Tropical Forest Research

The Significance of Secondary Forest Management for Development Policy

ECO —
Society for socio-ecological programme consultancy

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Preface

Adopted at the 1992 United Nations Conference on Environment and Development, at which 178 countries were represented, Agenda 21 includes a section devoted to forests. Together with the UNCED Forests Statement, Agenda 21 forms a basis for international cooperation on the management, conservation and sustainable development of all types of forests. The Rio resolutions also serve as the foundation for a process of national-policy modification designed to stimulate environmentally compatible sustainable development in both industrialized and emerging countries.

Ideally, sustainable development builds on three primary guiding principles for all policy-related activities: economic efficiency, social equity and ecological sustainability. With regard to the management of natural resources, this means that their global utilization must not impair future generations' developmental opportunities. With their myriad functions, forests in all climate zones not only provide one of humankind's most vital needs but also help preserve biological diversity around the world. Forest resources and wooded areas must therefore be sustainably managed, preserved and developed. Otherwise, it would neither be possible to ensure the long-term generation of timber, fodder, food, medicine, fuels and other forest-based products, nor sustainably and appropriately to preserve such other important functions of forests as the prevention of erosion, the conservation of biotopes, and the collection and storage of the greenhouse gas CO$_2$.

Implemented by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), the "Tropical Forest Research" and "Support to National Forest Programmes in the Global Context" projects have compiled this study on the realisation of potential value of secondary forests together, in order to highlight the ecological and socioeconomic value of secondary forests within the context of sustainable national development. They aim to improve the scientific basis of sustainable forest development and, hence, to help implement the Rio resolutions within the context of development cooperation.

Application-oriented research serves to improve our understanding of tropical forest eco-systems and their reciprocity with the economic and social dimensions of human development. The project also serves to promote and encourage practice-oriented young German and local researchers as the basis for development and dissemination of ecologically, economically and socially appropriate forestry production systems.

Through a series of publications, the "Tropical Forest Research" project makes the studies' results and recommendations for action available in a form that is generally comprehensible both to organizations and institutions active in the field of development cooperation and to a public interested in environmental and development-policy affairs.

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The issue of secondary forests and the potential contribution these forests can make to development is receiving increasing attention among experts, especially as the loss of primary forests means that the emergence and sustainable management of secondary forests will become more and more important. A large number of studies and publications have looked at this issue in the past. The main focus of these studies has been on the natural composition and succession dynamics of these forests. The main point of interest has usually been timber production. Very few authors have looked at other functions of these forests and at the social conditions which influence their development and use.

Secondary forests, just like all other natural resources, are located within a framework of differing and sometimes conflicting interests. In order to grasp the potential of secondary forests for development policy, it is therefore not sufficient to analyse and evaluate the natural resource. The differing objectives in the use of the resource and the varying capacities of the participants, as well as the sociocultural, economic, political and legislative framework must also be considered.

This study aims to relate the issue to a wider context and to show the topical framework within which a discussion of the relevance of secondary forests for development policy and their potential should be conducted. In order to do this, a global and usually very general approach was chosen which cannot take account of regional differences, particular groups of people or different types of secondary forests in greater detail. The study is based on an analysis of available literature on the subject, a questionnaire conducted with field staff of the GTZ, as well as many with GTZ staff in Eschborn, staff of other organisations and independent experts. The study should be seen as a contribution to the general debate and not more. The complexity of the issue and the many unanswered questions mean that the subject cannot be dealt with completely and finally here.

We would like to thank all the people who took part in the discussions for their help, and in particular Dr. Dietrich Burger, Thomas Heindrichs, Martin Homola and Dr. Jörg Linke, who made the completion of this study possible by their advice and expert opinions.

**Abbreviations**

- **DC** Development Cooperation
- **FAO** Food and Agriculture Organisation of the United Nations
- **FC** Financial Cooperation
- **GEF** Global Environmental Facility
- **GTZ** Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
- **IFF** Intergovernmental Forum on Forests
- **IPF** Intergovernmental Panel on Forests
- **LUP** Land use planning
- **M.** millions
- **NTFP** Non-timber forest products
- **TC** Technical Cooperation

**PREFACE**

The issue of secondary forests and the potential contribution these forests can make to development is receiving increasing attention among experts, especially as the loss of primary forests means that the emergence and sustainable management of secondary forests will become more and more important. A large number of studies and publications have looked at this issue in the past. The main focus of these studies has been on the natural composition and succession dynamics of these forests. The main point of interest has usually been timber production. Very few authors have looked at other functions of these forests and at the social conditions which influence their development and use.

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SUMMARY

General remarks

The debate on secondary forests increases in importance as the decrease in area of primary forests continues. The aim of this study is to contribute to this debate, thereby offering a first basis on which decision-makers and those on the ground can judge and effectively use the development potential dormant within secondary forests.

After a description of the current extent and utilisation of secondary forests in the first chapters, the study then analyses the potential utilisation of secondary forests in producing certain benefits advantageous for a sustainable development. The basis of the analysis are the interests of the user groups from the local to international levels together with their different possibilities of intervention. Finally, various recommendations are made on how the utilisation of this identified potential can be supported by the measures open to technical cooperation (TC). Many of the statements made in the study are hypothetical in character and are intended to encourage a further discussion of secondary forests in the context of development cooperation (DC).

The term 'secondary forest'

The study is mainly concerned with the secondary forests of the Tropics and Subtropics. However, large parts can also be applied to the forests of the temperate zones. 'Secondary forest' is difficult to define and the term is interpreted differently by different authors. Although any demarcation involuntarily excludes certain forests which could be rightly characterised as secondary forests by other authors, the following definition has been chosen for the study:

**Secondary forest** is a forest succession vegetation which
(i) emerged after the total (more than 90%, more than 90,7%) man-made destruction of the primary forest vegetation, which (ii) covers a large enough area to create a different microclimate and new regeneration conditions which lead to a stand structure, composition of tree species and stand dynamics distinct to the original stand and (iii) which has not yet returned to its original state (and differs perceptibly from the original stand).

This definition still encompasses so many different types and stages of secondary forests that a classification system should be developed, with which the 'type of secondary forest' together with important framework Conditions can be described in more detail and which would make an international and unequivocal comparison possible. The development of such a system was not possible in the context of this study, however.

Extent and distribution of secondary forests

The area covered by secondary forests in the Tropics is estimated by BROWN and LUGO (1990) to be more than 600 million ha. This is equivalent to roughly 35% of the total forest area in the Tropics. The wide range of varying estimates of secondary forest area found in the relevant literature is due firstly to the different definitions of secondary forests used and secondly in different interpretations of the basic data. This data originates mainly from FAO publications, in which the category 'secondary forest' does not exist.

Of great importance is an understanding of secondary forests in the context of deforestation and reforestation. The FAO inventory of 1993 shows that forest destruction is continuing in most countries of the Tropics, at an average annual deforestation rate of (net) around 0.8%. Despite this continuing deforestation, it is possible that the area covered by secondary forests is increasing in certain countries and regions, not only relatively but also absolutely.

Of great importance for the potential utilisation of secondary forests is not only the development of area but also the qualitative development in the context of the regional or national situation. This can have possible effects on

- changes in the composition of the resource (an unchanging area can experience a slow degradation through over-exploitation)
- the succession stages (a tendency that only early stages occur due a shortening of fallow periods)
- the geographic distribution (local emergence or reduction of secondary forests on slopes, on marginal soils etc.)
The current use of secondary forests

Many secondary forests are being used intensively and in a more or less systematic and permanent way, especially in the proximity of human settlements for local consumption, and to a lesser extent for sale. A large part of secondary forests is part of a continual use cycle in which forest clearings for agriculture is followed by forest regeneration aimed at regaining soil productivity (shifting cultivation). High exploitation pressure means that the danger of over-exploitation is often very real. Current use includes wood (timber and fuel), non-timber forest products, forest fallow (for the regeneration of the area) and forest pasture. The biggest economic importance of secondary forests lies in their fuelwood production and in their role as forest fallow in the cycle of shifting cultivation.

Successful utilisation concepts are also available for multi-purpose use of secondary forests with agro-forestry and silvopastoral elements. These are often a further development of traditional systems. One example is the systematic encouragement of certain tree species (for timber, fruit, oil, etc.) during the fallow period whilst at the same time cultivating agricultural plants (like coffee or cocoa) in the lower story (or combined with forest pasture).

In some countries, environmental functions of secondary forests (for water quality for example) have been acknowledged. In Costa Rica, for example, the water resources office buys up agricultural land in important watershed areas in order to let them regain forest cover by natural succession (FEDLMEIER 1996). In Puerto Rico, secondary forests are accorded an important role for recreation and tourism.

Secondary forests which are hardly used (for example only for hunting) tend to be in remote areas, or are poor in resources or in an unattractive succession phase (for example being too young for industrial logging).

Reasons for 'under-utilisation' - given otherwise promising preconditions with regard to resources, infrastructure and access to markets - can also be insufficient investment capacity (labour power/ labour time etc.), lack of utilisation rights, insufficient knowledge, restrictive legislation and also a (temporary) disinterest on the part of the owners due to other more attractive alternatives.

Factors influencing the formation, development and character of secondary forests

Secondary forests (understood according to the definition applied by this study) can be formed by the following human activities:

1. Logging (clear-felling)
2. Shifting cultivation
3. Abandonment of previously permanent pasture, farmland or tree plantations (for example due to failing market prices connected with structural change, exodus of productive forces etc.)

Certain authors also include natural causes for deforestation in their definition of secondary forests which grow up as a result. These can be fire, wind, water, and volcanic eruptions. These natural causes can often be aggravated and their consequences enhanced by anthropological influences (for example fires which get out of control after burning for agricultural clearing or because of hunting with fire, which, if practised repeatedly, lead to the loss of forest cover).

The development of secondary forests is directly related to the total system of land and resource management applied in the region. Of decisive significance is the level of exploitation pressure, which again is influenced by ecological, but also economic and sociocultural factors.

Natural factors like site quality and remaining regeneration resources (themselves influenced by human activities, in particular by the nature and intensity of former forest use) also play a role in the formation and development of secondary forests.

The potential of secondary forests

Secondary forests are an inexpensive and site-appropriate form of forest restitution and have in principle a high regenerative potential. They can fulfil a whole range of functions which can benefit humanity. Usually, more than one of these functions is utilised at the same time. Three groups of use potentials can be defined:

- forestry uses (fuelwood, timber, non timber forest products, tourism)
- agricultural uses (agro-forestry systems such as forest fallow, forest pasture, cultivating agricultural
plants)  
- environmental protection functions (water-, soil- and climate protection including CO2 sink functions and the conservation of biodiversity)

As a general rule, the potential benefits of a secondary forest can only be discussed from the perspective of the specific user-group and its own objectives (for example satisfying fuelwood needs, the sale of certain NTFPS, commercial logging).

For this study, the potential interest and user-groups of secondary forests have been divided into three main categories:

- local population (for example farmers, women farmers, traders, herdsmen)
- regional and national population (including consumers and small industry)
- global community (consumers, governments, industries etc.)

These groups are naturally inhomogeneous within themselves and can include many sub-groups with differing interests in forest utilisation and with different use capacities. A more detailed differentiation and analysis of the user groups is beyond the scope and intention of this general paper however.

In the context of a specific objective and when developing a concrete plan of action on the ground, a detailed analysis of the interests and use capacities of the target groups and other actors must naturally be prepared with utmost care and attention.

An analysis of conflicting interests (or of the compatibility of interests), of the current level of exploitation (over-exploitation, under-exploitation) and of the overall framework is also necessary for the analysis of use potential and the course of action to be taken.

Furthermore, a comparison with other possible production systems (primary forest, afforestation, agro-forestry) is to be recommended, in order to find the best possible solution within a range of alternatives.

As a whole, the analysis of the potential of secondary forests for various functions shows promising possibilities. This is shown in detail in chapter 5 of this study. A summary of favourable conditions for the sustainable provision of specific benefits from secondary forests is given in table A below:

### Table A: Favourable conditions for the sustainable of specific benefits from secondary forests

<table>
<thead>
<tr>
<th>Benefit/function</th>
<th>Target group</th>
<th>Site quality</th>
<th>Geographical location</th>
<th>Stand quality</th>
<th>Age of stand</th>
<th>Framework conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timber</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Commercialisation</td>
<td>Regional and national population</td>
<td>middle-high</td>
<td>far from settlements</td>
<td>high</td>
<td>mature</td>
<td>Infrastructure, marketing structures, use rights</td>
</tr>
<tr>
<td>- Subsistence</td>
<td>local population</td>
<td>middle-high</td>
<td>near settlements</td>
<td>middle</td>
<td>young-middle</td>
<td>use and ownership rights</td>
</tr>
<tr>
<td><strong>Fuelwood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Commercialisation</td>
<td>regional population</td>
<td>middle-high</td>
<td>market proximity</td>
<td>indifferent</td>
<td>middle</td>
<td>Infrastructure, marketing structures, concessions, co-operatives</td>
</tr>
</tbody>
</table>
Recommended courses of action

TC has a range of different possibilities to promote secondary forests depending on the identified objective and the problem situation. However, little experience or systematised knowledge exist onto the impact of direct (silvicultural measures) and indirect (influencing underlying conditions) measures with regard to secondary forests. Therefore, all courses of action should be conducted as part of a learning process.

Most suggestions made for dealing with secondary forests focus on the management of the forest, whereby wood production is emphasised, with other functions being viewed as benefits which will follow in the wake of wood production.

Only a few projects of technical cooperation exist in which the support of a transsectoral approach with a forestry and agricultural multiple use of secondary forests is the objective.

Hardly any experience has been made with secondary forests as part of a dynamic mosaic of land use systems, in which forests are not solely defined by one land use and where they are often in a permanent state of conversion and transformation.

Which of these complementary approaches or which combination of all of them is most suitable, can only be decided case by case. However, it is always important to see secondary forests as an element of a regional land use system and to integrate corresponding measures in an overall land use plan.

Instruments available to development cooperation within the framework of multisectoral or sectoral strategies of support and guidance include:
Influencing the legal and political framework:
Secondary forests must become an object of political decision-making, and categories such as 'bare land' or 'bush' should be upgraded and receive a legally unambiguous status. User rights which promote a long-term interest in the land should be granted. The design of concessions and taxation and subsidisation policy also falls into this category.

Integration of secondary forests into the overall land use planning and into agricultural and forestry planning:
In this way secondary forest functions can be optimised and differing interests can be brought together more easily. Contradictory or mutually disruptive regulations can be minimised.

Silvicultural and technical measures:
Secondary forests react positively to silvicultural management, which can significantly increase the productive potential both qualitatively and quantitatively. However, low budget measures should be developed which can be implemented by the local population.

Marketing support:
Market access of previously unknown secondary forest species can be supported as well as wood processing industries

These instruments can also be used to actively create secondary forest or to influence the development of the forest. The formation of secondary forests on land which is unproductive or of little interest for agriculture can be supported, for example. These legal, planning and technical instruments can guide a naturally developing process towards certain desired succession products.

DC can support these various approaches at different levels of intervention. A combination of support at different levels usually makes sense:

- on the international level
  Introduction of the subject in international initiatives and global objectives, creating awareness of the problem, introduction of secondary forest species to markets, certification;
- on the national level
  Policy advisory services on changing the political, legal and economic framework, integration into the regional and land use planning, development and implementation of land rights, concession law, incentives (taxes, subsidies), promotion of industries;
- on the local level
  The equal consideration of the functions of secondary forests for the production of forest products, forest fallow and for conservation, support in improving the realisation of the potential of the forest and its sustainable management, the improvement of traditional land use systems, integration into land use plans, creating awareness of the problem, development of the local and regional wood processing industries and of market structures, strengthening of local groups.

All measures should be primarily oriented towards the needs of the local population. The focus should not be solely towards solving perceived problems but rather mainly on the better use of hitherto unrecognised potential.

The enhancement and better use of existing potential benefits from secondary forests can contribute to sustainable development by inducing value generation in the region, by reducing poverty and by the conservation of resources. Experience has shown that this can only be accomplished by a multisectoral strategy.

In order to put suggested measures into practice, suitable financing mechanisms has to be found. Apart from the traditional bilateral cooperation within the framework of TC and FC, a range of new international financing mechanisms have become available. In the context of the IPF and IFF process, the current state and future perspectives of 'Sustainable Forest Management' have been discussed. It is clear that national as well as international and private as well as public funding need to be mobilised. Suitable funding sources for measures in the context of secondary forest management include:

- Global Environment Facility (GEF);
- Dept-for-Nature-Swap;
- Mechanisms of the Kyoto Protocol
1 Introduction

The debate on secondary forests increases in importance as the primary forests decrease in area. However, at the political and social level, the potential of secondary forests often remains ignored, whereas plantations receive state subsidies. In addition, the analysis of potential benefits is largely restricted to wood utilisation, which is analysed - often unjustly - as unpromising. Prejudices abound which state that secondary forests are made up of valueless tree species, whose timber is not marketable, that increment is low and that natural regrowth on wastelands proceeds too slowly.

