



ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests

ITTO Policy Development Series No 13

International Tropical Timber Organization
in collaboration with the Center for International Forestry Research (CIFOR), the Food and Agriculture Organization of the United Nations (FAO), the World Conservation Union (IUCN) and the World Wide Fund for Nature (WWF) International

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ITTO is an intergovernmental organization promoting sustainable development through the sustainable management, use and conservation of tropical forests. It has 57 member governments, which collectively represent about 80% of the world's tropical forests and 90% of the global tropical timber trade. Development projects in member countries are one important mode of operation; the Organization has funded more than 400 such projects at a total value of about US$240 million. At any one time it employs, through its project program, about 500 field staff in the tropics.

ITTO has developed a series of internationally agreed policy documents for achieving sustainable forest management and forest conservation and assists tropical member countries to adapt these to local circumstances and to implement them in the field. In addition, ITTO collects, analyzes and disseminates data on the production and trade of tropical timber and funds a range of projects aimed at developing value-added industries at both the community and industrial scales.

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Foreword

The extent of forest degradation in the tropics is vast. According to estimates given in these guidelines, some 350 million hectares of tropical forest land have been so severely damaged that forests won't grow back spontaneously, while a further 500 million hectares have forest cover that is either degraded or has regrown after initial deforestation.

Such large areas of damaged forest and land are cause for concern, but they also represent a potential resource of immense value. The *ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary forests* have been formulated to help communities realize that potential.

Forests can serve many functions at the local, landscape, national and global levels, but only if they are in good health. They can provide local communities with sustainable supplies of clean water, timber, fuelwood and other products and services, and they can contribute to the global quest to conserve biodiversity and reduce atmospheric carbon. Restoring, rehabilitating, managing and protecting forests for such functions are undeniably important tasks.

These guidelines provide a powerful introduction to the issues confronting the policy-makers, forest practitioners, extension workers and others who want to restore and manage degraded or secondary forests. They stress that the policy, legal and social conditions in and outside the forest must be analyzed and addressed before restoration, management and rehabilitation activities are decided on. They point out that many people have a stake in the forest and any restoration, management or rehabilitation efforts must be made with their full participation. Land tenure issues must be resolved, and transparent mechanisms for sorting out conflicts over property and access rights must be established. Silvicultural techniques that can be understood and implemented by owners of small areas of forest need to be developed.

These guidelines synthesize a vast quantity of information, not only from the literature but also from many tropical forest stakeholders. ITTO is particularly indebted to Jürgen Blaser, of the Swiss development agency Intercooperation, and César Sabogal, of the Center for International Forestry Research, who wrote an initial draft of the guidelines after wide consultations. A panel of 14 forest restoration and secondary forest management experts then met for five days to review and add to the draft. I thank all participants of this panel and particularly WWF International's Jeffrey Sayer, who was its chair and who later also edited the resulting document in collaboration with Dr Blaser.

This pioneering attempt to provide comprehensive guidance on the restoration, management and rehabilitation of degraded and secondary tropical forests has only been possible with the close cooperation of many institutions, in particular CIFOR, FAO, IUCN and WWF International. In the process, the informal network of international organizations involved in forest restoration has been strengthened; this augers well for future collaborative work, which must aim to increase the amount of forest restoration being carried out in the field.

These guidelines constitute a substantial effort by ITTO and its partners to further the cause of forest conservation and management. I fully expect that they will prove a major force for change in tropical forestry, stimulating the adoption of innovative management practices for conserving and improving the production capacities of degraded and secondary forests, and helping to focus policies so that ground-level action becomes easier and more rewarding for all stakeholders.

Manoel Sobral Filho
Executive Director
International Tropical Timber Organization

Acronyms

CIFOR	Center for International Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPF	Collaborative Partnership on Forests
FAO	Food and Agriculture Organization of the United Nations
IPCC	Intergovernmental Panel on Climate Change
ITTO	International Tropical Timber Organization
IUCN	The World Conservation Union
IUFRO	International Union of Forest Research Organizations
NFP	National forest program (in the framework of the UNFF)
NGO	Non-governmental organization
UNCBD	United Nations Convention on Biological Diversity
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nations Convention to Combat Desertification
UNFF	United Nations Forum on Forests
WWF	Worldwide Fund for Nature

1 Scope of the guidelines

Concern about the destruction of the world's forests, and in particular tropical forests, has grown considerably in the past two decades and has resulted in various initiatives to reverse this trend and to develop strategies and actions for sustainable forest management. Within this context, policy-makers, researchers, forest practitioners and advocacy groups have tended to focus on large tracts of tropical primary or pristine forests, while the conservation value and development potential of degraded and secondary forests[1] have been neglected. If properly managed, restored or rehabilitated, degraded and secondary forests have the potential to generate significant environmental and livelihood benefits. Under certain conditions they can mitigate pressure on primary forests through their ability to produce both wood and non-wood forest products. Furthermore, they can often provide environmental functions and make valuable contributions to biodiversity conservation.

Human activities, exacerbated by poverty and population pressure on the one side and human greed on the other, are by far the dominant causal factors in forest degradation. Degraded primary forests result from the unsustainable use of primary or managed primary forests, either through the over-harvesting of wood and/or uncontrolled extraction of other forest products. Secondary (second-growth) forests are, often, an integral part of subsistence agricultural systems. Degraded forest lands may remain degraded for long periods of time because of continuing misuse. They are generally a result of overuse on sites where persistent physical, chemical and biological barriers limit the capacity of trees and forests to regrow.

The restoration and management of degraded and secondary forests and the rehabilitation of degraded forest lands must be based on the priorities and objectives of all concerned stakeholders. Degraded and secondary forests are often used by the poorer segments of rural populations because they are accessible and can provide a range of goods that meet immediate livelihood needs (eg energy, food and medicine). A large portion of these lands can also support food production using improved land-use practices such as agroforestry. In addition, degraded and secondary forests are today the largest land reserve for agriculture and livestock production. Conversion into these alternative land-uses, if adequately planned and if the converted areas are properly managed, can minimize local pressure on the remaining primary forests.

Nevertheless, there remain large tracts of degraded and secondary forests that cannot be converted economically for agricultural or intensive tree-crop development. They may also be financially less attractive for commercial timber exploitation. Yet such forests have considerable potential to be rehabilitated and managed under collaborative arrangements as multiple-use forests. Properly restored, managed and valued, they can play an important role in the production of timber, wood and non-wood forest products for local and national use and international trade and, as such, can directly help reduce poverty. The environmental and socio-cultural benefits of restoring and managing degraded and secondary forests should, therefore, be fully recognized and endorsed at the national and international levels.

These guidelines have been prepared to highlight the increasing importance of the current and potential roles of degraded and secondary forests in tropical landscapes. They provide a set of principles and recommended actions to promote and encourage the management, restoration, rehabilitation and sustainable utilization of degraded and secondary forests as a component of sustainable social and economic development. They fill a gap between two existing ITTO policy documents: the ITTO Guidelines for the Sustainable Management of Natural Tropical Forests, and the ITTO Guidelines for the Establishment and Sustainable Management of Planted Tropical Forests (Figure 1).

[1] The term 'degraded and secondary forests' is used here to describe forest conditions other than those found in protected or managed primary and planted forests: it includes degraded primary forests, secondary forests, and degraded forest land (see Box 1).

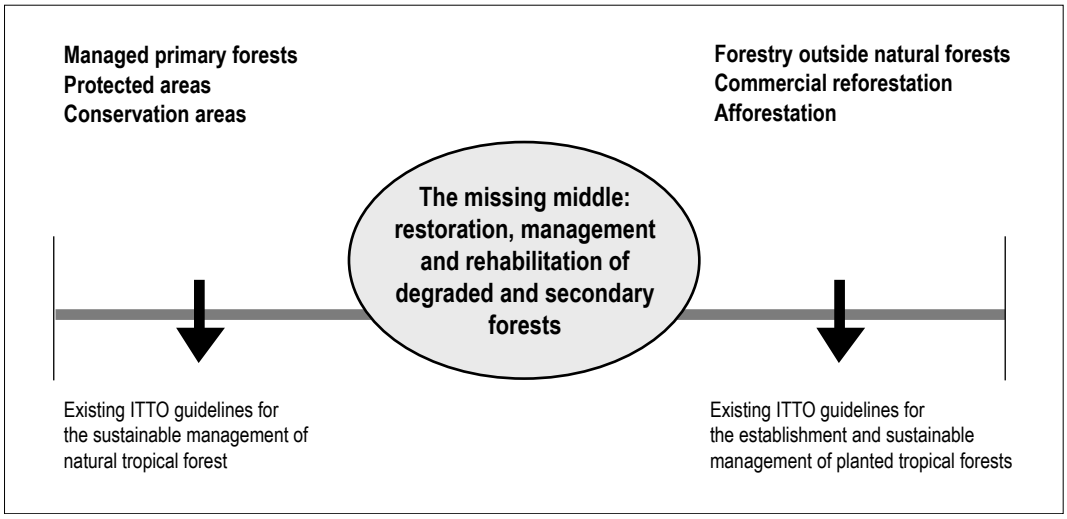

Figure 1 *The missing middle: the restoration, management and rehabilitation of degraded and secondary tropical forests*

The scope of the guidelines is shown schematically in Figure 2. The guidelines are intended to:

- provide a knowledge base on key policy, socioeconomic, legal, institutional, ecological and silvicultural issues that need to be taken into account in the planning and implementation of appropriate strategies and viable options for the restoration of degraded primary forests, the management of secondary forests, and the rehabilitation of degraded forest land;
- help planners to integrate the restoration, conservation and management of degraded and secondary forests and degraded forest lands at the local and landscape levels;
- collate and build on relevant experiences in the use and management of degraded and secondary forests;
- stimulate the adoption of appropriate and adaptive management practices for conserving and enhancing production capacities of degraded and secondary forests; and
- help create a policy focus on degraded and secondary forests at the local, national and international levels to promote their sustainable and equitable management and use, prevent degradation and inappropriate conversion, and guide the development of such forests according to clearly defined management strategies.

The primary target groups for these guidelines are those involved in the planning and management of rural lands and forests, including:

- public policy-makers, such as government agencies dealing with rural landscape use and management (departments of forestry, planning and finance) and development and extension agencies;
- civil society, NGOs, and private and public decentralized management agencies;
- forestry and other land-use practitioners acting at a site level; and
- education, training and research institutions.

The guidelines are also intended to inform the international environmental processes (the United Nations Forum on Forests – UNFF, the United Nations Convention on Biological Diversity – UNCBD, the United Nations Framework Convention on Climate Change – UNFCCC, and the United Nations Convention to Combat Desertification – UNCCD), as well as development banks and bilateral and multilateral aid agencies.

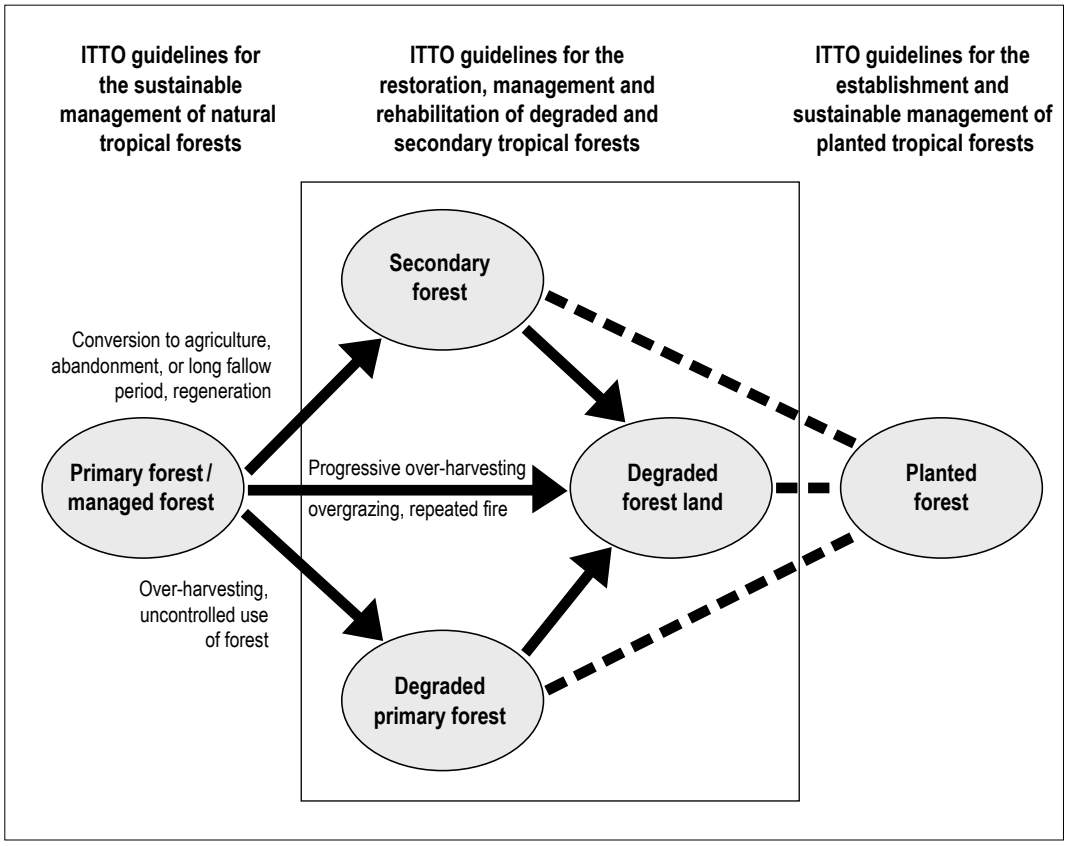

Figure 2 *Scope of the guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests*

The guidelines are a checklist of prime objectives, principles and recommended actions. They are not intended to be a detailed operational manual prescribing site-specific techniques and procedures. The objectives, principles and recommended actions are meant to constitute an international reference standard for the management, restoration and rehabilitation of degraded and secondary forests. They provide a framework for the development of more specific guidelines at the regional, national, local and site levels.

Most of the 49 principles and 160 recommended actions are relevant to all forest types in tropical countries. However, emphasis is given to situations in the humid and semi-humid tropics, the areas of main concern to ITTO. Annex 6 provides additional guidance on the management, restoration and rehabilitation of degraded and secondary forests in the dry tropics.

The listed principles and recommended actions are not exhaustive; they should be viewed as guides to be further developed and implemented by relevant local stakeholders. No two forest sites are the same and these guidelines will always have to be used in the context of local conditions; they should be applied within a framework of management that is constantly adapted to changing conditions and to the changing needs of society. The importance of the full involvement of all stakeholders in decision-making about forest restoration, management and rehabilitation cannot be over-emphasized.

2 What are degraded and secondary forests?

Definitions[2]

The term **forest degradation** refers to the reduction of the capacity of a forest to produce goods and services. A **degraded forest** delivers a reduced supply of goods and services from a given site and maintains only limited biological diversity. It has lost the structure, function, species composition and/or productivity normally associated with the natural forest type expected at that site.

Box 1 presents the main definitions used in these guidelines. Table 1 outlines the distinguishing characteristics of the three broad conditions of degraded and secondary forests that are described in Box 1. Figure 3 provides an overview of the functional linkages between the different forest conditions.

Box 1: *Categories of forests in the tropics*[3]

PRIMARY FOREST[4]: forest which has never been subject to human disturbance, or has been so little affected by hunting, gathering and tree-cutting that its natural structure, functions and dynamics have not undergone any changes that exceed the elastic capacity of the ecosystem.

MODIFIED NATURAL FOREST: primary forests managed or exploited for wood and/or non-wood forest products, wildlife or other purposes. The more intensive the use, the more the structure and composition is altered from that of primary forests. Ecologically, the alteration often represents a shift to an earlier successional stage. Two major categories can be distinguished:

- **managed primary forest:** primary forest in which sustainable wood and non-wood harvesting (eg through integrated harvesting and silvicultural treatments), wildlife management and other uses have changed the forest structure and species composition from the original primary forest. All major goods and services are maintained;
- **degraded and secondary forests:** forests and forest lands that have been altered beyond the normal effects of natural processes through unsustainable use or through natural disasters such as storms, fire, landslides and floods. Three different conditions can be distinguished within this sub-category:
  - i) **degraded primary forest:** primary forest in which the initial cover has been adversely affected by the unsustainable harvesting of wood and/or non-wood forest products so that its structure, processes, functions and dynamics are altered beyond the short-term resilience of the ecosystem; that is, the capacity of these forests to fully recover from exploitation in the near to medium term has been compromised;
  - ii) **secondary forest:** woody vegetation regrowing on land that was largely cleared of its original forest cover (ie carried less than 10% of the original forest cover). Secondary forests commonly develop naturally on land abandoned after shifting cultivation, settled agriculture, pasture, or failed tree plantations;
  - iii) **degraded forest land:** former forest land severely damaged by the excessive harvesting of wood and/or non-wood forest products, poor management, repeated fire, grazing or other disturbances or land-uses that damage soil and vegetation to a degree that inhibits or severely delays the re-establishment of forest after abandonment.

PLANTED FOREST: a forest stand that has been established by planting or seeding:

- **afforestation:** the establishment of a planted forest on non-forested land;
- **reforestation:** the re-establishment of trees and understorey plants at a site immediately after the removal of natural forest cover; and
- **enrichment planting** (assisted regeneration, complementary regeneration): the planting of desired tree species in a modified natural forest or secondary forest or woodland with the objective of creating a high forest dominated by desirable (ie local and/or high-value) species.

In these guidelines, forests that have been altered beyond the normal effects of natural processes are categorized as either degraded primary forest, secondary forest, or degraded forest land. This is done for the purpose of illustrating concepts, but it should be noted that this is a simplification of what is always a much more complex reality on the ground. Degraded primary forests, secondary forests

[2] The definitions given here are context-specific to ITTO and these guidelines and may not necessarily conform with definitions by FAO, UNFF, UNCBD, UNFCCC and other institutions. Annex 7 shows the terms and definitions used by a range of other organizations, institutions and international processes.

[3] The terms used in these guidelines are based on ITTO forest categories (see also Annex 7).

[4] Forests used by indigenous and local communities with traditional lifestyles consistent with the conservation and sustainable use of biological diversity are included in this category (as per the UNCBD).

and degraded forestlands usually exist in complex mosaics that are constantly changing. Indeed, intermediate stages and/or combinations of conditions will exist in close proximity and it is often difficult to distinguish between them. Each of the three conditions, however, has characteristics (as shown in Table 1) that must be taken into account when developing management strategies.

The formation and subsequent dynamics of degraded and secondary forests are often caused by interrelated forces acting at a broader landscape level. The forces that lead to forest degradation exist across a continuum of forest-use intensity (see Table 2, and for a more detailed prescription Annex 5).

Table 1 *Differences between the three major categories of degraded and secondary forests*

	Degraded primary forest	**Secondary forest**	**Degraded forest land**
Intensity of disturbance	▪ Slight to moderate intensity within the range of common natural disturbances	▪ Severe intensity, caused by the clearing of at least 90% of the original forest cover	▪ Drastic and repeated intensity with complete removal of the forest stand, loss of topsoil, and change in microclimate
Common causes of disturbance (human-induced or natural)	▪ Excessive wood exploitation ▪ Over-harvesting of non-wood forest products ▪ Destructive natural disturbances such as forest fires, storms ▪ Over-grazing	▪ Clear-cutting, burning and subsequent abandonment of an area ▪ Catastrophic large-scale natural disturbances: eg fire, flooding, storms, landslides	▪ Repeated over-use, repeated fire, grazing, or ecological mismanagement on fragile soils ▪ Soil erosion
Vegetation development process	▪ Relatively small changes in growth and regeneration dynamics, except where over-grazing prevents natural regeneration ▪ Relic trees are often damaged (crown, stem), or are potential 'losers' unable to achieve dynamic regrowth or are phenotypically inferior ▪ Recovery mainly through autogenous and spontaneous cycle replacement regeneration, usually complemented by coppice and seed bank ▪ Species composition change with over-exploitation of timber ▪ Successional changes are limited to more intensively affected areas	▪ A sequence of successional changes takes place after the perturbation. In this process, several phases or stages with specific floristic, structural and dynamic characteristics can be distinguished. Plant species composition changes in dominance gradually from early to late successional species ▪ Start of a highly dynamic growth process, with high rates of carbon assimilation and biomass aggregation	▪ There is only very sluggish successional development after the cessation of the main disturbance ▪ The process generally leads directly from forest cover to grassland or bushland, or, in extreme cases, to barren soil surface
Characteristics	▪ Forest structure not significantly damaged ▪ In forests subject to over-grazing, poor understorey development and absence of young age classes of the canopy species ▪ Light-demanding species regenerating after the disturbance are usually similar to those in the original forest stand	▪ Regrowing forest differs in species composition and in physiognomy from primary forest. Species are highly light-demanding	▪ Forest vegetation is lacking; single or small groups of pioneer trees and shrubs may or may not occur

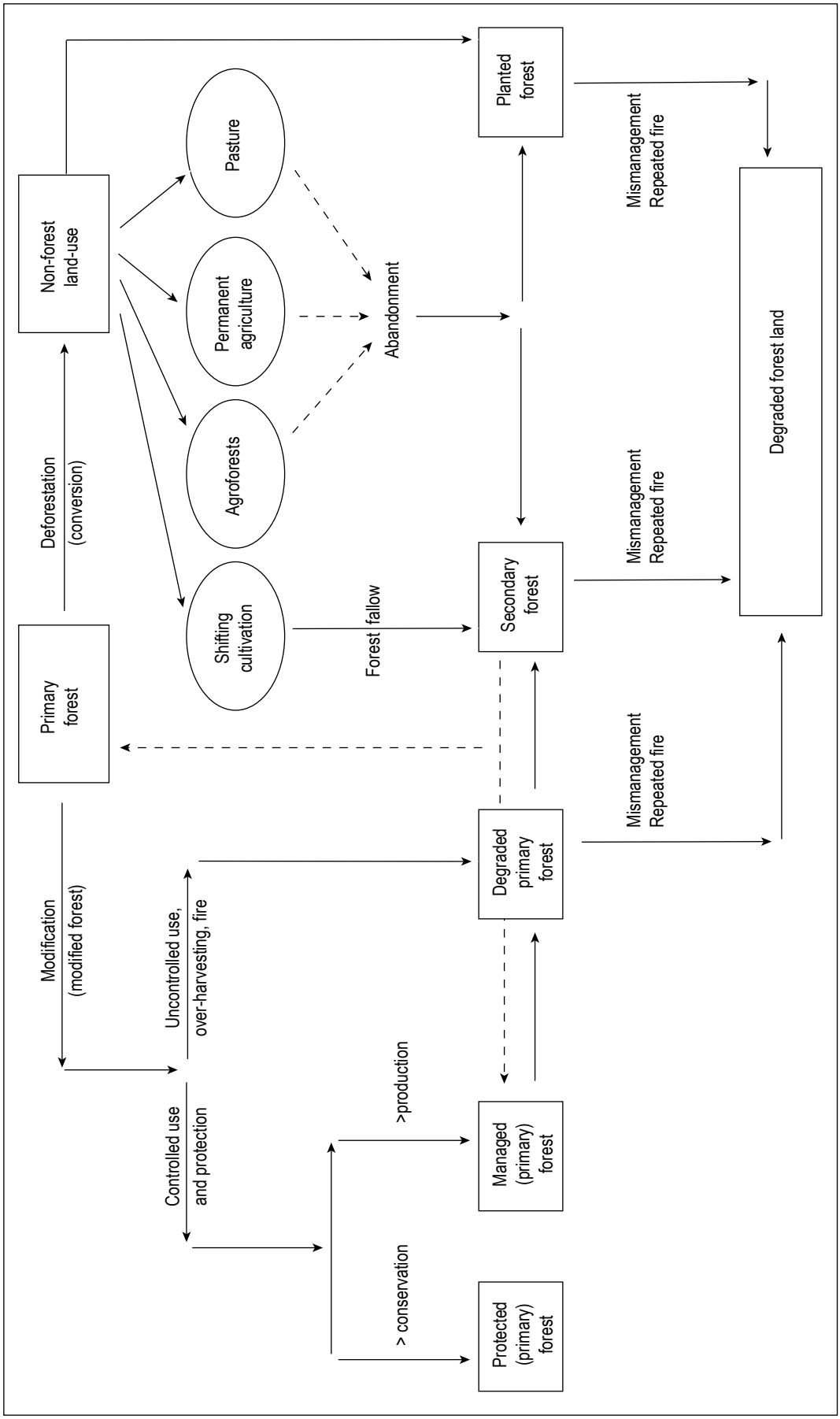

Figure 3 *Conceptual dynamic model of the formation of different forest and non-forest conditions*

Table 2 *Use patterns that lead to a continuum of degraded and secondary forests and their approximate occurrence throughout the tropics (modified after Chokkalingam et al. 2001)*

Extensive-use stage	**Intensive exploitation stage**	**Forest-depleted stage**
• Slow decline of forest ecosystem through selective logging	• Rapid decline of forest ecosystems through timber mining, the extraction of other forest products and/or shifting cultivation	• Only fragmented forests left in an open rural landscape
• Limited areas of secondary (fallow) forests	• Large tracts of degraded primary forests, and secondary forests	• Forests remain mainly on marginal land
• Mosaic of intact forest landscapes	• Rapid increase of degraded and secondary forests	• Agricultural landscape predominant
Remote areas of Southeast Asia and tropical America, and the Congo Basin in tropical Africa, where population and economic pressures are still insignificant	Tropical timber-producing countries in Southeast Asia, in some West African countries, and in Central America (secondary forest)	Densely populated areas in South Asia, medium altitude areas, and semi-humid areas of Latin America and Africa

Degraded and secondary forests in tropical landscapes

Degraded and secondary forests are an integral part of tropical landscapes (Figure 4). This means that the formation and dynamics of degraded and secondary forests are not only influenced by site-level factors but also by an array of interrelated biological and social forces acting at a larger scale – what is referred to here as the landscape scale. Conversely, the extent and configuration of degraded and secondary forests across a tropical landscape will determine the functionality of that particular landscape.

