keep the gene pool of those species intact. Areas in the forest that are high in seedfall should be identified as natural germplasm banks. It is therefore important that the regenerating seedlings on the forest floor of logged areas be given appropriate attention (Jonson and Lundgren 1990).

Preliminary results from planting trials of six-year seedlings of species belonging to *Dipterocarpaceae* indicate an annual mortality rate of 10 percent in the first three years and 5 percent in the next three years (Kochummen 1985).

A very relevant system called "enrichement par layons" has been practiced in Africa for more than 50 years (Lamprecht 1989). In this system, parallel lines are cut at intervals of 10–25 meters, preferably in an east-west direction. One meter either side of the line is then completely cleared; climbers and brushwood shorter than 4 meters can be cut up to 5 meters beyond. Seedlings at least 1 meter tall, of appropriate species, are planted on the lines. Weeding around the planted seedlings is done about three times the first year and as necessary in subsequent years. A somewhat modified version of this method, called "tunnel planting," has been adopted in parts of the Arunachal Pradesh and Andamans moist evergreen forests of India.

After overlogging, if the residual vegetation is protected it naturally regenerates into secondary forest (East Kalimantan, Indonesia). *(photo McGean and Poffenberger)*

Clearfelling with artificial plantation

Overlogged forests contain a large number of medium and small trees that have been either damaged or felled but not removed during harvesting operations. The forest floor is usually full of debris because only usable logs are removed. Much of the soil (often 60 percent) is compacted due to the use of heavy machinery. All of these factors usually make the planting of artificial plantations very expensive.

In artificial plantations, the three preplanting operations of clearfelling and clearing, burning, and soil working should be followed by the planting of appropriate species and by the post-planting operations of protection and management. Clearfelling can be done by bulldozers, knockdown booms or sawing. Use of the first two methods clear the area of stumps making further operations easier but also making the soil over the whole area susceptible to water and wind erosion. Sawing therefore is a more acceptable method of clearfelling the stand. After the useful logs are removed, the area is burned, usually by windrowing the slash across the slopes (Banerjee 1990). Ash from burning releases nutrients into the soil and creates a good seed bed for the seedlings.

The nature of soil working will depend on the degree of the soil compaction. Particularly in areas where roads have been made or where heavy machinery has been used to harvest logs, the soil often needs to be shattered by heavy tractors provided with rippers. Plants are planted in small pits made at set intervals.

Matching species to the site is essential and there are two options available—indigenous species or exotics. The general experience is that indigenous species are more difficult to raise, are slow growing, and are more easily affected by pathogens if the species is grown pure (for instance, by attack from defoliators and *Loranthus* on *Gmelina arborea* in Bhutan *terai* and attack of borer *Urostyles punctigera* on *Michelia champaca* in North Bengal, India). On the other hand, exotics such as *Eucalyptus, Casuarina* and *Acacias* have certain advantages: "...(a) they have usually left behind the co-adapted pests and diseases which evolved in parallel with them in their natural habitat; (b) they are often pioneer species which are fast growing on deforested areas and poor soils; (c) their wood has a recognized utility and marketability; (d) they usually require relatively easy techniques of seed collection and long term storage and nursery technology; and (e) considerable information is available on seed source performance and a start has been made on genetic improvement of the better seed sources (Davidson 1985)." Despite these advantages, however, exotic plantings in logged forests have often been found unsatisfactory. For example, *Albizia falcataria* in Bangladesh have been badly affected by mistletoe and *Eucaluptus grandis* in Kerala and Karnataka, India, by pink disease.

On the other hand, except for some *Dipterocarpaceae (Dipterocarpus acrocarpus* in India, native Dipterocarp planting by the Tropenbos method in East Kalimanthan, and so forth), there has been limited success with indigenous species in plantations of overlogged forests. Selection of species to match the site and at the same time satisfy the objectives for which they are being planted therefore needs to be done very carefully. It is also necessary to keep in mind the experience with the species in earlier planting attempts. Post-planting protection from pathological damages and biotic interference should be provided.

With clearing, burning and deep working of the soil, weeds become a difficult problem in these forests. For example, Chaplin (1985) describes infestation in Solomon Islands plantations by *convolulaceae* climbers in the genera of *Merremia* and *Operculina*. Use of weedicides have been found to be expensive and environmentally unacceptable. Continuous manual weeding is equally expensive. Chaplin proposes an integrated silvicultural approach consisting mainly of correct choice of species, selection and planting of good quality nursery seedlings, and close spacing of the seedlings. He proposes a spacing of 4x3 meters for *Gmelina arborea*, which closes canopy in two to three years and thus preventing weed growth.

Clearfelling followed by planting has been successful over limited areas in some countries. A few examples are:

- The Gogol Valley in Papua New Guinea, where 68,000 hectares of rain forest are under timber concessions; a total of 4,755 hectares have been developed for reforestation (Seddon 1984).
- Peninsular Malaysia, where a compensatory forest plantation program was proposed, with a target of planting 182,000 hectares over 15 years and 74,000 hectares during 1980-90 (Fifth Malaysia Plan 1986).

The trees considered are *Albizia falcataria, Gmelina arborea, Acacia mangium* and *Eucalyptus deglupta*. By 1984, Sabah Softwoods, a joint venture between the Government and North Borneo Timbers Company, had planted 25,000 hectares in Sabah, mainly with *Albizia falcataria, Acacia mangium, Gmelina arborea* and *Eucalyptus deglupta*.

Conclusions

It is not possible to provide one model for rehabilitating overlogged forests. Selection of the method depends on the objectives, the nature of the site, infrastructure, staff, and availability of investment funds.

Overlogged forests are characterized by low-value sparse crops (some of which are damaged), debris on the ground, compacted soil and plenty of weeds. Rehabilitation of these forests is a difficult and expensive task. Methods usually employed are natural regeneration, enrichment planting, and clearfelling followed by artificial planting. The natural regeneration method requires the least financial investment but does necessitate protecting the forest from any biotic interference (such as cutting, grazing, and burning) over a long period before the forest will play its full ecological and commercial role.

Enrichment planting involves planting of indigenous or exotic species in large gaps. The plants can be collected from the seedlings in the forest floor or they can be grown in nurseries before planting. Problems associated with enrichment planting are lack of light due to the shed cast by the overhead canopy of the residual stand of the overlogged forest, abundant regeneration of weeds that can overtop the planted seedlings, and the requirement of additional staff to maintain the large area of plantation. Where the logged area has been more or less cleared and chances of natural regeneration or regeneration by enrichment planting is not possible, artificial regeneration is the only method possible. It has been successfully practiced in many overlogged areas with fast-growing exotic species as a first rotation crop. In the second rotation, since the soil has been improved by organic matter from the first rotation trees and weeds (under control), indigenous seral and climax species can be introduced to correct the loss of biodiversity. To be successful, however, the forests and the plantations have to be protected from unplanned biotic interference.

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