Some initial analyses now exist which this study aims to support, which view secondary forests not solely for their purely forestry functions but for the whole range of functions which they can fulfil and which look at their role within the totality of the existing land use system.

The purpose of looking at the topic secondary forests within development cooperation (DC) is to discern and support the potential role of secondary forest utilisation for sustainable development. This contribution to development can only be defined for each particular target group and for a specific locality and can include poverty alleviation, resource conservation, and in certain cases also increased income, a better supply of forest products for subsistence, the improvement of agricultural yields etc. This does not automatically always involve keeping a long term secondary forest cover and developing forest management. Under certain conditions, a larger contribution to development can just as well be achieved by a continuous shift between forestry and agricultural use of the area, or by a permanent conversion of secondary forests. This means that the potential of secondary forests can only be grasped and enhanced for specifically defined objectives and for specific target groups. The course of action followed to enhance and realise this potential must include biological-technical dimensions as well as socio-political and socioeconomic dimensions. The fact that a large part of this study covers silvicultural aspects in more depth is due to the fact that in the past, secondary forests - if taken notice of at all - have been viewed as forests, so that there is substantially more information and experience on forestry objectives and operations. Forestry management can also contribute to objectives which go beyond the forestry sector as such. Sectoral recommendations given in this study should therefore be viewed in the overall context of the pursued objectives and the given framework and need to be implemented within multisectoral strategies.

The aim of the study is to

- describe and evaluate the ecological, economic, political and sociocultural situation of secondary forests today.
- evaluate the potential of secondary forests for sustainable development from the perspective of the relevant user-group (potential for whom?)
- develop recommendations for the practical consequences which can mobilise the identified potential with the help of possibilities of support open to technical cooperation.

The target groups of this study are decision makers and practicians in forest DC.

The study looks at the situation of secondary forests in developing countries. It therefore focuses on the secondary forest of the Tropics and Subtropics. However, there are also developing countries in temperate zones which have large areas of secondary forests (for example Argentina, Latvia, China).

The basis of the study is an analysis of existing literature, the evaluation of a questionnaire which was sent to forestry projects of technical cooperation (TC) and discussions with GTZ-staff at the central office.

Many of the conclusions have the character of working hypotheses and are intended to encourage further discussion of secondary forests within the development political context. In lots of cases, the study cannot provide exhaustive answers to relevant questions because of insufficient experience and knowledge.

2 The Term 'Secondary Forest'
2.1 Different Definitions of Secondary Forest

The term 'secondary forest' has been applied in scientific nomenclature at least since the 1950's (RICHARDS 1955, GREIGH-SMITH 1952). Although the term has become more widespread in recent years, it is still uncommon in many countries. In these countries, forests which are composed of indigenous tree species are usually defined as forest or natural forest, independent of whether they are primary forests, exploited forests or regrowth forests. This means that the term secondary forest can have very different meanings, something which is aggravated by the fact that the word 'secondary forest' as the counterpart of the term primary forest evokes spontaneous and subjective associations which are difficult to systematise. Forests are defined as secondary forests which have evolved very differently and which therefore possess a wide range of characteristics (CORLETT 1995).

Various authors have tried to give an unambiguous definition to the heterogeneous mix of secondary forest formations. These attempts at definitions are only compatible, however, in the observation that secondary forests evolve largely independent of human influence after initial interference. Differing opinions on the nature and intensity of these interference's abound, which is partly due to the fundamental problem of scientific definition making, in which boundaries are artificially drawn which in reality do not exist in a natural continuum (CORLETT 1995). This problem becomes especially clear when we recollect that all tropical and subtropical forests have in some way and in many cases in a massive way, been subject to human influences; but that the changes thereby occurring can only be proven historically or with the help of relicts (BUDOWSKI 1961; CORLETT, 1994, GOMEZ-POMPA & VAQUEZ 1974; GOMEZ-POMPA ET AL. 1987; LANLY 1982).

The FAO has dispensed totally with the term 'secondary forest'. Instead, different terminology is used in different FAO publications, which can be seen as rough synonyms of secondary forest formations2. In 1996, the FAO defined four types of forest which differ in crown density (‘closed forest’ and ‘open forest’), in the nature of destruction through shifting cultivation (‘long fallow’) and in other, undifferentiated factors (‘fragmented forest’). Only the closed forest is described as ecologically undisturbed natural forest, and is therefore equated with primary forest in this study. All other forest categories can be seen as secondary forest according to the definition applied here. Due to the lack of other data, the extent of secondary forests described in chapter 3.1 is based on these FAO categories.

An analysis of the definition of secondary forest in the scientific literature shows differing opinions on the causes of interference, the grade of interference, the development process and on the question whether interference's must still be discernible in order that the forest be classified as secondary forest. A systematic presentation of these differences can be found in table 1.

**Table 1: Overview of the criteria applied in relevant literature to define the term secondary forest**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Cause of interference</th>
<th>Grade of interference</th>
<th>Development process</th>
<th>Discernible interference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Human</td>
<td>unsp.</td>
<td>large scale</td>
<td>unsp.</td>
</tr>
<tr>
<td>ANONYMOUS (1992)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>BROWN and LUGO (1990)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CORLETT (1994)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
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<td>FINEGAN (1992)</td>
<td>x</td>
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<td>x</td>
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<tr>
<td>GREIGH-SMITH (1952)</td>
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<td>HUSS (1996)</td>
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<td>KAFFKA (1990)</td>
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<td>LAMPRECHT (1986)</td>
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<td>LANLY (1982)</td>
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<td>SIPS (1993)</td>
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<td>UNESCO (1978)</td>
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<td>x</td>
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<tr>
<td>WWF (1988)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
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</table>

unsp. = unspecified
The differing opinions in Table 1 can be summarised as:

**Cause of interference**

For many authors, a decisive criteria for the definition of secondary forest is that human interference in the form of clear-felling or selective logging, for example, initiated the further development of the forest. For others, human interference is one criteria, but not exclusive. For the latter, natural causes (like fire, wind, water, volcanic eruption) can also lead to the formation of secondary forests. For this definition, the decisive criterion is an interruption of the continuity of the forest, which is determined by the grade of interference.

**Grade of interference**

In particular for those authors who include natural causes in their definition of secondary forests, the grade of interference is the decisive defining criterion. The crucial question is then whether the original vegetation has been destroyed to such an extent that regrowth can occur independently of the surrounding autochthonous vegetation. If the interference affects small areas, the authors speak of primary forest degradation. In some cases, demarcations are advanced with which a distinction between primary forest degradation and secondary forest formation can be made, for example, a reduction of tree cover under 10% (LANLY 1982; FAO 1993).

**Development process**

After initial interference, the forests then develop largely independent of human influence. For some authors, the development of a natural succession is an important criterion for the definition as secondary forest.

Succession is a sequence of different vegetation which occupy the same area after each other (BURSCHEL and HUSS 1984). However, other authors have pointed out that the development of secondary forests does not automatically lead to a sequence of different vegetation, and that more simple growth and regeneration processes can take place (coppice sprouting, seeds which are already in the soil) so that the initial stage of regrowth can also be dominated by species of the final succession stage.

**Visibility of the interference**

Some authors point out that secondary forests, if left to themselves, develop into primary forests again, or into forests indistinguishable from primary forests. In this sense, secondary forest is understood as a stadium, which, in a biological process of reorganisation, becomes a primary forest-like mature forest (BORMAN & LIKENS 1981). For these authors, forest is only then 'secondary' if the previous interference's are discernible in the vegetation species and structure. BUDOWSKI (1961) and RICHARDS (1955) assume that this becomes impossible after more than 60-80 years of undisturbed development. However, most authors estimate that this period can last substantially longer, reaching up to several centuries (CORLETT 1994; RISWAN and KARTAWINATA 1989).

### 2.2 The use of the term in this study

The wide range of definitions of secondary forest shows that the diversity of the 'secondary' forests itself hinders a universally valid and unambiguous definition. Although any demarcation involuntarily excludes certain forests which could be rightly characterised as secondary forests by other authors, a limited definition has been chosen in the context of this study in order to have a basis for common communication within the GTZ.

Whenever the term secondary forest is used in this study, it describes a forest succession vegetation which

1. is man-made in origin
2. emerged after the total (more than 90%) destruction of the primary
Point 1. A restriction to human causes of interference can certainly be discussed controversially. On the one hand it can be argued that DC has people as their focus of interest and that DC-measures usually aim to change the behaviour of people. On the other hand, this definition leaves out large areas in which secondary forests have emerged because of ‘natural’ fire for example, which in turn has a major impact on the quality of life for the affected population.

Point 2. Every allocation of an indicator in the form of percentages of destruction is arbitrary and cannot do justice to all situations. Forests which are treated to a permanent over-exploitation (timber extraction, forest pasture) and which show serious signs of degradation are left out by this definition. This applies to large forest areas in Africa and also to the South American Chaco forest.

Point 3. The area which is needed for the emergence of a ‘secondary forest’ is difficult to define, especially in distinction to gaps and holes in a primary forest. While this distinction is relatively easy to make in regard to the microclimate, regenerative material from surrounding primary forest can be transported over long distances (for example by vertebrates). Using the criterion microclimate in the chosen definition means that the mosaic of small ‘secondary forest areas’ which occur for example in Latin America after agricultural use can be included in the analysis.

Point 4. The term ‘perceptible’ needs to be defined more precisely. The evaluation of the state of the forest can occur by simple observation but also by scientific measurement for example. The object of observation must also be defined. This certainly cannot be restricted to aspects concerning timber. On the other hand, including too many factors of the ecosystem can make the practical application more difficult.

Secondary forest is seen in this study in distinction to ‘primary forest’, afforestations - including (tree-plantations) - and to tree stands within agricultural land use management with an agro-forestry character.

Even with this narrow definition, there are still very many different forest formations which fall under the heading ‘secondary forest’. In the interest of better communication, it is therefore helpful to describe the specific secondary forest in detail. (LINDEN & SIPS 1988). Whether it is possible and helpful to combine forests with similar characteristics to definite types of secondary forests remains to be seen. This could be accomplished on the basis of the natural forest characteristics but could also directly include socioeconomic conditions into the categorisation. If a classification along natural characteristics proves the most clear, then these categories should definitely be complemented with the different frameworks in which they are based.

---

1 Utilisation in its broad sense, i.e. including conservation and also the conscious conversion of secondary forests.

2 Related expressions for secondary forest are "not disturbed recently" “forest fallow” “degraded forest” (Forest Resources Assessment (FRA), FAO, 1980). Since the FRA of 1990, forests are divided into natural forest and plantations, for the Global Forest Resource Assessment 2000, a categorisation into "natural forest" "semi-natural forest" and "plantation" is planned (personal information SCHARPENBERG, Forest Products Division, FAO, 30.01.1997).

3 Plantations can be: Forest tree plantations for wood production, plantations for NTFP extraction, agricultural tree plantations (e.g. fruit trees) or plantations with agricultural crops but with shade giving trees in the upper story (e.g. coffee or cocoa plantations).
3 Distribution and use of secondary forests

3.1 The current distribution of secondary forests

Due to the differing definitions of secondary forests (see above), it is very difficult to establish and calculate the world-wide area covered by secondary forests. In particular, different studies are incompatible because of the different basis on which they collect their data.

Lots of studies concerned with ‘forestry resources’ gain their basic data from publications of the FAO. One possible interpretation of FAO data (1996, see chapter 2.1), using the total sum of all vegetation cover which can be equated with secondary forest (open forest, long fallow, fragmented forest), would give the total area of 532 million ha. With forest cover estimated at a total 1,812 million ha this comes to a percentage of secondary forests in the tropical total forest area of 32%. The biggest area covered by these land cover categories (in sum) can be found in Africa (with 313 million ha), followed by Latin America (130,4 million ha) and Asia (88,3 million ha) (see figure 1). It is still an open question how closely these land cover categories open forest, long fallow and fragmented forest can be equated with the definition of secondary forests in this study.

Distribution of 'Secondary Forest' in the Tropics
(1990, in million ha)

Source: Compiled on the basis of FAO data (1996)

Figure 1: Distribution of 'Secondary Forest' in the Tropics (1990, in million ha)

3.2 Secondary forests in the context of deforestation and reforestation

Of greater importance than the exact number of hectares covered by secondary forests is an understanding of the development of secondary forests in the context of deforestation and reforestation. Around 15 million ha of forest are currently destroyed every year in the Tropics. This is a deforestation rate of 0.8% per year (FAO 1993b). Outside the Tropics, in contrast, the forest area remains more or less stable (FAO 1995). If the deforestation is differentiated according to the land cover categories used by the FAO, then it becomes clear that closed forest, which is overwhelmingly primary forest, decreased in area between 1980 and 1990 by 6.4%, and that the other forest area decreased by only 0.8%. Here, a significant decrease in the area of open forest can be observed, whereas the categories long fallow and fragmented forest have increased in area (FAO 1996) (see figure 2).

Change of areas of different forest formations
(1980-1990)
The net rate of decrease in secondary forest area is substantially lower than with primary forest. This is not necessarily caused by a lower rate of destruction of secondary forest, but instead by the substantially higher rate of regeneration, which - compared to primary forest - leads to a lower net loss of secondary forest area. Estimates of the total area of secondary forest which is destroyed every year (gross loss, i.e. without including the newly emerging secondary forest areas) vary between 13.5 million ha and 18.6 million ha (DEUTSCHER BUNDESTAG 1990).

Secondary forests are often part of a dynamic land use system, within which they can either be transformed by human influence into agricultural, forest or degraded land, or over a longer period of time regenerate back into primary forests. The transition between the various forest and land-use types is a gradual one. Figure 3 describes the relation between each schematically:
A large part of secondary forests are part of a closed circle of use, in which utilisation and regeneration alternate. The effect of use on the secondary forest and on the sustainability of this use depend heavily on the intensity of the utilisation.

**Agricultural use** is often connected to the total clearing of the secondary (or primary) forest. Regeneration can only start at the end of this form of use and leads to the emergence of a new secondary forest. A smaller percentage of these secondary forests seems to develop into primary-type forest again or is converted permanently into agricultural land (e.g. pasture, permanent dry farming land, irrigated farm land). Even the permanent degradation of agricultural land (e.g. alang alang - *Imperata cylindrica* - areas in Indonesia) probably happens less on a global scale than the recolonisation by tree species. However, the intensification of agriculture world-wide leads to a shortening of the fallow periods and in turn to an increase in degraded areas, on which a regeneration of forests is only sometimes possible.

The **forestry use** of the secondary forest takes place in contrast to the agricultural use (with exception of agro-forestry) within the forest area. Only intensive interference (e.g. clear-felling), especially on steep slopes and in connection with heavy rainfall, and repeated over-exploitation lead to the creation of degraded land.

### 3.3 The use of secondary forests today

Today, most human utilisation of forests already takes place in secondary forests. These forests are often situated near human settlements and frequently satisfy the manifold needs of the local population. In practice then, the utilisation can be characterised as a (more or less organised) forestry and agricultural multiple use of secondary forests. Main benefits are fuelwood, construction wood and Non-timber forest products (NTFP). The agricultural utilisation includes forest fallow, forest pasture, and the cultivation or direct planting of annual and perennial agricultural plants within the forests. Both agricultural and forestry use is primarily subsistence oriented. Local and regional sales of forest products are only relevant in individual cases (for example wood charcoal).

<table>
<thead>
<tr>
<th>The most important current uses of secondary forests are:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. the use of wood as fuel (fuelwood, charcoal)</td>
</tr>
<tr>
<td>2. the use of secondary forest area as fallow within shifting cultivation systems.</td>
</tr>
<tr>
<td>3. the extraction of Non-timber; Forest Products (NTFP).</td>
</tr>
</tbody>
</table>

In contrast, the commercial use of timber from secondary forests is currently negligible.

**Fuelwood** is the most important form of fuel in the Developing Countries. In some countries, over 90% of all energy consumption is supplied by fuelwood. The overwhelming part of fuelwood is collected in secondary forests and is subsistence oriented. Usually, dead wood is used, when this is scarce, then green wood is also cut. Particularly in and regions, fuelwood collection can lead to the destruction or over-exploitation of secondary forests. In more humid regions, the supply of fuelwood in generally guaranteed.

In addition, secondary forests are often an integrated part of small farmers' agricultural systems, in which they primarily function as **forest fallow** for the regeneration of soil fertility. Shifting cultivation is a form of agricultural production which is practised by 200 - 500 million farmers on one fifth of the world's tropical forest area (AMELUNC, & DIEHL 1991).