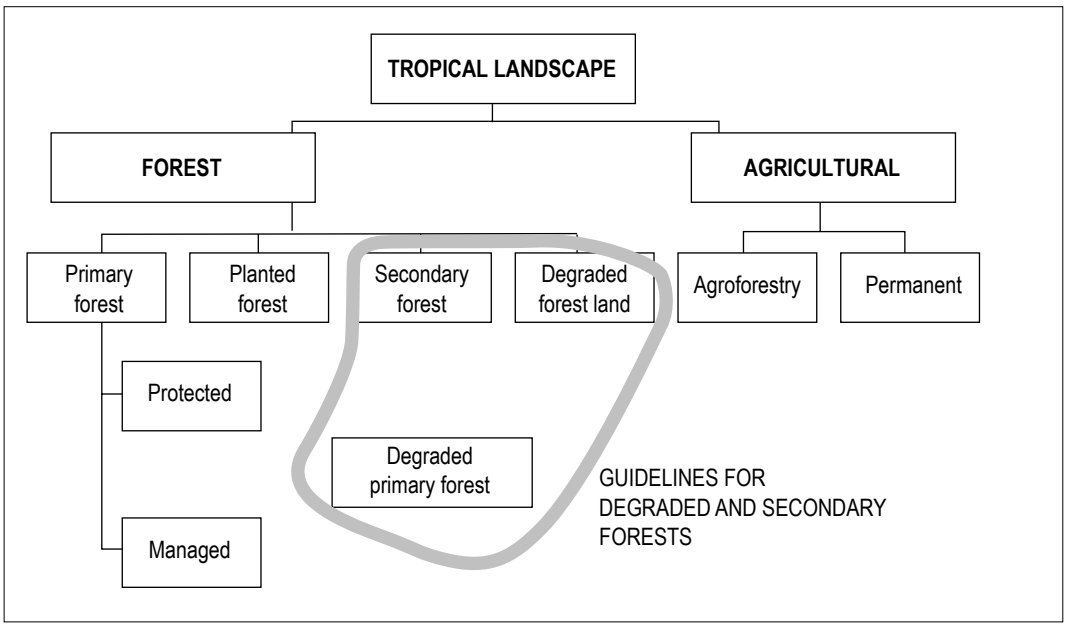

Figure 4 *The different land-use types and forest conditions in a schematized tropical landscape*

Landscape functionality is a measure of the quality and quantity of goods, services, ecological processes and future options provided by any particular landscape. The functionality of a landscape whose original extent and configuration of forest types has been preserved will conserve biodiversity and maintain ecological processes. Forest condition can be modified without a noticeable decline in functionality, as can be seen in many traditional forest-based agricultural systems, such as that of the Krui people of southwest Sumatra. However, large-scale forest clearance or deterioration in forest condition – through destructive logging practices, for example – will inevitably lead to a decline in the quality and quantity of forest functions delivered at the landscape level. Unfortunately, those goods and services that end up being supplied at sub-optimal levels are often those that while delivering tangible societal and ecological benefits have little market value. In degraded tropical landscapes, degraded primary forests, secondary forests and degraded forest lands can, with the right policy and program mix, contribute to the replenishment of lost or declining forest functions that in turn will have real benefits for rural communities. Alternatively, land-use decisions to further simplify the land-use mix – through the large-scale conversion of degraded primary forest to industrial plantations, for example – risks a further decline in landscape functionality.

Landscapes therefore provide the context for determining the right mix of policies and actions that are necessary to support the restoration, management and rehabilitation of degraded and secondary forests. Given that human needs change over time, the landscape context also helps decision-makers and resource managers identify policy options and management strategies that are flexible enough to meet the needs of rural communities.

The restoration, management and rehabilitation of degraded and secondary forests should take into account the complementary roles of various landscape components in sustaining a broad range of goods and services over a long period of time. This means that although individual forest stands alone cannot be expected to supply all major goods and services, it is important to ensure that the mosaic of land-uses in a landscape meets the full range of society's needs.

The following criteria need to be considered in order to assess functionality at a landscape level:

- supply of goods and services where they are needed;
- benefit for agriculture: shelterbelts, soil fertility, erosion control, etc;
- upstream watershed management, downstream protection;
- connectivity between protected areas to assure biodiversity conservation; and
- keeping options open for future uses.

There is a need, particularly in heavily degraded tropical landscapes, to monitor and manage the landscape as a whole, and not just its various components. The restoration, management and rehabilitation of degraded and secondary forests, in particular, need to be seen in such a holistic overall landscape-level context.

Extent and distribution of degraded and secondary forests

Due partly to differing definitions of the terms, it is difficult to establish the extent of degraded and secondary forests in the three tropical regions. Nevertheless, some estimation has been made. For example, FAO (1993) estimated that 532 million hectares, or 29% of the total tropical forest area, was degraded[5] in 1990. Wadsworth (1997) estimated that, worldwide, 494 million hectares were "cutover tropical forests, and 402 million hectares tropical forest fallow".

Table 3 gives estimates of the extent of degraded and secondary forests in 77 tropical countries in the year 2000 based on country statistics extrapolated from various sources. The total area of degraded and secondary forests is estimated at about 850 million hectares, corresponding to roughly 60% of the total area that is statistically classified as forest in the tropics. Degraded primary forests and secondary forests cover about 500 million hectares, while 350 million hectares of formerly forested land was deforested between 1950 and 2000.

[5] This corresponds to the sum of all vegetation cover which can be equated with secondary forests: open forest, long fallow, fragmented forest (Emrich et al. 2000).

Table 3 *Estimated extent of degraded and secondary forests by category in tropical Asia, tropical America and tropical Africa in 2000 (million hectares, rounded to the nearest 5 million)*

	Asia 17 countries	America 23 countries	Africa 37 countries	Total
Degraded primary forest and secondary forest	145	180	175	500
Degraded forest land	125	155	70	350
Total	270	335	245	850

Derived from: FAO (1982, 1993, 1995, 2001), Sips (1993), Wadsworth (1997), and other sources. In tropical America, about 38 million hectares are classified as secondary forests (second-growth forests). For the other regions it is not possible to distinguish between degraded primary forests and secondary forests.

The annual loss of natural forests in the tropics during the 1990s was estimated at 15.2 million hectares, of which 14.2 million hectares were converted to other land-uses. Against this, an estimated 1 million hectares of abandoned land previously under a non-forest use (mostly agriculture) were reforested by 'natural expansion of forests' through natural succession (FAO 2001).

Functions, roles and uses of degraded and secondary forests

Degraded primary forests and secondary forests are becoming the predominant forest types in many tropical timber-producing countries. These forests are gradually having to provide the productive and environmental functions of primary, old-growth forests. Their ability to do this will depend on the management to which they are subject.[6] The degradation processes deplete the economic forest resource, and often – as in timber mining – almost completely destroy it. Consequently, degraded and secondary forests cannot play the same economic role as primary forests, although they may still be able to perform important ecological and protective functions – provided that the agents of forest degradation are no longer active (see Box 2).

Degraded and secondary forests today represent a major, if not the main source of forest products in several countries. For instance, in Costa Rica the area covered by degraded primary forests and secondary forests is estimated at more than 600,000 hectares, an area larger than all remaining primary and old-growth forests in the country and representing the nation's most abundant forest resource. In the Philippines almost all the dipterocarp forests are now highly degraded. They occupy around 28 million hectares and today provide the country's main domestic source of wood. Most forests in Sri Lanka are secondary; they are mainly confined to the dry zone and have developed following shifting cultivation. A similar situation is found in Nepal, largely as a result of episodes of large-scale wood harvesting in the subtropical lowlands along with the accumulated small-scale extraction of wood and non-wood forest products by local people over centuries. Shifting cultivation and related secondary forests are widespread in the Indonesian islands of Sumatra, Kalimantan, Sulawesi and Irian Jaya, where they cover an area of more than 17 million hectares. In the Brazilian Amazon, degraded and secondary forests cover over 50 million hectares and this area is expanding rapidly. In West Africa the forest landscape has been drastically modified by fire, shifting cultivation and excessive timber extraction over the past century and secondary forests now predominate. Degraded and secondary forests are important for the livelihood of indigenous people, forest dwellers and small-scale farmers throughout the tropics; for example, the World Bank estimates that 300 million people depend on degraded or secondary forests for their livelihoods.

[6] Wildlife conservation and timber production, for example, are clearly affected. Other important roles of the forest ecosystem – eg soil conservation and hydrological functions – may not be so badly affected.

Box 2: *Functions, roles and uses of degraded and secondary forests*

- Worldwide, most forest utilization by humans takes place in forests with a history of natural disturbance and human modification. Degraded primary forests and secondary forests tend to be located in more accessible areas close to human settlements and are thus served with relatively good infrastructure. They are an increasingly important component of the forest resource in the tropics, providing a wide range of valuable goods and services at local, national and international levels.
- Degraded and secondary forests can fulfill a variety of productive, social and protective functions that benefit or could benefit people's livelihoods and the environment. As a resource often located where the rural poor live, degraded and secondary forests can serve as 'safety nets' for the poor while still providing environmental services.
- The single most important human use of tropical secondary vegetation is as fallow within the shifting cultivation systems that are currently practised by 250–500 million farmers on one-fifth of the world's tropical forest area. Secondary forests are often an integral component of small farmers' agricultural systems and have important functions for the regeneration of soil fertility and the containment of pests and diseases.
- Secondary forests and degraded primary forests are low-cost sources of a tremendous variety of forest products. Among them the most important is wood as fuel (fuelwood, charcoal), which is the primary energy source for many rural people in tropical regions. Most fuelwood is collected in degraded and secondary forests for subsistence use.
- Non-wood forest products such as animal and vegetable foods and other useful plants are frequently extracted from secondary forests and degraded primary forests. Bamboo, rattan, edible fruits, medicinal plants, etc, are harvested in degraded or secondary forests because these forests are usually more accessible.
- Degraded and secondary forests are important as sources of timber for local needs (house-building, posts) and for sale (sawn wood, veneer wood, industrial wood). However, there is little experience so far in the large-scale and sustainable management of secondary forests for timber production. Examples of tree species from secondary forests already on the market are: *Aucoumea klaineana, Ochroma lagopus, Simarouba amara, Cordia alliodora, Shorea leprosula, Dryobalanopsis lanceolata, Chloroxylon swientenia*, *Alstonia angustiloba* (see Annex 3).
- Secondary forests and degraded primary forests are also important providers of environmental services. If properly restored and managed, they protect soils from erosion; regulate the water regime, reducing water loss through run-off on hillsides; fix and store carbon, which contributes to the mitigation of global warming; serve as refuges for biodiversity in fragmented/agricultural landscapes and provide templates for forest rehabilitation; contribute to reducing fire risk; and help conserve genetic resources, among other roles.
- The use of degraded forests may reduce pressure on primary forests, thus reducing deforestation rates. However, this is only true when the users of primary forests are the same as those of the degraded forests. It applies when the products from the degraded primary forests are suitable for the same uses as those from primary forests, if the financial rewards from exploiting degraded forests are comparable to those obtainable from primary forests, and if economic conditions do not encourage the simultaneous use of both. Access to secondary forests and degraded primary forest resources are also a valuable means of stabilizing small-scale colonists in agricultural frontier areas.

Degraded and secondary forests can offer some benefits for the immediate livelihood needs of the rural poor. Degraded and secondary forests are generally more accessible than primary forests and can be used for shifting cultivation, hunting and the gathering of other forest products. However, these benefits will be short-lived if such use leads to more degradation.

Forest restoration and the management of secondary forests play important roles in the global carbon cycle. Tropical forests are the single most important biome in terms of biomass carbon storage. The carbon pool in tropical forests is about 250 gigatonnes of carbon, about 42% of the global carbon stock stored in biomass. Hence, changes in tropical forest biomass have a substantial impact on the global carbon cycle. Humid tropical forests are characterized by an annual biomass production that is at least twice that of temperate forest ecosystems. This makes tropical forests, and particularly humid forests, a prime biome for potential carbon sequestration. Forest restoration that aims to increase biomass and biological productivity can therefore contribute significantly to the reduction of atmospheric carbon.

Socioeconomic and cultural aspects

Different constituencies may have fundamentally different perceptions of the socioeconomic and cultural values of forests. One perception common in environmental circles is that primary forests are the major source of biodiversity and therefore need to be protected and conserved. Restoration is accepted only if it aims to repair damaged forest ecosystems and if it leads to a complete re-establishment of the initial biodiversity. As commendable as this goal is, it is only achievable in some special cases. The costs of such complete ecological restoration may be high and may not be justified given the social and political realities of tropical countries.

Another, diametrically opposed perception is that unless the volume yield and value of secondary forests and managed natural forests compare favourably with those of industrial plantations, they are not worth the investment. Such a view ignores the potential benefits-to-cost ratios in the different management strategies in degraded and secondary forests. For instance, it ignores the fact that the biodiversity of such forests is not found in industrial plantations. It sees labour-intensive silvicultural interventions as a cost rather than a social asset. It also assesses the returns on the basis of wood alone. Furthermore, it is based only on the experience of producing the small fraction of forest products that have become marketable and ignores the wide range of potential new products. It also ignores the service functions of secondary forests and degraded primary forests. It is a fact that today a much wider array of forest products and services is valued in monetary terms than was the case 20 years ago. This trend is continuing and other new possibilities and perspectives exist for forest restoration and rehabilitation that, in certain cases, can generate a higher economic return than wood.

A third perception is one held by many people whose cultures and livelihoods are strongly linked to the forest. This values the degraded forest landscape differently. The perception of these stakeholders towards the resource may be influenced by their desire to gather forest products for immediate household consumption, the protection provided to the hydrological functions of a catchment above irrigated fields, spiritual, religious and other cultural values attached to the forest, or the potential to attract tourists. In contrast, many settlers, new to an area, may have little cultural attachment to the forest, little knowledge of the products it generates and little interest in (for example) conserving catchment values for those living downstream.

It is essential that the different perceptions of degraded and secondary forests are recognized and, to the extent possible, reconciled in forest restoration and rehabilitation strategies. Choices between different values will have to be made in each landscape in response to local social, cultural and economic circumstances. Whatever management strategy is chosen, local communities and forest users should be fully integrated into the decision-making processes. They must participate actively in resource planning and they must benefit from resource management.

Ecological context

Degraded primary forests: depending on the length and intensity of use, degraded primary forests retain many of the physical (soil, humidity) and structural characteristics of the former primary forest, as well as a generally heterogeneous species composition. Without silvicultural interventions, natural succession in degraded primary forests will eventually restore most of the characteristics of primary forests. The process depends on prevalent site conditions and the severity and duration of past disturbances, as well as on the availability and proximity of seed sources and seed-dispersing animals. Degraded primary forests are generally impoverished in stand quality (species composition, percentage of high-value timber species, stem form, pest and diseases, etc) and quantity (number of trees, volume of wood), because former logging operations concentrated on the best (ie commercially most valuable) species and individuals. Degraded primary forests generally contain more timber species than secondary forests, but they tend to be less uniform in tree size and canopy structure. They also may carry non-economic but ecologically important species in all strata. An important variable in degraded primary forests is the likely impact of logging damage, as the effects of injury to stem and crown are both immediate and long-term. Another unfavourable characteristic in

degraded primary forests is the unknown age of the trees. Smaller trees are not necessarily younger, and trees long constrained by suppression, unlike young trees, may be slow to accelerate growth once they have been liberated. Heavy damage is commonplace in most of the logged forests of the tropics. In this they differ from well-managed forests, where silvicultural planning and low impact logging retain a large proportion of trees below harvestable size. In a degraded primary forest these remnant trees have mostly been eliminated or heavily damaged. In addition, there is a high risk of the genetic degradation of favoured tree species over time.

Secondary forests comprise various stages in the process of succession and are less heterogeneous within and between sites, at least during the early pioneer stages. They are also generally less diverse. The dominant trees of the initial colonizing phase are short-lived, fast-growing pioneers and the forests are characterized by rapid changes in structure and species composition. The quantity of biomass will approach that of the primary forest in the course of one to two centuries, depending on site quality, but restoration of the full range of species may require several centuries. A range of factors determines the pace at which succession proceeds, including the intensity and duration of the perturbation, the distance to primary forest and the availability of seed-dispersers. Site conditions (eg local topography and climate, soil characteristics and light availability), the nature of the seed bank in the soil and the potential for root and stump resprouting will all influence successional processes.

The successional process operates through sequences of change usually described as stages, which may be distinguished by the dominance of a given group of plants. In a basic model of succession, herbs, shrubs and climbers dominate the first stage. They establish quickly after disturbance and become scarcer under the shade of the emerging pioneer tree species, which are able to develop a canopy very quickly and will dominate the second phase for 10–20 years (depending on their lifespans). As they die off, other already established light-demanding species at the site take advantage of improved growth conditions and gradually become dominant. This is the third stage of succession, which may last for 75–100 years depending on the lifespans of the species. The gradual occupation of the site by more shade-tolerant species is very likely to be continuous during this and subsequent stages. Differences in survival and growth rates among species at different stages play an important role in succession, determining the set of species that will be present in a given stage. Decreasing light availability at the forest floor during the course of succession is a major reason for these differences.

One of the most typical characteristics of secondary forests is the high floristic heterogeneity between stands only short distances apart, at the level of both the canopy and the understorey. This is mainly due to phenological variations in colonizing species at the moment of land abandonment (fallow period), the type of regeneration (resprouts versus seeds), as well as the presence of different species of remnant trees, which can influence species composition. At the regional scale, however, abiotic effects such as differences in rainfall and elevation mostly determine the rate of succession.

The availability of different regeneration mechanisms plays a crucial role in the speed and course of secondary succession. Resprouts from tree stumps and rootstocks form an important component of the regenerating vegetation, both in dry and moist forests. Regeneration from seed is, however, the main regeneration mechanism for widely dispersed pioneer species, especially after repeated crop-fallow cycles over long periods of time. In such circumstances, the future tree flora will be formed mainly by that subset of species capable of resprouting repeatedly from vegetative parts. In highly fragmented landscapes in particular, resprouting is an important mechanism for the regeneration of remaining primary forest species.

The productivity of secondary forests may vary in relation to factors such as site conditions (in particular topsoil and humus conditions), time since settlement and, more specifically, the number of crop-fallow cycles at a particular site. The type and intensity of land-use during the cropping stage and the prevalence of disturbances such as accidental burning during the fallow period will all influence productivity. As succession progresses, total stem density tends to decrease and the stand increases in height, basal area and volume. The first 15 years or so of succession are characterized

by rapid biomass accumulation (in exceptional cases up to 100 tonnes per hectare per year). The relative amount of woody biomass increases rapidly during the first 15–20 years, followed by a steady but slower rate until maturity.

Degraded forestlands are typically characterized by eroded or nutrient-deficient soils, hydrologic instability, reduced productivity and low biological diversity. Persistent physical, chemical and biological barriers often prevent natural succession from operating on a time-scale compatible with short- and medium-term human needs. These barriers to natural forest regeneration may include low propagule availability (seeds, rootstocks), excessive seed predation, the non-availability of suitable microhabitats for plant establishment, low soil nutrient availability, the absence of obligate or facultative fungal or bacterial root symbionts, seedling predation, seasonal drought, root competition with old field vegetation (particularly grasses), and fire. Stressful microclimatic conditions may also limit seedling survival and growth. The relative importance of these factors depends on the original ecosystem, the history of the disturbance, and the landscape pattern. The lack of forest seeds appears to be the overriding factor in most cases. If few forest seeds are available, grass competition, water stress and the lack of soil nutrients limiting vegetation survival and growth become largely irrelevant.

In some situations the intensity, frequency and scale of the disturbance may push the system over an ecological threshold. This may mean that recovery is slow or impossible and that, once abandoned, the site may remain as it is or even continue to degrade.

Silvicultural context

Silvicultural treatments in degraded primary forests should not differ fundamentally from the treatments of managed primary forests described in the ITTO Guidelines for the Sustainable Management of Natural Tropical Forests and the ITTO Criteria and Indicators for Sustainable Management of Natural Tropical Forests. Silvicultural treatments must consider both the species composition and structure of the forest. Silviculture in degraded and secondary forests should be based in the first instance on existing natural regeneration: inducing new germination or planting seedlings is more difficult than tending those seedlings already present. Therefore, one of the most important silvicultural tasks in the initial stage of management is the assessment of existing natural regeneration.

Tropical humid and semi-humid trees and other woody plants have remarkable recuperative capacities and rapidly reoccupy disturbed forests and open spaces. However, the number of economically and socially desirable species present following disturbance is seldom adequate. Regenerating an adequate number of desired species that are used locally and/or have a marketable value will therefore usually require additional silvicultural interventions. Stimulating natural regeneration and, in certain cases, enrichment planting are appropriate treatments for forest restoration and the management of secondary forests. The key question is how much tending is required and how the benefit/cost ratios compare with those of other land-uses such as plantations and agricultural crops.

Other important silvicultural treatments applied in forest restoration are refining and liberation thinning. Refining is the elimination of silviculturally undesirable trees, climbers, shrubs and other plants that will inhibit site occupation by desirable trees. It allocates growing space to one group of species, the so-called potential final-crop trees, at the expense of others. To some extent, refining can jeopardize species diversity and may even endanger the ecological integrity of a stand. A reasonable compromise is to leave the C- and D-layers of the canopy (see 'canopy' in glossary) as intact as possible, removing only those trees and climbers that overtop the desired crop trees. Liberation thinning is defined as a cutting that relieves young seedlings, saplings and trees in the C-layer from overhead competition. It stimulates growth, since tree growth is directly related to the formation of a healthy and dense crown. Refining and liberation thinning are costly and yield only distant future returns. They are, however, important in the initial stage to demonstrate measurable effects from forest restoration, management and rehabilitation efforts. They also reduce the time in which

a merchantable crop of wood and non-wood forest products will become available. Therefore, silvicultural interventions need also to be considered as an important policy tool in the restoration, management and rehabilitation of degraded and secondary forests.

Policy, legal and institutional framework

Despite their large extent, rapid growth and increasing importance at the local, national and regional levels for the products and services they provide, degraded and secondary forests are not afforded adequate prominence in forest policy, planning and research. There is a general lack of policies regulating and encouraging their management, use and conversion. Ecological, silvicultural and socioeconomic knowledge regarding degraded and secondary forests exists to a certain extent, and there is an increasing volume of research regarding forest restoration, rehabilitation and secondary forest management. However, existing experiences have not yet influenced policy development.

The lack of a policy focus on degraded primary forests and secondary forests results from a combination of factors. Apart from problems of definition and perception, there is a lack of information on the extent and current and potential value of these resources. The 'invisibility' of degraded and secondary forests leads to low political priority and a scarcity of financial resources and constrains the development of research, training and dissemination programs.

The legal framework in many tropical countries does not make a distinction between primary and modified forests, in particular secondary forests. In many cases the forest or environmental legislation refers in general to the rehabilitation (or restoration) of degraded (forest) lands, which may or may not include forest categories still capable of fulfilling important social, environmental and economic roles. Not being adequately defined or properly recognized, degraded primary forests and secondary forests are thus exposed to the same legal requirements as primary forests. This increases the transaction costs associated with conventional management plans, harvest regulations and the extraction and utilization of forest products, all of which restrict small-scale extractors/ farmers and local communities.

Nevertheless, there has been a trend in recent decades in the forest policies and legislation of some countries (especially in South and Southeast Asia) to promote community-based forest management. This provides a more favourable framework for strategies to restore and manage degraded primary forests and secondary forests. Experience during the past several decades indicates that local communities are prepared to accept responsibility for sustainable forest management in exchange for socioeconomic development and forest-use benefits. Policies and legislation that can motivate and provide incentives for rural communities in forest management, protection and rehabilitation are particularly critical for ensuring cooperation. Unclear and unstable land and resource tenures pose serious obstacles to any management strategy. Clear resource use rights must be provided.

Various possible pathways can be followed in the development of a degraded primary forest or secondary forest at the landscape level. These pathways or 'use options' will depend on who takes and who implements the decisions (private sector, government, communities, outsiders) and are driven by a combination of internal or external factors (Table 4).

Possible pathways for **degraded primary forests** include:

- leave to regenerate (eg as part of a conservation strategy);
- manage for wood production or multiple-use;
- progressive degradation, ie continue with uncontrolled extraction (open access); and
- convert to tree-crop plantation or to a non-forest land-use.

Possible pathways for secondary forests include:

- leave to regrow (eg as a land reserve);

- manage as fallow vegetation in the crop-fallow cycle;
- manage as part of an agroforestry system for producing mixed/multi-purpose trees;
- manage as a high-forest production system for wood or multiple-use; and
- convert to tree plantation or a non-forest land-use.

Possible pathways for degraded forest lands include:

- progressive degradation, ie continue with uncontrolled extraction (open access);
- protect from degrading forces and leave to regrow (to become a future land reserve);
- introduce lightly managed plantings, involving a variable number of (nurse) species intended to catalyze natural forest succession and ecosystem restoration primarily for environmental benefits (such as soil conservation and watershed stabilization) in the near term but offering multiple economic, social and ecological benefits in the longer term;
- manage under a multiple-use system (agro-sylvo-pastoral, agroforestry), combining tree crops for timber, fuelwood, fodder production and soil amelioration with the cultivation of food crops and high-value species such as medical plants and/or fodder;
- less intensively managed tree plantations designed to yield economically valued wood and non-wood forest products; and
- intensively managed single- or mixed-species plantations primarily for timber or fuel production.