Forest fallsows follow a natural succession which is either not at all influenced or influenced by simple management methods, for example by

- the selective encouragement of certain economically or ecologically valuable tree species
- the integration of enrichment plantings; as well as
- agro-forestry measures

Depending on management intensity and intention, these measures can create extensively used forest fallsows in areas with low population density and intensively managed secondary forests with garden character in areas with high population density.
Other important forestry use functions of secondary forests are the extraction of timber and of Non-timber Forest Products (NTFP).

**NTFP**, such as food (of animal or vegetable origin), medicinal plants etc. are already mainly extracted from secondary forests (PEREZ 1995). NTFP collected where they are usually easily accessible and near markets, which makes their sale simpler. FALCONER (1992) and WALTER (1996) describe for Ghana and Madagascar the intensive use of forest fallow for the extraction of medicinal plants, construction material and resins. Only products which are not available in secondary forests (for example certain bamboo-, animal and palm species) are extracted exclusively from the more distant primary forest. Forest gardens, like the tembawang gardens of the Dayak in Kalimantan (Indonesia) can also be important habitats for the use of NTFP (see also MOMBERG 1992).

Secondary forests are also used for ‘timber’ (i.e. wood put to other uses than fuel) for local needs (house building, posts) but also for sale (saw timber, veneer wood, industrial wood’). However, there is little experience so far in a large scale and sustainable management of secondary forests for timber production.

Apart from the fallow function, the agricultural use of secondary forests also encompasses grazing and the introduction of cultivated plants in the context of agro-forestry use systems. The latter is restricted (especially given a closed canopy) to annual agricultural plants which are tolerant of shade (in particular tuberous plants like taro and yams) or to perennials like cacao and coffee. These kinds of complex systems of cultivation were traditionally found in house gardens and are now propagated and optimised as agro-forestry use systems within DC-projects. In and regions, secondary forests have a more open canopy which makes it easier to plant annuals. In this way, an input of nutrients through leaf fall and shade can lead to increased agricultural production (V. MAYDELL 1986, POSCHEN 1986).

The use of secondary forests for pasture occurs mainly in the dry forests of the Tropics and Subtropics. Here, silvopastoral use systems include tree cultivation which themselves supply important fodder and nutrients, thereby adding to the grazing potential (TORRES 1983; V. MAYDELL 1987). In the humid Tropics, livestock husbandry is concentrated in mountain regions, where forest pasture provides an alternative source of income (TORRES 1983; V. MAYDELL 1986).

On the HUMID plains, infertile soil and climatically induced diseases hamper forest pasture. In Africa in particular, the Nagana fever transmitted by the tsetse fly restricts the pastoral use of secondary forests. Even so, livestock husbandry is often carried on by small farmers within agrosilvopastoral use systems. The livestock is put to graze in secondary forests, as these supply enough fodder and it is possible to leave the animals without supervision.

Although they are not usually prescribed this function within official land use planning, secondary forests also have diverse protective functions. Depending on geographic location, size and character, they can be a habitat, refuge or corridor for animals and plants, can reduce soil erosion and protect water supplies. They can also be a CO₂ sink as well a buffer for protected areas. Secondary forest also play a role in tourism and recreation. In Puerto Rico for example, these forests have an important recreation function in connection with of primary forests.

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4 This figure is only a rough estimate. Other authors estimate the world wide area covered by secondary forests at between 600 (BROWN & LUGO 1990) to 900 million ha (WADSWORTH 1982) or do without such estimates altogether, instead simply stating that the majority of tropical countries now have more secondary forests than primary forest (CORLETR 1995).

5 Only two countries (Puerto Rico and Grenada) can boast of a net increase of their forest area (FAO 1993). These are both countries which only have minimal left-over areas of primary forest (in remote and impenetrable places) and in which economical structural changes have resulted in pasture, plantations and fields being given up, which are now being reforested naturally.

6 Forest fallows are areas on which secondary forests develop during agricultural fallow periods

7 One example for such a land use system is the cultivation and use of the fast growing legume *Schizolobium amazonicum* in Rondonia (Brazil). The tree is cultivated during the fallow phase within the shifting cultivation system and in the next phase used as a shade giver for growing coffee and cocoa (personal communication by M. RICHARDS, 13.02.1997).
Tree species from secondary forests which are already on the market include Cordia alliodora, Swietenia spp. and Ceiba pentandra. Species like Callophyllum brasiliense, Cordia alliodora, Didymopanax morototoni, Inga spp. Various palm species supply timber as well as fruit, oils and medicine (Browder et al. 1996; Finegan 1992; Sips 1993; Weaver and Birdsey 1986).
4 Human influences on the emergence, development and nature of secondary forests

The development and nature of secondary forests are usually heavily influenced by human activity. These are dependent in a decisive way on the social, cultural, economic and legal conditions, which constitute the focus of TC-measures. Some important aspects of the biological processes underway in the formation and development of secondary forests (regenerative resource, ecological site factors) and the influence of human intervention are portrayed in the appendix of this study. The following figure 4 gives an overview of the main influencing factors.

![Diagram of Influencing factors on the formation and development of secondary forest](image)

Source: ECO

**Figure 4:** Influencing factors on the formation and development of secondary forest

4.1 Causes and underlying conditions for the formation of secondary forests

The formation of secondary forests is directly connected to the total land and resource use system of a particular region. Within this system the level of exploitation pressure, which is decided by ecological but also economic and sociocultural factors, plays a decisive role.

Secondary forests can emerge both after forest and agricultural use. It can be assumed that the relevant actors behave rationally from their point of view. Some dominating factors for certain courses of action (underlying conditions) which lead to the formation of secondary forests will be listed in the following.

A secondary forest emerges after **timber extraction** above a certain level of interference. The definition of secondary forest applied here implies a clear-felling operation as the level of interference. From the point of view of the concessionaire, a short-term over-exploitation is rational, as long as no long-term interest in the use of that area exists. Under these circumstances, it makes sense to clear cut stands which have a high component of commercially interesting trees with big diameters in order to realise maximum profit. On the other hand, it can also be rational from the point of view of the concessionaire to compensate a lack of quality by quantity, i.e. to clear cut less interesting and thinner trees in order to cover costs.

A decisive factor for a more long-term interest is the length of the utilisation rights given (concession period). This aspect is of increasing interest for the concessionaire when alternative areas become scarce.

Apart from the direct user, the interest of the forest owner (state, municipality, ownership cooperatives, private
persons) in forest conservation and his position in relation to the concessionaire is of central importance with regard to the scale of logging and therefore for the creation of secondary forests. Disinterest in conserving the forest can arise when other land uses are more profitable or when unclear ownership rights prevail. A more general ecological understanding of forest functions and of their social and cultural importance for society can also determine decisions made by the forest owner.

Secondary forest can also be created when the agricultural use of an area is given up. The cessation of agricultural production can either be temporary (e.g. within the system of shifting cultivation) or permanent. Factors which support the cessation of agriculture are:

- A decrease in yields due to deteriorating soil fertility. This needs to be seen in its socioeconomic context. It is possible for example that the farmer lacks the know-how or the resources for alternatives. Alternately, it can be part of an adapted traditional system, in which forest fallow is an integral component.
- Uncertain ownership and use rights Investment and labour input for permanent systems (like agro-forestry) are withheld - a rational behaviour for farmers who do not have ownership rights or guaranteed long-term user rights.
- Migration The loss of productive forces to urban areas results in insufficient labour power for the working of all agricultural land.

4.2 Determinative Factors for the development of secondary forests

After the original vegetation has been destroyed, the secondary vegetation develops in phases or directly (without a succession of different associations) in the direction of the climax vegetation. The character and dynamic of this process is the result of a complex interaction of many natural and human factors. The changes occurring here determine the preconditions for forest management. As this process is itself influenced by the human use of the secondary forest, we need to look at the framework for forest use within the development of the secondary forest.

Lots of secondary forest areas are part of small farmer land use systems and are located near settlements. In general, the better the natural conditions and the more pressure there is between competing land uses, the higher the probability will be that the secondary forest will be reconverted back into another (e.g. agricultural) land use.

Both components are dynamic and feed back into each other. There is a general tendency for the natural conditions to improve because the soils regenerate with progressing forest development. Again, this leads to - given a relevant population density - increased pressure from competing land use systems.

The intensity and duration of the human influence decides whether a secondary forest

1. proceeds through all stages of succession and can be kept as forest in the long-term;
2. remains caught in one particular succession phase over a long period of time or keeps being restricted to this phase;
3. is converted permanently into another system of land use.

Point 1. This can take place when the cause of the initial formation has disappeared or when:

- the forest use system can compete economically with other forms of land use;
- the forest is given a higher importance by society;
- the conservation functions of the forest have a local significance and this is recognised and acknowledged by the residents;
- the forest is given legal protection and this protected status is fundamentally accepted by the population and controlled by the relevant state institution;
- a land use planning acceptable to all parties exists which declares relevant areas to be forest and which at the same time allocates sufficient land for agricultural use.

Point 2:

When exploitation pressure is high, the development of the secondary forest gets stuck in the early
succession stages, in other words the reconversion into agricultural land takes place before a certain stage of maturity can be reached. In Latin America, the conversion of secondary forest into agricultural land often takes place after 6-8 years. Under the given socio-economic conditions, namely the insufficient supply or access to the means of production and the unclear land tenure situation, forest fallow, the first phase of the secondary forest succession, is the most sensible 'low input' method to regain soil fertility in agriculture.

**Point 3:**

On fertile soil, when land is scarce and when forest management - as in many cases - is less profitable than other land uses, then it makes sense for the local population to convert forest areas into agricultural land.

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9 In contrast, Brown & Lugo (1990) see secondary forest as a result of selective logging and note that in Asia, half of all secondary forests were created as a result of selective logging (Latin America: 32%; Africa: 21%).

10 According to Brown & Lugo (1990) (and based on their definition of secondary forests) nearly half of all secondary forests in Latin America were created by agriculture (in both Africa and Asia 27%).
5 Potential contributions of second forests towards sustainable development (analysis of potentials)

Secondary forests can fulfil a variety of functions which benefit or could benefit people. In order to evaluate the potential of secondary forest use, it is useful to look at each specific secondary forest functions and its use potential. In doing so, it should be kept in mind that normally, more than one of these functions or benefits is used simultaneously. There are basically four groups of use potentials:

- Forestry use potentials, which include the production and processing of timber, fuelwood and NTFP as well as the development of industry in the neighbourhood of secondary forests;
- agricultural use potentials, which can be the agro-forestry use of secondary forests as forest fallow, the introduction of agricultural plants and forest pasture, as well as
- protective potentials like water, soil, climate and emission avoidance, the conservation of biodiversity and CO₂-fixation.

The analysis of each function and their specific criteria of evaluation are dealt with in chapters 5.2 to 5.5. Some general criteria for evaluating these potentials\(^{11}\) which are relevant for all functions and for development policy as a whole are discussed in chapter 5.1.

In order to locate the contribution to development made by the various use, conservation and protection potentials and on this basis the need for intervention by DC, it is necessary to analysis the benefits of each potential for one or more user groups. In particular, the analysis of possible or already existing utilisation conflicts is an important component of the potential analysis.

The potential sustainable use needs to be compared to the existing use intensity, which gives us the utilisation rate of the potential. This is of great importance, as different courses of action for DC result depending on whether the utilisation rate exceeds or remains under potential productivity.

Finally, the use potential of the secondary forest must be compared with other available forest or forest-like systems of production. These include primary forest, afforestation and agro-forestry use systems, which are established on agricultural land outside forest areas.

5.1 Evaluation criteria for use potential

5.1.1 User groups

In order to analyse the relevance for development policy, each secondary forest function needs to be seen in its role for particular user groups under particular circumstances. For this study, the potential interest groups or user groups have been divided into three main groupings, which can obviously be further subdivided into manifold smaller groups with very differing user interests and capacities. This more detailed differenation is beyond the scope of this study, however. The three main groupings are:

- the local rural population (farmers, women farmers, the landless, herdsmen and women, local merchants and tradespeople and others)
- the regional and national population (including consumers, politicians, environmentalist groups, wood-processing industry)
- the global international community (including consumers, governments, experts, relevant industries)

In the context of DC, the decision needs to be made as to which user groups represent the target groups. Conflicting interests often emerge within or between different user groups. These can arise because of interests over the same benefits of the forest or over different competing benefits. The following table 2 gives a general overview of the currently most important diverging interests on different secondary forest functions. Forest products should also be differentiated between commercial and subsistence interests.

Table 2: The currently most important diverging interests between different user groups over different secondary forest functions.
5.1.2 Realisation of potential benefits

If the existing potential is fully realised in the sense of a long-term contribution to development, then there is no need for DC intervention. This becomes necessary when an over-exploitation or under-utilisation of the secondary forest is taking place.

- An over-exploitation exists when the current utilisation exceeds the potential to such an extent that a continuing degradation takes place. This is often the case when the secondary forest ‘unintentionally’ does not develop further in the direction of the climax vegetation.
- The under-utilisation of secondary forest functions can only be established in relation to certain (expressed or unconscious) needs or to an expected contribution to development caused by increased use.

A local over-exploitation of secondary forests takes place for example in The Gambia and other Western African states because of forest pasture and fuelwood collection. Pressure for agricultural land means that the fallow cycles become shorter which then causes continuous degradation of the area culminating in the loss of forest regeneration possibilities. In Indonesia, such over-exploitation has led to these areas being colonised by Elephant Grass (*Imperata cylindrica*) which impede natural forest regeneration.

In Latin America, on the hand, the existing capacities of secondary forests for the production of timber and other benefits tend to be under-utilised. (Sips et al. 1993). Globally, when forest fallow is reconverted into agricultural land, the wood is usually not used but burnt.

<table>
<thead>
<tr>
<th>Secondary forest functions</th>
<th>Local population</th>
<th>Regional and national population</th>
<th>Global community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- commercialisation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- subsistence</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuelwood</td>
<td>+/-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>- commercialisation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- subsistence</td>
<td>+</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>NTFP</td>
<td>+/-</td>
<td>+/-</td>
<td>+</td>
</tr>
<tr>
<td>- commercialisation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- subsistence</td>
<td>+</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Forest fallow</td>
<td>+</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Forest pasture</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
</tr>
<tr>
<td>Agriculture (introduction of agricultural plants)</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Protection of water, soil, climate and against emissions</td>
<td>+/-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Conservation of habitats for animals and plants, conservation or enhancement of biodiversity.</td>
<td>+/-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>CO₂ fixation</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Substitute for utilisation of primary forests</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

+ major interest; - little interest
5.1.3 Alternative production systems

Whether it is good policy to support the supply of a certain function by secondary forests also depends on the use potential of alternative production systems. In the following paragraphs

- primary forest
- afforestations and
- agro-forestry systems

as alternative production systems will be compared with secondary forest. Other alternatives will not be discussed. For the comparison, different criteria need to be applied according to the specific function. Whereas for timber production, the quality and quantity of commercially viable tree species is decisive, for the protection of the climate function, other criteria, for example the net primary production of leaves, need to be compared.

5.2 Potential forestry benefits

Of importance for the evaluation of forestry use potentials, i.e. timber, fuelwood and NTFP, are the properties of the forest and tree resources, the physical and legal conditions for their extraction and the costs of production. In table 3, these criteria are portrayed and compared for secondary forests and for alternative production systems.

An important determinative factor for the use potential are the natural properties of the forest and tree resources. This becomes clear with the criteria variety of supply and abundance of suitable species. In general, a high variety of supply (for example in primary forests) correlates with a low level of suitable species, and reciprocally, the higher the supply of commercial species (especially in plantations) the lower the variety of species. In secondary forests, the variety of species tends to be lower than in primary forests, but higher than in reforestations and in agro-forestry use systems.

The physical and legal conditions for extraction are usually better in secondary forests than in primary forests, but worse than in afforestations and agro-forestry use systems. In particular physical access, which tends to be better because of the proximity to settlements, makes secondary forest management easier than in primary forests. And whereas the use of primary forests becomes more and more restricted legally, the ownership and user rights in secondary forests tend to be unclear. In afforestations and in agro-forestry use systems, clear user rights usually exist, which are then restricted to a closely defined user group or to individual owners.

Production costs only have a meaning in relationship to the benefits and profits they create. They tend to be lower in primary and secondary forests than in other production systems, as little or no silvicultural measures or establishing of stands are required. Harvesting and transport costs are lower in secondary forests which have a better infrastructure than primary forests. In contrast, afforestations require high investments from the onset for planting, investments which usually cannot be afforded by the local population.

Because of the low production costs and good physical access, secondary forests are often used by the local population. Commercial plantations, on the other hand, are usually managed by transregional user groups with access to capital. The use of primary forests is more variable, agricultural and forestry functions are used by all user groups. In contrast, agro-forestry is an agricultural production system and is therefore practised by the local population.

Table 3: The characterisation of forestry use potential of secondary forests in comparison with other production systems

<table>
<thead>
<tr>
<th>Resource properties</th>
<th>Secondary forest</th>
<th>Primary forest</th>
<th>Aforestation</th>
<th>Agro-forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>variable</td>
<td>variable</td>
<td>controlled</td>
<td>variable to controlled</td>
</tr>
<tr>
<td>Variety of supply of</td>
<td>relatively low to</td>
<td>very high</td>
<td>very low, often</td>
<td>variable depending on</td>
</tr>
</tbody>
</table>
The criteria used in table 3, resource properties, utilisation possibilities and harvesting and transport costs are applied in the following sub-chapters for each specific forestry use potential.

### 5.2.1 Timber

The production of timber still plays a decisive role in forestry. Other objectives have gained in importance and the increase of timber yield is now pursued under the condition that other important benefits of the forest are not restricted. Even so, in most management plans, timber production is still the central focus because in general this creates the highest monetary result whilst at the same time - with the respective management - maintaining the other functions.

Depending on the later use of timber, one can differentiate between:

- timber for private consumption in subsistence economies (house- building, timber for agricultural use like posts and poles, self-made furniture and articles of daily use)
- timber for local, regional and national markets
- timber for export

The possibilities and extent of commercial timber production are dependent on the biological forest potential (increment, stand volume, size and quality of commercially interesting tree species) and on a range of other parameters. Of special importance are:

- size and distribution of the forest areas;
- the accessibility of the resources dependent on appropriate infrastructure, nature of the terrain (which determines working conditions) and on ownership structure;
- labour and investment capacities;
- a functioning timber market;
- a legal and fiscal framework which is friendly towards timber sales.

In the past, the potential within the natural resources of secondary forests for timber was seen as lower than in primary forests with their valuable tree species and impressive dimensions. Secondary forests usually contain less commercially viable tree species, but this has more to do with the fact that these species have not been introduced to markets so far. The wood properties of typical secondary forest tree species are often characterised by a lower density than species from primary forests, but a whole range of secondary forest

<table>
<thead>
<tr>
<th>useful products</th>
<th>middle</th>
<th>monoculture (plantation)</th>
<th>the use system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance of species</td>
<td>high because of homogenous stand</td>
<td>low</td>
<td>high, because fully controllable and benefit oriented</td>
</tr>
<tr>
<td></td>
<td>variable depending on the use system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Utilisation possibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>physical access</td>
</tr>
<tr>
<td>Utilisation rights</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting and transport costs</td>
</tr>
<tr>
<td>Silvicultural measures</td>
</tr>
<tr>
<td>Stand establishment</td>
</tr>
<tr>
<td>Main user group</td>
</tr>
</tbody>
</table>
species which have been produced as plantation timber, have been introduced into markets successfully (*e.g.* *Gmelina*).  

In this area, there is a need for more research in wood technology and for public relations work, in order to increase our knowledge about secondary forest tree species and their international popularity. Even so, it is true that lots of secondary forests are still (currently) very young and therefore cannot supply the relevant timber dimensions or an optimal standing stock per hectare of the sought after tree species.

Advantages in the utilisation of secondary forests are that silviculture] operations can have substantial effects in the young stages (increase in the financial yield of the stand) and that the higher homogeneity (species, wood density, dimensions) of lots of secondary forests simplifies later harvesting and marketing operations. In addition, secondary forests are often more accessible, especially compared to the remaining primary forest areas, which are now mainly situated in difficult and remote terrain (see table 4).

Production costs vary in secondary forests, depending on whether thinning operations or enrichment plantings are undertaken or if only harvesting and transport costs arise.

**Table 4: Comparison of potential timber production in different production systems**

<table>
<thead>
<tr>
<th>Production systems Characteristics*</th>
<th>Secondary forest</th>
<th>Primary forest</th>
<th>Afforestation**</th>
<th>Agro-forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>good resources properties</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+/-</td>
</tr>
<tr>
<td>good utilisation possibilities</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>low production costs</td>
<td>+/-</td>
<td>+</td>
<td>-</td>
<td>+/-</td>
</tr>
</tbody>
</table>

+ positive evaluation  
+/- average evaluation  
- negative evaluation for the specific utilisation objective  
* see table 3 for more details of these characteristics  
** Afforestations for timber production (pure or mixed stands)

The local population uses timber mainly for their own needs and only to a small extent for commercial sale. Nearby secondary forests and small to medium tree dimensions are ideal for the timber requirements of this user group (see also table 5). The objective of establishing a sustainable timber production, which implies mid-term to long-term production cycles, can only be realised if long-term ownership or user rights can be guaranteed and if there is the possibility of commercial production or of the conservation of the forest being seen as a 'public service' which is correspondingly paid for.

Buyers in the regional, national and international timber markets are timber traders and wood processing companies and industries of different sizes and with various objectives. Secondary forests can be interesting as a source of lumber if natural resource properties and location are suitable, and can compete with plantations and primary forests (often relatively homogeneous stands, accessible location and existing infrastructure, low production costs). In order to open up new markets, certification could be a help. It is important that processing and upgrading (small industries, furniture factories) take place in the locality or region so that the value generation can stay in the region or producer country.

With regard to productivity, safe user rights and pre-planned tree species composition and wood quality, however, afforestations are often advantageous for timber production. The decision for one of these two production systems, either secondary forest management or afforestation, can only be made in a given situation, depending on the capacity of the relevant target group, on economic feasibility studies and on the specific objectives (e.g. multiple benefits).

Primary forests are still targeted for commercial logging because of their very valuable tree species, the larger dimensions of the trees and the low investment costs. However, because of destructive logging, decrease in area and the protected status of more and more primary forest, the potential for timber production is on the decline. Timber felling for subsistence, as well, is becoming more difficult for the local population, due to the larger distances and larger tree dimensions of primary forests.

**Table 5: Comparison of potential timber production for different user groups in different production systems**
In many countries, wood is the most important source of energy and it plays a central role in the subsistence production of agricultural households as well as in the commercial sale in urban centres. Wood is either used directly as fuelwood or it is processed to charcoal.

In general, secondary forests of every kind and stadium are well equipped to supply fuelwood. Compared to timber production, the demands on the resource properties of these forests are low and are more flexible. The potential for fuelwood production in a comparison between secondary forests and other production systems (primary forests, afforestations, agro-forestry) (see table 6) differs according to the location of the resource (proximity to settlements), composition of tree species (some tree species are more suitable for creating energy due to better energy data and burning properties or are favoured by the population), tree dimensions (harvesting possibilities, harvesting costs) and user rights.

Table 6: Comparison of potential fuelwood production in different production systems

<table>
<thead>
<tr>
<th>Good resources properties*</th>
<th>Secondary forest</th>
<th>Primary forest</th>
<th>Afforestation**</th>
<th>Agro-forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>good utilisation possibilities</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>low production costs</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
<td>+/-</td>
</tr>
</tbody>
</table>

+- positive evaluation  
+/- average evaluation  
- negative evaluation for the specific utilisation objective
The differences between the various production systems are generally slight. Compared to islands of remaining primary forest, for example, secondary forests can offer a higher potential for the fuelwood supply of the local population, especially for local needs, because these forests are usually nearer and more accessible and have normally less legal restriction on their use. The contribution which afforestations can make to fuelwood supply depends on ownership and management objective, They remain of little importance for subsistence, however, as investment is too high (see table 7).

For local subsistence needs, fuelwood production does not usually lead to over-exploitation, as normally dead wood and smaller dimensions like branches are collected. The commercialisation of fuelwood, on the other hand, can lead to local over-exploitation (particularly in dryer areas and when living trees are felled) and even to the denuding of large areas. The processing into charcoal (for which in secondary forests late pioneers are preferred, due to their higher wood density) can raise the demand for wood substantially.

Within a orderly forest management, and given reasonable planning, fuelwood can be produced 'in the wake' of the production of other forest products.

### Table 7: Comparison of potential fuelwood production for different user groups in different production systems

<table>
<thead>
<tr>
<th>Main user group</th>
<th>Secondary forest</th>
<th>Primary forest</th>
<th>Afforestation**</th>
<th>Agro-forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>local population</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>regional/national population</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>global community</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

The gathering of fuelwood and the production of charcoal is an additional source of income for lots of people in rural areas. For fuelwood, local markets usually emerge, because the transport costs for longer distances are too high. Charcoal can be transported for hundreds of kilometres.

### Characteristics of secondary forests which are suitable for fuelwood production

**Natural properties:**
- abundance of favoured tree species
- existence of tree species which can be coppiced and with relatively high rates of increment
- small tree dimensions
- high level of dead wood

**Social framework:**
- good accessibility and close proximity to settlements
- safe user rights for adjoining population
- existing (simple) management rules or the possibility of introducing them (e.g. rotation by areas)

#### 5.2.3 Non-Timber Forest Products (NTFP)

NTFPs (following the definition given by the FAO) comprise of all tree products and wild growing habitat products (plants and animals) from woods and from forest-type use systems (agro-forestry, house gardens, plantations etc.) as long as they are not wood products. The main importance of non-timber products is in their use by the rural population for meeting basic needs and for product diversification in all areas of life (foodstuff, cult items and articles of everyday use, clothing, building material, medical supply) as well as an additional
source of income. This includes hunting and gathering animal products, which can be of immense importance for the population. In this sense, NTFPs contribute considerably to the preservation and improvement of the quality of life. In addition, certain individual products can gain access to transregional markets and consequently be produced agriculturally or industrially. NTFPs are a major reason for the conservation of natural forest ecosystems.

The currently existing uses of NTFPs in secondary forests already point to a high use potential of NTFPs in these forests. Resource properties in secondary forests can be advantageous for certain NTFP uses, as the relative homogeneity of the forests mean that a more intensive extraction of the dominant flora and fauna is possible and that corresponding gathering distances can be reduced. Compared to primary forests, however, the diversity of species is restricted and often, the demise of the original vegetation is accompanied by the disappearance of certain traditional forest products and the knowledge of their use.

Those NTFP which exist naturally in secondary forests have no or little need of human support for their growth and dispersal. This means that apart from further processing, the only costs for their ‘production’ lie in the labour invested in their harvesting and gathering.

As with secondary forests, agro-forestry production systems with an abundance of species, in which wild NTFPs can be collected, have a very high use potential with regard to NTFPs. In addition, the conscious cultivation of certain products within these systems or in plantations (afforestations) is possible, although this is connected to substantially higher investment. (see also Table 8).

Table 8: Comparison of potential use of NTFPs in different production systems

<table>
<thead>
<tr>
<th></th>
<th>Secondary forest</th>
<th>Primary forest</th>
<th>Afforestation**</th>
<th>Agro-forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>good resources properties*</td>
<td>+/-</td>
<td>+/-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>good utilisation possibilities</td>
<td>+</td>
<td>-</td>
<td>+/ -</td>
<td>++</td>
</tr>
<tr>
<td>low production costs</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>+/ -</td>
</tr>
</tbody>
</table>

+ positive evaluation
+/- average evaluation
- negative evaluation for the specific utilisation objective
* see table 3 for more details of these characteristics
** Afforestations (plantations) for the conscious cultivation of a certain NTFP

The extraction of NTFPs from secondary forests is especially important for the local rural population (see table 9) and, as mentioned above, in particular in order to fulfil basic needs and for the diversification of products.

Primary forests, in contrast, are often in remote and inaccessible areas and are often under protective legislation. In such cases, the utilisation of NTFPs, if at all, focuses on individual products which are of great importance for the local population or other actors (medicinal plants for example) or which have a high monetary value (wild animals).

The conscious cultivation of NTFPs in agro-forestry systems for home use and for commercial sale is also a viable alternative for the local population, even though it is connected to more input, and this increases in relation to the demand of a certain product and inversely to the size of the (secondary) forest area.

This applies in a similar way to plantations. However, Organisation and capital requirements are much higher, so that this form of management is restricted to a few (private or public) individual initiatives and is oriented towards the (usually transregional or international) commercialisation of those products.

Table 9 Comparison of potential use of NTFPs for different user groups in different production systems

<table>
<thead>
<tr>
<th>Main user group</th>
<th>Secondary forest</th>
<th>Primary forest</th>
<th>Afforestation</th>
<th>Agro-forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>local population</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>regional/national population</td>
<td>+/-</td>
<td>+</td>
<td>++</td>
<td>+/-</td>
</tr>
<tr>
<td>global community</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+/-</td>
</tr>
</tbody>
</table>
In sum, secondary forests have a very high use potential for NTFP, which is already being realised to a high extent by the local population. In this realisation, the utilisation of NTFP for home consumption plays a much larger role than commercial sales.

### Characteristics of secondary forests which are suitable for NTFP use

#### Natural properties:
- Existence of interesting NTFP species
- Sufficient abundance of these species (for a sustainable subsistence oriented use or for commercial sale)

#### Social framework:
- Good accessibility (gathering distance)
- Existing knowledge on the species and products
- Existing demand (subsistence or commercial)
- Existing use rights
- Existing (simple) management rules

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### 5.3 Agricultural potentials for use (agro-forestry)

The agricultural use examined here in connection with secondary forests is made up of agro-forestry use systems, in which forestry use is combined either spatially or temporally with pasture and/or with agricultural crops.

The simultaneous combination of agriculture, pasture and forestry is intended to let natural factors (like shade, moisture, soil protection) complement each other, thereby increasing the total potential benefit.

In the temporal combination of these factors, a certain limited area is used for agriculture for a several years and is then converted into regenerating forest fallow. The long-term productivity of the area depends ultimately on the length of this fallow period, at best regenerating totally and at worst degrading into steppe or grassland, which have little or no use value.

#### 5.3.1 Forest fallow as an intermediate agricultural land use

Forest fallow (or long fallow) are often an important component of agro-forestry use systems (in the sense of a chronological alternation between forestry and agriculture). In the context of shifting cultivation, they play a big role in re-establishing soil fertility after agricultural use. Given a sufficiently long fallow period, forest fallow can safeguard a sustainable supply of nutrients in the soil (for example by the recolonisation of mycorrhiza) and by doing so guarantee the long-term use of even marginal soil locations. In particular farmers who have no access to fertilisers are dependent on the natural regenerative capacity of the forest.

Increasing exploitation pressure from agriculture leads however to the shortening of fallow periods, and this results in less productive yields. The shorter fallow periods have, in the first instance, the effect that a sufficiently developed secondary forest, which is suitable for multiple use (e.g. fuelwood, timber, forest pasture), is prevented from maturing. In extreme cases, bush or savannah can emerge instead.

A reduction of the fallow period without these effects can either be accomplished by using artificial fertiliser or by the cultivation of nitrogen-binding plants (ecologically improved fallow). The use of artificial fertilisers is dependent on monetary capital, which is often not available. In order to introduce soil-improving plants, these plants need to be available in sufficient numbers. The management of the fallow area is then more labour intensive. This means that enough labour capacity must also be available. In addition, guaranteed ownership or use rights must exist in order to make a more long-term management of the fallow area attractive.
In many areas which have sufficiently long fallow periods, the potential cultivation of economically valuable products (e.g. rattan extraction on Borneo), which could contribute to subsistence and to income generation (NTFP, fuelwood, timber) is not adequately realised. The selective encouragement of desired species could raise the economic value of secondary forest areas substantially (economically improved fallow).

The management of fallow areas can ultimately lead to the emergence of permanent, productive and sustainable land use systems, in which annual agricultural plants and perennial woody plants are grown simultaneously on the same area (e.g. 'alley cropping', house gardens) (RAINTREE 1983, RAITREE 1986, SPIELMANN 1989, VAN DEN BELT 1990, SHANKARNARAYAN 1989). This can reduce the clearing of old secondary forest stands and of primary forests by shifting cultivation, with agro-forestry systems thereby potentially contributing to the conservation of primary and secondary forests.

### Characteristics of secondary forests which are suitable for forest fallow as an intermediate agricultural land use:

**Natural properties:**
- a rapid recolonisation and high regenerative capacity
- existence of soil-improving plants (nitrogen binders, fast litter decomposition)
- existence of species which are suitable for multiple use

**Social framework:**
- low exploitation pressure (a minimum area in relation to the population density)
- no legal disadvantage for farmers who let forest grow on their fields; the right to reconvert
- long-term use rights which also apply to the period of forest fallow

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### 5.3.2 Introduction of agricultural crops in secondary forests

The cultivation of annual crops, perennials and fruit trees in the lower story of a secondary forest can significantly enhance the multi-purpose use of the secondary forest. If followed to the end, this can lead to the creation of forest gardens, in which more than 250 species are used (FERNANDES & NAIR 1986; SOEMARWOTO 1987).

In humid regions in particular and because of the increasing crown density as the succession process matures, the introduction of agricultural crops into secondary forests requires a complex and labour intensive management be it for annual and perennial crops or for woody plants. This means that long-term use rights and sufficient labour capacity are absolute prerequisites. As the perennial crops (e.g. cocoa, coffee, spices) are usually cash crops, their cultivation necessitates the existence of market access.