Policies can direct the choice of pathways towards those leading to the sustainable use and management of degraded and secondary forests. Apart from an appropriate policy and legal framework, policy interventions will also be needed to increase the attractiveness and profitability of forest restoration and secondary forest management. These include policies related to markets for forest products, policies that allow producers to capture the benefits from maintaining forests, policies that create incentives, and policies to support research on technologies and policies.

Table 4 *Factors determining the potential development of degraded and secondary forests*

Degraded primary forest				
Causal factors/drivers	Leave to regenerate	Manage for wood or multiple-use	Continue progressive degradation	Convert to non-forest land-use
Accessibility	X			
Increased population/land pressure			X	X
Need for agricultural crops			X	X
Development need		X		X
Timber demand		X	X	
Market opportunities for non-wood forest products and services	X	X	X	
Policies/legislation	(X)	X		(X)
Insecure tenure			X	X
Incentives/enforcement		X	X	
(Mis-)Application of technological development		X	X	
Corruption			X	X

Table 4 *(continued)*

Secondary forest					
Causal agents/drivers	Leave to regrow	Manage as fallow vegetation	Manage as agroforest	Manage for wood/ multiple-use	Convert to non-forest land-use
Accessibility (as a limiting factor)	X	(X)			
Increasing population/land pressure		X			X
Declining productivity	X	X			
Demand for land (grazing)			X	X	
Market opportunities for non-wood forest products and services	(X)		X	X	
Policies/legislation (regulated land-uses/crops)			X	X	X
Incentives/enforcement			X	(X)	X
Need for agricultural crops		X			X
Insecure tenure	(X)	X			X
Household needs		X	X	X	
Need for income			X	X	
Cultural values		X	(X)		X
(Mis-) Application of technological development		X	X	X	X
Degraded forest lands					
Causal agents/drivers	Leave to regrow	Manage as fallow vegetation	Manage as agroforest	Manage for wood/ multiuse	Convert to non-forest land-use
Accessibility (as a limiting factor)	X				
Increasing population/land pressure	X				X
Declining productivity	X				X
Natural hazards (fire, droughts, flooding)	X	(X)			X
Market opportunities for non-wood forest products and services	(X)				
Policies/legislation (regulated land-uses/crops)					X
Incentives/enforcement					X
Need for grazing land	X				X
Insecure tenure	(X)				X
Household needs	X	X	X	X	X
Need for income	X		X	X	(X)
Cultural values					X
(Mis-) Application of technological development	X	X	X	X	X

3 Management strategies for degraded and secondary forests

Management strategies in the context of these guidelines are planned processes that aim to enhance the functionality of degraded and secondary forests. They should be based on a sound analysis of the general social, economic, institutional and ecological context (Figure 5). The restoration of degraded primary forests, the management of secondary forests and the rehabilitation of degraded forest land must therefore be viewed in the context of an overall landscape approach and in the framework of sustainable development. At a local level, sustainable development requires effective natural resource management; the restoration of degraded and secondary forests is an integral part of this. If perceived in such a holistic manner, forest restoration and rehabilitation are likely to be effective and to lead to sustainable outcomes. The development and selection of site-specific integrative ecosystem designs is the most crucial stage in developing a suitable management approach.

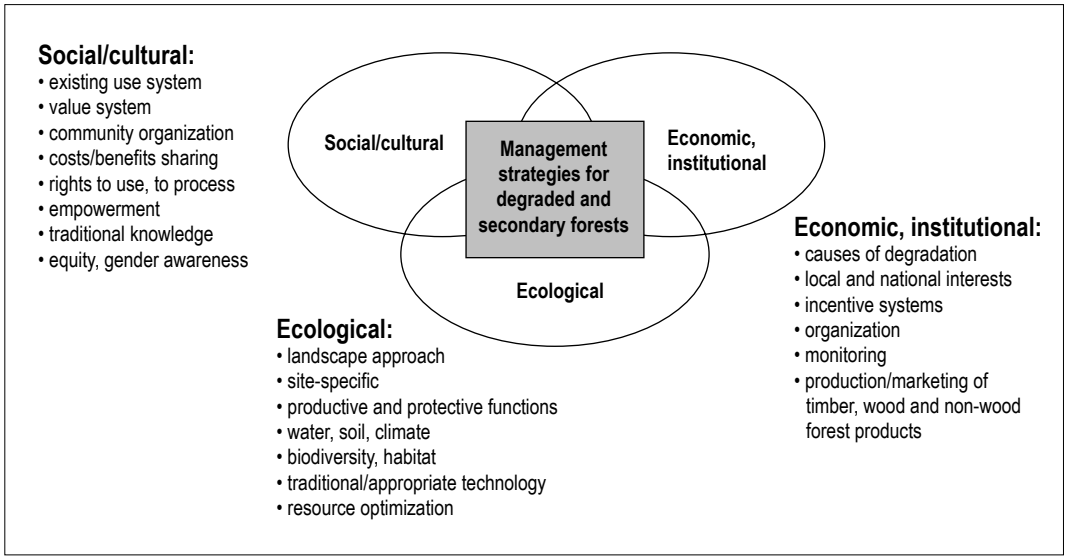

Figure 5 *Context for determining management strategies for degraded and secondary forests*

In general terms, management strategies for degraded and secondary forests aim to regain ecosystem integrity: that is, the maintenance of the potential to provide a certain set of goods and services for which the site is suited, implying the maintenance of biological diversity, ecological processes and structure, and sustainable cultural practices. Ecosystem integrity is subject to the condition that in a complex, dynamic ecosystem the only constant is change. Ultimately, forest management strategies aim to enhance human well-being. Choices about the forest management strategy to be employed should be made on a landscape scale based on specific local conditions. The present guidelines make a distinction between three principal management strategies:

- **forest restoration**, which is the principle management strategy for degraded primary forests;
- **the management of secondary forests**, applied where conditions are such that active forest management leads to the desired output; and
- **the rehabilitation of degraded forest land**, applied where the site is so heavily degraded that the spontaneous regeneration of tree and shrub species is severely limited.

Enough experience has been accumulated in various tropical forest ecosystems to permit informed choices to be made on the management strategy to be applied in a particular situation and to

predict how the forest ecosystem will respond. In this regard, the four basic silvicultural questions in Table 5 need to be thoroughly addressed. It is essential that these questions are posed and answered by the immediate user of the forest, and not in isolation in the offices of a government agency, forest service, research institution or NGO.

Table 5 *The four basic silvicultural questions for determining the management strategy for degraded and secondary forests*

1. What are the present stand and site conditions?	• Stand: species composition, structure, health, age, regeneration capacity, etc • Site conditions: edaphic, hydrologic, etc • Socioeconomic context: who uses the forest, what for, what kind of impact
2. What are the stand and site histories?	Determine the cause(s) of degradation: eg was the area under shifting cultivation? If yes, what intensity? Is the stand a logged-over forest? Did forest fire occur?
3. How would the site develop in the absence of planned management interventions?	What will happen to the stand if there is no management? For example, ecologically (succession, etc) and socially (conversion into other land-use, etc)
4. What management strategies are needed to achieve a particular outcome (restoration, secondary forest management, rehabilitation)? Depending on who manages the forest, the question of who plans, who harvests and who monitors will influence how this will be done.	Participatory and adaptive management planning for the particular forest stand or the degraded site: silvicultural options, collaborative use management, multiple-use management • define objective • specify methods used • specify monitoring of forest development, and adopt, if necessary, the strategy and the course of action

Even when the knowledge and experience of local people, foresters and ecologists are used to develop strategies for degraded and secondary forest management, the outcome will rarely be totally predictable. Because of this, an adaptive management approach is needed. Rather than rigidly pre-determining management strategies based on previous experiences at different locations, a monitoring program linked to periodic assessments of project results should form the basis of management decisions regarding the species or species mixtures to include in restoration and rehabilitation programs.

The particular ecological and socioeconomic criteria and indicators adopted should be linked to site-specific objectives and goals. For example, monitoring may include evaluations of tree growth rates, forest stand structure and composition, changes in physical and chemical properties of soils and the frequency of fire or other major disturbances. Figure 6 illustrates some of the possible objectives and desired future conditions for each of the three categories of degraded and secondary forests.

Box 3 summarizes the basic prerequisites for the effective application of any of the management strategies proposed for degraded and secondary forests.

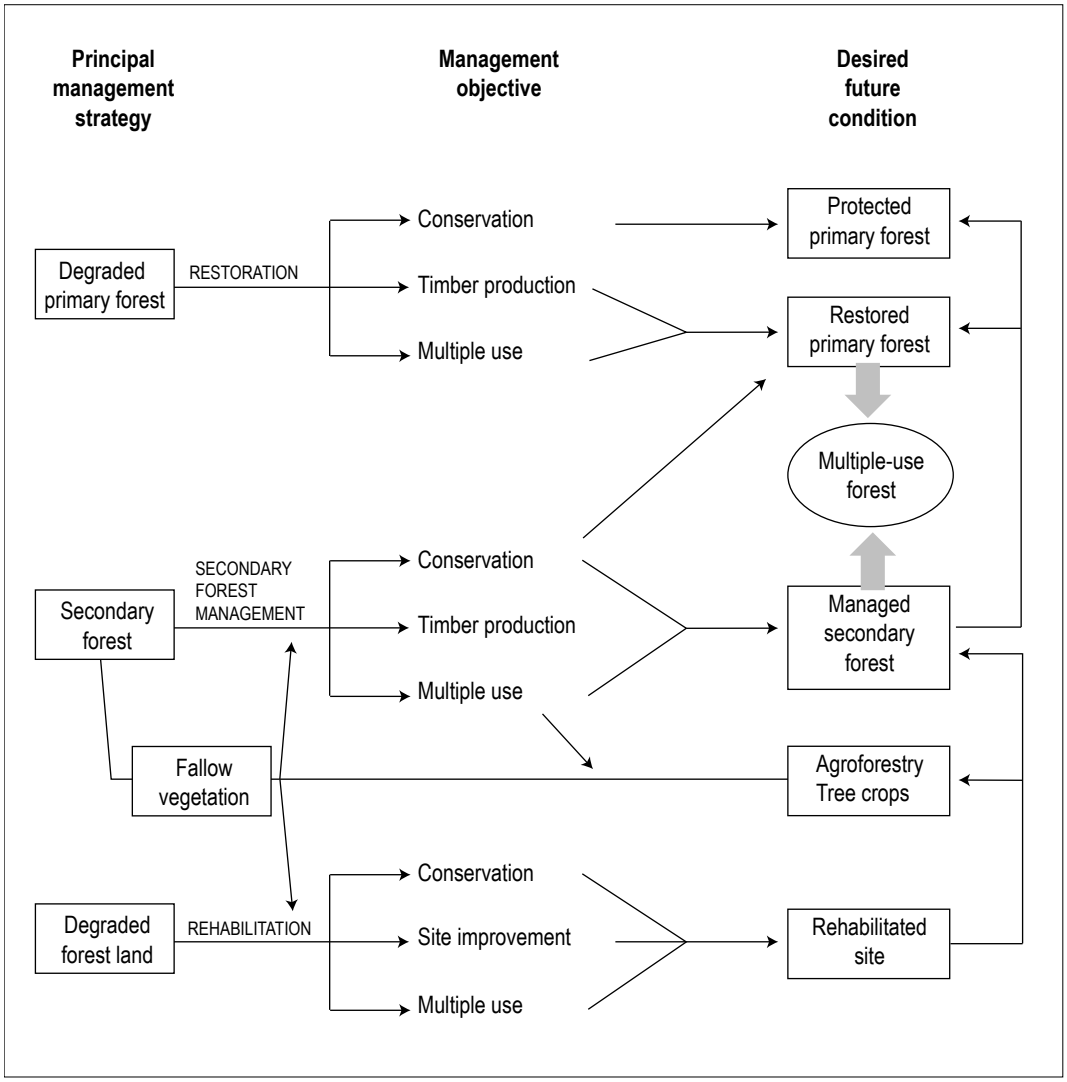

Figure 6 *Principal management strategies and possible pathways to promote forest-based land-use options in degraded and secondary forests*

Box 3: *Basic conditions for the effective management of degraded and secondary forests*

- In order to succeed, restoration and rehabilitation should have the strong support and participation of local stakeholders in the planning, implementation and monitoring of activities. The rights and responsibility of ownership, including customary claims and rights, must be clearly defined and mutually agreed.
- The restoration of degraded primary forests, secondary forest management and the rehabilitation of degraded forest land will only succeed if local forest users obtain some short-term economic benefits; these must be in addition to any potential future benefits that might not yet have a monetary value.
- Restoration will not succeed unless there is a comprehensive understanding of the complexities and dynamics of the forest ecosystem and of the interacting socioeconomic and political systems.
- Forest restoration, secondary forest management and the rehabilitation of degraded forest land are more likely to succeed if they lead to a general improvement in local soil fertility, hydrological conditions and the quality of the water supply and if the self-regeneration processes of the ecosystem are exploited and the dependence on outside inputs (eg planting, soil treatment, etc) is minimized.
- Unless land capability is analyzed and overall land-use relationships are understood and legally defined, restoration, secondary forest management and rehabilitation may not be effective or sustainable.

Restoration of degraded primary forests

Forest restoration is the principal management strategy applied to degraded primary forests. Forest restoration aims to enhance and accelerate natural processes of forest regeneration in order to re-establish a healthy and resilient forest ecosystem. Forest restoration is perceived in a way that the species composition, stand structure, biodiversity, functions and processes of the restored forest will match, as closely as feasible, those of the site-specific original forest.

Tropical (and many other) forests are robust and possess high elasticity, resistance and resilience and have a high repair capacity which is often underestimated. The possibilities for forest restoration are governed by the ecological status and remaining species' associations, along with the structure of the canopy and history of disturbance. A basic management principle for forest restoration is to use the natural dynamics existing in a degraded primary forest stand as much as possible. Restoration will usually be derived from advance growth existing in a degraded primary forest, as the inducement of regeneration is often difficult. Seed sources are often absent and the ground vegetation (D-layer) dense and highly competitive. According to the severity of the disturbance at a particular site, forest restoration can include a variety of silvicultural interventions to facilitate the survival and growth of existing seedlings and, where necessary, to restock depleted forests.

The silviculture of forest restoration can involve various methods and depends on the major products expected from a given stand. Generally, the following methods may be applied when multiple-use management, including timber production, is employed: guiding natural regeneration; refining; liberating; assisting regeneration by enrichment; and, in a more advanced stage, liberation and improvement thinning and integrated harvesting systems.

The management decision to initiate a forest restoration process must be based on a thorough and comprehensive analysis of the situation (see Table 5). A subsequent synthesis will allow the development of feasible and viable ecosystem management approaches. Under certain conditions, the magnitude of the change, such as in species loss, heavily damaged forest structure or topsoil erosion may be so great that forest restoration becomes too difficult to achieve even if the technical means are available. The risk of failure and cost of attempts to fully restore the original system might simply be too high. Natural processes are complex and often unpredictable. In some cases, social factors may also severely constrain forest restoration measures. Some land-users may be unwilling to agree to forest restoration because it is not a goal they share or because it might somehow lessen their rights to future use of the land.

Forest restoration can be a very cost-effective measure to regain the ecological and protective functions of a forest ecosystem. To do so, some prerequisites include: political support to make forest restoration an attractive undertaking; acceptance by and collaboration with those stakeholders directly concerned with the forest; a commitment that the forest will be kept within the legally defined permanent forest estate and protected from further disturbances; and economic security, because forest restoration will eventually need significant financial inputs before generating any substantial income. In order to lead to a desired outcome, forest restoration needs to be based on sound ecological and silvicultural knowledge.

Silviculture in degraded primary forests

Destructive logging practices in primary forests create a more heterogeneous, patchy structure (eg felling gaps, skid trails, etc), and the proliferation of undesirable 'weed' species (such as vines), making effective management expensive and difficult. The extraction pressure on a set of high-value species may cause a dysgenic trend (removal of large trees with each cut leaving genetically inferior trees for future crops and seed sources), further reducing management options. In general, silvicultural treatments are necessary to overcome the relative depletion of commercial tree species, to compensate for the slow growth rate and to ensure the future commercial timber value of the forest.

Before any silvicultural intervention is made, however, some key corrective measures or improvements need to be set in place in order to avert further degradation and provide a basis for

sustainable use. A comprehensive evaluation of the factors that created the present forest condition is usually a first step. This includes a field assessment of the exploitation practices and their consequences/impacts, a review of government concession agreements and/or agreements with the local population, etc.

The potential for timber production in a degraded primary forest will very much depend on the past intensity and quality of timber extraction, the advance growth of commercially valuable species, and their use and marketing prospects. A list should be prepared containing all species with current and potential commercial interest.

The advanced regeneration of current and potential commercial tree species is the most crucial target for interventions. Diagnostic sampling can be used to determine the stocking of potentially commercial regeneration, its silvicultural condition and the need for treatment. Liberation thinning and refinement can be used to reduce basal area to roughly 15 m^2/hectare. Other interventions that may be considered include cleaning operations to control vines and species such as bamboo or undergrowth palms or ferns, and soil treatments to provide substrate conditions for the establishment of seedlings of desired species.

Enrichment plantings may be used where they can be justified, such as when the natural regeneration of desired species is not adequate or when the objective is to introduce high-value species that do not regenerate easily (see Box 4).

Secondary forest management

In general, secondary forests are managed for multiple purposes. Options may include management for wood and non-wood forest products, the provision of environmental services in exchange for payments, or any combination of those products/benefits. The specific objectives will depend on the needs, interests and capacities (land, labour, capital, skills) of the farmer or landholder, the resource (eg the existence, density and size of economically valuable species) and external factors (such as markets for forest products and services, and policies and regulations).

Box 4: *Enrichment planting*

Enrichment planting has commonly been used for the restoration of logged primary forests and for increasing the wood volume and economic value of secondary forests. The experience with enrichment plantings in secondary forests has generally been more favourable than when applied in primary/logged-over forests.

The success of enrichment plantings has been variable and its efficacy questioned and the use of this silvicultural option has declined in the tropics. Some of the reasons cited in Southeast Asia are: planting work is difficult to supervise; seedlings have to be regularly released from regrowth; a regular supply of seedlings is needed; and it is costly (labour-demanding). In general, failures are attributed mainly to the poor selection of species and/or the lack of adherence to sound planting and tending practices. In tropical America, the poor reputation and expensive failures associated with enrichment planting are largely attributable to the improper selection of planting stock, insufficient overstorey opening prior to planting, insufficient follow-up tending, and pest attack.

There are, however, biological, environmental and economic arguments in favour of enrichment planting. When compared to other artificial regeneration systems, enrichment planting has the advantages of mimicking natural gap dynamics and protecting the soil by maintaining vegetation on site. Necessary conditions for successful enrichment planting include the provision of adequate light conditions, proper supervision, and follow-up maintenance (especially canopy-opening treatments).

Important silvicultural characteristics for species ideal for enrichment planting include:

- produce timbers of high value
- regular flowering and fruiting
- rapid height growth
- good natural stem form
- low crown diameter
- wide ecological amplitudes
- tolerance to moisture stress
- free of pests and diseases.

Secondary forest can be managed directly for a sustained yield without the need for specific measures to restore or rehabilitate. This is particularly the case in intermediate to late successional stages of secondary forests where a desired species or group of species dominates the forest. Examples include: i) for timber production: balsa (*Ochroma lagopus*) stands in Latin America and okoume (*Aucoumea klaineana*)-dominated secondary forests in Gabon; ii) for non-wood forest products: secondary forest rich in bamboo and/or rattan, particularly in Southeast Asia, Indochina and tropical America; and locally, throughout the tropics, secondary forests rich in species with edible fruits and roots and stems (eg *Garcinia*-rich secondary forests in Southeast Asia, palm-rich secondary forest stands in tropical America, etc). The management challenge in these forests is to maintain a certain species composition and structure in the long term and to guarantee the regeneration of the desired species.

Important prerequisites for sustainable secondary forest management are social acceptance, adequate policies and the recognition of the economic and ecological values of the secondary stand.

Silviculture of secondary forests

Managed secondary forests are often able to provide diverse products and services of social and economic importance. Box 5 illustrates the relative ecological advantage of secondary forests as a production system. However, the high variability by age, floristic composition and geographical distribution of secondary forests influences this potential and makes it difficult to define general principles for management.

The age and composition of the forest need to be taken into account in planning, as do the history of the site, the local conditions, and the aim of management. Given that secondary forests may be located on the land of smallholders, the role of this resource in farm production systems and the factors that underlie decision-making by farmers must be understood. Socioeconomic surveys are needed to provide information on the roles and expectations of landowners and/or forest users and communities in regard to the forestry component of farm production and to identify possible options for secondary forest management.

The management strategy will vary from field to field and farm to farm, depending on the resources available (land, labour, capital), biophysical characteristics, markets, opportunity costs, etc. Fallow vegetation managed as part of shifting cultivation systems will require techniques that allow short fallow periods without compromising agricultural productivity. For instance, the incorporation of 'regenerative' species such as leguminous woody species will contribute towards a more rapid recovery of soil nutrients during the fallow period.

When managed as part of the farming system to generate forest products for subsistence or sale, silvicultural practices that favour the establishment and optimal growth of locally desired tree species should be promoted. This can be done through the seeding or planting of target species during the crop phase of the agricultural cycle ('taungya'), followed by tending and weeding as tree crops develop. Some characteristics of species easy to manage under these conditions include: resprouting capacity (after fire and cutting); compatibility with the agricultural cycle (eg peak of seed dispersal just before, or during, crop establishment); short production cycles (capable of producing a marketable product within the fallow period); and tolerance of shade in plants other than trees. A list of possible species is presented in Table 8 of Annex 3.

In a management regime aimed at the sustainable production of wood and/or non-wood forest products (Box 6), landowners and/or forest users will probably have to take land out of the crop-fallow cycle, intensify agriculture, or use areas of low productivity for farming. In any case, the change in land-use must generate a benefit that is greater than that received in an alternative use of the land. The multiple-use of many species growing in secondary forests is perhaps the most important feature to take into account for management purposes (eg medicinal plants, edible fruits, firewood, and wood for rural construction and handicrafts).

The silvicultural treatments used to stimulate the production of commercial timber species in tropical primary forests, such as liberation thinning and refining, may also be applicable in

secondary forests. Experience has shown that young secondary forests are more receptive to silvicultural manipulations because of their manageable tree size and rapid growth response. This also applies to enrichment plantings, as enrichment requires canopy manipulation in order to optimise the growth and survival of planted trees. Generally, experiences with enrichment planting when applied in young secondary forests have yielded promising results.

Box 5: *Secondary forests as production systems*

Secondary forests share a number of ecological characteristics that tend to favour their management in production systems. These include:

- the existence of natural regeneration;
- relatively uniform species composition and uniform species temperament (strongly light-demanding);
- greater homogeneity in age and size (applicable to young secondary forests);
- rapid tree growth (initially, but tree increment decreases with age); and
- a relatively large number of species with similar wood characteristics.

On the other hand, due to the diverse causative factors in the formation of secondary forest and the complex biophysical and socioeconomic interactions, such forests also present many ecological characteristics that challenge their sustainable use and management. These include:

- factors such as past land-use, the proximity to seed sources and the stage of successional development generate a high between-stand variability of productivity and species composition, which may complicate forest management;
- the regeneration of valuable, primary-forest timber species can be endangered in fragmented landscapes due to depleted seed sources and the absence of animal and avian pollinators and seed dispersers;
- the dominance of seed banks and seed rains by herbaceous, shrub and climber seeds is a common phenomenon in forest stands surrounded by agriculture, pasture or early successional vegetation, making interventions more labour-demanding and costly;
- the low-density woods of the pioneer trees which dominate secondary forests are susceptible to rapid fungal attack after cutting; and
- the fact that secondary forest comprises approximately-even-aged vegetation arising on agricultural or pastoral land means that the time elapsed until marketable products can be obtained from it may be relatively long.

When high timber productivity is a main objective, a monocyclic system that relies on creating an even-aged stand by opening the middle and upper canopies shortly before tree harvesting is perhaps the most appropriate. This strategy is indicated for pioneer/light-demanding species that require almost complete canopy removal either for stimulating seed germination or for sustaining seedling growth and survival. In any case, the ability to compete financially with timber plantations has to be taken into account when this silvicultural management option is considered.

Rehabilitation of degraded forest land

The rehabilitation of degraded forest land is required at sites where mismanagement has led to the total replacement of forest ecosystems by grassland, bushland or barren soil. Characteristics of degraded forest lands include low soil fertility and poor soil structure (soil compaction, waterlogging, salinization or other physical and chemical limitations), soil erosion, recurrent fire and increased susceptibility to fire, the absence of fungal or root symbionts, a lack of suitable micro-habitants for seed germination and establishment, and severe competition with other plant forms, especially grasses and ferns. The rehabilitation of such degraded land aims to re-establish the production and protection functions of a forest or woodland ecosystem.

The first consideration in attempting any recovery of degraded forest land is to understand the processes and underlying causes leading to degradation (the 'stress' factors) and then to try to remove or correct them. Since the causes of degradation often involve socioeconomic factors, local

needs and the value systems of local actors need to be considered. The nature of tenure and access rights to resources by different sectors of society will also be important.

The rehabilitation of degraded forest land can be done by facilitating natural regeneration through measures such as protection from chronic disturbance, site stabilization or water management. Ecological stability may be regained more rapidly through the planting of nurse or framework species that help to provide basic protective functions.

Silviculture on degraded forest land

The decision on what to do about degraded forest lands and which strategies or approaches to adopt (Box 6) is necessarily guided by the ecological, social, cultural, economic and institutional context. Initial efforts should focus on strategies for facilitating succession rather than trying to either plant or seed a wide variety of species. In this regard, one possible option for degraded forest lands is to allow the ecosystem to recover naturally (depending on the ecology and disturbance history of the area). In many situations, however, the high pressure on land by an increasing population may mean that this approach is not viable. Alternative approaches for ecosystem rehabilitation aim to facilitate, accelerate and direct natural successional processes so as to increase biological productivity, reduce rates of soil erosion, increase soil fertility (including soil organic matter), and increase biotic control over biogeochemical fluxes within the recovering ecosystem.