If sufficient labour capacity, guaranteed use rights and market access are given, then the introduction of agricultural crops into these forests can be an economically attractive and sustainable management form of secondary forest areas. It can increase the area productivity, expand agricultural production and reduce the economic risk for the farm by its diversification effect.

The cultivation of crops in secondary forest stands is in principle a extensive form of land use performed by the local population. Because marketing is an important element of this production system, regional user groups can play a role as intermediate traders or as bulk consumers.

### Characteristics of secondary forests which are suitable for the introduction of agricultural crops

**Natural properties:**
- productive soil location
5.3.3 Forest pasture

Animal husbandry plays an important cultural and economic role especially in and regions. This is particularly the case in the agronomic dry zone (500 mm rainfall) where animal husbandry is of exceptional importance in the context of silvopastoral use systems and where other alternative production systems often do not exist. Leaf fodder and tree seeds, as well as the grass and bush vegetation function as fodder for goats, sheep and cattle, which then themselves encourage the distribution and dominance of certain tree species. In some cases, the fodder is cut manually and fed to the animals outside the forest area ('cut and carry system'). Leaf fodder is especially important during the dry seasons. The shade given by trees reduces stress and perspiration of the animals and is thereby also an important element of forest pasture. A growth in the number of animals and the increasing sedentariness of previously nomadic peoples is now leading to more and more overgrazing and to the degradation of the natural (forest) resources.

In humid areas, animal husbandry and forest pasture are of less importance. The managed grazing of forest fallow can be very useful by helping to conserve soil fertility in the long-term and thereby improving agricultural production. The 'agricultural potential' of secondary forests can be realised more fully and the farms can diminish their economic risk by diversification.

In Asia and the Pacific, the herbaceous undergrowth of the large number of coconut -, oil palm -, rubber - and Indian-rubber plantations is used as forest pasture. The prime objective here is to keep the weeds down through grazing. At the same time, the manure acts as an additional fertiliser, which increases the yield of the tree plantation. Coconut and oil palm plantations create particularly good grazing conditions because of the low shade (GLATZLE 1990; TAJUDDIN 1986).

An important factor which should be given close attention in pasture systems is the influence of fire. Grazing is usually connected to the yearly burning of the vegetation, which encourages the growth of fodder suitable grasses. In and regions in particular, this regular burning of the vegetation then leads to the development of a fire climax forest. The damaging of forest can be reduced by regular grazing, as flame height and intensity are reduced when less inflammable biomass is lying around, so that fire damage to the trees can be minimised.

Characteristics of secondary forests which are suitable for forest pasture:

Natural properties:
- light foliaged forest structure; young stadium of succession or a mature stadium with high trees and sufficient undergrowth
- productive soil location
- existence of plant species which are suitable for fodder and have high biomass production in the herbaceous and brushwood layers
- existence of tree species which can be coppiced and which are resistant to animal browsing or which develop root suckers or early bark formation.
- existence of enough trees which supply seeds and fruit suitable for fodder

Social framework:
- clear use rights
5.4 Conservation potential

5.4.1 Conservation of soil, water and climate

Secondary forests have a high potential to fulfil soil-, water-, and climate protection functions (for a deeper analysis of these functions, in particular for the Tropics, see THREN 1997). Except for cases in which the soil is already highly degraded or when recurrent intervention (repeated disturbance) of fire for example, or competing vegetation (like the foreign exotic *chromolaena odorata* in Western Africa) restrict its development, forests usually grow up quickly and thereby provide for a rapid cover of the top soil (reducing the loss of nitrogen) and the generation of nutrient cycles. This can be shown by the high net primary leaf production in the first 20 years (12 - 15 t/ha) and by the fact that due to the fast decomposition, more organic material can be found within the nutrient cycle than in the dead or live biomass. Even so, the net primary wood production, which ranges between 2 - 11 t/ha/a is still higher in a young secondary forest than in a primary forest.

This high regenerative capacity, which enables the rapid recolonisation of former forest areas, is most pronounced in the secondary forests of the humid Tropics and temperate zones, and less evident in semi-arid areas. The biomass of leaves and fine roots is adequate after about 5 - 10 years. Early pioneers, in particular, have a relatively large leaf surface which enables them to better utilise the existing site conditions, and this is of special importance for climatic protection. Soon after agricultural use is terminated, these early pioneers colonise the abandoned area and prevent the bleaching out of nutrients, which sinks quickly to the level of primary forests. Mineralised nutrients are taken up by the plants. The level of soil nitrogen, phosphor and sulphur increases within the organic humus.

This means that secondary forests are nutrient sinks in their initial stage, quickly accumulating nutrients. Only after a certain period does this intake of nutrients decrease, and a steady state is reached in which the same amount of nutrients are released by the decomposition process as the amount taken in for the accumulation of biomass. After 50 - 80 years, when the net primary production tends towards zero, i.e. when there have been several ‘turnovers’ of organic material and in the composition of the vegetation, secondary forests reach their full ecological value.

The ecological value of afforestations varies strongly depending on the combination of tree species, the type of management and economic objective. In general, however, it can be assumed that secondary forests, because of their structural variety and the natural and site-adapted way in which they develop, are better suited than plantations to fulfil water and soil protective functions. This is the more so because afforestations, especially as tree plantations, often cause soil erosion and are often treated with pesticides and/or fertilisers (which can have negative effects on streams and rivers, coastal areas and ground-water).

The local population benefits directly from the protective functions of secondary forests when their village owned areas or resources are directly affected. If larger areas are affected (e.g. a whole watershed) then these functions are of direct interest for the regional and national population (higher water quality, a more balanced water supply, fewer and weaker floods). Water and soil protective functions of secondary functions are especially important in hilly areas with steep slopes.

Climate and emission protection can also be important for the local and regional population. Secondary forests can fulfil these functions once they have reached a certain height and area. Climate protection is directly relevant for agriculture in the form of wind barriers and for the balancing out of temperature and moisture. Even the forest area of a neighbouring or distant region can have an effect on the local climate (especially on rainfall levels). In urban areas, emission protection can also be important, and secondary forests can provide this as a buffer against noise, a sight screen and also as a filter of emissions and dust.

Primary forests are usually no longer found in the vicinity of settlements (agricultural and pasture land, urban centres) and therefore cannot perform protection functions in the same way. Secondary forests can be a viable alternative. In comparison with plantations, they are less cost-intensive and due to their multiple-story and varied structure are more capable of fulfilling protective functions.
5.4.2 Conservation of habitats for animals and plants and the conservation and enhancement of biodiversity

Biodiversity is the variety of life or of life-forms in a given ecosystem. Genetic resources are generally defined as for a certain location autochthonous population of plants or animals which are characterised by a common genetic pool, a minimum number of individuals (preservation of the genetic variety by the recombination of genes) and a minimum habitat size.

Secondary forests, although the variety and abundance of species differs significantly from primary forests, are still important habitats for plants and animals. As the primary forest area decreases, secondary forests play an increasingly decisive role as a habitat and refuge for native flora and fauna.

With regard to variety of species and ecological stability, secondary forests generally exceed afforestations, in particular plantations with very few species, but also agro-forestry areas. Depending on the original situation and on disturbances during the succession and development process, secondary forests can sometimes reach the variety of species existing in primary forests in less than 80 years, especially when climax tree species can recolonise through dormant seeds or coppicing. Even so, secondary forests have a relatively higher proportion of pioneer tree species which would otherwise only occur sporadically in the primary forest. The overall structure of secondary forests is significantly different from primary forests over a long period of time, however. For example, in a 1200 year old secondary forest in Mexico, which was created by clear-felling by the Maya, the combination of species was still found to be irregular today. According to GERECKE, 1991, secondary forests which emerge through natural succession are clearly ecologically and economically superior to afforestations. In one managed secondary forest in Costa Rica, 30 commercially valuable tree species were found after only 30 to 40 years of succession.

Depending on the previous forest history and the way in which the secondary forest was created, climax tree species can also be almost totally lacking. These secondary forests which are dominated by the pioneer species are poorer in the variety of species and in structure, and this restricts their function in conserving habitats and biodiversity.

Apart from these manifold geo-botanical differences between primary forests and secondary forests (e.g. the lack of shade epiphytes); secondary forests also have a lower fauna diversity. In particular, specialised plant and insect eaters are lacking, because their ecological niches have disappeared. Those animal species which do survive in secondary forests therefore do so in larger numbers. A larger number of fruit eaters can be explained by the larger amount of available fruit and less seasonality, for example.

From an ecological point of view, secondary forests can only replace complex primary forests to a certain extent. However, they do contribute considerably (depending on location and characteristics) towards the conservation of genetic resources, especially under conditions which are favourable for unrestricted development where secondary forests can, as they mature, gradually attain the state of original primary forests until they can hardly be distinguished from them.

<table>
<thead>
<tr>
<th>Natural properties:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• good root penetration or soil which makes this possible</td>
</tr>
<tr>
<td>• rapid and dense recolonisation</td>
</tr>
<tr>
<td>• structural variety</td>
</tr>
<tr>
<td>• in particular hilly terrain (for water and soil protection)</td>
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<table>
<thead>
<tr>
<th>Social framework:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• little pressure by other land use systems</td>
</tr>
<tr>
<td>• legally clear and implemented status of the forests</td>
</tr>
<tr>
<td>• the existence and inclusion in a forest function classification</td>
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</tbody>
</table>

Characteristics of secondary forests which are suitable for the conservation of habitats for animals and plants and for the preservation of biodiversity

<table>
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<th>Natural properties:</th>
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</tr>
<tr>
<td>• the existence and inclusion in a forest function classification</td>
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</tbody>
</table>
5.4.3 Reduction of atmospheric CO\textsubscript{2} by the sustainable management and use of (secondary) forests

Since the onset of the industrial revolution in the industrial countries, the use of fossil fuel has risen dramatically (and is still rising) and this has led to a measurable long-term increase in the CO\textsubscript{2} concentration in the Earth's atmosphere of several per thousand points. This increase has had the effect that the short wave sunlight can still penetrate the atmosphere and can heat up the Earth's surface, but that the longer heat waves this causes are reflected back towards the Earth. The hereby created warming of ground level atmospheric layers is commonly known as the greenhouse effect. Even though the scientific debate on the possible consequences of this development is still raging, it is an educated guess to say that the greenhouse effect will have a long-term effect on the global climate.

The main carbon sinks at the global level which can work against the increase of CO\textsubscript{2}-concentration described above, are the oceans (CaCO\textsubscript{3} fixation) and the forests. In the following passages, the relevance of (secondary) forests for the global carbon balance will be discussed. To start with, the terms accumulation and fixation need to be defined.

Mature climax forests phases, which typically are attained in primary forests, are characterised by high standing volume in which a large amount of carbon is bound (accumulated). At the same time, this kind of mature forest stadium is in a steady state, i.e. dissimilation and assimilation compensate each other. An additional, net accumulation is therefore no longer possible. Mature primary forests are subsequently carbon binders, but are not carbon sinks.

In contrast, the assimilation rate is substantially higher in young forests or in forests which are kept artificially young than the dissimilation rate: the typical build-up of standing volume during the so-called productive phase of the stand is connected to a substantial net-fixation, which lasts until the mature stadium is reached.

Every forest - whether after some catastrophe (storm damage, large scale fire, insect attack) or after logging - moves in its development towards the steady state mature stadium. A sustainable forest management has, with regard to the CO\textsubscript{2} balance of forests, the effect that repeated timber use, i.e. the extraction of biomass, keeps the stand permanently in its productive phase.

Different types of use have different effects in this context:

- timber extraction for the production of long-lasting wood products (furniture, parts of buildings): **net fixation** of carbon dioxide within these products, which is released only after the burning or rotting of these products.
- Wood extraction for fuelwood: if undertaken within a strict regime of sustained yield management, fuelwood use is CO\textsubscript{2}-neutral. This can be shown by a simple example: A forest area of ten hectares is managed for fuelwood production in a ten-year cycle. Every year one hectare is clear cut and subsequently reforested again. The total amount of wood is burnt completely, with the effect that the amount of CO\textsubscript{2} which was bound by one hectare forest over the previous ten years is released. This amount of carbon is the same as the amount which a) is bound within one year on the total forest area or b) is bound on the cleared area during the following ten years until the next utilisation.
- If we assume that the total sum of all goods and energy which are used remains the same, then there is also the possibility of a **net-reduction** of CO\textsubscript{2} concentration by substitution: if a given amount of

<table>
<thead>
<tr>
<th>Natural properties:</th>
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<tbody>
<tr>
<td>• large enough area</td>
</tr>
<tr>
<td>• Connection with other forests (e.g. relicts of primary forest)</td>
</tr>
<tr>
<td>• primary forest-type combination of species (or enough time to develop into one)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social conditions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• little pressure from other land use systems</td>
</tr>
<tr>
<td>• Restrictions on use (e.g. protected area status)</td>
</tr>
</tbody>
</table>
furniture, for example, is made with wood instead of with steel, glass or aluminium or if a certain amount of energy is gained from wood instead of from fossil energy, then an additional amount of CO$_2$ emissions can be bound (for energy production this substitution effect could also be affected with wind and water energy).

To summarise:

- forest destruction sets large amounts of bound carbon free (even when part of the wood is used for long-lasting products)
- forest conservation keeps accumulated carbon bound
- only forests which are sustainably managed for timber production (or more generally young forests until the mature stadium is reached) can fixate additional carbon,
- the utilisation of timber from sustainable forestry for construction or furniture (especially when it substitutes other material) binds carbon long-term,
- the utilisation of fuelwood from sustainably managed forests as a source of energy (especially when it substitutes fossil energy) is at least CO$_2$ neutral.

Secondary forests which are managed according to the sustained yield principle therefore have a fundamentally positive effect on the climate. With regard to the carbon-binding intensity of secondary forests in comparison with afforestations and plantations, this is answered differently in the relevant literature, so none of these different forest types can be given priority.

<table>
<thead>
<tr>
<th>Characteristics of secondary forests which are suitable for carbon dioxide fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural properties:</td>
</tr>
<tr>
<td>- young stage of development</td>
</tr>
<tr>
<td>- high growth production</td>
</tr>
<tr>
<td>- tree species which are suitable for wood processing, especially those whose wood is commercially interesting for long-lasting products</td>
</tr>
<tr>
<td>Social framework:</td>
</tr>
<tr>
<td>- little pressure from other land use systems</td>
</tr>
<tr>
<td>- a ban on conversion</td>
</tr>
<tr>
<td>- forest management systems with maximum rates of increment, intensive timber extraction and relatively short felling cycles</td>
</tr>
<tr>
<td>- an incentive system and favourable marketing structures which encourage timber use for long-lasting products and which can discourage the burning of areas for example within the shifting cultivation system.</td>
</tr>
</tbody>
</table>

5.4.4 Use of secondary forests as a substitute for the utilisation of primary forests

A sustainable use of secondary forests as permanent forest formations or within agro-forestry systems is fundamentally possible. The type, quality and quantity of the benefits and products are to varying degrees similar to primary forests, depending on the secondary forest.

The main uses of secondary forests which can function as a 'substitute' and thereby relieve pressure on primary forests are mainly commercial timber production and the use of the area for agricultural goals in the context of clearing cycles and agro-forestry systems.

As a rule, secondary forests are closer to settlements and are more accessible for industrial wood utilisation because of the better infrastructure. If the commercial timber extraction from primary forests could be substituted by a corresponding management of secondary forests, then this could support a more effective protection of the remaining primary forests. This is also true of settlement activities (in particular conversion of forest for agriculture) which are encouraged by the opening up of forests for commercial logging. This possible conservation effect must still be born out in practice, however.
The potential possibilities of industrial wood production in secondary forests remain largely unrealised. With forest management, new technology and marketing strategies, this potential can be better tapped. To what extent secondary forests will be able to meet actual demand is not yet clear.

The success of such substitution objectives depends largely on the general population pressure (demand for agricultural land), which can only partly be buffered by good management and land management concepts.

Demand for subsistence needs of timber, fuelwood and NTFPs in contrast, can usually be met by the utilisation of secondary forests, if these are available and are just as near and accessible than the primary forest to be protected. These subsistence uses do not fundamentally threaten the primary forest and are usually relatively unproblematic.

In the case of primary forests which are particularly rich in commercially interesting tree species or are on productive soil locations, it will remain difficult to divert attention away from logging and agricultural use. This is also the case for regions where the secondary forests are situated on relatively marginal soils. They can still be a useful addition for the protection of soil, water and species, but are not really able to relieve the exploitation pressure on remaining primary forest areas.

Helpful for the objective of conserving primary forests are complementary incentives (tourist potential, NTFP) and governmental regulations which support the intensification of secondary forest use (e.g. the safe-guarding of use rights).