Attempts to plant trees to accelerate regeneration or influence its direction should be based on a thorough understanding of the likely pathways of regeneration without interventions. For this it will be important to establish plots to determine how the vegetation will recover without significant management interventions.

There are several strategies for accelerating recovery. The planting of native tree seedlings is most commonly used. Others include the planting of native and non-native tree seedlings as nurse trees or framework trees, the retention of remnant trees, the planting of patches of trees and seeding shrubs, etc.

The choice of plantation species can influence both the rate and trajectory of rehabilitation processes. The species to be used should have a traditional economic value or be suitable for existing or potential markets. Multi-purpose trees may have an especially important role for local communities. In addition, these species should tolerate unfavourable conditions, and they should be easy to raise in large numbers in nurseries, fast-growing, and able to shade out grasses or other unwanted plant species. Species capable of coppicing and soil improvement (ie organic matter development, nitrogen fixation, etc), tolerant of heavy pruning or pollarding, and resistant to fire, pests and diseases are all to be preferred.

In some highly degraded sites a nurse crop might be necessary to improve the site so that target species can become established (for example, by shading out weeds, fixing nitrogen, improving soil organic matter or changing the microclimate to prevent insect attack and facilitate natural regeneration). An alternative to using temporary mixtures such as target trees beneath a short-lived nurse crop might be to use permanent plantation mixtures.

Prioritizing restoration, management and rehabilitation within tropical landscapes

Many modified and degraded tropical landscapes do not possess the critical complement of forest goods and services that are necessary to sustain rural livelihoods and ecosystem integrity; well-targeted restoration, management and rehabilitation activities can make a significant contribution to addressing such deficits. However, not all site-based actions are capable of making the same contribution to improving the functionality of the degraded tropical landscape.

The selection of priority areas in which to promote forest restoration, secondary forest management and the rehabilitation of degraded forest land, as well as the configuration of restored and rehabilitated forest resources, will depend on the broad social and ecological context that exists within the landscape. For example:

a) where the opportunity exists to improve landscape-level biodiversity, activities should target those sites within and between protected areas or other forests of high conservation value, such as habitats of endangered, vulnerable or rare species, relatively undisturbed forest remnants, etc;

b) where degradation has brought about failures in ecosystem functioning, activities should be targeted along riparian strips, steep slopes, field boundaries, etc; and

c) where the opportunity exists to enhance human well-being, and in particular to support income-generating activities, priority areas should be those sites that are suited to the production of high-value species and are close to existing infrastructure.

In reality, any one landscape will provide a range of opportunities and challenges. Policy-makers, resource managers, civil society organizations and local communities will need to ensure that the benefits of restoration, management and rehabilitation are realised at the landscape scale and are not only limited to producing immediate site-level benefits.

Box 6: *Strategies for accelerating the rehabilitation of degraded forest lands*

- *Planting native tree seedlings*: the most commonly used strategy for accelerating tropical forest succession is planting seedlings of a few native tree species that are fast-growing, drought resistant, and able to grow in low-nutrient soils. Direct seeding may be a viable option, but weed invasion and predation rates are often sufficiently high to preclude this option.
- *Planting non-native tree seedlings as nurse trees*: tree plantations may help to shade out aggressive pasture grasses, increase nutrient levels and enhance seed dispersal while also providing a source of income to landowners. The use of non-native trees as nurse species should be considered carefully with regards to their aggressiveness, and their potential to spread and to alter soil chemistry.
- *Remnant trees and planting patches of trees*: remnant trees play a critical role in natural forest recovery by increasing seed dispersal, ameliorating microclimatic conditions, and increasing soil nutrients. Leaving some seed trees in areas that are logged and planting or maintaining trees in agricultural lands should be encouraged both to improve the quality of the habitat while the land is used for agriculture and to facilitate recovery if the land is abandoned. The importance of isolated trees and patches of trees for facilitating seed dispersal and seedling establishment suggests that planting patches of trees may be a cost-efficient method of facilitating recovery. It may also provide a level of spatial diversity characteristic of the ecosystem.
- *Seeding shrubs*: naturally colonizing shrubs may play a critical role in improving adverse conditions and aiding succession in abandoned tropical pastures. Seeding early-successional shrubs may be an inexpensive strategy to accelerate recovery in regions where shrubs facilitate tree seedling establishment; unlike most tree species, many shrubs produce copious, easily-collected seeds all year round (eg *Lantana spp., Solanum spp., Grevillea banksii,* etc). Care is required, as these species can easily become dominant and can hamper the establishment of other desired species. It is better to avoid introducing seeding shrubs that have little socioeconomic value.
- *Clearing existing vegetation*: establishing vegetation that shades out grasses has generally proven to be the most economically and ecologically effective strategy. The initial clearing of vegetation to facilitate establishment during the first year of seedling growth may be important. This is effective only if followed by other silvicultural treatments (planting or direct seeding).
- *Fire prevention*: an essential component of any tropical forest restoration effort in areas with extended dry seasons is fire prevention. This can be done by patrolling areas susceptible to burns and educating landowners on the risk of burning at dry times of the year.

4 Principles and recommended actions

The restoration, management and rehabilitation of degraded and secondary forests are important challenges in tropical forestry as we begin the new millennium. With most of the primary forests gone in many tropical countries, degraded and secondary forests are becoming a major part of many rural landscapes and their importance in the supply of goods and services is growing rapidly. It is in these forests that stakeholders should strive for an acceptable balance between the three basic parameters of sustainability:

- a yield of goods and services that is ecologically and economically sustainable;
- broad social satisfaction and human well-being, especially among those people who depend on forest resources for their livelihoods; and
- a high level of environmental quality at all levels: local, national and global.

A fundamental problem in trying to achieve this balance is the question of change over time. Communities evolve – in numbers, skills, aspirations and expectations. Markets change and fluctuate in response to intrinsic dynamics and changing human values and demands. However, the restoration of degraded forest ecosystems is a long-term enterprise. The social and economic conditions that exist when a forest crop is harvested are seldom the same as those prevailing when a tree seedling first takes root, nor do the priorities of individuals remain the same. Strategies for the restoration, management and rehabilitation of degraded and secondary forests must adopt a long-term perspective, anticipating, as far as possible, future trends. But they must also be flexible and capable of adaptation to changing circumstances.

The principles and recommended actions presented here are based on this rationale. They stress that the policy, legal and social conditions, and the formal problems and risks, must be analyzed before restoration, secondary forest management and rehabilitation activities are decided on and implemented.

The principles and recommended actions are divided into two sections:

- **Section I: Policy, planning and management principles and recommended actions**
  In this section, seven main objectives for the restoration, management and rehabilitation of degraded and secondary forests are defined. Under each main objective, a number of principles, and under each principle a number of recommended actions, are listed. Section I comprises a total of 31 principles and 105 actions.
- **Section II: Stand-level principles and recommended actions**
  Eighteen principles and 55 actions are listed under a specific objective concerned with the restoration of degraded forests, the management of secondary forests and the rehabilitation of degraded forest lands at the site level.

The eight main objectives for the restoration, management and rehabilitation of degraded and secondary forests are:

I Attain commitment to the management and restoration of degraded and secondary forest landscapes

II Formulate and implement supportive policies and appropriate legal frameworks

III Empower local people and ensure the equitable sharing of costs and benefits

IV Employ integrated approaches to resource assessment, planning and management

V Take an adaptive and holistic approach to forest management, emphasizing environmental and social values

VI Promote economic efficiency and financial viability

VII Guarantee participatory monitoring and evaluation as a basis for adaptive management

VIII Utilize appropriate ecological and silvicultural knowledge and efficient management practices.

Section I of this chapter addresses in particular the following major target groups:

- public policy-makers, such as government agencies dealing with rural landscapes (departments of forestry, planning and finance) and development and extension agencies; and
- civil society, NGOs and private and communal extension agencies.

Section II addresses the following major target groups:

- civil society, NGOs and private and communal extension agencies;
- forest practitioners, extension agents and others working at a site level; and
- education, training and research institutions.

Section I: Policy, planning and management principles and recommended actions

I Attain commitment to the management and restoration of degraded and secondary forests

Greater awareness of the current and potential value of degraded and secondary forests and their important roles in the rural landscape and in rural livelihoods is required. Improved information, communication and collaboration among policy-makers and stakeholders can build consensus and support for local, national and international initiatives to more effectively manage these lands for the benefit of present and future generations.

Principle 1: Landscape context	**Recommended actions 1–3**
Degraded and secondary forests are an integral part of land-use systems. Degraded and secondary forests need to be seen as integral parts of the rural tropical landscape that are affected by off-site conditions. Restored primary forests, managed secondary forests and rehabilitated forests lands can provide numerous benefits and services to society; they fulfill productive and protective functions and need full recognition as an important land-use element. Within any given landscape, some degraded primary forests and secondary forests may need to be converted to other uses, but such conversion should be part of an overall land-use plan that optimizes the allocation of land within the landscape.	1) Incorporate degraded and secondary forests into land-use planning at the micro and macro scales. 2) Establish integrated land-use plans that reflect an appropriate balance between conservation, production and sustainable livelihood needs from forests. 3) Explore options for restoration and rehabilitation before allocating degraded and secondary forests to non-forest uses.

Principle 2: Livelihoods concerns	***Recommended actions 4–5***
Degraded and secondary forests make valuable contributions to rural livelihoods, particularly those of the poor. The value of degraded and secondary forests for all those people who depend directly or indirectly on forest resources for their livelihoods needs to be documented and formally recognized. The inadequate participation of local stakeholders in policy processes and an inadequate consideration of local needs, site conditions and land-use practices may result in degradation and the inappropriate conversion of degraded primary forests and secondary forests.	4) Emphasize recommendations for the management of degraded and secondary forests in national forest policy and legislation. 5) Give priority to the interests and knowledge of local stakeholders when managing degraded and secondary forests and adapt management strategies to local socio-cultural and economic conditions.

Principle 3: Information/communication	*Recommended actions 6–8*
Quality information, communication and networking promote collaboration and validate commitment to the management of degraded and secondary forest. Managing, restoring or rehabilitating a forest ecosystem requires the changing of people's perceptions, attitudes and behaviours. Unless the affected people and user groups appreciate the reasons for change and the benefits they will derive from this, they will have little motivation to do so. The lack of adequate data, knowledge and expertise on the ecological, socioeconomic, silvicultural and institutional dimensions of secondary forests affects and influences people's perceptions of the resource, masks its importance and potential, and often results in poor management, resource degradation and inappropriate conversion.	6) Develop awareness regarding the characteristics and importance of, and management options for, degraded and secondary forests at the local, national and international levels. 7) Foster national and local working groups involving the various stakeholders and encourage other forms of networking to share experiences and develop ideas and actions for the management of degraded and secondary forests. 8) Devise/adapt communication tools to match the message, the medium used and the target group.

II Formulate and implement supportive policies and appropriate legal frameworks

The flow of goods and services from degraded and secondary forests can be enhanced through supportive actions taken by policy-makers. Effective forest governance, including improved institutional capacity, can create conditions that enable stakeholders to take advantage of opportunities to better manage the forests and to minimize conflicts that lead to resource degradation. Issues related to land tenure, access and the use of forests must be resolved before effective management can be undertaken.

Principle 4: Governance	**Recommended actions 9–12**
The restoration, management and rehabilitation of degraded and secondary forests can only succeed if forest governance is effective. Effective forest governance is a necessary framework condition for restoring and managing forests and for the sustainable management of forests as a whole. This implies national policies and legal measures, appropriate economic governance and incentives and appropriate institutional frameworks. Adequate policies focusing on degraded and secondary forests at the local, national and international levels need to be developed. This principle is a prerequisite to promote the sustainable management and use of secondary forests and degraded natural forests and to prevent further degradation and inappropriate conversion to other land-uses.	9) Develop and apply procedures to ensure transparency, disclosure and accountability at all levels of public administration in decisions that relate to the management and use of degraded forest landscapes. 10) Where appropriate, recognize degraded primary forests, secondary forests and rehabilitated forest land as legitimate land-use types. 11) Establish effective institutional frameworks and regulatory mechanisms for resource security and the restoration, management and rehabilitation of degraded and secondary forests. 12) Develop incentives and sanctions to ensure that forest restoration, management and rehabilitation is sustainable and locally appropriate.

Principle 5: Property and access rights	**Recommended actions 13–16**
Secure land tenure, land-user access, customary rights and property rights are fundamental to the restoration, management and rehabilitation of degraded and secondary forests. Clear land tenure and property rights to enable the sustainable management and use of degraded and secondary forests need to be in place in order to prevent further degradation and inappropriate conversion to other land-uses. In many cases, degraded forests have overlapping tenure claims involving the state, the private sector and local communities. As a result, conflicts over access rights are common, often resulting in unsustainable use and further degradation of the resource.	13) Clarify and legitimize equitable tenure, access, use and other customary rights in degraded and secondary forests among national and local stakeholders. 14) Strengthen the rights of forest dwellers and indigenous people. 15) Establish a transparent mechanism for conflict resolution where property and access rights are not clear. 16) Provide incentives for stabilizing colonists/farmers in agricultural frontier zones.

Principle 6: Public institutions	Recommended actions 17–21
Public administrations responsible for forests and other natural resources require the capacity to deal with the restoration, management and rehabilitation of degraded and secondary forests. Extensive bodies of information and knowledge are available on the restoration and management of degraded and secondary forests but in many cases this information remains inaccessible to practitioners. There is a need to clearly define units within national forest services that specialize in these areas. These units should become centres of excellence that cooperate and coordinate activities with all concerned stakeholders in an open and transparent way. Concise guidelines, adapted to local conditions, can provide the framework for the development of operational programs in forestry practice.	17) Develop national guidelines for the restoration of degraded primary forests, the management of secondary forests and the rehabilitation of degraded forest lands. 18) Include forest restoration, the management of secondary forests and the rehabilitation of degraded forest lands in national forest programs or in other relevant national plans, programs and action plans. 19) Facilitate access to information and organize training for all interested stakeholders on the aims, objectives, methods and activities related to the restoration and management of degraded forest landscapes. 20) Promote interagency collaboration for the restoration, management and rehabilitation of degraded and secondary forests. 21) Reconcile policies that impact on the restoration, management and rehabilitation of degraded and secondary forests across all sectors.

Principle 7: Decentralization	Recommended actions 22–23
Decentralized control and decision-making provides the conditions for restoring, managing and rehabilitating degraded and secondary forests at the local level. Present policies and possible changes to extra-sectoral policies (eg agriculture, land-use planning, transport) influence the use and management of degraded and secondary forests at the farm and community levels. Incentives for stabilizing colonists/farmers in agricultural frontier zones are important instruments that need to be further explored and used in the framework of the management of degraded and secondary forests.	22) Devolve responsibility and accountability to local management institutions (including both governmental and civil society organizations) for restoring, managing and rehabilitating degraded and secondary forests. 23) Empower decentralized institutions to restore, manage and rehabilitate degraded and secondary forests and provide adequate resources.

III Empower local people and ensure the equitable sharing of costs and benefits

Stakeholder participation and collaboration is essential for the effective long-term restoration and management of degraded and secondary forests. In developing management approaches, the diverse requirements, values and perspectives of relevant stakeholders need to be harmonized and their knowledge and experience utilized to the greatest extent possible. The environmental, social and economic costs and benefits associated with the management of these resources should be shared equitably and should contribute to a reduction in rural poverty.

Principle 8: Stakeholder participation	Recommended actions 24–27
Local communities and stakeholders actively participate in and share the responsibility for decision-making in planning and implementing restoration, management and rehabilitation strategies. To be effective and to produce sustainable results, the restoration, management and rehabilitation of degraded and secondary forests need to be understood and supported by all concerned stakeholders. Forest restoration and rehabilitation can only be sustainable in the long term if they are socially acceptable. The principal stakeholders (forest owners, local communities, concessionaires, forest authorities) need to reach agreement on an equitable distribution of incentives, costs and benefits. Conflicts are inevitable in decisions over the strategies to be implemented in areas designated as multiple-use.	24) Identify all local stakeholders and facilitate consultations for decision-making and planning at a landscape level. 25) Create opportunities for the economic empowerment of all forest-dependent local stakeholders. 26) Explore options for collaborative management between local and national stakeholders. 27) Identify areas of conflict, and develop common approaches to deal with them.

Principle 9: Social equity	Recommended actions 28–30
Market and non-market costs and benefits need to be shared by all stakeholders. Policy decisions need to be based on a full benefit/cost assessment and identified transfer payment mechanisms for forest products and services. The inadequate assessment and sharing of costs and benefits related to the management and use of degraded forest landscapes could result in resource degradation and inappropriate conversion. Local communities are entitled to a share of both the market and non-market benefits arising from restoration, management and rehabilitation activities on their land, and, equally, they are entitled to compensation for any third-party restoration, management or rehabilitation activity that negatively affects them.	28) Analyze and quantify the costs and benefits associated with the management and restoration of degraded and secondary forests. Determine beneficiaries and environmental and economic costs and benefits (including hidden and long-term costs and benefits). 29) Seek the equitable sharing of costs and benefits in the management and restoration of degraded and secondary forests through national and international transfer payment mechanisms. 30) Create mechanisms and adopt 'polluter pays' principles to the distribution of costs and benefits.

Principle 10: Traditional knowledge	Recommended actions 31–32
Local and indigenous knowledge is a valuable resource that should be given equal weight to other knowledge systems. Local stakeholders possess considerable knowledge about the management and use of tropical primary and secondary forests. This must be taken into account in the management and restoration of degraded forests.	31) Ensure that the values stemming from the relationship between people and their natural resources are sustained and enhanced. 32) Ensure that the restoration, management and rehabilitation of degraded and secondary forests build on the body of knowledge held by local stakeholders, including indigenous communities and farmers.

IV Employ integrated approaches to resource assessment, planning and management

A thorough assessment and evaluation of the socioeconomic and ecological context at the rural landscape level greatly facilitates the formulation of strategies for the restoration, management and rehabilitation of degraded and secondary forests and degraded forest lands. A participatory planning approach at the landscape scale involving all relevant stakeholders will help to minimize conflicts and risks and to optimize the environmental, social and economic benefits of forest management.

Principle 11: Land-use options	Recommended actions 33–37
The appropriate land-use option for a given site needs to be chosen carefully. Incentive schemes to promote the restoration, management and rehabilitation of degraded and secondary forests should prioritize those sites where both local and landscape-level benefits can accrue. At the level of land-use planning, clear decisions need to be taken on which forest areas will be used for agricultural production in the short and long terms and which will be devoted to conservation, the sustainable production of forest goods and services, or forest restoration. It is important to avoid investments in forest restoration and rehabilitation if no guarantee can be given that the land will remain under permanent forest cover.	33) Clearly identify the site location (eg through the delineation of boundaries) and clarify ownership and/ or tenure rights and possible user rights. 34) Assess the area, distribution and functionality of degraded forest landscapes. 35) Through discussions with local people and site inspections, identify the reasons why management, restoration or rehabilitation is needed and the general strategies to be employed. 36) Integrate planning work related to degraded forest landscapes in an overall rural landscape planning approach. Prepare benefit/cost and risk analyses of different land-use options in degraded forest landscapes, taking into account local, regional, national and possibly international concerns. 37) If a decision is taken that the degraded forest landscape should remain or be established as permanent forest estate, work with all stakeholders involved to define an adequate management strategy (restoration, secondary forest management, rehabilitation, etc).

Principle 12: Environmental assessment	Recommended actions 38–41
The initial environmental conditions, particularly the stress and risk factors present in landscapes containing degraded and secondary forest, must be assessed. The feasibility of forest restoration and the rehabilitation of degraded forest land depend on the extent and nature of the existing environmental and socioeconomic stresses. Sites with a strong seasonal climate, low soil fertility and other environmental stresses are likely to be more difficult to restore than those that have more benign conditions. Frequent periodic but unpredictable stresses and strains (eg fires, droughts), episodic climatic anomalies, and the potential for long-term global climate change, may make restoration goals elusive. The evaluation and measurement of success or failure depends in part on being able to contrast the site before and after any of the three management strategies have been applied.	38) Determine the specific physical and environmental risk and stress factors for the area that is being restored or rehabilitated or managed as secondary forest. To do so, assess and monitor the physical site conditions (eg soil, water regime, climatic conditions). 39) Analyze outcomes and assess whether the effects of these stress factors will allow a socially and economically feasible approach to forest restoration, secondary forest management or site rehabilitation. 40) Determine if stress factors may be affected by climate change. If so, assess the feasibility of undertaking restoration and rehabilitation activities under a mechanism proposed within the UNFCCC, and in particular within the framework of climate change adaptation programs. 41) Document the baseline situation through adequate ground photographs, aerial photographs, or satellite imagery. To the extent possible, document the site history that led to the need for restoration or rehabilitation.

Principle 13: Multiple-use	Recommended actions 42–46
Degraded and secondary forests need to be managed under an adaptive and multiple-use management approach. Degraded forest landscapes should be managed under the general principle of multiple-use management in order to derive maximum benefits from the resource. Planning needs to consider a dual purpose: on the one hand, management should boost the productivity of specified forest products; on the other, it should restore the protective functions of forest and soils. The restoration of degraded primary forests for timber alone is not a valid option in most cases because forests are accessible to a variety of stakeholders, or they are fragmented, making the single purpose of timber production unsustainable. Management plans need to be precise, simple, clearly understandable by all parties, accessible to all interested parties and cost-effective in their implementation. The management plan should be based on an adequate characterization of the social, cultural, economic and biophysical context in order to identify and describe the scenarios, the actors and their perceptions, and the potentialities and needs. Management plans should be adapted to each forest condition and should include descriptions of the main biophysical and socioeconomic issues.	42) Evaluate prospects for forest products and payments for services. This includes assessing the feasibility of producing high-value timber, timber and firewood for industries, non-wood forest products for local needs and markets, etc. 43) Assess watershed protection, biodiversity conservation and carbon sequestration and storage capacities and the possibility of payments at the national and international levels for such services. 44) Reach agreement between stakeholders on the main purpose(s) of forest management after a thorough evaluation of all existing options from ecological, economic and social viewpoints. 45) Based on the results of a participative planning process, elaborate simple management plans for degraded forest landscapes. Such management plans include: mapping; identifying tenure and ownership arrangements; establishing a typology of forest conditions; developing a management strategy for each forest condition; and establishing a monitoring framework. Clearly indicate who is responsible for the implementation of different tasks. Formal arrangements for coordination should be stated in the management plan, including descriptions of and purposes for planning meetings, reporting, review of results, and so on. 46) Consult and validate such a plan with all concerned stakeholders at the local, regional and national levels.

V Take an adaptive and holistic approach to forest management, emphasizing environmental and social values

The success of strategies developed to restore degraded primary forests, improve the management of secondary forests and rehabilitate degraded forest lands requires a holistic perspective that integrates social and environmental values and the goals of relevant stakeholders. An adaptive management approach is required that recognizes environmental and socioeconomic limitations, fully utilizes the self-recovery potential of secondary and degraded forests, and understands the uncertainty often associated with forest restoration, rehabilitation and management as well as the changing needs and aspirations of landowners and rural communities. Such an approach can help to reduce risks and enhance the environmental, economic and social goods and services derived from management at the local and rural landscape levels.

Principle 14: Adaptive management	**Recommended actions 47–49**
Adaptive management approaches minimize the ecological and socioeconomic risks associated with degraded and secondary forest management. Considerable ecological and silvicultural knowledge exists to guide secondary and degraded forest management. However, the response of the forest cannot always be predicted. In addition, stakeholder objectives and needs may change over time. To overcome potential risks and respond to changes in priorities, a flexible or adaptive management approach is required. Information derived from the periodic monitoring of the ecological and socioeconomic effects of degraded and secondary forest management should be used to evaluate success and to indicate possible changes in management interventions in order to attain the desired outcomes.	47) Develop and apply effective ecological, silvicultural and socioeconomic monitoring. 48) Periodically assess and review management plans with the participation of relevant stakeholders. 49) Promote applied and participatory research to extend and communicate knowledge and experiences on all aspects of forest restoration, secondary forest management and the rehabilitation of degraded forest lands.

Principle 15: Socioeconomic objectives	**Recommended actions 50–54**
Management goals for degraded and secondary forests are based on socioeconomic objectives and cultural values. The primary objective of forest restoration and management is to regain the ecological robustness and health the forests possessed before degradation and therefore to guarantee that the forest ecosystem can evolve naturally over longer time spans and adapt itself to changing environmental conditions. However, forest restoration needs to be perceived from a socioeconomic viewpoint in order to make it attractive. If degraded and secondary forests are to be managed productively, stakeholders must receive benefits exceeding those from alternative land-uses. The development of management strategies for secondary forests requires an understanding of the role of secondary forests in farmer production systems and in the factors that underlie decision-making by farmers with respect to secondary forests. Whatever its main purpose, forest restoration should aim at optimizing not only a single function but also the overall performance and health of the forest ecosystem.	50) Define jointly with all concerned stakeholders the main restoration goal and subsequent secondary objectives. 51) With the participation of interested stakeholders prepare a simple forest restoration plan for an initial period of at least ten years that sets out goals, restoration strategies, activities, inputs, outputs and a monitoring scheme. Emphasize the multiple-use approach, including the production of high-value timber, wood, non-wood forest products and environmental services. 52) Ensure that the forest restoration plan is consistent with the overall land-use policy applied in the area, and in particular that the area will be maintained as part of the permanent forest estate. 53) Based on soil and site surveys and mapping, determine areas and stands that are likely to grow into long-term secondary stands and that can be classified as permanent forest estate. 54) Assess the potential trade-offs between cropping, pastoralism and forest cover. Consider whether permanent secondary forests could be compatible with increases in the productivity of the agricultural system.