<table>
<thead>
<tr>
<th>Characteristics of secondary forests which can substitute primary forest use</th>
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</thead>
<tbody>
<tr>
<td>Natural properties</td>
</tr>
<tr>
<td>• situated near primary forests</td>
</tr>
<tr>
<td>• a comparable supply of needed products as in the primary forest; commercially viable species</td>
</tr>
<tr>
<td>• larger area than the primary forest</td>
</tr>
<tr>
<td>• (more) productive soils</td>
</tr>
<tr>
<td>Social framework</td>
</tr>
<tr>
<td>• safe legal rights for secondary forest use</td>
</tr>
<tr>
<td>• economic incentives for secondary forest use</td>
</tr>
<tr>
<td>• good accessibility of the secondary forests</td>
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</tbody>
</table>

### 5.5 Tourism and Recreation

Tourism and recreation can be important at the local and national level. Tourism already generates a large portion of GDP in many countries. Locally, it can usually offer the population a variety of additional income sources.

Forests (even national parks) play a relatively subordinate role as a direct tourist attraction, which can be measured by the annual number of visitors (exceptions are savannah forests with big game like in Eastern Africa). The importance of forests for tourism is in its indirect and complementary effects. Forests can be additional targets for excursions and offer possibilities for activity (visits to remote villages, sport). They are also an enrichment as a natural element of landscapes, especially in areas which are otherwise heavily settled and cultivated.

With the continuing destruction of primary forests, secondary forests are gaining in importance for agriculture. This importance is more indirect, for example by conserving natural waterways and by protection against erosion in mountain areas. However, primary forests remain unique as the goal of ‘nature tourism’ and can hardly be replaced by secondary forests as such. The attraction of secondary forests increases firstly with the maturity of the succession stage and secondly when activities in secondary forests can be combined regionally and chronologically with other tourist attractions.14.

Compared with afforestations, secondary forests have a higher potential for tourism. They are more natural
and usually have a more varied structure. Afforestations - which are conceived as plantations in many countries - are often geared at intensive wood production and often have corresponding ownership and access regulations which restrict multiple use.

The recreational function of forests in the local context, i.e. for the indigenous population independent of tourism, has until now only been of importance in the industrialised countries. This includes the effect of forests on their direct surroundings and on the well-being of the people living there (climate and emission protection, a place to withdraw to, a place for recreation, variation of landscape). In future, the recreational function will increase in importance in the less industrialised countries as well, especially in the proximity of urban centres. Secondary forests and afforestations, with the right size, location and character, can both contribute to fulfilling this function.

<table>
<thead>
<tr>
<th>Characteristics of secondary forests which are suitable for tourism:</th>
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<tbody>
<tr>
<td>Natural properties:</td>
</tr>
<tr>
<td>- mature succession stadium</td>
</tr>
<tr>
<td>- varied structure</td>
</tr>
<tr>
<td>- high variety of species or high density of some attractive species</td>
</tr>
<tr>
<td>- large coherent area</td>
</tr>
<tr>
<td>Social framework:</td>
</tr>
<tr>
<td>- good infrastructural connection</td>
</tr>
<tr>
<td>- accessible or situated so that activities in the forest can be combined with other attractions</td>
</tr>
<tr>
<td>- basic structures for tourism should already exist in the region</td>
</tr>
</tbody>
</table>

11 The terms 'value' (Wert), 'evaluation' (Bewertung) and 'realisation of potential value' (Inwertsetzung) are defined and discussed in THREN 1997.

12 Given certain utilisation objectives, the freezing of the secondary forest in a certain phase of succession may be intended, or the management might be oriented towards a certain tree species, without this leading to over-exploitation.

13 Potentially commercially valuable timber species from secondary forests include: *Carapa guianensis*, *Cedrela odorata*, *Ceiba pentandra*, *Cordia spp*, *Goupia glabra*, *Pourouma spp*, *Swietenia macrophylla*, *Virola spp* and *Vochysia spp*. The secondary forest species tend to contain less waxes and resins than primary forest species. This facilitates their use (but makes impregnation necessary).

14 BIRDSEY and WEAVER (1982) in their analysis of Puerto Rico have established that the potential for tourism and recreation can become very high with the combination of different natural attractions of the island (beaches, waterfalls, mountains etc.). The public forest, which is predominantly secondary forest, in connection with the recreational and sport activities on offer in them, plays an important role in this.
6 Proposals for courses of action in the context of Technical Cooperation

The courses of action which can be taken result fundamentally from the potentials described in the previous chapters. In the following discussion of the measures and approaches available to us, it is assumed that the objective and appropriateness of an TC intervention has been clarified along these principles:

- the needs of the specific target group
- the ecological potential
- an established over - or under-exploitation
- an analysis of alternatives which could supply the aimed for benefits and functions (e.g. by afforestation)

All courses of action proposed in this chapter should be implemented as part of a learning process, as knowledge and experience concerning the current state of secondary forests and the effect of direct (silvicultural and technical) and indirect (influencing framework parameters) interventions are still insufficient.

The proposals made here are not only aimed at solving identified problems, but are designed to improve the utilisation of unto unrealised potentials. They are derived partly from traditional management systems which have been developed by indigenous peoples. Very few results from field studies are available. The current informal use, non-use or over-use of secondary forests and their causes were disregarded for the initial development of the possible courses of action.

There are basically two types of approaches which DC can follow in order to support sustainable development by a better realisation of secondary forest potentials:

1. influence the formation of secondary forests
2. guide the development of secondary forests

Point 1. Influencing the formation of secondary forests

Depending on the specific context, the encouragement or the reduction of the formation of secondary forests can be necessary.

If secondary forests emerge by the recolonisation of unproductive and for agriculture uninteresting barren land and if there are insufficient amounts of other forest resources for the supply of the population, then measures which support the formation of secondary forests should be taken.

The encouragement of new secondary forests or conservation of existing areas is however normally dependent on low population pressure or on the availability of sufficient amounts of agricultural land.

Technical measures which can encourage the formation of secondary forests can be the active encouragement of natural regeneration (for example by regular cutting back of competing vegetation) or even the advance-planting of tree species (perennial pioneers) which can quickly subdue competing vegetation (like grass, chromolaena and others), so that secondary forest vegetation can recolonise more quickly 15.

At the same time, legislation and social processes need to be formed in such a way as to encourage the abandoning of agricultural land and pasture and to include these future forest areas in regional and land use planning.

In the other extreme, whereby secondary forest is created by the over-exploitation or clear-felling of primary forest by logging concessionaires, measures should be taken which stop or slow down this process. Possible courses of action are the improvement of the concession system, the support of ecological consciousness in the timber industry and the introduction of improved management techniques in the primary forest. The latter could be helped by incentives such as the introduction of certification.

Point 2. Guiding the development of secondary forests

The development of a secondary forest - usually in the form of succession - can also be influenced by measures undertaken within TC. In this case, the natural development process of the vegetation, soil and animals is merely supported, accelerated or guided in the direction of required succession products. This might be the acceleration or the supplement of the natural process, the removal of a barrier in the further development or can also involve stopping the succession at a certain phase. Succession management of secondary forests has been effectively practised by the Mayas and other ancient Indian cultures, in order to

6.1 Experience so far

Most studies and proposals for dealing with secondary forests are concerned with their management as forests. The existence of secondary forest is seen as a proof of a forest location, so that the preservation of the land use form 'forestry' is not questioned. The focus is then on timber production. Field studies prove that silvicultural and technical measures can significantly increase the timber production potential of secondary forests. Practical experience with pure timber management of secondary forests are still rare, however. Certain important silvicultural insights are summarised in the appendix of the study.

So far, management operations for the support of protection and conservation functions or of the production of NTFP were very rarely the main focus of concepts for secondary forest use in the context of DC or national forestry administrations, although they have sometimes been incorporated into the decision making process. Generally, objectives like the conservation and regeneration of soil fertility and of genetic resources are pursued 'in the wake' of forest management.

Only individual cases exist today of DC measures which aim at supporting the trans-sectoral multiple use of secondary forest areas. Traditionally, however, there exists a wide range of experience because this form of use is practised extensively. In this case, secondary forest is viewed in its function for forestry and agriculture. If the area is needed for both agricultural and forestry production, then the management objective for a secondary forest is for example the establishment of permanent agro-forestry and silvo-pastoral systems.

There is hardly any experience in the treatment of secondary forests as part of a dynamic, mosaic-like land use system. This concept acknowledges that secondary forests are often part of a permanent process of conversion and transformation and that therefore they cannot be unambiguously allocated to only one form of land use. Here, operations must be oriented towards improving these processes and towards an optimal realisation of those potentials which are available in the different phases.

Which of these three approaches is best can only be established within the total understanding of each specific situation, in which secondary forests function as one element of a regional land use system. The management of secondary forests can only be carried out on the basis of a local consensus on the overall resource use of a given planning unit (with the elements pasture, agriculture, forestry, protection of soils etc.)

6.2 Instruments for promotion within the context of development cooperation

The instruments open to development cooperation within the context of multi-sectoral or sectoral strategies for guidance and support comprise of exerting influence on the legal and political framework, the integration of secondary forests within the overall land use planning, silvicultural and technical operations and the support of marketing structures.

6.2.1 Influencing the legal and political framework

The first important step is to ensure that secondary forests become an issue for political decisions in legislation, in basic agreements concerning Technical Cooperation, in mechanisms concerning economic incentives and regulations and in public relations (see also 6.4).

For example, the clarification and implementation of long-term use rights can be a decisive factor for a sustainable forest management. In many countries, the legal status of use rights for certain areas depends on the vegetation growing on them: whereas categories like barren land or unproductive 'bush', are usually *de jure* and *de facto* open access resources, the ownership or use rights of areas with forest cover are claimed by individuals or the state. For this reason, the current users of these areas actually prevent forest cover from developing. Unclear use rights create conflicts over the resource or a general reluctance to accept responsibility for the resource. This can lead to an increased exploitation of the forests.

6.2.2 Integrating secondary forests into land use planning
Secondary forests, with their own location-specific functions, should always be incorporated into a regional and local land use planning. As soon as a consensus has been reached with all relevant actors that the secondary forests should remain forest areas in the long-term, then they become the object of forest planning, and accordingly, a forest inventory needs to be taken (nationally, regionally and for the forestry enterprise) in line with the established management goal.

Large scale inventories should not only include all forest formations (along with agricultural areas, settlement activity etc.) by way of principle, but in future should also identify their condition and change, for example concerning biodiversity, forest area and forest development.

For this objective, features and indicators need to be identified which can be integrated into a combined method of terrestrial inventory and remote sensing data. The availability of quantitative and qualitative information is a precondition for forestry and rural development planning. In future, secondary forests need to be evaluated according to their multiple functions. The registration of forest functions is just as important as the consideration of determinative socioeconomic factors. Forests are Part of the 'living-space' of people. If these 'living-spaces' and the needs of the population are not incorporated, then a qualified prognosis and planning for a sustainable development is not possible. The planning of secondary forest management cannot be done in isolation, and the forests cannot be viewed in isolation from the general land use system.

6.2.3 Silvicultural and technical operations

Apart from this political and economic framework, on the technical side, the management of secondary forests depends on the following factors:

- the objectives for each forest area
- knowledge available to the people working in the forest
- the initial situation of the secondary forest
- accessibility and the prevalent level of mechanisation

Secondary forests react well to silvicultural operations which aim to improve timber production. Because of the enormous variety of situations, there is still some uncertainty over the technical details of these operations. Extensive management systems (low expenditure) are preferred in order to keep costs low, scarcity of resources, in contrast, necessitate productive management systems and ecological considerations call for cautious operations.

Silvicultural operations which would have positive effects on the natural development of the forests, often generate such high costs that only a limited large-scale or intensive application on the ground is possible. In particular, costly initial thinnings which do not produce timber or fuelwood are, given the long investment periods, difficult to realise. Therefore, the most cost-extensive silvicultural methods possible should be implemented. This is doubly relevant with regard to the possibilities open to the local population of implementing such methods.

According to LAMPRECHT (1986), the precondition for a sustainable and economically viable secondary forest management aimed at timber production is that a sufficient number of selected future crop trees of commercially interesting species (at least 100 future crop trees per hectare) must exist and be evenly distributed over the forest area. The future crop trees must have a sufficient capacity to react to preferential treatment (crown expansion, diameter and height growth). A functioning forestry service with sufficiently qualified staff is also very important.

Even though some proven techniques now exist, fundamental basic data on the dynamics of secondary forests and the effects of silvicultural operations is still lacking. For this reason, the establishment of monitoring systems and long-term experimental plots will be of crucial importance for a future success of silvicultural management. (WADSWORTU, 1987; LAMPRECHT, 1989; POKORNY, 1997).

6.2.4 Promoting marketing

The commercial access to markets for products from secondary forests can be improved by a range of different measures. In addition to timber, other wood products and non-timber products must be included. The following possibilities exist in order to support market accessibility:

- research into wood technology properties of unto unknown tree species and their possible uses and into NTFPs;
- making these possible uses and products known (international advertising, support for the introduction
of products into new markets)
- impede the marketing of products from unsustainable exploitation of primary forests;
- a preferential treatment of secondary forest products in tax regulations.

Within the current debate on the promotion of sustainable (forest) management, a special role can be played by 'certification'. The certification of forestry enterprises arose out of the discussion concerning the destruction of forest resources. According to HEINDRICH, 1996, certification is the evaluation of the sustainability of the management practise of forest enterprise and the corresponding distinguishing of all their commercial products (enterprise certification and product certification). However, certification is primarily interesting for international markets. On the regional or local level in most countries, there is not enough interest or financially relevant demand.

6.2.5 Research

Research can contribute to the support and guidance of sectoral and multisectoral strategies. There are often knowledge gaps and a lack of adapted concepts for a sustainable development on the basis of an ecologically, economically and socially acceptable use of the land resources. Research can help to close these gaps. Of fundamental importance is that the research topics and approaches are practically relevant. Only when the developed results and proposals become relevant for political decisions is research an effective and important instrument of DC. Decisions can be related to political, planning, organisational and technical aspects of one or more sectors (for example land use planning).

The GTZ Tropical Ecology Support Programme (TOEB) supports studies and research projects which are connected to bilateral DC programmes. This can benefit the projects and it guarantees that the results are practically relevant for development policy and that they are really taken up and implemented. TOEB only supports applied science projects in contrast to basic research. Relevant research institutions in the partner country and local experts (for further training in the tandem procedure, for example) are incorporated. From the onset, a realistic concept for the use of hoped for results must be thought out. Methodologies with model character are applied which can have a broad impact over and above the specific research topic.

Fields of research in TOEB studies include the dynamics of ecological processes, instruments of planning and of joint management, economic aspects, framework conditions, sociology (e.g. the use of indigenous knowledge).

Research on secondary forests funded by TOEB have taken or are taking place in Costa Rica and in Madagascar. Workshops on this subject are planning for Asia, Africa and Latin America.

6.3 The realisation of identified potentials

The different instruments and measures can be combined, according to which objective is followed or what function is to be supported. An overview of the possible courses of action for the different secondary forest functions is given in table 10.

Table 10: Overview of possible courses of action for specific functions and target groups and necessary research

<table>
<thead>
<tr>
<th>Secondary forest function</th>
<th>Target group</th>
<th>Possible courses of action</th>
<th>Research needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Commercialisation</td>
<td>Local and regional population</td>
<td>Improvement of marketing and silviculture (tending interventions); forest management; encouragement of user-cooperatives; definition as a permanent forest area in LUP; introduction of long-term concessions and guaranteed use rights; certification of sustainably produced wood products</td>
<td>Research into wood technological properties; Analysis of commercial potential</td>
</tr>
<tr>
<td>- Subsistence</td>
<td>Local population</td>
<td>Safe-guarding of user rights; introduction of marketing</td>
<td>Analysis of commercial potential</td>
</tr>
<tr>
<td>Fuelwood</td>
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<td></td>
<td></td>
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</tbody>
</table>
When supporting certain functions, it is important to know possible use-conflicts. These are shown in table 11. Forest pasture and the introduction of agricultural crops in secondary forests have a high conflict potential, both with each other and with other uses. Both agro-forestry measures reduce the natural abundance of species and restrict timber production on these areas. Forest pasture also prevents a simultaneous field crop production to a large extent. Over-grazing can reduce the regenerative capacity of the forest and soil fertility for long periods of time.

Another large conflict potential is usually caused by timber production and by the objective to conserve biodiversity. Timber production is currently usually connected with negative effects on the preservation of biodiversity (degradation of the habitat) and on water supply and soil protection (creation of cleared areas, nutrient bleaching, timber harvest damage). On the other hand, if the timber is then utilised for long-term products, then timber production can help to protect the climate (CO$_2$-fixation).

All other forest functions also carry potential conflicts, but to a lesser extent:

- Fuelwood production is connected to CO$_2$-fixation. Furthermore, and particularly in arid and semi-arid regions, a reduction of the forest fallow potential can be expected.

<table>
<thead>
<tr>
<th>- Commercialisation</th>
<th>Local and regional population</th>
<th>Improvement of carbonisation; creation of central fuelwood markets</th>
<th>Research into alternative energy sources; improvement in the efficiency of stoves</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Subsistence</td>
<td>Local population</td>
<td>Safe-guarding of user rights</td>
<td>Research into commercial potential</td>
</tr>
<tr>
<td>Forest fallow</td>
<td>Local population</td>
<td>Improved use of forest products (multiple use); introduction of ecologically improved fallow if exploitation pressure is high; introduction of economically improved fallow if exploitation pressure is low</td>
<td>Identification of potential useful species (preferably authochtonous species)</td>
</tr>
<tr>
<td>Introduction of agricultural crops</td>
<td>Local population</td>
<td>Introduction into markets or optimisation of market access.</td>
<td>Identification of existing and potential use systems</td>
</tr>
<tr>
<td>Forest pasture</td>
<td>Local population</td>
<td>Safe-guarding of user rights</td>
<td></td>
</tr>
<tr>
<td>Tourism and recreation</td>
<td>Local population; also regional, national and global</td>
<td>Safe-guarding of local user rights; encouragement of user cooperatives; support of eco-tourism; awareness-building with demonstration tracks (environmental education)</td>
<td>Analysis of potential demand</td>
</tr>
<tr>
<td>Water, soil, climate and emission protection</td>
<td>Local and regional population</td>
<td>Policy advisory service; awareness-building; regional land use planning; possibly compensation for the local population</td>
<td>Implementation of regional and trans regional land use planning</td>
</tr>
<tr>
<td>Conservation of biodiversity</td>
<td>Local and regional population</td>
<td>Bring on the agenda of international initiatives (e.g. International Panel on Forests, Forest Partnership Agreement)</td>
<td>Identification of ecologically sound forms of forest use</td>
</tr>
<tr>
<td>CO$_2$-Fixation</td>
<td>Global population</td>
<td></td>
<td>Potential analysis</td>
</tr>
<tr>
<td>Substitute for primary forest exploitation</td>
<td>Local and regional population</td>
<td></td>
<td>Potential analysis</td>
</tr>
</tbody>
</table>
The extraction of NTFPs for regional or international sale is often accompanied by a specific over-exploitation of resources.

Forest fallow is only compatible to a limited extent with simultaneous pasturage use or with timber production.

The objective to protect water supply and soil limits the extent and methods of other uses, without ruling them out.

**Table 11: Evaluation of possible use conflicts given the priority support of one secondary forest function**

<table>
<thead>
<tr>
<th>Effect on Other functions and benefits</th>
<th>Main forest function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Timber</td>
</tr>
<tr>
<td>Timber</td>
<td>-</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>-</td>
</tr>
<tr>
<td>NTFP</td>
<td>+</td>
</tr>
<tr>
<td>Forest fallow</td>
<td>-</td>
</tr>
<tr>
<td>Forest pasture</td>
<td>-</td>
</tr>
<tr>
<td>Introduction of agricultural crops</td>
<td>-</td>
</tr>
<tr>
<td>Tourism</td>
<td>+</td>
</tr>
<tr>
<td>Water and soil protection</td>
<td>+</td>
</tr>
<tr>
<td>Conservation of biodiversity</td>
<td>+</td>
</tr>
<tr>
<td>Co₂-fixation</td>
<td>+/-</td>
</tr>
</tbody>
</table>

+ use conflict can be expected; - no use conflict to be expected; Explanation of table see text.

**Examples for understanding table 11**

- If the main function of the secondary forest is timber production (column 2), then no use conflict with fuelwood production (row 3) is to be expected.
- If the main function of the secondary forest is the conservation of biodiversity (column 10), then a use conflict with timber production (row 2) can be expected.

**6.4 The level of approach**

The courses of action can be supported on different levels of intervention. Usually, a combined support on several levels is helpful in order to create synergy effects.

**6.4.1 Approaches on the international level**

On the international level, the main task is to create an awareness for the subject secondary forest. The potential for supporting measures with global objectives has to no extent been exhausted. Similarly, it needs to be remembered that a clear definition of the term (and perhaps the classification of certain types) and their coherent and consistent use can simplify the process of communication. In the context of DC, the following approaches in particular can be supported:
• Introducing the subject into international initiatives and post-Rio activities (e.g. the new international arrangement 'United Forum on Forests', UNFF));
• Encouraging the creation of secondary forests for global objectives (CO₂, biodiversity) with possible compensation for residents;
• Information about unto unknown secondary forest products and their introduction into international markets (especially unto unknown timber species and their wood technological properties);
• The explicit incorporation of secondary forests into measures for certification;
• Implementation of joint research projects, for example for the
  o research into traditional use systems,
  o development of adapted courses of action (local population),
  o further development of existing approaches.

A further approach is the use of international financial sources for a enhanced realisation of potentials. GEF funds can be directly used for the support of secondary forest management. GEF operational programmes for example, identify the rehabilitation of degraded areas and the development of sustainable forest management methods as part of an integrated land management. There is a direct connection here to the possibilities mentioned above. Again, the funding in the context of 'debt for nature swap', has so far been aimed at conserving biodiversity in primary forests, but it could also be used for the conservation of and long-term reconversion in climax-near forest systems.

6.4.2 Approaches on the national level

On the national level, TC services in the form of advisory services for the adaptation of underlying conditions (political, legal, economic etc.) are appropriate. These need to have a different focus according to the specific objective, and can be both sector specific and trans-sectoral:

• Encouraging the discussion of the subject within national forestry programmes;
• Integration into regional, land use and forestry planning
• Supporting a long-term interest in forest conservation and sustainable management, supporting the possibility of long-term use by the corresponding design of:
  o land tenure
  o concession regulations
  o fiscal policy
• Support of research and training
• Enhancement of the value of forests through:
  o incentive systems (taxes, subsidies etc.),
  o education and public relations,
  o supporting the introduction of unto commercially unknown products into markets,
  o promotion of wood-processing industries.

6.4.3 Approaches on the local level

As the analysis of the human influences has shown, the participation of the population in secondary forest management is indispensable. Accordingly the function of secondary forest as forest fallow and for transsectoral utilisation should be put on equal footing with forestry utilisation. Most of the approaches described in chapter 5.1 can be implemented by technical, institutional and awareness rising measures:

• Regulation of use rights, ownership rights;
• Integration into the local land use planning
• Information; awareness-building;
• Strengthening of local groups;
• Promotion of marketing structures;
• Silviculture / succession management.

These cannot be applied without considering and adapting to the concrete social and economic framework. At all events, the measures must be oriented towards the needs of the local population. The promotion of secondary forest management is meant to contribute to development, for example by value generation in the region, reduction of poverty or conservation of resources which is good for agriculture. At the same time, the measures must be socially and culturally acceptable, in particular by developing new use systems on the basis of existing use systems and by respecting and incorporating traditional roles, rights and customs.
7 Final Comments

Finally, it must be said that most of the topics and ideas mentioned in this discussion paper can basically also be applied to other forms of forest other than secondary forest. On the other hand, the term 'secondary forest' includes such a range of different histories of emergence and natural properties and the underlying conditions are so varied, that a generalisation of a recommended course of action for the secondary forest is not possible.

What the study has shown is that the potential of secondary forests in contributing to development by supplying products and benefits has often been underestimated and has remained unrealised.

The term 'secondary forest' is very rarely used. It neither appears in the forest policy and legislation of many countries nor in the concepts of national and international donor organisations. Additionally, some international instruments and funding mechanisms (GEF) are very much focused on primary forests. Therefore, it is imperative that in these countries secondary forests are given adequate attention in the future and are incorporated into coordinated management. The question is whether these secondary forests (including young fallow areas) are forgotten because of an apparently low potential or whether they are automatically included within forest policy and land use planning. Similarly, on the international level it must be examined whether these forests are incorporated sufficiently into international objectives and DC work.

Whether it makes sense to introduce the amorphous term 'secondary forest' needs further discussion and examination. If yes, then the term needs clear definition for each context and the situation of the forest and the underlying conditions need to be described accordingly. One possibility would be a classification with schematic sub-categories (initially for each country) which would enable a definition of each secondary forest according to its emergence, characteristics, existing use and social conditions.

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15 On many degraded forest sites, the recolonisation is obstructed because regenerative potential has been destroyed or because competing vegetation (grass, bamboo) prevent the natural seeding of initial pioneers. In these cases, the subduing of the competing vegetation can lead to a significant of regenerative conditions (KARTAWINATA 1994). However, mechanical countermeasures are labor intensive and chemical herbicides often ecologically harmful. Alternatively, the sowing or planting of advance stands of exotic tree species to support the development on grass infested areas is now in discussion (LUGO 1988).

Apart from improving the conditions for regeneration, another strategy suggested is the artificial regeneration of required tree species in the form of improvement plantings (WADSWORTH 1984; WEAVER and BIRDSEY 1986). By this means, the period of production can be shortened considerably and the often low proportion of commercially interesting tree species increased. The planting of individual trees has been proven successful (WEAVER and BIRDSEY 1986, RAMOS DEL AMO 1992) but is too expensive.
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ANNEX

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I Secondary Forest Definitions

BROWN & LUGO (1990) Secondary forests are “formed as a consequence of human impact on forest lands.”

Forests that develop as a consequence of human influence, usually after agricultural activity in cleared forest areas is abandoned. In this sense, secondary forests are an important component of shifting cultivation. (HOUGHTON et al., 1992, claim that 85% (= 365 Mio. ha) of the land utilised for shifting cultivation would redevelop into forests if left alone). The term secondary forests should be reserved for describing forests less than 60 - 80 years, since after that they are hard to distinguish from primary forests.

The types of agricultural utilization that precede the formation of secondary forests range from small-scale less than 1 ha) to large-scale shifting cultivation (slash and burn) with cultivation phases lasting from 1 to more than 3 years, to permanent utilization as grassland or sugar and coffee plantations. Also, continuous use as forest pasture or as a source for fuel wood, and repeated burning, especially in drier more open forest formations, as well as logging result in the formation of secondary forests.

CATTERTSON (1994) A forest type in succession that colonises areas previously denuded by natural or human-induced causes, and whose succession is largely unaffected by the surrounding, indigenous vegetation on account of the expansion of the deforested area. The following forms of vegetation can develop: wastelands artificial savannas / recently logged-over areas older logged-over areas.
<table>
<thead>
<tr>
<th>Author</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORLETT (1994)</td>
<td>The key features of secondary forests is an interruption of continuous forest cover, absolute dependence on outside forces for redevelopment of forest, and the fact that these features can be recognised in the structure and/or composition of the forest vegetation. Defining secondary forests is, as always, somewhat a matter of arbitrarily drawing lines within a continuum.</td>
</tr>
<tr>
<td>DEUTSCHER BUNDESTAG</td>
<td>Secondary forests comprise all stages of a succession that appear on an area that has been cleared by (1990) natural causes or human activity.</td>
</tr>
<tr>
<td>FAO (1993)</td>
<td>Secondary forest develops after a change in land-use connected with a reduction of tree cover to below 10% (deforestation), if the area is left undisturbed.</td>
</tr>
<tr>
<td>FINFGAN (1992)</td>
<td>&quot;...defined as the woody vegetation which develops on land that is abandoned after its original vegetation has been destroyed by human activity.&quot;</td>
</tr>
<tr>
<td>GREIGH-SMITH (1952)</td>
<td>Regrowth after clearance.</td>
</tr>
<tr>
<td>HUSS (1996)</td>
<td>After natural forests or remnants of natural forests are degraded as a result of selective logging or uncontrolled extraction of timber, secondary forests develop from the seeds of pioneers, coppices of tree remnants, or regeneration of climax tree species, as long as this process is left undisturbed. It follows that there is no sharp division between degraded forests and secondary forests. Secondary forests often form a small-scale, intricate mosaic of various forest communities and stages of degradation and regeneration.</td>
</tr>
<tr>
<td>KAFFKA (1990)</td>
<td>Forests which have been logged over and remain without further disturbances can develop into secondary forest.</td>
</tr>
<tr>
<td>LAMPRECHT (1986)</td>
<td>The term Secondary forest Comprises all succession stages, from a forest in its initial stage which appears in a natural or man-made clearing, to the purely climax forest stage.</td>
</tr>
<tr>
<td>LANLY (1982)</td>
<td>Secondary forests over 60-80 years old are classified as undisturbed forests or primary forests. Secondary forests or forest fallows are a mosaic of agriculturally utilised areas, largely untouched forests and forests of different ages that are composed of vegetation which developed after the clear-cutting of closed or open forest formations.</td>
</tr>
<tr>
<td>SIPS et al. (1993)</td>
<td>&quot;...type of tropical rainforest that is in a successive stage of reconstruction after complete removal through natural and/or human disturbances, and where, due to intensity, size and duration of the disturbance, the influence of the surrounding vegetation on regeneration is minimized.&quot; (&quot;...autogenous regeneration&quot; by surrounding forest vegetation is minimized).</td>
</tr>
<tr>
<td>UNESCO (1978)</td>
<td>A vegetation that colonises areas where, due to natural or human disturbances, the original vegetation has disappeared partly or completely.</td>
</tr>
<tr>
<td>WEAVER BIRDSEY</td>
<td>and Forests resulting from the abandonment of cropland or pasture, and forests</td>
</tr>
</tbody>
</table>
II Case Studies for Current Utilization of Secondary Forests

In a survey conducted beginning of 1997, members of development co-operation projects were questioned about the current significance of secondary forests. Responses were received from 31 projects (8 in the Asia/Pacific region, 10 in Africa, and 13 in Latin America). 70% of the respondents expressed great interest in the subject, and 60% rated the relevance of the subject for development policy as being high.

Shifting cultivation and logging were identified as the main causes for the formation of secondary forests. Roughly equal numbers of the respondents noticed an increase (54%) or rather a decrease (46%) in secondary forest area. Agricultural activity is the main reason for the decline in secondary forest area.

The most important function of secondary forests at present is to provide fuelwood, followed by other wood and non-wood products. According to the respondents, these products - along with various protective functions - provide the greatest potential for the utilization of secondary forests.

The intensity of utilization of secondary forests varies widely by region. In Africa, there is a tendency to overuse secondary forests, while they have been hardly utilised at all in Latin America and Asia so far. The respondents stated that sustainable utilization does not exist. Often, legislative, economic and/or technical obstacles can be identified as the responsible factors.

Case studies from Africa (Sao Tomé), Latin America (Costa Rica) and Asia (Indonesia, China) concerning secondary forests, are presented in the following. They are intended to provide the reader with an impression of different development histories of secondary forests, their biological characteristics, and the situation regarding their utilization.

**Case Study No. 1: Sao Tomé**

<table>
<thead>
<tr>
<th>1. Location</th>
<th>Sao Tomé, West Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Region</td>
<td>Northern Sao Tomé</td>
</tr>
<tr>
<td>1.2 Climate</td>
<td>Humid climate (2000 mm/a precipitation)</td>
</tr>
<tr>
<td>2. Development</td>
<td>Formed after 1975 in abandoned coffee and cocoa plantations (abandoned due to decreasing profits).</td>
</tr>
<tr>
<td>3. Distribution</td>
<td></td>
</tr>
<tr>
<td>3.1 Land area</td>
<td>90% of Sao Tomé is covered with forest, including 30% secondary forest, 32% &quot;shade forest&quot; and 29% primary forest (shade forest: trees planted/left to provide shade for coffee and cacao plants).</td>
</tr>
<tr>
<td>3.2 Area studied</td>
<td>190 ha, including 130 ha primary forest and two 30 ha areas of secondary forests (aged 20 and 25 years); the distance between primary and secondary forest is less than 500 m.</td>
</tr>
<tr>
<td>4. Current utilization</td>
<td>no detailed information available</td>
</tr>
<tr>
<td>5. Framework conditions</td>
<td>no detailed information available</td>
</tr>
<tr>
<td>6. Biological and ecological characteristics of the secondary forest</td>
<td>Compared with the primary forest, the secondary forest has:</td>
</tr>
<tr>
<td></td>
<td>- fewer tree species with dbh &gt;10 cm,</td>
</tr>
<tr>
<td></td>
<td>- a more irregular species distribution,</td>
</tr>
<tr>
<td></td>
<td>- a different species composition,</td>
</tr>
<tr>
<td></td>
<td>- a lower proportion of commercially valuable species in the regeneration growth.</td>
</tr>
</tbody>
</table>
There are few differences in total stem number and basal area, owing to the old stand of *Erythrina* sp. (the former shade trees) and *Cinchona* sp. (whose bark used to be harvested). Not counting these retained trees, which slow the speed of succession, the total basal area of the secondary forest totals 27-36% that of the primary forest.