Principle 16: Causes of degradation	Recommended actions 55–58
The causes of degradation should be eliminated. The disturbances that led to degradation of the forest or forest land may have been caused either by a single heavy impact on the site in the past, or by repeated low-level disturbances. In the latter case, it is important to make sure that these forces have ceased to influence the site before any restoration or rehabilitation work is started. To be effective and successful, the assessment of and decisions regarding the elimination of the causes of degradation must be made in a participative manner, including particularly the local land-users.	55) Identify the local pressures that have caused degradation and determine whether they are still present. Assess the probability that they can be permanently neutralized or removed. 56) Determine the underlying causes of these pressures and the possibility of mitigating them. 57) If possible, remove the pressures and observe the natural responses of the-vegetation. This may be sufficient for the low-cost restoration or rehabilitation of the site. 58) If additional planting or other interventions become necessary, ensure that the area is protected against any degrading forces and that the interventions are suitable for both the natural site conditions and the management objectives of the site.

Principle 17: Forest and climate change	Recommended actions 59–61
Degraded and secondary forests can be managed to mitigate the effects of climate change. The management and restoration of degraded and secondary forests need to take into account both the effects forests have on climate change and the effects of climate change on forests. Degraded primary forests and secondary forests sequester, store and release carbon and affect changes in surface features (eg roughness, thermal and radiation balance, hydrological cycles). They also affect the micro- and meso-climates, and to some extent the macro-climate. Global warming may make tropical climates more variable and extreme events more frequent and intense. Forest ecosystems may therefore be expected to suffer increasingly from stress and damage.	59) Develop strategies and approaches to promote the role of degraded-forest restoration and secondary forest management for the international carbon trade, for carbon sequestration and as carbon sinks. 60) Assess the potential impacts of climate change on forest landscapes (including fire), and develop and/or integrate adaptation responses as appropriate. 61) Promote the management of secondary forests and the rehabilitation of degraded forest lands as eligible activities under 'afforestation', and the restoration of degraded primary forests as an eligible activity under 'reforestation' in the framework of the Clean Development Mechanism, which generates co-benefits for local stakeholders based on their identified needs.

Principle 18: Silvicultural analysis	Recommended actions 62–64
The management of degraded and secondary forests should be based on sound ecological and silvicultural analysis and knowledge. The residual stand of a degraded primary forest or a secondary forest needs to be carefully analyzed in order to make the appropriate silvicultural decisions and to reduce costs. Non-commercial tree species and shrubs may have important ecological functions, such as fostering the development of symbiotic relationships, improving soil cover and litter diversity and providing habitat for wildlife. Forest restoration should carefully balance the potential benefits of residual stands against the costs of possible competition effects.	62) Fully include local people in a sound analysis of the four basic silvicultural questions (see Table 5): - What are the present stand and site conditions? - What are the stand and site histories? - How would the site develop in the absence of planned management interventions? - What management strategies are needed to achieve a particular outcome? Base management strategy decisions on such analysis. 63) Manage natural regeneration and integrate spontaneous auxiliary vegetation into silvicultural practice rather than eliminating such vegetation. 64) Introduce auxiliary vegetation where ecological stability reasons require such action (eg to maintain and favour seed-dispersing animals in the area).

Principle 19: Natural succession	Recommended actions 65–68
Degraded and secondary forests should be rehabilitated and restored wherever possible by natural succession. Favouring and accelerating natural succession processes is in most cases the ecologically most natural and economically most feasible strategy for the restoration of degraded primary forests, the management of secondary forests and the rehabilitation of degraded forest land. If natural succession cannot achieve the target in a reasonable period of time, planting may be necessary.	65) Review the ecology of a given forest type and define particular research needs in plant ecology, dendrology and forest dynamics. 66) Determine key species (trees, herbs, animals and microbial species) that are essential for forest succession in a given area and design strategies to support them. 67) Undertake measures to ensure that key species will not be eliminated from the area. 68) Utilize advanced regeneration rootstocks and natural seed banks as starting points for management.

Principle 20: Landscape restrictions	Recommended actions 69–71
The restoration, management and rehabilitation of degraded and secondary forests can be subjected to environmental and economic constraints. Forest restoration should not be attempted in landscapes that can no longer support the kind of ecosystem designated for restoration or which will likely be compromised later by the effects of land-use both at the site and offsite. To the extent possible, future threats to the integrity of the restored forest should be minimized by adequate mechanisms, such as rural landscape zoning and/or agreements with land-users adjacent to the forest restoration sites.	69) Analyze general land-use patterns in the region and determine if and how these land-uses will affect the restoration site. Combine this analysis with a soil and site survey and vegetation mapping. 70) Ensure that the factors that have led to the degradation of the primary forest have been or can be managed to the extent that they no longer constitute major risks to the restoration process. 71) Prescribe forest restoration in general land-use plans in the area, and ensure (through, for example, binding commitments with neighbouring landowners) that future restoration sites will not be affected by offsite land-use.

Principle 21: Biological diversity	Recommended actions 72–74
Conserving and restoring biological diversity, including genetic resources, is a particular concern in all programs to restore, manage and rehabilitate degraded and secondary forests. Whatever the primary objective of forest restoration, management or rehabilitation, biological diversity and genetic resources need to be conserved. An underlying objective in each management strategy applied in degraded and secondary forests is to increase species richness and to build up a complex community structure. Species listed in nationally developed red lists, in international threatened species registers and inventories and in the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) list of endangered species need full protection and, where feasible, active management. This should be extended to all tree and plant species that occur with low frequency at the landscape scale.	72) Wherever possible, create corridors between fragmented forest stands for wildlife and seed dispersal. 73) Conduct field surveys in secondary vegetation to collect information on plant community structure and floristics, seed sources and seed dispersal agents. 74) Gather information related to the reproductive cycle (ecology of pollination, fructification, seed dispersion, germination, and survival, and seedling and sapling growth) of colonizing species.

Principle 22: Local benefits from biodiversity conservation	Recommended actions 75–79
Ensuring that the benefits of biological diversity accrue to local people will favour the long-term success of restoration, management and rehabilitation programs. Agreements with local land-users are essential for the restoration, protection and conservation of degraded and secondary forests, particularly in areas where the forests are fragmented. Auto-control by local stakeholders is necessary with respect to the hunting, capture and collection of fauna and flora and the exploitation of wood and non-wood forest products. In order to achieve the effective protection of fauna and flora, collaborative arrangements between local and national stakeholders need to be established and maintained.	75) Make agreements with local land-users to conserve and protect small and fragmented natural forest areas. 76) Facilitate auto-control by local stakeholders with respect to the hunting, capture and collection of fauna and flora species that occur in managed and restored forest areas. 77) Empower local communities as natural resource wardens with full responsibility and competence to conserve and protect biodiversity and genetic resources. 78) Create partnerships with relevant national and local organizations that can help the implementers of forest restoration activities to recognize endangered species and to take adequate action. Examine the possibility of passing responsibility for enforcing national law to local communities. 79) Where feasible, develop a program and introduce incentives to promote the restoration and rehabilitation of endangered forest flora and fauna species.

Principle 23: Low-impact harvesting	Recommended actions 80–81
The harvesting and utilization of forest goods and services from degraded and secondary forests should be regulated to ensure that further degradation does not occur. A basic principle of sustainable forest management is that the harvesting of wood and non-wood forest products must not lead to further degradation of forest stands and site conditions. The traditional rights of local people to collect and utilize biological resources from the forest, where this is on a sustainable basis and does not lead to threats of species extinctions, must be respected and allowed. A quota system may be necessary to ensure that over-harvesting does not take place. The quota for each species should be set at a level likely to be sustainable and monitored carefully. Particular attention needs to be given to sustainable hunting.	80) Establish harvesting prescriptions for all forest products. Restrictions should be placed on the number or size of individual tree species and on other plant and also animal species to be harvested. 81) Carry out periodic surveys of the target species in areas under harvesting permits, including in areas where harvesting is not authorized, to monitor compliance with regulations. Give special attention to local hunting, wild animal capture and the commercialization of bushmeat.

Principle 24: Soil fertility	Recommended actions 82–83
Soil characteristics need to be maintained and improved to guarantee efficient stand restoration and rehabilitation. Soil biological, physical and chemical characteristics need to be assessed, restored and maintained over time to ensure the adequate regeneration of desired tree species and to maximize related environmental services. Together with litter supply and humus formation, the interaction of soil porosity and texture with other physical conditions is a most important factor affecting the fertility and biological activity of tropical soils.	82) Use appropriate soil conservation practices and careful planning to establish a desired soil environment for natural tree regeneration and growth and the development of biological diversity. 83) Consider the downstream effects of soil management and the collateral benefits of soil conservation in degraded and secondary forests.

VI Promote economic efficiency and financial viability

Management strategies for degraded primary forests, secondary forests and degraded forest lands must ensure a steady flow of economic and social benefits to stakeholders whose livelihoods depend on these lands. Markets or other mechanisms that enable stakeholders to capture these benefits may need to be developed. Governments and other funding sources should consider the provision of financial resources to stakeholders and supportive agencies and organizations for the promotion, development and implementation of forest restoration and management as an investment that will enhance the medium- and long-term capacity of the land to provide a range of local, national and international environmental and socioeconomic goods and services.

Principle 25: Economic viability	**Recommended actions 84–87**
Economic and financial viability is essential for the restoration, rehabilitation and management of degraded and secondary forests. Efforts to manage and restore secondary and degraded primary forests and rehabilitate degraded forest lands can only be sustainable if they are economically and financially viable. If the financial input to restore and rehabilitate is high and the return is unsure and in the distant future, investment will be difficult to justify. The most economically efficient method of resource management is to do as little damage as possible in the first place. That would allow sustainable resource management without needing additional inputs for restoration and rehabilitation.	84) Prepare benefit/cost analyses of the various management strategies applied to degraded and secondary forests, taking into account the full range of forest goods and services. 85) Explore opportunities for market-based incentives such as forest certification and transfer payment mechanisms for the environmental services provided by secondary forests. 86) Determine how to gain added value for the goods and services that degraded and secondary forests already provide. These may include: developing alternative sources of income for the rural poor; reducing wastage; improving the quality of products being marketed; and introducing mechanisms to discourage or eliminate the illegal exploitation of natural resources. 87) Identify a range of economically and ecologically sustainable non-wood forest products that could be introduced in the various management schemes as an economic incentive. Define the economic benefits available at each step of the market chain and foster the empowerment of local users to get better prices and direct access to end markets.

Principle 26: Resource allocation	**Recommended actions 88–91**
Sufficient resources must be committed to initiate activities for the restoration, management and rehabilitation of degraded and secondary forests. Forest restoration and the rehabilitation of degraded forest lands need considerable initial resources. However, returns are often only realized in the mid to long term. Restoration and rehabilitation efforts incur what has been called a 'time tax', which is the time that society must spend waiting for a resource to heal, during which the resource cannot be used and must be nursed. This implies costs in energy and resources without immediate returns on investment.	88) Base public funding for the restoration, management and rehabilitation of degraded and secondary forests on an evaluation of market and non-market benefits. 89) Encourage private-sector investments in the development of degraded and secondary forests while avoiding negative social and environmental impacts at the landscape level. 90) Establish measures to ensure compliance with agreed management and restoration procedures and performance standards. 91) Explore new and additional sources of funding for the restoration and rehabilitation of degraded and secondary forests, such as through the mechanisms and funds created within the UNFCCC.

Principle 27: Local income opportunities	Recommended actions 92–94
Improved income opportunities for forest products will provide an incentive for local stakeholders to participate in the restoration, management and rehabilitation of degraded and secondary forests. Rural people may be able to generate significant incomes from degraded and secondary forests. Market demand and the prices paid for forest products often determine whether forest management is profitable and attractive to farmers and rural communities as a land-use. The local processing of forest products adds value and may translate into higher prices for the raw materials.	92) Promote the local-level and value-added production and processing of wood and non-wood forest products. 93) Recognize gender-specific issues and other opportunities for labour as important determinants of the local acceptability of forest-based economic activities. 94) Develop opportunities to partner with communities, projects or institutions (public and private) with processing and marketing experience to strengthen efforts to gain access to markets.

VII Guarantee participatory monitoring and evaluation as a basis for adaptive management

Monitoring and evaluation is an important element in effective forest restoration and rehabilitation work. In this respect, applied and participatory research is essential to both support the implementation of adaptive management strategies (monitoring/feedback) and to facilitate information sharing and extension/education and hence local capacity-building.

Principle 28: Diagnosis	Recommended actions 95–96
A participatory diagnosis of the physical, economic and social conditions is required as a basis for monitoring and evaluation and adaptive management.	95) Address local stakeholder interests through participatory baseline surveys. Encourage the use of participatory rural appraisal and similar techniques. 96) Design socioeconomic and ecological baselines upon which the restoration, management and rehabilitation of degraded and secondary forests will be modelled and evaluated.

Principle 29: Monitoring	Recommended actions 97–98
Monitoring is an essential element of adaptive management. The restoration, management and rehabilitation of degraded and secondary forests need close monitoring, because high initial investments may be involved and returns are uncertain and long-term. There is an opportunity to implement meaningful activities if monitoring and evaluation are transparent. It is also important to evaluate past errors such as the non-involvement of local stakeholders, the use of non-adapted silvicultural methods, and the undue conversion of secondary forests to low-productivity forest plantations.	97) Build consensus among stakeholders on criteria and indicators to facilitate the monitoring and evaluation of performance. 98) Revise management strategies periodically and adapt management procedures as necessary.

Principle 30: Applied research	Recommended actions 99–101
Applied research is essential to guide and inform adaptive management. The restoration and management of degraded forest landscapes demand knowledge of the ecosystem repair processes. Forest ecosystems can develop in a multiplicity of ways and it is often impossible to direct restoration and rehabilitation to a specific final outcome. Applied research needs to be in place to help overcome these shortcomings. Of crucial importance is knowledge about the ecological behaviour and reproduction and growth dynamics of key species, in particular trees and seed-dispersers.	99) Direct national and international forest research institutions towards applied research in all aspects of the restoration, management and rehabilitation of degraded and secondary forests. 100) Include social, economic and ecological parameters in developing a holistic understanding of degraded and secondary forest management systems. 101) Integrate formal research findings and local traditional knowledge into the management and monitoring of forest restoration and rehabilitation activities.

Principle 31: Knowledge-sharing	Recommended actions 102–105
The dissemination and management of knowledge and information maximizes the effectiveness of, and public support for, the restoration, management and rehabilitation of degraded and secondary forests. Public accounting, publicity and documentation should be incorporated in the restoration, management and rehabilitation of degraded and secondary forests. Public accounting is fundamental to instituting the long-term stewardship of a restored or rehabilitated site. Policy-makers and the public need to be informed of the costs and benefits so that forest restoration and rehabilitation can be planned and budgeted appropriately.	102) Ensure that information on all aspects of restoration, management and rehabilitation programs is carefully maintained and continuously available to all stakeholders. 103) Develop awareness regarding the characteristics and importance of, and management options for, degraded and secondary forests at the local, national and international levels. 104) Use simple, honest and transparent communication and training modules about restoration, rehabilitation and management efforts. 105) Select restoration and rehabilitation sites that can serve as demonstrations for the general public.

Section II: Stand-level principles and recommended actions

VIII Utilize appropriate ecological and silvicultural knowledge and efficient management practices

The most important principle in the restoration, management and rehabilitation of degraded and secondary forests is to work with nature to the greatest extent possible. This implies making maximum use of natural regeneration and other self-recovery processes of the forest ecosystem. It is essential to take appropriate measures to remove degrading influences ('stresses') and other barriers to natural recovery, and to use the most appropriate and cost-effective silvicultural practices to attain the desired goals. However, as the outcomes of these silvicultural practices will rarely be predictable, an adaptive management approach is needed. Rather than rigidly applying pre-determined management strategies, monitoring linked to periodic assessments of project results should form the basis of effective implementation.

Principle 32: Sustainable yield management	Recommended actions 106–109
Management of degraded and secondary forests for sustainable yield must include consideration of ecological and silvicultural gain. The productive management of secondary forests maintains or restores: (a) the natural regeneration of commercially and/or socially desirable species; (b) enough genetic diversity to maintain the production system; (c) the natural processes affecting the productivity of the ecosystem; (d) the functions and processes of the natural drainage system; (e) areas designated for protection; and (f) the growth rate of commercial species. An important element in the management of degraded and secondary forests is to accelerate natural regeneration. Secondary forests are generally less diverse than degraded primary forests. Silviculture should take advantage of the greater uniformity of tree species or species' temperament groups in secondary forests and the tendency for a single species to dominate.	106) In the harvested area leave and mark uniformly distributed seed trees of commercial species. Select seed trees according to the following characteristics: reproductively mature; straight bole; well-developed crown; and free of pests and diseases. Determine a cutting cycle that is longer than the reproductive age of target commercial timber species. 107) Design and implement silvicultural operations involving tree harvesting using low-impact extraction methods. 108) Promote the growth rates of target commercial tree species through the application of appropriate silvicultural treatments such as liberation thinning, refinement, vine cutting, cleanings, etc. 109) Accelerate natural regeneration through soil treatment without accelerating erosion and leaching.

Principle 33: Simple silvicultural practices	Recommended actions 110–112
Wherever possible, use simple silvicultural practices. Simple and clear silvicultural techniques will produce fast results. Their use also tends to reduce costs and labour requirements and facilitates the participatory process.	110) Develop silvicultural techniques that can be understood by owners of small forests, particularly farmers. 111) Produce simple, illustrated silvicultural field guides and manuals. 112) Train forest staff and local stakeholders in the use of the silvicultural guides and manuals so developed.

Principle 34: Regeneration capacity	Recommended actions 113–115
24. The regeneration capacity of forest lands should be improved. The capacity of the forest stand to regenerate needs to be maintained and improved in order to make restoration and rehabilitation effective. This includes all aspects of site productivity, including, where necessary, improvement of the physical site conditions.	113) Identify and retain seed sources of all remaining valuable tree species in a wider area around the restoration and rehabilitation sites. 114) Establish, where feasible, pockets of valuable species as future seed sources for natural regeneration. 115) Consider cost-effective site preparation, if deemed appropriate, including practices such as mulching, fertilization, protective measures against soil erosion and wildlife, fencing from grazing animals, etc.

Principle 35: Restrictions in site conditions	Recommended actions 116–118
Limiting site conditions need to be identified prior to initiating restoration or rehabilitation work, particularly on degraded forest land. Some forests can be restored through interventions solely on biotic parameters. However, the rehabilitation of degraded forest land often has to start with repair work on the physical site conditions. This is often a prerequisite for successfully initiating a rehabilitation process at the level of plant and animal species.	116) Identify periodic stress factors – such as repeated fires, soil erosion, flooding and prolonged waterlogging, drought, salinity, wind and storms – that might impede rehabilitation work. 117) Improve soil conditions such as compaction, water infiltration, fertility and biological activity (eg through tillage, mulching, etc). 118) In areas where water is either in short supply or present in excessive amounts, improve hydrological functions at the rehabilitation site (eg through drainage or water storage).

Principle 36: Key species	Recommended actions 119–121
The rehabilitation of degraded forest land needs the careful assessment of key plant and animal species. Degraded forest land often occurs in fragmented forest landscapes, where seed sources of forest species and seed-dispersers are not present or abundant. Key species of trees, shrubs, herbs and animals may require reintroduction or their existing populations may need to be augmented.	119) Determine key species for the rehabilitation of the site. 120) Assess the need for introducing mycorrhizal fungi, nitrogen-fixing bacteria, and other microbial species at the nursery and/or field-planting stage. 121) Identify sources of seeds, plant propagules, nursery-grown planting stock, and animals for establishment at the rehabilitation site.

Principle 37: Weed and animal pest control	Recommended actions 122–124
The rehabilitation of degraded forest land requires the control and, if possible, elimination of aggressive weeds and animal pests, as well as invasive species. Degraded forest land is often affected by aggressive weeds and animal pests that can prevent natural succession. Particular attention should be given to so-called invasive species that can cover sites completely and impede effective rehabilitation.	122) Identify nuisance weeds and animal pests. 123) Control and eliminate weeds and pests as soon as they appear in order to limit opportunities for spread. 124) Identify and control invasive species and limit them to an appropriate role in the rehabilitation of degraded forest lands.

Principle 38: Role of multi-purpose species	Recommended actions 125–128
Multi-purpose native or exotic species will accelerate successional processes and increase biodiversity on degraded forest land and also provide direct socioeconomic benefits. Site preparation (soil and stand) through the imitation of forest succession by planting so-called framework tree species as nurse trees is a very important technique on degraded forest land. Framework tree species are adapted to a specific site and are capable of rapidly covering soils, shading out weeds and facilitating regeneration by attracting seed-dispersing animals such as birds and bats. It is important that nurse tree species are multi-purpose species that both accelerate or catalyze succession and provide direct social/economic benefits and environmental services.	125) Determine possible nurse trees (framework tree and shrub species) for a given rehabilitation site based on best-available ecological and silvicultural knowledge and stakeholder preferences. 126) Carefully match nurse species with site: nurse trees necessarily have to tolerate difficult site conditions and produce forest microclimatic conditions in a short period of time. They help to create a 'forest environment' by accumulating nitrogen and organic matter in the soil and by rapidly producing leaf litter. 127) Select tree species that rapidly shade out weeds. This will reduce weeding costs and help prevent fire. Competition with weeds is one of the most important factors in preventing forest regeneration in degraded areas. 128) Wherever feasible and compatible with the rehabilitation objective, integrate remnant trees and shrubs into the rehabilitation process instead of eliminating them.

Principle 39: Role of existing plantations	Recommended actions 129–131
Planted forest can be managed to catalyze native forest succession and biological diversity. Under certain conditions (particularly where forest remnants and forest seed-dispersing wildlife are present in the landscape), existing or new forest plantations significantly accelerate natural succession by overcoming barriers to natural regeneration. Plantations established for multiple social, economic and environmental objectives should be preferred to industrial forest plantations, particularly those that are financially unviable. Multiple-use plantations should be used as spearheads for forest restoration and to improve site conditions and biodiversity in forest-poor areas.	129) Assess species and plant diversity in existing forest plantations and determine their potential ecological and economic value. 130) Design stand structures which are favourable for species richness and diversity; in particular, consider the establishment of mixed-species plantations as a nucleus for the rehabilitation of degraded forest land. 131) Where appropriate, review and revise management strategies for forest plantations. A revision might include developing management objectives for encouraging spontaneous forest regeneration. Initial plantation objectives may be re-oriented towards the restoration, management and rehabilitation of degraded and secondary forests.

Principle 40: Multiple-use function	Recommended actions 132–134
Managed secondary forests have multiple-use functions. Management for a wide variety of species and products is likely to be appropriate in a range of situations. An increase in the value of products from existing areas of secondary forests may supplement incomes and diversify income sources. The identification of tree and non-tree species that have specific characteristics is a key element in such strategies. The specific characteristics include: capacity to resprout after fire or cutting; compatibility with the agricultural cycle; synergies between forest products and agriculture (eg providing shade to certain crops); and short production cycles (capable of producing a marketable product within the fallow period).	132) Design and implement multi-resource forest inventories on farmlands. These inventories should include information on the existence, abundance and distribution of all currently and potentially useful plants. Species identification should be done with the collaboration of local plant specialists and should be classified according to broad potential use groups, such as medicinal uses, roundwood for rural construction, sawn timber, and food products. 133) Identify tree and non-tree species with characteristics that might facilitate the development of adaptive silvicultural techniques. 134) Develop or improve management techniques adapted to the socioeconomic and ecological context of the secondary forest landscape.

Principle 41: Species diversity	Recommended actions 135–136
Managing a wider range of species will help achieve economic viability. The more intensive the utilization of the forest (the more tree species there are of commercial interest), the wider the range of silvicultural options available. A longer list of marketable species results in a larger number of trees (ie potential crop-trees selected) from which to take the next harvest. This, in turn, means that the time needed before stand volume is sufficient to justify extraction will be shorter, because 'merchantable' growth is achieved on more stems than would be the case with a smaller list of marketable species. However, markets must accept these 'lesser known' species.	135) Reduce the focus on or preference for the traditional high-value species and give more opportunities to the large group of other useful species the forest is regenerating. 136) Promote the utilization of more species through strategies for market opening, such as surveys on uses and preferences, analyses of wood properties, tests of raw materials for diverse industries, tests on suitability for the substitution of traditional species or parts, the elaboration and promotion of alternative products in fairs and exhibitions, and strategic alliances for integration in market chains.

Principle 42: Species selection	Recommended actions 137–139
Species selection for silvicultural work needs to be as broad as possible. Species selection needs to take into account the needs and beliefs of the main forest users, particularly those whose livelihoods depend most on the forests. Incorporating the social and cultural values attached to forest plant and animal species in the criteria used for species grouping and selection can contribute to a wider adoption of silvicultural practices for diversified management objectives. Management strategies for the multiple-use functions of degraded and secondary forests must be compatible with the current practices of farmers.	137) Take the needs and aspirations of the people living in or near the degraded forest landscape as a starting point for species selection. 138) Consider traditional/indigenous knowledge and practice in the planning of silvicultural work. 139) Group species not only according to ecological and/or economic criteria (current wood value, value of non-wood forest products, or marketability), but also include social values based on the needs and beliefs of the main forest users.

Principle 43: Silviculture only on best sites	Recommended actions 140–141
Intensive silviculture for improved production should preferably be applied on the best sites. Silvicultural interventions should be used to address specific objectives, sometimes in relation to particular species or products or to deal with specific ecological or social needs. The selection of species in the treatment increases the economic return significantly. Not all areas in the forest under management will require silvicultural treatment. The best sites are those with the highest productive capacity; on such sites, silviculture has to be competitive with land-uses such as tree crops and agriculture.	140) Stratify the degraded forest landscape and identify those areas where intensified silvicultural treatments (sampling selection, tending, weeding, liberation thinning, pruning, positive selection, high thinning) might be justified. 141) Include adequate ecological stratification in the silvicultural decision-making and, if the management strategy is based partly on enrichment planting, ensure the appropriate matching of species to the site and ecological niche.

Principle 44: Advanced growth	Recommended actions 142–145
Regulating advanced growth is essential for improving stand structure in degraded and secondary forests. Forest restoration should aim to optimize the overall performance and health of the forest ecosystem. It is important therefore to create an improved crop structure by appropriate spatial distribution and canopy manipulations. An optimal structure of the main canopy (big and healthy crowns, vertical integration) creates more favourable and diverse light and moisture conditions for a sub-canopy of a variety of trees, rattans and other palms, bamboo and herbs, and habitat for wildlife.	142) Conduct an inventory through diagnostic sampling and analyze the initial stand structure in all the layers (diameter distribution of remaining forest stand and status of advanced growth regeneration). 143) Based on the above, decide on the need to intervene in the remaining canopy. 144) Determine potential crop trees and promote advanced growth, in particular of potential crop trees, by thinning, weeding and coppicing damaged stems. 145) Record the silvicultural measures undertaken and close the forest to commercial timber operations for a period defined according to local conditions.

Principle 45: Stand structures	Recommended actions 146–149
A uniform structure needs to be created or maintained in secondary forests when wood production is the main management goal. This is of particular importance in young secondary forests and degraded forest lands. In situations where management for wood production is appropriate, such as in situations where secondary forest stands are dominated by commercially valuable tree species, the creation or maintenance of an approximately even-aged A-layer in a secondary forest through uniform or monocyclic but successional, structurally complex silviculture is desirable.	146) Identify and develop markets that demand the kind of wood products typical of secondary forests. 147) Identify conditions that favour a high density of the same fast-growing (light-demanding) tree species. This may be determined by substrate fertility, past use and seed availability. 148) Recreate the open conditions in which secondary forest establishes and maintains high levels of productivity. 149) Plan the timing of the management prescriptions in relation to processes such as seed dispersal.

Principle 46: Carbon sequestration	Recommended actions 150–152
Carbon sequestration is an important use option in degraded and secondary forests. Degraded and secondary forests can play an important role in carbon sequestration programs if they are included as an element in international carbon trade markets. Young secondary forests in particular are characterized by very high growth rates and sequester more carbon than many forest plantations. Financial incentives for retaining stand and soil carbon stocks could be justified as a way of limiting the conversion of degraded and secondary forests to other, unsustainable land-uses.	150) Develop model projects that investigate carbon accounting, permanence and leakage in secondary forests. 151) Integrate carbon goals in the overall planning of secondary forest management. Consider the production of high-value timber species from a carbon retention perspective. 152) Improve soil conservation practices to enhance carbon storage in soils.

Principle 47: Natural stand dynamics	Recommended actions 153–154
Natural stand dynamics are the basis of forest restoration, particularly in degraded primary forests. The potential for the lateral growth of crowns in a damaged canopy and of vertical growth of natural regeneration from the ground should not be underestimated. The species and genotypes in the residual growing primary stock and among invaders are adapted to the local site and their rooting systems are well established; thus, they are generally superior to planted trees.	153) Assess whether the remaining stand contains enough healthy trees of desired species (potential crop trees) and advanced growth (seedlings, saplings) to serve as a base for the restoration process. 154) Prepare a simple regeneration plan that sets the regeneration target for assisted natural regeneration for a given stand based on the above assessment.

Principle 48: Close-to-nature silviculture	Recommended actions 155–157
Silvicultural interventions should take advantage of and be adapted to natural ecological processes. The high repair capacity of tropical forests is generally underestimated. Rather than clearing, burning and planting over-logged and degraded forests, it is often economically and ecologically more appropriate to close a forest and to prudently assist already-ongoing natural recovery processes. It should be a principle to minimize, wherever possible, silvicultural interventions and to use methods that mimic nature so that maximum benefit is drawn from the self-repair capacity of the forest. Very badly degraded forests are often a tangle of excessive growth of bamboo and climbers, such as *Merremia spp*., and undershrubs such as *Chromolaena spp*. and *Eugeissonia spp*. The cutting of climbers often stimulates further climber growth. In many cases, the ecologically most appropriate and economically most feasible strategy is to wait.	155) Analyze the capacity of a degraded primary forest stand to regenerate with a minimum of assistance. Take into account the existence of seed trees in the wider restoration area, the number and kind of seed-dispersers, and the condition of the regeneration layer in the stand being restored. 156) Assist and accelerate natural regeneration where necessary by weeding, liberation thinning and, eventually, simple mulching. 157) Limit bamboo and climber cutting as much as possible, as climber cutting can set succession back and stimulate further climber growth.

Principle 49: Enrichment planting	Recommended actions 158–160
Enrichment planting may be justified in heavily degraded primary forests and young secondary forests. Over-logged natural forests on good soils require enrichment planting if they have been so severely depleted and degraded that natural recuperation will take more time than is desirable for economic and environmental reasons. Depending on the main objective of restoration, high-value timber species, multi-purpose trees of local value and trees and herb species attractive to wildlife may be selected. Enrichment planting can be in patches (gaps) or lines. Scattered single seedlings or saplings are to be avoided, as they will usually be suppressed by competition.	158) Assess the condition of the forest canopy: if the A- and B-layers are almost completely removed (80%) and more than 50% of the D- and C-layer have been destroyed or badly damaged, enrichment planting may be necessary. 159) Carefully select species for enrichment planting. Only species that are adapted to the successional and mature phases of the forest should be planted. Such trees are light-demanding (but may tolerate shade and root competition), and they grow fast, have narrow crowns and often produce high-value timber. All planting material must be of species and provenances of proven suitability for the site. 160) When planting commercial tree species, apply the following basic rules of enrichment planting[7]: (i) use close spacing along lines; (ii) align the lines east-west in order to maximize access to light; (iii) use only species capable of fast height growth in their juvenile stage; (iv) close the area to timber harvesting; (v) tend the whole area, not just the planted lines; (vi) liberate the planted trees from overhead and lateral shade and root competition; and (vii) monitor the behaviour of wildlife, because lines can become game tracks and the planted trees can attract the attention of wildlife.

[7] Developed by Foury (1956) and Dawkins (1958), as seen in Dawkins and Philip (1998)

5 Looking ahead

The first priority in the conservation and use of tropical forests should be to establish sustainable management so that degradation does not occur and restoration and rehabilitation are not necessary. If the policy context is conducive and sustainability is the goal of all stakeholders, the prospects for maintaining and enhancing flows of all products and services, including high-quality hardwoods, over long periods of time are good. However, militating against this is the fact that the mining of timber and non-wood forest products is still the predominant practice in natural forests throughout the tropics. Continuing to degrade the economic value of a tropical forest such that the residual stand needs substantial restoration and rehabilitation that will not produce a crop for 80 to 200 years is bad forestry.

Hence, although the management of degraded and secondary forests may be an important investment for various reasons, the sustainable management of existing intact resources remains the primary challenge.

Nevertheless, an increased policy focus on degraded and secondary forests is required. Such forests are increasingly important as a source of wood. They may become a major source in the future, especially given the decline of primary forest resources, the high cost of establishing and maintaining planted forest, and the greater vulnerability of forest plantations to pests and fire. If properly restored and managed, degraded primary forests and secondary forests still provide environmental benefits such as watershed and soil protection, land stabilization, biodiversity values and carbon sequestration better than do plantations and agroforestry systems.

Table 6 in Annex 2 summarizes the institutional, socio-cultural, economic and technical obstacles to improved management. Despite these, the use of degraded and secondary forests will inevitably become more important for local communities. Fragmented forests in a rural landscape are available for a variety of human uses and may be of great importance in the livelihoods of the rural poor. They are often already an integral part of production systems and may produce desirable forest products. They can potentially meet local needs for fuelwood, fodder, fruits, edible plants, construction wood and medicines and help reduce risk in the event of crop failure and other catastrophes.

Government forest policies and legislation need to formally recognize the value of degraded and secondary forests and investors need to look outside the paradigm of industrial plantations for the production of utility woods. Environmentally interested stakeholders need to include forest landscape restoration in their mandate and shift their focus from pure conservation to more integrated, multiple-use approaches.

Further actions

A number of immediate actions can be taken in the framework of the International Tropical Timber Agreement at the international, national and local levels. These immediate actions are:

- start testing and applying these guidelines, mainly through the ITTO project cycle but also through other bodies in non-ITTO member countries;
- encourage dialogue in the countries and at a regional level on restoration and rehabilitation issues based on these guidelines, giving special attention to case studies and workshops;
- identify a network of forest sites where restoration is clearly an environmental and local livelihood priority and make long-term commitments to restoration programs at these sites. Put in place mechanisms for learning and exchanging information between sites;
- build up the ITTO website and links with other institutions on issues related to degraded and secondary forests;

- create a community of practice among organizations and interested stakeholders to exchange information and experience, and to develop joint implementation strategies at international, national and local levels (eg through the WWF/IUCN forest landscape restoration campaign, a specific targeted approach by ITTO, a joint pledging approach, etc);
- advocate the restoration, management and rehabilitation of degraded forests in international conventions and processes;
- prepare manuals on the restoration of degraded forests, secondary forest management, and the rehabilitation of degraded forest land; and
- monitor the impact of these guidelines on changing practices in conserving biodiversity, protecting ecological services and improving local livelihoods, including quantitative measures and targets.

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- International Tropical Timber Organization: www.itto.or.jp
- Society for Ecological Restoration: www.ser.org

7 Glossary

Adaptive management	Process by which people adjust their management strategies to better cope with change, while also maintaining the integrity of their forest management objectives (Wollenberg et al. 1999)
Afforestation	The establishment of a planted forest on non-forested land.
Agroforest	A complex of tree areas within an area that is broadly characterized as agricultural or as an agro-ecosystem.
Alien species	A species or a sub-species or lower taxon introduced outside its normal past and present distribution.
Carbon offset	The result of any action specifically undertaken to prevent the release of carbon dioxide into the atmosphere and/or to remove it from the atmosphere in order to balance emissions taking place elsewhere.
Biodiversity	See 'biological diversity'
Biological diversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems [From the articles of the 1992 Convention on Biological Diversity]
Canopy	In a simplified model of a tropical rainforest, four canopy layers can be distinguished: A-layer containing emergent canopy species; B-layer containing intermediate canopy species; C-layer containing subcanopy species; and D-layer comprising tree regeneration.
Collaborative (forest) management	A working relationship between different stakeholders to manage forest and tree resources.
Degraded forest	Forest that delivers a reduced supply of goods and services from a given site and maintains only limited biological diversity. It has lost the structure, function, species composition and/or productivity normally associated with the natural forest type expected at that site.
Degraded forest landscapes	Forest conditions other than those found in primary or managed natural and planted forests. 'Landscape' is defined in this context as a cluster of interacting ecosystem types of forest and other woodland vegetation.
Degraded forest land	Former forest land severely damaged by the excessive harvesting of wood and/or non-wood forest products, poor management, repeated fire, grazing or other disturbances or land-uses that damage soil and vegetation to a degree that inhibits or severely delays the re-establishment of forest after abandonment.
Degraded primary forest	Primary forest in which the initial cover has been adversely affected by the unsustainable harvesting of wood and/or non-wood forest products so that its structure, processes, functions and dynamics are altered beyond the short-term resilience of the ecosystem; that is, the capacity of these forests to fully recover from exploitation in the near to medium term has been compromised.
Elastic capacity of a forest ecosystem	Dynamic forest processes within a range of changing vertical forest structure, species composition and biodiversity, and productivity normally associated with the natural forest type expected at that site.
Endemic species	A species native to, and restricted to, a particular geographical region.
Enrichment planting	The planting of desired tree species in a modified natural forest or secondary forest or woodland with the objective of creating a high forest dominated by desirable (ie local and/or high-value) species.
Forest degradation	The reduction of the capacity of a forest to produce goods and services. 'Capacity' includes the maintenance of ecosystem structure and functions.
Forest fallow	The intermediate time between two periods of shifting agriculture. In a functional shifting agricultural system, the fallow period is long enough that a functional secondary forest stand can develop (ie >20 years).
High forest	Generic term used to describe a forest close to its successional climax – most commonly synonymous with 'primary forest', but can also be achieved in a managed natural forest under a strict selection system.

Key species	A plant, animal or microbial species that binds together an interactive feedback loop in the trophic and functional networks on an ecosystem (Bruenig 1996).
Landscape	A cluster of interacting ecosystem types.
Liberation thinning	A cutting that releases young seedlings, saplings and trees in the canopy C-layer from overhead competition.
Managed primary forest	Forest in which sustainable timber and non-wood harvesting (eg through integrated harvesting and silvicultural treatments), wildlife management and other uses have changed forest structure and species composition from the original primary forest. All major goods and services are maintained.
Modified natural forest	Primary forests managed or exploited for wood and/or non-wood forest products, wildlife and/or other purposes. The more intensive the use, the more the structure and composition is altered compared to that of primary forests. Ecologically, the alteration often represents a shift to an earlier successional stage. Two major categories can be distinguished: managed primary forest and degraded and secondary forests.
Native species	A species that occurs naturally in a region.
Natural regeneration	Renewal of trees by self-sown seeds or natural vegetative means (Ford-Robinson, cited in Wadsworth 1997)
Non-wood forest products	All forest products except timber and wood, including products from trees, plants and animals in the forest area.
Nurse species	Robust tree and shrub species able to colonize degraded forest areas. They rapidly cover soils, shade out weeds and attract seed-dispersing animals. They are generally strongly light-demanding (pioneer species).
Nutrient cycle	A natural process in which nutrients, mainly minerals, are taken up from the soil, used for plant growth and, once the plant dies, returned to the soil through decomposition processes.
Old-growth forest	A primary or secondary forest which has achieved an age at which structures and species normally associated with old primary forests of that type have sufficiently accumulated to act as a forest ecosystem distinct from any younger age class (UNEP/CBD/SBSTTA 2001).
Participatory forest management	Attempts to secure and improve the livelihoods of local people dependent on forest resources by involving all key stakeholders in the process of forest management, understanding their needs and situations, allowing them to influence decisions and receive benefits, and increasing transparency (DFID 1996). Participatory forest management is used as an umbrella term to include shared forest management, joint forest management, collaborative forest management and community forestry.
Permanent forest estate	Land, whether public or private, secured by law and kept under permanent forest cover. This includes land for the production of timber and other forest products, for the protection of soil and water, and for the conservation of biological diversity, as well as land intended to fulfill a combination of these functions.
Pioneer species	Heavily light-demanding and short-lived species that can rapidly invade large canopy gaps in disturbed natural forests and colonize open land.
Planted forest	A forest stand that has been established by planting or seeding.
Primary forest	Forest which has never been subject to human disturbance, or has been so little affected by hunting, gathering and tree-cutting that its natural structure, functions and dynamics have not undergone any changes that exceed the elastic capacity of the ecosystem.
Refining	The elimination of silviculturally undesirable trees, climbers, shrubs and other plants that will inhibit site occupation by desirable trees.
Reforestation	The re-establishment of trees and understorey plants at a site immediately after the removal of natural forest cover.
(Forest) Rehabilitation	A management strategy applied in degraded forest lands that aims at restoring the capacity of a forest to produce products and services.
Residual stand	Forest that remains after harvesting and extraction
(Forest) Restoration	A management strategy applied in degraded primary forest areas. Forest restoration aims to restore the forest to its state before degradation (same function, structure and composition).

Secondary forest	Woody vegetation regrowing on land that was largely cleared of its original forest cover (ie carried less than 10% of the original forest cover). Secondary forests commonly develop naturally on land abandoned after shifting cultivation, settled agriculture, pasture, or failed tree plantations.
Silviculture	The art and science of producing and tending forests by manipulating their establishment, species composition, structure and dynamics to fulfill given management objectives.
Stakeholders	Any individuals or groups directly or indirectly affected by, or interested in, a given resource (in this case forest).
Shifting agriculture	Used here as a synonym for shifting or swidden cultivation. The burning and cleaning of forest vegetation and subsequent plantation of agricultural crops for a short period of time (1–5 years) followed by abandonment.
Succession	Progressive change in species composition and forest structure caused by natural processes over time.
Sustainable forest management	The process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undesirable effects on the physical and social environments.
Sustained yield	The production of forest products in perpetuity, ensuring that the harvesting rate does not exceed the rate of replacement (natural and/or artificial) in a given area over the long term.
Tenure	Agreement(s) held by individuals or groups, recognized by legal statutes and/or customary practice, regarding the rights and duties of ownership, holding, access and/or usage of a particular land unit or the associated resources (such as individual trees, plant species, water or minerals) therein.
User rights	The rights to the use of forest resources as defined by local custom or agreements or prescribed by other entities holding access rights. These rights may restrict the use of particular resources to specific harvesting levels or specific extraction techniques.
Yield regulation	The techniques for calculating and controlling the harvesting level to ensure that sustained yield is respected.

Annex 1

Characterization of forestry use potential of primary, managed natural, primary degraded, secondary and planted forests*

Characteristics	Primary forest[1]	Managed forest[4]	Degraded primary forest[2]	Secondary forest[3]	Planted forest
Resource properties					
Quality	variable	variable	variable	variable	controlled
Variety of supply of useful products	very high	high to middle	middle	relatively low to middle	very low; often monoculture
Abundance of timber species	low	middle (to high if managed over a long period)	low to middle	variable; high in early stages	high (because fully controllable and profit oriented)
Harvesting of non-wood forest products	informal harvesting schemes usually exist	according to management plan	variable	possible, often common	low, only if specially designed
Utilization possibilities					
Physical access	far from settlements; usually low accessibility	variable, generally accessible	variable, but often near settlements	near settlements; usually good accessibility	good infrastructure and accessibility
Utilization rights	legally restricted use	legally restricted use	usually legally restricted use	often unclear or restricted	often clear
Production costs					
Harvesting and transport costs	-	high initial cost, later rather low	variable; middle cost where there is good infra-structure	relatively low cost (because of homogeneous stand and good infrastructure)	low costs (because homogeneous stand and good infrastructure)
Natural and economic risks	low	low	low	moderate	high
Silvicultural measures	-	according to management prescriptions	not always necessary	not always necessary, but desirable in young stands	necessary
Stand establishment	-	not necessary	not necessary	not necessary	necessary

Management options					
Characteristics	**Primary forest[1]**	**Managed high forest [4]**	**Degraded primary forest [2]**	**Secondary forest[3]**	**Planted forest**
Management difficulties	low (managed for conservation)	low (nature does the work)	medium	low to medium	low
Possibilities for certification	-	high	possible, but uncertain	good, relatively manageable	high
Provision of soil and water conservation services	excellent	excellent	good	good	low
Total biodiversity	high	medium to high	medium to high	low to medium sometimes high	very low
Carbon sequestration	constant	constant to high	moderate	high up to 50 years, depends on age	high when young
Future source of timber production	available area is decreasing	increasing in some areas, some prospects for high-quality timber exist	increasing in some areas, decreasing in others	increasing	rapidly increasing, but only for utility woods, not for high value timber
Ecotourism potential	high	high – depending on quality of forest stand	medium, variable, depend on intensity and quality of past and present use	low to medium, sometimes high for birds, monkeys, etc	usually low
Main user group	local to international	mainly national and international	local to national	often local population	usually trans-regional
Future availability of land	diminishing	increasing in some areas with management certification schemes	increasing in some areas – but diminishing with land-use intensification	increasing	increasing

* Compilation by Jürgen Blaser and César Sabogal, partially based on Emrich et al. 2001 and Budowski 2000

1 Primary, heterogeneous lowland forest

2 Degraded primary forest, commonly by over-harvesting of timber and/or non-wood forest products

3 There are large variations due to biophysical (eg age, origin, species composition and phenology) and socioeconomic conditions, which result in high variability of secondary forest stands

4 Managed forest: managed primary, heterogeneous lowland forest

Annex 2

Characteristics of the different situations of degraded and secondary forests in the three tropical regions

Tropical Asia[1]

- The extent of degraded primary forests and secondary forests in tropical Asia is estimated to be 145 million hectares, or 46% of all forest area (see Table 3). In many countries, there remain only small areas of primary forest cover; in India, Nepal, Sri Lanka, tropical China, the Philippines, Thailand, and Vietnam, for example, most forests are secondary forests and degraded primary forests – although they are considered to be a valuable resource. The remaining primary forests are mainly in remote, inaccessible areas and are usually legally gazetted as protected forests. Most forest products are obtained from degraded forest landscapes, and high extraction pressures combined with poor regeneration may lead to further degradation.
- The different types of degraded forest landscapes and their relative importance across this region remain indeterminate. Secondary forests, forming parts of swidden agriculture, smallholder plantations ('forest gardens') or the rehabilitation of degraded lands, play an important role in local livelihoods in terms of forest products and soil recuperation across tropical Asia. There also appears to be much active management by local stakeholders of such forests ranging from facilitation to manipulation, enrichment, and more intensive planting of desired species.
- Intensive timber mining episodes in the past appear to have been responsible for the development of degraded forest landscapes in countries across tropical Asia and continue to play a role in some countries.
- Secondary forests arising from fire events may be important in regions ravaged by catastrophic fires in recent times but their extent and status remain largely unknown, especially given the vulnerability of such sites to repeated fires and further degradation.
- Unlike in the cases of smallholder systems, degraded high forests arising after large-scale timber mining and fires are usually subject to open-access informal use and may not be directly and tightly linked to local livelihoods or subject to deliberate management. They are also often considered by development planners as economically degraded and are the prime areas for conversion to pulpwood and agricultural tree-crop plantations. However, they are often the largest categories of forests in many Asian countries arising directly from rapid intensification of forest use and, once adequately restored, may be very important for the future production of forest products and environmental stability.
- In forest-depleted regions such as South Asia and mainland Southeast Asia there is greater state recognition and encouragement of restoration and rehabilitation, especially in sensitive areas as a land-stabilizing factor, for watershed protection, soil conservation, and biodiversity values. In insular Southeast Asia, which still has large tracts of primary forests, degraded forest landscapes are more prone to be converted to plantations or agriculture and are often considered to be degraded land.

Examples:

- In the Philippines, post-extraction secondary forests (degraded primary forests) are the main source of industrial timber;
- In Nepal, rehabilitated secondary forests are highly valued by local communities for products and environmental services;
- In parts of China, smallholders provide commercial small-diameter timber from secondary forests. Also in these forest-depleted regions, there is greater state recognition and encouragement of secondary forest management and protection, especially in sensitive areas as a land-stabilizing factor, for watershed protection, soil conservation, and biodiversity values; and

- In other countries which still have large tracts of primary forests and are currently experiencing intense exploitation of their forest resources – such as in Indonesia, Malaysia, Cambodia and Laos – there are large and expanding areas of degraded primary forests. These forests are generally undervalued, are often considered to be degraded land, and are more prone to be converted to plantations or agriculture.

Tropical America[2]

- The extent of degraded primary forests and secondary forests in tropical America is estimated to be about 180 million hectares, or almost 21% of all natural tropical forests (see Table 3). However, the area covered by these forests may be much higher: in 1990 FAO estimated the area in Latin America at 335 million hectares, of which 165 million hectares were secondary forests.
- There are large differences in the percentages covered by degraded and secondary forests among the countries. In general, countries in Central America and the Caribbean present the largest relative area (up to 100% as in the case of El Salvador and Haiti). In Costa Rica the area covered by degraded primary forests and secondary forests is estimated at more than 600,000 hectares, an area larger than all remaining primary and old-growth forests and representing the country's most abundant forest resource. Degraded and secondary forests also occupy significant areas in some South American countries (particularly in Brazil, Ecuador and Paraguay). In the Brazilian Amazon, degraded and secondary forests cover over 50 million hectares and this area is expanding at an accelerating rate.
- Most secondary forests in the region originated in the abandonment of areas previously used for agriculture and extensive cattle ranching in the colonization process. Other causes of secondary forest formation are internal political conflicts (as, for instance, in Nicaragua, Guatemala or Colombia).
- Secondary forests are important for rural people, contributing to their livelihoods and to environmental conservation. Their main role is in restoring and maintaining soil productivity and water regulation, mainly as part of shifting cultivation. But secondary forests are also important providers of forest products. Most important among these is fuelwood, still the major source of energy in several countries of the region (eg Guatemala). Wood for rural construction and the manufacture of tools and handicrafts are also important for some local economies. The commercial value of most timber trees growing in secondary forests is still low or non-existent, but it tends to increase in some countries (particularly those with less remaining primary forest). In Costa Rica, for example, it was found that 50% of the species present in secondary forests had commercial value. Secondary forests seem to be more valued by the local population for the non-wood forest products they can extract from them for a diversity of uses, especially as medicines and for food. Some of these products already have commercial value, as the case of cat's claw, *Uncaria tomentosa*/*U. guianensis,* in Peru or *Platonia insignis* in Brazil.
- The interest in managing secondary forests varies substantially from country to country and from region to region. In countries like Costa Rica, where large areas have been deforested, secondary forests are likely to play a more important role as source of forest products than in countries with lower deforestation rates. Additionally, several socioeconomic factors will influence the decision of farmers to manage their secondary forests (see Table 6). Among these is the existence of a market for lesser-known timber species or for non-timber forest products, accessibility to the market and to land, land tenure, stage of the agricultural frontier, and governmental policies.
- There are valuable experiences with the use of light-demanding tree species growing in secondary forests such as *Schizolobium amazonicum* and *S. parahybum* in Brazil and Ecuador; *Cordia alliodora* in northern South America and Central America; *Calicophyllum spruceanum* in Peru, Bolivia and Brazil; *Ochroma lagopus* in Ecuador and Venezuela; *Guazuma crinita* in

[1] Based on Chokkalingam et al. (2001).

Peru. Experiences range from some kind of stand manipulation to favour desirable natural regeneration through thinnings and enrichment plantings to the establishment of open plantations, sometimes using an agroforestry system. Several experiments have indicated that the prospects of secondary forest management for the sustainable production of quality timber are good.

Tropical Africa

- The extent of degraded primary forests and secondary forests in tropical Africa, including in humid, semi-humid and gallery forests in dry zone areas, is more difficult to estimate than in other regions because in large parts of Africa, degraded primary and secondary forests do not occur in large tracts due to the intensive use of the landscape. As a rough estimate the figure of 245 million hectares can be advanced, or 53% of the closed forest area (see Table 3). In most of the African countries only very small areas (0–10%) of primary forest cover remain – such as in the countries of the Sahel belt, West Africa, East Africa and Madagascar. The exception are the countries in the Congo Basin, namely the Republic of Congo, the Democratic Republic of Congo, Gabon and to some extent Cameroon, where large areas of tropical rainforests remain untouched by recent human interventions. However, the remaining primary forests of the Congo Basin have been opened up in recent years through the allocation of forest concessions.
- All over Africa, tropical humid forests have been in productive use for a long time. Three different forest situations can be roughly distinguished: (i) in areas where population pressure is great (eg Ghana, Côte d'Ivoire, Togo): salvage felling, off-reserve felling, collaborative forest management in particular in degraded primary and secondary forests, small-scale plantation/ enrichment forestry are the commonly used methods; (ii) in remote areas with low population pressure (eg the two Congos) forest extraction activities occur. In these areas, the extraction of a few trees of precious wood is the only economically attractive option. Where population pressure is low, timber extraction competes with the goals of totally protected areas and usually dominates as the preferred land-use practice; and (iii) the area where secondary forest management and restoration and rehabilitation of degraded primary forests have the best chance of success is in accessible areas with moderate population pressure (eg in large parts of Cameroon, Central Africa and Gabon). Here, new competencies are needed in order to secure access and management of the resource base. Long-term managed concessions, forest restoration, secondary forest management, silvicultural management, wildlife management strategies, and so on, should be part of an integrated package. For these areas, a specific investment climate must be created to sustain forests.
- Secondary and degraded primary forests are considered to be a valuable resource all over Africa. Most forest products are obtained from degraded forest landscapes, particularly fuelwood in drier zones and non-timber forest products, particularly bushmeat. Linked with increased population pressure, such high extraction activities combined with poor regeneration is leading in many parts to further degradation and loss of fertile land (eg in large parts of West and East Africa and Madagascar).
- The different types of degraded forest landscapes and their relative importance across Africa remain little studied. In large parts of Africa, ferralitic soils are the dominant soil type, and any modification of vegetation through overgrazing and human induced fires often lead directly to seriously degraded landscapes. Secondary forests mainly occur in areas where population pressure remains moderate and where swidden agriculture can still be practised as a sustainable land-use system. Secondary forests also occur where large-scale industrial plantation investments have failed, or where wildfires have occurred.
- Secondary forests ravaged by bush fires in recent times are potentially important in the Sahel belt and East Africa but their extent and status remain largely unknown, especially given the vulnerability of such sites to repeated fires and land degradation.

[2] Based on TCA 1997, TCA 1999

- Timber mining in the past appears to have been responsible for the development of degraded forest landscapes, mainly in West Africa. In recent years, it has also become a potential threat to forest resources in the countries of the Congo Basin. There is hope however that through better information and international networking, and improved policy and law enforcement, forest concession management and timber certification, such activities will not lead to complete degradation. In these areas, secondary forest management can potentially play an important role as a source of fuelwood and other forest products in the rapidly growing population centres which have developed over past years as a result of forest concession and forest industry development.
- Examples of forest successions:
  - Young secondary forests all over humid Africa have very similar structural and species succession patterns, with dominance of one to four species out of the group of: *Macaranga hurifolia, Macaranga barteri, Harungana madagascariensis, Musanga cecropioides, Anthocleista nivilis, Vismia guineensis, Trema guineensis, Vernonia conferta*, and, in West Africa particularly, by introduced species like *Solanum verbascifolium* and *Cecropia peltata*.
  - In Côte d'Ivoire, late secondary forests (30–40 years) are characterized by a relative abundance of commercial tree species like *Fagara macrophylla, Terminalia superba* (limba), *Terminalia ivorensis* (frakire), *Triplochiton scleroxylon* (samba) and *Ceiba pentandra* (fromager). These species are highly light-demanding, install themselves in an early stage and can form the dominant layer of late-secondary stands. Other commercial species that are light-demanding and long-living can develop in the shade of secondary forests: *Entandrophragma angolense, Uapaca guinneensis, Canarium schweinfurthii* in West Africa and *Canarium madagascariensis, Uapaca spp*. and *Intsia bijuga* in Madagascar, for example. A great number of the commercial tree species exploited today in African rainforests originated in secondary forests and are moderately to highly light-demanding.
  - The most characteristic species in young and late secondary forests in the western part of the Congo Basin is okoume (*Aucoumea klaineana*).

Table 6 *Some constraints to managing degraded and secondary forests*

Policy and institutional constraints	- Secondary forests, degraded primary forests, and degraded forest land receive insufficient attention in international conventions (UNCBD, UNFCCC, UNCCD), agreements (ITTO) and processes (UNFF) - National policies often ignore degraded and secondary forests. In addition there is no clear definition/classification of the various conditions of degraded and secondary forests in resource assessment, policy planning and legal frameworks. (The question is often: is it an agricultural or a forest resource?) - In addition, forest policies and economic studies often fail to recognize the value of natural regeneration - There are often excessive regulations for the use and harvesting of products from degraded and secondary forests. Forest legislation often imposes high bureaucratic requirements that discourage harvesting and the marketing of wood, timber and certain non-wood forest products - Insecure land tenure or use rights often apply to degraded areas - Levels of corruption are often high
Socio-cultural constraints	- Agricultural use of degraded and secondary forests predominate as part of the fallow cycle in shifting cultivation systems - Cultural practices may be contrary to the maintenance of forests (lack of a 'forest culture') - Low levels of organization and managerial capacity of local populations - Low negotiation capacity of main actors

Economic constraints	- Low prices of forest products (other than high-value tropical hardwoods) - Lack of financial incentives for management, non-recognition of the specific situation of secondary forests in existing incentives schemes (Global Environment Facility, Clean Development Mechanism, Climate-Change Adaptation Fund, etc) - Markets are not known or developed for most 'secondary' wood species (the question of lesser-known species) - Localized, poorly organized/developed markets for non-wood forest products - Limited availability of labour as a result of competition with agriculture/subsistence activities
Technical constraints	- Lack of real-scale models/demonstration of viable management strategies for degraded and secondary forests - Lack of (documented) experience; poor dissemination of information - Lack of local technical experience in the management of degraded and secondary forests - Lack of experience in processing products from secondary forests and degraded primary forests (eg by local carpenters and furniture makers) - Poor access to information technologies and markets

Annex 3

Examples of promising species to use in the restoration, management and rehabilitation of degraded and secondary forests in the tropics

Table 7 lists high-value species (timber and multi-purpose) that might be introduced into a degraded primary forest. Enrichment species must be light-demanding but able to tolerate shade and root competition, they must grow fast with a narrow crown, and they must produce high-value products. They can occupy the A, B or C canopy layers.

Table 7 *Open-ended list of promising species for enrichment planting in the restoration of degraded primary forests*

Humid and semi-humid tropics	Humid and semi-humid tropics	Tropical highlands
T/Agathis alba (SEA) *T/Amburana cearensis (TAM)* *T/Anacardium excelsum (TAM)* *T/Anacardium rhinocarpus (TAM)* *T/Anthocephalus chinensis (SEA)* *M/Bertholletia excelsa (TAM)* *M/Calamus spp. (SEA, IND)* *T/Calophyllum brasiliense (TAM)* *M/Canarium madagascar. (AFR)* *T/Cariniana pyriformis (TAM)* *T/Cedrela angustifolia (TAM)* *T/Cedrela odorata (TAM)* *T/Cedrelinga catenaeformis (TAM)* *T/Chlorophora excelsa (AFR)* *T/Cordia alliodora (TAM)* *T/Cordia goeldiana (TAM)* *T/Dipterocarpus cornutus (SEA)* *T/Dipterocarpus costulatus (SEA)* *T/Dryobalanops aromatica (SEA)* *T/Dryobalanops lanceolata (SEA)* *M/Durio zybethinus (SEA)* *T/Dyera costulata (SEA)* *T/Entandrophragma excelsum (AFR)* *T/Entandrophragma utile (AFR)* *M/Eugeissona utilis (SEA)* *T/Gonystylus bancanus (SEA)* *T/Goupia glabra (TAM)* *T/Hyeronyma chocoensis (TAM)* *T/Intsia palembanica (SEA)* *T/Intsia bijuga (AFR)* *T/Khaya anthotheca (AFR)* *T/Khaya ivorensis (AFR)* *T/Parashorea tomentella (SEA)* *T/Simarouba amara (TAM)* *T/Sindora echinocalyx (SEA)* *T/Shorea johorensis (SEA)*	*M/Shorea macrophylla (SEA)* *T/Shorea parvifolia (SEA)* *T/Swietenia macrophylla (TAM)* *T/Tabebuia rosea (TAM)* *T/Tarrietia utile (AFR)* *T/Tectona grandis (SEA)* *T/Terminalia ivorensis (AFR)* *T/Triplocloton sceroxylon (AFR)* *T/Virola surinamensis (TAM)* ***Semi-arid (and dry) tropics*** *M/Bambusa spp. (IND)* *T/Bombacopsis quinatum (TAM)* *M/Dendrocalamus spp. (IND)* *T/Enterolobium cyclocarpum (TAM)* *T/Khaya senegalensis/madag. (AFR)* *T/Pterocarpus dalbergioides (IND)* *T/Pithecelobium saman (TAM)* *T/Shorea robusta (IND)* *T/Simarouba glauca (TAM)* *T/Tectona grandis (IND)* *T/Xylia kerrii (IND)*	*T/Agathis damara (SEA)* *T/Araucaria cunninghamii (SEA)*

M = multi-purpose species (timber, fruits, bark, etc); T = predominantly a timber species

Primary distribution of the species: AFR = tropical and subtropical Africa; IND = India, subtropical Indo-China, and subtropical and tropical China; TAM = tropical and subtropical Americas; SEA = Southeast Asia, including the Mekong; TRO = pan-tropical

The primary role of the group of tree species listed in Table 8 is to help to rapidly build the canopy and to increase the economic value of a secondary forest.

Table 8 *Open-ended list of promising species to use in the management of secondary forests*

Humid and semi-humid tropics	Semi-arid (dry) tropics	Tropical highlands
M/Achras sapota (SEA) *T/Acacia mangium (TRO)* *T/Agathis borneensis (SEA)* *M/Artocarpus spp. (TRO)* *T/Aucoumea klaineana (AFR)* *M/Averrhoa carambola (TRO)* *T/Bagassa guianensis (TAM)* *T/Bombacopsis quinata (TAM)* *M/Calamus spp. (SEA)* *T/Calicophyllum spruceanum (TAM)* *T/Calophyllum spp. (SEA)* *T/Campnosperma spp. (SEA)* *M/Canarium spp. (SEA)* *T/Carapa guianensis (TAM)* *M/Ceiba pentandra (TRO)* *T/Cratoxylon spp. (SEA)* *T/Didymopanax morototoni (TAM)* *T/Dyera costulata (SEA)* *M/Durian durian (SEA)* *T/Goupia glabra (TAM)* *T/Guazuma crinita (TAM)* *T/Lophira alata (AFR)* *M/Maesopsis eminii (AFR)* *M/Manilkara zapota (TRO)* *T/Milicia excelsa (AFR)* *M/Nephelium spp. (SEA)* *T/Ochroma lagopus (TRO)* *T/Octomeles sumatrana (SEA)* *M/Paraserianthes falcataria (SEA)* *M/Pithecellobium dulce (SEA)* *T/Pterocarpus macrocarpus (IND)* *M/Samanea saman (SEA)* *T/Schizolobium amazonicum (TAM)* *T/Schizolobium parahybum (TAM)* *T/Shorea leprosula (SEA)* *M/Shorea macrophylla (SEA)* *T/Shorea ovalis (SEA)* *T/Shorea parvifolia (SEA)* *T/Simarouba amara (TAM)* *M/Spathodea campanulata (AFR)* *T/Terminalis superba (TRO)* *T/Toona ciliata (SEA)* *T/Vochysia máxima (TAM)*	*T/Acrocarpus fraxinifolius (IND)* *M/Anacardium occidentale (TRO)* *T/Anthocephalus cadamba (IND)* *M/Azadirachta indica (TRO)* *M/Bambusa spp. (IND)* *M/Dendrocalamus spp. (IND)* *M/Ficus spp. (TRO)* *T/Pithecelobium saman (TAM)*	*M/Alnus acuminata (TAM)* *T/Betula alnoides (IND)* *T/Callicarpa arborea (SEA)* *T/Paulownia tomentosa (IND)*

M = multi-purpose species (timber, fruits, bark, etc); T = predominantly a timber species

Primary distribution of the species: AFR = tropical and subtropical Africa; IND = India, subtropical Indo-China, and subtropical and tropical China; TAM = tropical and subtropical Americas; SEA = Southeast Asia, including the Mekong; TRO = pan-tropical

The main role of the tree and shrub species listed in Table 9 is to rapidly capture a site and to promote natural regeneration through the creation of a 'forest environment' and accelerated forest tree seed inputs by wildlife. Such forests are used to initiate the rehabilitation of biodiversity in both the soil and vegetation. These forests may also be managed for wood or non-wood forest products,

although their primary purpose is site rehabilitation. Nurse tree species should help to rapidly increase soil fertility and soil organic matter content, shade out competing herbaceous vegetation, and thereby create conditions favourable to the natural regeneration of forest species.

Table 9 *Open-ended list of promising species (framework or nurse species) to use in the rehabilitation of degraded forest land*

Humid and semi-humid tropics	Semi-arid and dry tropics	Tropical highlands
Acacia auriculiformis (SEA)	*Acacia spp. (TRO)*	*Acacia mearnsii (SEA/IND/AFR)*
Acacia mangium (TRO)	*Ailanthus excelsa (IND)*	*Acacia decurrens (SEA/TRO)*
Albizia chinensis (SEA)	*Albizia lebbeck (IND/TAM/SEA)*	*Alnus acuminata (TAM)*
Albizia falcataria (SEA)	*Anogeissus latifolia (IND)*	*Alnus nepalensis (IND)*
Azadirachta excelsa (SEA)	*Azadirachta indica (TRO)*	*Balakata baccata (SEA, IND)*
Balakata baccata (SEA)	*Balanites aegyptiaca (AFR)*	*Betula alnoides (IND)*
Calicophyllum spruceanum (SEA)	*Cassia siamea (TRO)*	*Callicarpa arborea (SEA)*
Calliandra calothyrsus (TAM/SEA)	*Colophospermum mopane (AFT/IND)*	*Engelhardia spicata (SEA, IND)*
Cassia siamea (IND, SEA)	*Combretum micranthum (AFR)*	*Grevillea robusta (AFR, TAM)*
Casuarina equisetifolia (TRO)	*Conocarpus lancifolius (AFR/IND)*	*Harungana madagascariensis (AFR)*
Cecropia spp. (TAM)	*Dalbergia sissoo (IND/AFR)*	*Helicinia nilagirica (IND)*
Cinnamonmum iners (SEA)	*Emblica officinalis (IND/SEA)*	*Inga spp. (TAM)*
Derris indica (IND/SEA)	*Harungana madagascarensis (AFR)*	*Litsea cubeba (IND)*
Erythrina stricta (SEA, IND)	*Parkinsonia aculeata (TAM/AFR/IND)*	*Paulownia tomentosa (IND)*
Ficus benjamina (SEA)	*Pithecellobium dulce (TAM/TRO)*	*Prosopis juliflora (TAM)*
Ficus microcarpa (SEA)	*Populus euphratica (IND/AFR)*	*Prunus cerasoides (IND)*
Fragrea fragens (SEA)	*Prosopis cineraria (IND)*	*Schima wallichii (SEA)*
Gliricidia sepium (TAM)	*Prosopis juliflora (TAM)*	*Toona ciliata (SEA)*
Gmelina arborea (TRO)	*Prosopis pallida (TAM)*	
Heynea trijuga (SEA)	*Schima wallichii (SEA)*	
Hibiscus tiliaceus (TRO)	*Sesbania sesban (AFR.IND/SEA)*	
Hopea odorata (SEA)	*Tarchonanthes camphoratus (AFR)*	
Intsia palembanica (SEA)	*Ziziphus mauritiana (IND/TRO)*	
Leucaena leucocephala (TRO)	*Ziziphus numularia (IND)*	
Macaranga spp. (SEA)	*Ziziphus spina-christi (AFR)*	
Maesopsis eminii (AFR/TRO)		
Melaleuca leucodendrum (TRO)		
Melia azaderach (SEA, AFR, TAM)		
Mimosa scabrella (TAM)		
Musanga cecropioides (AFR)		
Ochroma lagopus (TRO)		
Octomeles sumatrana (SEA)		
Palaquium gutta (SEA)		
Parkia velutina (TAM)		
Phoebe lanceolata (SEA, IND)		
Pithecellobium dulce (SEA)		
Pterocarpus macrocarpus (IND)		
Samanea saman (SEA)		
Sesbania grandiflora (IND/SEA)		
Simarouba amara (TAM)		
Schima wallichii (SEA)		
Schizolobium amazonicum (TAM)		
Syzygium cumini (IND/SEA)		
Tabebuia serratifolia (TAM)		
Terminalia catappa (TRO)		
Trema spp. (TRO)		
Toona ciliata (SEA)		
Vismia guianensis (AFR)		
Vochysia ferruginea (TAM)		
Vochysia hondurensis (TAM)		

All species listed in Table 9 are considered multi-purpose species.

Primary distribution of the species: AFR = tropical and subtropical Africa; IND = India, subtropical Indo-China, and subtropical and tropical China; TAM = tropical and subtropical Americas; SEA = Southeast Asia, including the Mekong; TRO = pan-tropical

Annex 4

An example of a typology of secondary forests*

Post-catastrophic secondary forest	**Forest → Catastrophic natural disturbance → Natural regeneration**
Forests regenerating largely through natural processes after significant reduction in the original forest vegetation due to a catastrophic natural disturbance or succession of such disturbances, and displaying a major change in forest structure and canopy species composition. Catastrophic natural (often involving a human element) disturbances include fires, tornadoes, hurricanes, landslides and floods. Depending on the nature of catastrophic natural disturbance, numerous subtypes can be further distinguished: eg *post-fire*, *post-flooding*.	a) White spruce (*Picea glauca*) stands transformed into aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) following fire in boreal forests of Alaska (Whelan 1995) b) Dipterocarp-dominated forests transformed into *Melaleuca spp.* forests in swamp ecosystems of southern Sumatra following logging and fire (Giesen 1991) c) Mature rainforest damaged by Hurricane Joan in 1989, colonized by fast-growing, short-lived (*Croton smithianus*) and long-lived (*Vochysia ferrugina*) pioneer trees in eastern Nicaragua d) Cyclone forests in Australia-Pacific e) Post-fire forests after 1888, 1932 and 1998 fires in Borneo
Post- extraction secondary forest/ degraded primary forest	**Forest → Extraction/harvest → Natural regeneration**
Forests regenerating largely through natural processes after significant reduction in the original forest vegetation through tree extraction at a single point in time or over an extended period, and displaying a major change in forest structure and canopy species composition.	a) Dipterocarp-dominated forests transformed into forests dominated by *Macaranga spp.* and *Trema spp.*, among others in East Kalimantan following intensive logging (Abdulhadi et al. 1981) b) Dipterocarp-dominated forests transformed into forests dominated by short-lived *Trema orientalis* and *Macaranga spp.*, *Alphitonia spp.*, and *Mallotus spp.* following intensive logging in the Philippines (Weidelt and Banaag 1982)

* Modified after Chokkalingam and de Jong 2001.

Swidden fallow forests	**Forest ➔ Clear and burn ➔ Crop ➔ Fallow regeneration**
Forests regenerating largely through natural processes in woody fallows of swidden agriculture for the purposes of restoring the land for cultivation again.	a) Tropical rainforest of *Terminalia amazonia* transformed to forests dominated by *Trema micrantha* and *Heliocarpus appendiculatus* in the Chinantla, Mexico following swidden cultivation (van der Wal 1998) b) Lower montane rain forests transformed into forests dominated by *Schima wallichii*, *Eurya acuminata*, *Castanopsis armata,* etc, in shifting cultivation fallows of northern Thailand (Schmidt-Vogt 1999) c) Primary rain forests converted to *Cecropia* sand *Orbygnia* dominated young (6–10 year-old) secondary forest stands in the Brazilian Amazon following swidden cultivation (Moran et al. 1996)
Forest gardens[1]	**Forest ➔ Smallholder plantation (low intensity management) ➔ Natural regeneration** **OR** **Forest ➔ Clear and burn ➔ Crop ➔ Considerably enriched fallow regeneration**
Considerably enriched swidden fallows, or less-intensively managed smallholder plantations or home gardens where substantial spontaneous regeneration is tolerated, maintained, or even encouraged. Secondary forest gardens have a substantial planted or tended component, but the majority of the vegetation is of spontaneous origin. Where the planted or tended component increases, this type turns into *agroforests*.	a) Dipterocarp-dominated forests converted to jungle rubber systems after swidden cultivation in Kalimantan (Penot 1997) b) Semi-deciduous moist forests of *Sterculiaceael Ulmaceae* transformed to mixed cocoa agroforests in the Tikar plains on Cameroon or lowlands of Sao Tome (Dounias 1999) c) Swidden fallows enriched with fruit trees (eg of *Bactris gasipaes*, *Inga spp.*, *Paraqueiba spp.*, *Persea americana*, *Theobroma grandiflorum*), a common practice among indigenous groups, eg the Secoya, Witoto and Bora Indians in the northern Peruvian Amazon (Dubois 1990) and the Ka'apor in the eastern Brazilian Amazon (Balée and Gély 1989)

1 The processes leading to forest gardens can be highly varied; those described here are examples of multiple possible pathways

Post-abandonment secondary forests	**Forest ➔ Alternative land-use ➔ Abandonment ➔ Natural regeneration**
Forests regenerating largely through natural processes after total abandonment of alternative land-use (eg plantations, agriculture, pasture) on formerly forested lands. Depending on the nature of the land-use prior to abandonment, numerous subtypes can be further distinguished, eg *post-agriculture*, *post-ranching*.	a) Mixed tropical rainforests of coastal areas in Gabon transformed into pure stands of *Aucoumea klaineana* following clearing for cultivation and subsequent abandonment of agricultural use in the 1950s (White et al. 1996, Nasi 1997) b) Subtropical wet forest association of *Dacryoides-Sloanea* in Puerto Rico used for agroforestry, selective logging, charcoal production, and timber management. Each of these activities affected forest structure, composition and regeneration, and caused a varied mosaic at the landscape level (Garcia-Montiel and Scatena 1993) c) Floodplain forests of the Amazon estuary have been profoundly altered by long-term, continuous human occupation and are almost exclusively secondary in nature (Dubois 1990). Intensive exploitation has concentrated on valuable timber species such as *Virola surinamensis*, *Carapa guianensis*, *Hura crepitans*, and the useful palm tree *Euterpe oleraceae* d) Fruit trees planted in regenerating forests by the Mayas. After several hundred years the Maya forests in northern Mesoamerica show a high dominance of useful trees such as *Brosimum alicastrum*, *Acrocomia mexicana*, *Casimiroa edulis* and *Theobroma cacao* (Gomez-Pompa 1991) e) Coppicing succession in swidden farming systems associated with the practice of minimal cultivation in old forest fallows – eg the Susu farmers in northwest Sierra Leone (Nyerges 1989)
Rehabilitated secondary forest/rehabilitation of degraded forest land	**Forest ➔ Degraded land ➔ Rehabilitation + Natural regeneration**
Forests regenerating largely through natural processes on degraded lands, often aided by rehabilitation efforts, or the facilitation of natural regeneration through measures such as protection from chronic disturbance, site stabilization, water management, and planting.	a) Native plant species recruitment in North Queensland following rehabilitation efforts on degraded forest lands (grasslands and eroding river banks). Most common species regenerating were *Omalanthus novo-guineensis* and *Cryptocarya triplinervis* (Tucker and Murphy 1997) b) Degraded forest lands (grasslands) in Kibale National park, West Uganda were planted to *Pinus caribeae,* which catalysed the establishment of natural fast-growing genera such as *Albizia* and *Milletia* (Fimbel and Fimbel 1996)

Annex 5

Conceptual framework for the restoration, management and rehabilitation of degraded and secondary forests*

The need for a conceptual framework

Disturbance and vegetation regrowth dynamics are largely a result of social interactions with the natural environment and require a holistic analysis of ecological, social, economic, technical and policy aspects. Understanding and working with these dynamics requires a conceptual framework that brings together information from these different disciplines in a meaningful manner (Skole et al. 1999). Also, considerable site-specific information exists with regard to dynamics and the importance of different types of degraded and secondary forests in the tropics, and the threats and opportunities they face. However, these show a high degree of variability in space and time, and the underlying causative factors are complex and interlinked. A dynamic conceptual framework can help organize the apparently random variability by identifying systematic processes/trends and their underlying driving forces.

The dynamic framework developed conceptualises the evolution of the role and importance of different types of degraded and secondary forests and related land-use based on the underlying systematic driving forces responsible for forest land disturbance and subsequent regrowth dynamics over time and space in tropical countries. This framework is potentially useful for guiding management and policy options in each stage of the intensification continuum; it may also play a potential role in anticipating and preventing problem situations beforehand.

The development/intensification continuum as a relevant framework

The forest land-use intensification continuum provides a relevant and useful framework for assessing forest regrowth dynamics because the systematic driving forces responsible for the disturbances and subsequent forest regeneration change and evolve along this continuum. This intensification continuum also allows for the consideration of different types of significant human-initiated disturbances and land-uses that give rise to forest regeneration.

Disturbances include intensive extraction of forest products for subsistence and commercial purposes, the conversion of forests to other land-use, and incidences of catastrophic events such as fire. *Regeneration* can occur after intensive disturbance as a part of an alternative land-use, with the abandonment of an alternative land-use and with the rehabilitation of degraded forest lands. After intensive disturbance through extraction (or fire), the regeneration of degraded primary forests or secondary (successional) forests will continue as long as extraction pressures are not excessive and as long as forests can compete with other land-uses. *Degradation* will occur when extraction (or fire incidence) is greater than the regenerative capacity. High population density, land scarcity, and infrastructure development may lead to excessive disturbance.

Four stages are identified in the intensification continuum based on the intensity of exploitation and use of forests and forest lands:

i) extensive use stage: associated with an early, low-level, steady decline in forest cover;

ii) intensive exploitation stage: associated with a sharp, accelerated decline in forest cover;

iii) forest-depleted stage: associated with a slowdown in forest destruction and the subsequent

iv) maintenance of remaining forest cover; and

v) forest recovery stage: associated with a subsequent rise in forest cover.

The last stage, forest recovery, is not really significant at the current time in terms of natural forests or forest plantations in the three tropical regions.

Table 10 briefly describes some key socioeconomic, resource, institutional and policy-related characteristics of the three stages of the development/intensification continuum. Table 11

summarizes basic characteristics of degraded and secondary forests in the three stages. The underlying driving forces tend to change along the intensification continuum. In the intensive exploitation stage, large areas of degraded primary forests and secondary forests regenerate following industrial and local extraction and fire because they can still compete with other land-uses given land availability, tenure insecurity, and the difficulty of monitoring remote sites. But the scope for maintaining and enhancing the contribution of degraded primary forests and secondary forests may be higher in the early extensive use and later forest-depleted stages. This is because in the extensive use stage, secondary forests originated from shifting agriculture (the dominant type) form an integral part of smallholder production systems.

In the forest-depleted stage, the situation is more ripe for policy changes and implementation favouring tenure clarity, sustainable management, rehabilitation, local livelihoods and environmental services. However, in the intensive exploitation stage, there is scope for applying paradigms developing in areas further along the intensification continuum and trying to revert degradation trends in advance.

This framework can help in developing management and policy options based on threats and relative endowments, infrastructure and the policy and institutional environment present at each stage. The framework suggests that interventions directed at sustainable degraded and secondary forest use and development needs to be integrated into a long-term land management strategy based on a strong knowledge base, the equitable participation of relevant stakeholders, clear tenure definition, and a long-term perspective in all stages. Management options and policy interventions suggested by the framework need to be verified with empirical data. The intensification model presented above is not to be viewed as overly deterministic. The underlying driving forces include substantial policy interventions and economic developments that could be altered and managed.

Table 10 *Socioeconomic, resource, institutional and policy-related characteristics of the three stages of the development/intensification continuum*

I. Land-use			
Characteristics	**Extensive use stage**	**Intensive exploitation stage**	**Forest-depleted stage**
Main activities	- Shifting (long-fallow) agriculture - Local extraction of forest products	- Intensive commercial logging - Industrial-scale plantations - Mining activities - Development activities (eg roads, dams - Intensive local extraction of forest products - Shifting (short-fallow) or permanent agriculture - Secondary forest gardens and smallholder plantations - Grazing	- (Small-scale) local extraction of forest products - Sedentary agriculture - Grazing - Protected forest areas - Some agroforests and home gardens – more in wetter areas - Some plantation forestry - Some rehabilitation of degraded lands
Main actors	- Indigenous groups/ forest-dwellers	- Timber concessionaires - Mills and processing industries - Plantation companies - Mining companies - Government departments (forestry, mining, sponsored migration, plantation) - Migrants (colonists, labourers) - Traditional forest-users/ residents	- Local communities (traditional forest-users + migrant settlers) - NGOs - Extension agencies - Government

* This conceptual framework is based on Chokkalingam et al. 2001 and draws on existing theories and models on underlying factors of forest change relevant to tropical Asia, emphasizing factors related to secondary forests. It has been adapted to the scope and terminology used in these guidelines.

Table 10 *(continued)*

Objective	- Subsistence - Some cash income in areas of market access	- Large-scale industrial activities: profits and economic growth - Infrastructure: development and economic growth - Migrant activities: cash income and subsistence - Traditional forest-users: subsistence and cash income	- Communities: subsistence and some cash income - Private landholders: cash income, investments - Forest protection and restoration measures: environmental services and/or forest products - Plantation forestry: cash income, forest products and services
II. Relative resource endowments			
Characteristics	**Extensive use stage**	**Intensive exploitation stage**	**Forest-depleted stage**
Population density and labour availability	Low	Tends to increase – migrants (transient and permanent settlers) and natural increases in local population	High, medium, or low depending on whether people continue to reside in area, or move to better opportunities available elsewhere
Natural resource and forest land availability	Plenty	Less	Low
Capital and technology	Low	High – availability of private and government finance, improved harvesting and processing technologies, chemical inputs, improved biological stocks and extension support [Lower in drier less-productive areas or higher population centres]	High in private operations Medium in government-owned operations Lower in open-access and community-owned operations
III. Infrastructure			
Characteristics	**Extensive use stage**	**Intensive exploitation stage**	**Forest-depleted stage**
Transport and access	Limited – mainly water and animal transport	Better – road networks developed and more-powerful motorised road and water transport available	High – already-established road networks, though they may become degraded in poorer areas. More efficient transport systems available for those who can pay
Markets	Limited – mainly along waterways and coastal zones	Increased access to local, regional, national and global markets	Accessible

Table 10 *(continued)*

IV. Institutional endowments			
Characteristics	**Extensive use stage**	**Intensive Exploitation Stage**	**Forest-depleted stage**
Land tenure	Traditional claims apply. Opening up forest for shifting agriculture confers nearly exclusive use rights on the individual	Overlapping conflicting tenure relations with government owner-ship of forest lands, leases given to industry, traditional claims still held, and migrant squatting on opened-up land	Large areas still government-owned, either totally protected or open access. Move towards privatization (to communities or households) or joint management of some forest lands
Governance	Limited government intervention. Traditional local councils govern resource use	Centralised conferment of resource use rights, monitoring and control of use. Influence of traditional local councils more limited	The start of devolution of governance of some forest and land-use to local levels, both governments and communities
V. Policy environment			
Characteristics	**Extensive use stage**	**Intensive exploitation stage**	**Forest-depleted stage**
Policy environment	Forests away from urban and development centres not subject to many government policy initiatives	Forests and forest lands viewed as national resources and source of wealth, and their exploitation and conversion promoted to further national development and economic growth through subsidies to industry, development projects, etc Tendency to marginalize local resource needs, traditional management and use practices	Higher environmental and social awareness. Concern for low forest cover, loss of environmental services, product scarcity, land degradation and local livelihood needs begin to guide policy initiatives. Greater emphasis on reforestation, natural regeneration, community forestry, sustainable forest management, watershed protection, etc

Table 11: *Characteristics of degraded and secondary forest in the three stages of the continuum*

Characteristics	Extensive use stage	Intensive exploitation stage	Forest-depleted stage
Absolute and relative (vis-á-vis primary forest) cover	Low absolute and relative cover	Higher absolute and relative cover	Stable or declining absolute cover, but very high relative cover
New degraded + secondary forest formation	Some	Considerable	Insignificant
Importance to local livelihoods	Secondary forests from shifting agriculture systems are the dominant forest type (in some areas also forest gardens). Secondary forest is very important for soil rejuvenation, subsistence products, and some cash income in areas of market access	Degraded forests resulting from intensive logging are the dominant type. Degraded forests are not very tightly linked to smallholder land-use, but still very important for subsistence and cash income. Illegal logging could be a major source of income for local people. In some areas, important to industry for timber	Degraded and secondary forests dominate. Degraded and secondary forests are important for local livelihoods when there are high population pressures and resource scarcity, even more so if they are involved in management, restoration and benefit sharing. Increasing rehabilitation efforts in degraded forest lands, but not always contributing to local livelihoods
Management practices	Low-intensity management of (fallow) secondary forest based on traditional technical knowledge	Uncontrolled extraction in primary forests and progressive exploitation of degraded forest by different users. Secondary forests give way to more intensively managed secondary forests favouring commercially desired species	Degraded forest and advanced secondary forest protection in reserves, low-intensity management in community-owned areas, intensive management in small private holdings, and progressive exploitation (= degradation) of degraded forest in open-access areas
Environmental dimensions	Not much damage in formation of secondary forest, keeps early successional forests and species on the landscape in a shifting mosaic	Lots of environmental damage in formation of degraded forest due to large-scale and intensive nature of forest exploitation (and fire). Subsequent secondary forest regrowth is important for environmental stability	Secondary forest formation and management on degraded lands could contribute greatly to environmental stability
Ecological characteristics	Rapid regrowth of fallow secondary forest and good forest conditions	Degraded forest regrowth difficult because of soil destruction, lack of seed sources in the vicinity, and repeated disturbance, with the forest getting more degraded as a result	Existing degraded and secondary forest further degraded under conditions of open-access and high population pressures, but can be in good condition when protected or otherwise managed. Rehabilitation of degraded forest lands difficult because of highly degraded site conditions and chronic disturbance
Landscape characteristics	Large sections of primary or mature secondary forest; broken up by little pockets of settlements, fields, fallow secondary forests of various ages, and some forest gardens in certain areas	Degraded and secondary forests in different recovery/ regrowth stages, degraded forest lands, agriculture, smallholder and large-scale plantations and estate crops (more in moist areas), industries and development projects, mines, road networks, settlements, and primary forest patches on inaccessible sites	Predominantly an agricultural landscape intermixed with urban developments, large areas of degraded forest, secondary forest and degraded forest lands, and some plantations. Primary forest scarce and confined to inaccessible areas. Secondary forest also restricted to hilly terrain or less accessible areas

Annex 6

Specifics of forest restoration in the dry tropics*

Definition

Dry forests (classified by FAO as dry deciduous, very dry, and desert forests) make up some 14% of the world's tropical forests. Located between the evergreen tropical rainforests and the dry savannas and deserts, these forest formations broadly correspond to FAO's open forests, defined as "formations with discontinuous tree layer but with a coverage of at least 10% and less than 40%. Generally there is a continuous grass layer allowing grazing and spreading of fires. Examples are various forms of 'cerrado' and 'chaco' in Latin America, wooded savannahs and woodlands in Africa" (FAO 2000).

There is a large variation among dry tropical forests in terms of structure, diversity, species composition, the frequency of evergreen species in the upper tree layer(s), and height, and in their production and other functional aspects. The delimitation of these forests towards the rainforest is related to the length of the dry period rather than to annual precipitation (Gerhard and Hytteborn 1992).

Causes of forest degradation

Intensive human intervention – fire, grazing, agriculture, firewood, fodder, etc – dating far back into history has significantly transformed the dry forest almost everywhere. Those formations which have not been more or less completely destroyed are generally impoverished and open. The degradation processes thus initiated lead to a shift away from the original vegetation types to drier, less productive and less resistant forest types, and finally to communities without trees or other woody vegetation.

Forest clearing for agriculture and livestock husbandry (particularly in South America) is among the main causes of deforestation in the dry tropics. Overgrazing is also a factor in forest deterioration in Africa and India. Forests are one of the few places where livestock feed is available in the dry season. Woody vegetation is then browsed and stripped of its bark, and the dried-up soils are compacted, condemning regeneration establishment. Fires used in particular by livestock breeders to assist grass regrowth are a hindrance to woody vegetation productivity. The excessive trimming of branches in the dry season depletes the trees and increases fire risk.

Multiple-use management of dry tropical forests

Forest land in the dry tropics is usually the object of multiple demands from a wide range of land users (farmers, herders, foresters, bee-keepers, hunters, etc). Firewood is by far the most extracted product. Livestock husbandry and agriculture also constitute an essential part of the dynamics of dry tropical forest lands. Managing silvo-pastoral resources must in most cases become a substitute for forest management.

Any management, especially in small-scale farming areas, must necessarily attempt to enhance all products and services in the face of strong competition from alternative land-uses. Successful management is likely to be based on low costs, easy execution, local acceptance, and environmentally sound interventions.

As much as possible, management via natural regeneration (seedlings, sprouts, root suckers, etc) should be preferred to planting in stand establishment and/or regeneration. Three basic silvicultural systems are being used in dry tropical forests: the coppice system, the coppice-with-standards system, and the high forest system. Other systems include the 'coppice selection' method, the 'simple coppice' system, and the 'coppice of two rotations' system (see definitions in Bellefontaine et al. 2000). For forests whose main product is timber, high forest or selective coppice-with-standards are preferred systems (if favourable conditions exist that permit the production of larger-diameter timber). In the less dry zones of these forests, regeneration can be through regeneration cutting, provided that the crowns and branches are left on the ground to act as mulch.

* Based on Lamprecht 1989, Shepherd 1992, Bellefontaine et al. 2000

In forests where firewood and fodder are the main products, the simple coppice system has often been used, but it is being replaced by the coppice selection system, provided that the forest is not already over-harvested. This form of harvesting through wood-gathering, small-wood rummaging or by large wood selection and by topping and pruning park trees is wholly appropriate, provided that the volumes harvested do not exceed production. Around large towns and in all over-harvested forests, the simple coppice system should be adopted excluding fruit trees, fodder trees and medicinal trees.

The choice of the period and the optimum height of the cut would seem to be during the vegetation rest period (dry season). This must also take into account the cropping calendar, particularly in regions where seasonal shortages of labour might arise. Cutting should be level with the ground in order to encourage the emergence of sprouts and, for some species, root suckers.

In seriously degraded forests a longer rotation period should be prescribed, with improvement planting/seeding of forest clearings followed by a grazing exclusion period. The golden rule is to harvest less than the allowable cut. In burnt forests all timber exploitation should cease, at least until they are fully recovered. This measure aims to protect remaining large trees which are valuable both as a source of seeds and for the shade they provide.

A wide range of silvicultural practices may be used for dry forest management, depending on the different management objectives, the forest condition and the available means. Thinning operations are restricted to certain dry tropical forests when justified in economic terms, mainly for timber production. In such cases it is always to the detriment of very common species as well as species for which there is low demand. It could also prove to be useful to thin out species which are not sought-after locally during the least favourable season for their vegetative multiplication or at a height, to be established, which would inhibit shooting. Conversely, in order to encourage root suckers or sprouts on multiple-use species, thinning operations could be planned during the most favourable period.

Release cutting (a term used for specific types of thinning, relating for example to young sprouts or young saplings in order to improve individual growth) seems to be very useful for improving a stand by encouraging the growth of selected shoots. In the dry tropical savanna zone, pruning, as generally conducted, is a practice used to supply fodder and/or firewood and to reduce crop shade.

Pollarding (or trimming-out), which consists of cutting off tips of branches or young shoots on the main stem of a tree, is a practice very widely used by dry tropical zone pastoralists in order to increase fodder availability at the end of the dry season. The trimming-out of branches for firewood is also very widespread in Latin America and forms an integral part of the natural stand management system used by the small farmers. Topping, which often involves the removal of all the branches, is a common practice with a number of different objectives: fodder production (at the end of the dry season), fruit production (by controlling tree height to facilitate fruit gathering), and sprout positioning (high enough to be out of reach of browse or fire damage).

Direct seeding is an effective silvicultural technique due to its low operational cost and comparative simplicity. It is easily accessible to small farmers when rainfall is regular; however, fast-growing or non-palatable tree species must be selected in order to shorten the production period required. The main drawback is the great deal of protection this practice requires to prevent seeds and seedlings from being destroyed.

Woodlots and plantations are particularly unsuccessful in areas with less than 800 mm of rainfall, except where trees can be irrigated. 'Fast-growing' exotics grow little faster under these conditions than does the pre-existing vegetation and are outperformed by indigenous species in drought years. Managing woodland for firewood rather than establishing plantations becomes economic once plantation yields are below 6 m^3/hectare annually, a figure quickly reached if water is unavailable or plantations poorly managed. The drawbacks with plantings in dry tropical zones are numerous: unpredictable outcome closely related to rainfall regularity; the need for protection under long deferred grazing/browsing periods; initial medium-to-low growth rates; indispensable beating-up and intermediate treatment and tending operations; high costs; etc.

Fire protection

Fire is a very important management tool. It is both a cleanser and enricher of the earth, and an essential part of agriculture as well. However, fire is also a major cause of forest degradation in tropical dry zones. In order to protect woodlands from early burning it is essential to encourage the joint involvement of herders, farmers, foresters and other economic agents. In particular, fire prevention should involve the education of local farmers and other land users whose fires may be a major source of ignition in forests. Direct protection of forests by firebreaks is one measure to reduce the problem. Firebreaks have the purpose of creating discontinuity in the forest stand in order to reduce fire intensity and effectively control it at specific points. The choice among the several types of firebreaks (see Bellefontaine et al. 2000) depends upon soil conditions, the investment means available and people's aspirations. 'Green' firebreaks, formed by swathes of non-inflammable vegetation which would require little maintenance compared with traditional, bare-soil firebreaks, are often preferred. Firebreaks must form part of a basic infrastructure and can be used to demarcate forest boundaries, delimit transhumance corridors (thoroughfares through which livestock move in response to the seasonal availability of feed) and in some cases facilitate forest access.

Grazing regulation

Grazing is a common use in dry forest formations. The growth of woody plants can be increased by reducing herbaceous competition, namely by moderate grazing, under normal rainfall. Grazing also maintains a balance between annual, perennial and dwarf vegetation. Grazing in the forests is also an effective way of combating fires. However, without proper control and management, overgrazing occurs. Its first manifestation is the modification of the floristic composition. The sought-after palatable species disappear, giving way to non-palatable species which have been given the chance to multiply. The other visible evidence is better known because it brings erosion, and sometimes to a spectacular degree.

Enforcing grazing exclusion within newly exploited forest compartments over a long period seems to have been a popular operation until quite recently. Its relevance in woodlands, however, is being partially challenged, particularly in terms of tree cover. For instance, in a Sudanian-Sahelian savanna, grazing had little impact on post-logging regeneration, and production was even better if the land was grazed, particularly where no fire control existed.

It is essential to give local people more responsibility for land care in order to limit the amount of livestock per village or the length of time taken for the transhumant herdsmen to pass through. This seems presently to be the only way to effectively integrate a standardized and acceptable form of silvo-pastoralism, avoiding overgrazing. To achieve this, it is necessary to know the various categories of livestock-breeders and to involve them, taking their needs into consideration. In the case of forests under timber production management, the above observations need to be moderated, knowing that the highly valuable species are often very palatable. In order to prevent them from acquiring a shrub-like habit, it is indispensable to protect them from browsing (eg by grazing exclusion for three-year periods).

The management of grazing lands in tropical dry zones necessarily requires that certain rules of use be generally accepted and adopted. These include the adoption of geographical pastoral units; complementary approaches and objectives between pastoralists, agro-pastoralists and foresters; respect for regular rest periods; and an agreed calendar of early bush-fire prescribed burnings and stocking rates.

Restoration methods

Given the relatively favourable silvicultural conditions found in dry tropical forests, most disturbed ecosystems within the dry tropics will naturally regenerate into forest if left alone. The first step toward their restoration or rehabilitation is, of course, to prevent further damage to the forest and the soil. Overcoming these obstacles involves factors far beyond the sphere of influence of forestry. In some respects, comprehensive land-use planning is more urgently needed in the dry tropics than in the humid tropics. The most important thing is that all resource users try to reconcile the numerous mutually competing claims on the land.

Suitable and well-tried silvicultural techniques from forests within and beyond the tropics are available for the restoration or rehabilitation of dry tropical forests. Specific restoration methods include favouring the natural regeneration and resprouting capacity, enrichment planting, direct seeding and planting.

It is likely that satisfactory natural regeneration could be expected in many types of dry tropical forests after grazing and fire have been eliminated. If the degradation of the stand and soil is so advanced that, for one reason or another, natural regeneration is insufficient or lacking, then recovery can be supported and accelerated by enrichment planting (see Box 4). In extreme cases, as when the degradation appears to be irreversible, the use of direct planting would be advisable.

Annex 7

Related definitions from other organizations and processes

Forest

UNFCCC 2001	A minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30% with trees with the potential to reach a minimum height of 2–5 m at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30% or tree height of 2–5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.
UNEP/CBD/ Subsidiary Body for Scientific, Technical and Technological Advice (SBSTTA) 2001	Forest is a land area of more than 0.5 hectares, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use. In the case of young forests or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5 m *in situ*, and of meeting the canopy cover requirement.
FAO 2001	Forest includes natural forests and forest plantations. It is used to refer to land with a tree canopy cover of more than 10% and area of more than 0.5 hectares. Explanatory note: Forests are determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 m. Young stands that have not yet but are expected to reach a crown density of 10% and tree height of 5 m are included under forest, as are temporarily unstocked areas. The term includes forests used for purposes of production, protection, multiple-use or conservation (ie forest in national parks, nature reserves and other protected areas), as well as forest stands on agricultural lands (eg windbreaks and shelterbelts of trees with a width of more than 20 m), and rubberwood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantations. It also excludes trees planted in agroforestry systems.

Primary forest

UNEP/CBD/SBSTTA 2001	A forest that has never been directly disturbed by humans and has developed following natural disturbance and under natural processes, regardless of its age. The term includes forests used inconsequentially by indigenous and local communities living traditional lifestyles. ['Direct human disturbance' means the intentional clearing of forest by any means (including fire) to manage or alter the forest for human use.]
FAO 1998	Natural forest undisturbed by man – forest which shows natural forest dynamics such as natural species composition, occurrence of dead wood, natural age structure and natural regeneration processes, the area of which is large enough to maintain its natural characteristics and where there has been no known human intervention or where the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established.

Old-growth forest

US Forest Service	An ecosystem distinguished by old trees and related structural attributes. Old-growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics, which may include tree size, accumulations of dead woody material, the number of canopy layers, species composition, and ecosystem function. Old-growth is not necessarily synonymous with virgin or primeval, and could develop following human disturbance.
UNEP/CBD/SBSTTA 2001	A primary or secondary forest which has achieved an age at which structures and species normally associated with old primary forests of that type have sufficiently accumulated to act as a forest ecosystem distinct from any younger age class.

Degraded (primary) forest

UNEP/CBD/SBSTTA 2001	A secondary forest which has permanently lost, or is unlikely to regain, the structure, function, species composition, or productivity normally associated with a natural forest type expected on that site. Hence a degraded forest delivers a reduced supply of goods and services from the given site and maintains only limited biological diversity.
FAO 1998	Natural forest disturbed by man – includes (i) logged-over forests associated with various intensity of logging, (ii) various forms of secondary forest, resulting from logging or abandoned cultivation.

Secondary forest

UNEP/CBD/SBSTTA 2001	A forest that has been directly disturbed by humans and has recovered naturally or artificially.
Chokkalingam and de Jong 2001	Forests regenerating largely through natural processes after significant human and/or natural disturbance of the original forest vegetation at a single point in time or over an extended period, and displaying a major change in forest structure and canopy species composition.

Degraded forest land

Brown and Lugo 1994	Lands are described as degraded when their edaphic conditions and/or biotic richness have been reduced by human activity to such a degree that their ability to satisfy particular uses has declined.

Forest degradation

FAO 2000	A reduction of the canopy cover or stocking within the forest through logging, fire, windfelling or other events, provided that the canopy cover stays above 10%. In a more general sense, forest degradation is the long-term reduction of the overall potential supply of benefits from the forest, which includes wood, biodiversity and any other product or service.
UNEP/CBD/SBSTTA 2001	A degraded forest is a secondary forest that has lost, through human activities, the structure, function, species composition or productivity normally associated with a natural forest type expected on that site. Hence, a degraded forest delivers a reduced supply of goods and services from the given site and maintains only limited biological diversity.
Lamb 2001	A loss of forest structure, productivity, and native species diversity. A degraded site might still contain trees (ie a degraded site is not necessarily deforested) but it has lost at least some of its former ecological integrity.

Deforestation

FAO 2000	The conversion of forest to another land-use or the long-term reduction of tree canopy cover below the 10% threshold.
UNFCCC 2001	The direct human-induced conversion of forested land to non-forested land.

Reforestation

FAO 2000 (UNEP/CBD/SBSTTA 2001)	The re-establishment of forests after a temporary (<10years) condition with less than 10% canopy cover due to human-induced or natural perturbations.
UNFCCC 2001	The direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land.
Lamb 2001	The re-establishment of trees and understorey plants at a site previously occupied by forest.

Afforestation

FAO 2000 (= UNEP/CBD/ SBSTTA 2001)	The conversion from other land-uses into forest, or the increase of the canopy cover to above the 10% threshold.
UNFCCC 2001	The direct human-induced conversion of land that has not been forested for a period of at least 50 years to forest land through planting, seeding and/or the human-induced promotion of natural seed sources.

Forest improvement

FAO 2000	The increase of the canopy cover or stocking (FAO 2001) of the forest through growth. In a more general sense (cf. forest degradation) forest improvement is the long-term increase of the overall potential supply of benefits from the forest, which includes wood, biodiversity and any other product or service.

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