The immediate neighbourhood to primary forest does not appear to have any significant effect on the development of the secondary stand in this case.

### 7. Management possibilities and recommended measures

The increment of the commercially valuable trees (shade tolerant species, long-lived pioneer species) should be stimulated. Exposure to light must be managed carefully, as too much light would enhance the growth of less valuable short-lived pioneer species.

### 8. References


---

**Case Study No. 2: Costa Rica**

1. **Location**
   - Costa Rica, Central America

1.1 **Region studied**
   - Huerta Norte, north-eastern Costa Rica

1.2 **Climate**
   - Humid climate; precipitation > 3000 mm/a; annual average temperature: 22-27°C

2. **Development**
   - Development on abandoned pasture and crop land. (FEDLMEIER’S study, 1996, is limited to secondary forest on former pasture land.)

3. **Distribution**
   - 3.1 **Land area**
     - 28% of Costa Rica's land area is covered by forest, of which 70% are classified as protected area, 9% are secondary forest, and 3-4% are commercially used primary forest.
   - 3.2 **Area studied**
     - Two areas of secondary forest (each with 4 plots of 500 m² >5 cm BHD and 4 plots of 100 m² <5 cm dbh); age: 12 and 18 years.

4. **Current Utilization**
   - Secondary forests are used as forest fallow and for acquiring non-wood forest products (medicinal plants, honey, ornamental plants, lianas), timber and fuel wood. Important ecological functions are the maintenance and improvement of soil and water quality, and the corridor function for passage of animals. Overall, however, little importance is assigned to secondary forests in Costa Rica.

5. **Framework conditions**
   - Secondary forests are treated like primary forests and are governed by the national forest legislation. However, they are often not classified as forests, but rather as scrub or abandoned agricultural land, which reduces their protection status.

6. **Biological and ecological characteristics of secondary forests**
   - Compared with the primary forest, the secondary forest has:
     - a comparable basal area,
     - 40-50% less biomass development with very high growth increments (exceeded only by plantations),
     - a different species composition as resulting from the succession process, seed sources, terrain and soil quality,
     - a comparably high number of species, which even exceeds that of the primary forests in some cases.

   Grazing has caused a compaction of the soil. In the case of the 12 year-old secondary forest, though, the soil structure has almost completely recovered.

   A succession from early pioneer tree species to longer-lived shade intolerant and latter more shade tolerant species is taking place. The proportion of
commercially valuable timber is increasing during the course of the succession.

- Commercial specimens with dbh < 30 cm: approx. 30% of the total number
- Commercial specimens with dbh > 30 cm: approx. 2% of the total number.

7. Management possibilities and recommended measures

Efforts should be made to preserve the natural seed sources. The importance of secondary forests should be emphasised via educational campaigns, expert advice, PR work, and specialist seminars for various target groups. The fact that the secondary forests often only cover a small area poses a problem for their profitable management.

8. References


Case Study No. 3: Indonesia

1. Location

Indonesia, Kalimantan (Southeast Asia)

1.1 Region

Mahakam, East-Kalimantan

1.2 Climate

no detailed information available

2. Development

Successive utilization of the primary and secondary forest by

a) Logging: By opening the canopy and increasing brush development, logging is leading to the formation of secondary forest, which is less resistant to fire than the primary forest.

b) Shifting cultivation: Road construction and relocation projects (transmigration) have promoted an increase in shifting cultivation. During a dry period in 1982/83, a forest fire destroyed 3.2 million ha. The fire was probably caused by the activities of shifting cultivators.

3. Distribution

3.1 Land area

83% of East-Kalimantan are covered by forest

3.2 Area studied

2.7 - 3.2 million ha, damaged by forest fire

4. Current utilization

The development of secondary forest after the influence of fire has various consequences for the economic and protection functions of the forest

- decrease in soil fertility,
- increase in soil erosion,
- reduction of the water infiltration capacity,
- increase in damage to crops caused by animals (birds, wild boar, monkeys),
- improvement of hunting conditions during the first years after forest fire,
- deterioration of possibilities for extracting (economically valuable) non-wood forest products (e.g. Rattan, resin),
- decrease in volume of commercial tree species, logging is concentrated in areas with little forest fire damage,
- the total economic loss from said forest fire (1982/83) was estimated at U.S. $ 8.7 billion. In addition, much of the secondary forest is converted into plantations or farmland.

5. Framework conditions

The forest is state owned. The introduction of a classification system for forest functions (protected area, commercial forest, limited use commercial forest) at provincial level sets the frame for land-use.

6. Biological and ecological characteristics of the secondary forest

All succession stages and degrees of damage (ranging from slightly to heavily damaged) occur in the secondary forest.

The species composition shifts towards *Euphorbiaceae* secondary forest species as a result of forest fire. The secondary forest consists of only one
storey with few commercially valuable species.

The period required for the succession to reach the climax forest stage is estimated at 30-500 years. Reoccurring forest fires, however, lead to the development of *Imperata cylindrica* (alang alang) grassland and impede the secondary forest succession.

### 7. Management possibilities and recommended measures

The proposal is to rehabilitate the forest by means of:

- Plantations in heavily damaged secondary forest stands on fertile soil,
- Enrichment planting in slightly damaged secondary forests,
- Natural regeneration on all other sites. Measures to prevent forest fires should be further implemented.

### 8. References

SCHINDELE, W. (1989): Investigation of the steps needed to rehabilitate the areas of East Kalimantan seriously affected by fire (FR-Report No. 1)

---

**Case Study No. 4: China**

1. **Location**
   - **China**

1.1 **Region**
   - Heilongjiang Province, Daxinganling Forestry District

1.2 **Climate**
   - Temperate zone; average annual temperature: -2 to -4°C, boreal coniferous forest

2. **Development**
   - Forest fire (1987), in which 1 million ha of natural forest were damaged and 430,000 ha were completely destroyed.

3. **Distribution**
   3.1 **Land area**
       - The proportion of land covered with forest in China is 13%. The forestry district Daxinganling has a forest cover percentage of 71% and thus belongs to the most forested areas in PR China.
   3.2 **Area studied**
       - 1 million ha

4. **Current utilization**
   - 70% of the population employed in the forestry district work directly or indirectly for the forest service. In addition, fuelwood and non-wood forest products (mushrooms and berries) are harvested.

5. **Framework conditions**
   - No detailed information available

6. **Biological and ecological characteristics of the secondary forest**
   - No detailed information available

7. **Management possibilities and recommended measures**
   - 300,000 ha are being artificially reforested, and natural regeneration is promoted on 110,000 ha.

8. **References**
   - Proposal for the GTZ project: "Rehabilitation of Areas Affected by Fire", People's Republic of China; PN 91.2163.3

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**III Case Study¹: Secondary Forests in Costa Rica**

**Authors:** Dr. Eva Müller/Ing. Manuel Solís

**Project COSEFORMA - GTZ**
1 Introduction

Costa Rica is a small country in Central America with an area of 51,000 km² and a population of 3.2 million. The country is characterised by a wide diversity of landscapes and ecosystems, a large part of which have been successfully preserved by means of an extensive system of National Parks and protected areas comprising 25% of the country's territory.

The land outside the National Parks is mostly privately owned and has been subject to severe deforestation throughout the past 50 years. The primary forests have been eliminated to gain land for agricultural production. Currently only 200,000 hectares of productive primary forest remain in A of Costa Rica.

According to data published in 1991, however, Costa Rica possesses more than 400,000 hectares of secondary forests, which have developed on abandoned agricultural land. This means that secondary forests now constitute the country's most abundant forest resource.

The objective of this case study is to analyse the principal factors that have influenced the development of Costa Rica's secondary forests. In addition, it presents some of the results achieved by the COSEFORMA project in its efforts to promote secondary forests as a new option for forest production in the country.

2 Political and institutional factors relevant to secondary forests

Various governmental policies have had an impact on the development of secondary forests:

- land colonisation policy,
- livestock policy,
- forest policy,
- banana growing policy.

2.1 Land colonisation policy

Costa Rica's land colonisation policy in the early years of the twentieth century, such as those governing land title awards, stimulated the clearing of forests. In order to obtain title to land, an owner had to carry out certain "improvements" on the land, consisting of clearing the forest and changes in land use, mainly towards the utilization as pasture. As a result of the various colonisation policies, a total of 2.2 million hectares of land under the state's control passed into private ownership between 1950 and 1973, with 70% of this being used for livestock production.

The governmental Institute for Agricultural Development (IDA) responsible for distributing the land, bought large landholdings to divide them up into smaller lots. The farmers who received wooded plots had the right to clear them to plant crops or, in the majority of cases, to establish cattle ranches.

In the case of cattle ranches without official registration, owners ran the risk of losing title to their lands if they allowed brush (Charrales) to develop on fallow land.

2.2 Livestock policies

The development of livestock farming in Costa Rica can be divided into two phases, summarised in the following two tables.

Phase 1: Livestock development policies (1954-1978)
(Source: Ortiz Valverde, 1996)

<table>
<thead>
<tr>
<th>Situation</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favourable credit situation: an average of 22% of the agricultural loans were extended for livestock farming, with peak levels near 60%;</td>
<td>Conversion of large forest areas into pastureland: increase from 600,000 hectares of pasture in 1954 to 1.7 million hectares in 1974;</td>
</tr>
<tr>
<td>Average interest rates between 8 and 12%;</td>
<td>Clearing of 847,000 hectares of forest, of which</td>
</tr>
</tbody>
</table>
• Increasing consumption of meat in the USA;
• Rise of meat exports from 4.6% of total exports in 1950 to 10.3% in 1984. More than 95% of the meat exports were intended for the USA;
• Stable market prices for meat of $2.6/kg.

57% were turned into pastures.


<table>
<thead>
<tr>
<th>Situation</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Decrease in the percentage of agricultural loans for livestock raising from 34.3% in 1983 to 7% in 1994;</td>
<td>• Declining number of cattle raised;</td>
</tr>
<tr>
<td>• Increase in real interest rates from 7.8% in 1980 to 16.4% in 1990;</td>
<td>• Reduction in the area of pastureland from 2.4 million hectares in 1984 to 2.0 million hectares in 1994;</td>
</tr>
<tr>
<td>• Declining demand for meat in the USA by annualy 7.5%;</td>
<td>• Increase in the area of secondary forest from around 230,000 hectares in 1984 to 425,000 hectares in 1994.</td>
</tr>
<tr>
<td>• Decrease in meat exports to the USA by 13%;</td>
<td></td>
</tr>
<tr>
<td>• Decrease in international meat prices by 15% between 1986 and 1994.</td>
<td></td>
</tr>
</tbody>
</table>

The stage of development of the now existing 425,000 hectares of secondary forest is presently unknown. As the abandonment of pastureland is a recent process, it is highly probable that most of the secondary forests are still young, meaning 15 years old or less. Generally, the sizes of the forests are small, comprising only a few hectares, usually located in areas of the cattle ranches which, on account of their biophysical properties are least suited for pastureland.

2.3 Forestry policies

In 1969, the first Forest Law (No. 4465) was passed in Costa Rica, followed by Law No. 7174 in 1990 and Law No. 7575 in 1996. Tables 1 - 3 list some of the principal characteristics of these laws and their implications for the country's secondary forests.

Table 1: Impacts of the first Forest Law on secondary forests 1969 - 1990 (Law No. 4465)

<table>
<thead>
<tr>
<th>Instruments applied</th>
<th>Impacts on secondary forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Permits a change in land-use in any project devoted to land colonisation, division of land into plots, or any agricultural or livestock operation whose work plans involve clearing forest;</td>
<td>• Large forest areas were cleared without the intention of agricultural use;</td>
</tr>
<tr>
<td>• The Forest Administration may restrict the use of forest areas as deemed necessary;</td>
<td>• Insecure tenure situation on forested land;</td>
</tr>
<tr>
<td>• Tax deductibility of costs incurred for forests and reforestation;</td>
<td>• Direct incentives are provided for forest plantations only, and only large non-forestry operations may benefit =&gt; a direct disincentive for keeping forests.</td>
</tr>
<tr>
<td>• Secondary forests do not qualify/are not classified as forest.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Impacts of the second Forest Law on secondary forests 1990 - 1996 (Law No. 7174)

<table>
<thead>
<tr>
<th>Instruments applied</th>
<th>Impacts on Secondary Forests</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Management plans are required before forest trees may be cut;</td>
<td>• The procedures for granting permits and the costs of management plans work against forests;</td>
</tr>
<tr>
<td>• Introduction of Certificates of Forest Credit</td>
<td>• CAF constitute a direct disincentive for the</td>
</tr>
</tbody>
</table>
The new Forest Law from 1996 is innovative with respect to secondary forest, in the sense that, for the first time, incentives are established in the frame of the Forest Conservation Certificate (CCB) for the promotion of natural regeneration on abandoned land (Article 24).

**Table 3: Impacts of the new Forest Law from 1996 on secondary forests (Law No. 7575)**

<table>
<thead>
<tr>
<th>Instruments applied</th>
<th>Impacts on Secondary Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prohibition on changing forest into other land-use forms;</td>
<td>• Protection at the same time implies devaluation: The development of secondary forests on abandoned land involves major restrictions and responsibilities for further use of the land (long-term commitment, management plans);</td>
</tr>
<tr>
<td>• Introduction of Certificates of Forest Conservation (CCB) and payment for forest environmental services. Article 24 states that &quot;natural regeneration&quot; (= development of secondary forest) shall benefit from the established incentives;</td>
<td>• For the first time, incentives are possible for the establishment of secondary forests;</td>
</tr>
<tr>
<td>• The Law neither mentions nor defines &quot;secondary forest&quot;;</td>
<td>• For cultural reasons, secondary forest is not recognised as forest; instead, the agricultural point of view still prevails, according to which brush land (&quot;Charral&quot;) merely serves to improve the soil and is cleared soon afterwards;</td>
</tr>
<tr>
<td>• Ambiguous definition of the term &quot;forest&quot;</td>
<td>• Lack of terminological clarity causes insecurity with regard to the legal situation of secondary forests.</td>
</tr>
</tbody>
</table>

**Article 24:**

Land owners of fallow land suited for forest, who voluntarily wish to leave this land to the natural regeneration of forest, have the right to benefit from incentives according to Article 22 (CCB) of this Law for areas that, owing to their deteriorated state and environmental requirements, should be converted to forestry use, based on technical criteria defined by the Ministry of Environment and Energy.

The measures of this provision shall be entered in the Public Registry as an encumbrance on the property for a period of time determined by the respective contract. This period may not be less than twenty years.

In addition, the law calls for environmental services to be funded by a selective consumption tax on fuel; these environmental services include the fixation of CO₂. Efforts are now under way to define the priorities and the sums to be paid for these services. The new Law eliminates the CAFs and the CAFMAs (with the exception of pending cases and CAFs for smallholder farmers); nevertheless, for political reasons, they will be continued in 1997. Other aspects of the new Forest Law, however, work against secondary forests. The wording of the Law also reflects the ambiguous attitude of the legislators toward secondary forests.

**2.4 Banana-growing policies (Atlantic and Northern Zones)**

Banana growing activities increased in the Northern and Atlantic Zones of Costa Rica, primarily during the early 1990s. For the establishment of new banana plantations, permission was granted for converting land holding primary and secondary forests.
The Ministry of Agriculture and Livestock Farming (NMG) and the Ministry of Natural Resources, Energy and Mines (MIRENEM, today MINAE) held conflicting views on the issue, with the MAG having the stronger position, as the expansion of banana plantations was considered a matter of national interest (see Annex for a copy of the open letter by COSEFORMA to the Minister of MAG, published in the newspaper La Nación from 8th December, 1991).

The expansion of banana growing ended in 1993, when the European Community established quotas for banana imports from Latin America.

3 Socio-economic aspects

3.1 From the point of view of the land owners

- The secondary forests are privately owned;
- The presence of brush and thickets (Charral and Tacotal) on the land is considered to be a sign of poor management;
- The development of brush and thickets is a sign that the land has been abandoned; there is then a risk of losing title to the land;
- The concept of "letting the soil rest": The brush is allowed to grow for several years in order to improve the soil, and is then cut down in order to plant crops or once again use the land for livestock farming;
- The mentality of farmers: In order to achieve high yields on agricultural or forest land, it is considered necessary to actively sow or plant crops of trees and to tend the developing vegetation. The attitude is that natural regeneration, which develops by itself, cannot possibly result in high yields;
- Allowing secondary forest to grow on abandoned areas also has long-term legal consequences for land owners: as soon as the succession has reached the point that is defined by law as forest ("the presence of more than 60 trees with a diameter at breast height greater than 15 cm, with a one or more storeyed crown canopy covering more than 70% of an area of at least 2 hectares"), all of the restrictions of the Forest Law pertaining to forests apply: it is no longer permitted to switch to another type of land use, and in order to utilise the trees a management plan must be prepared and submitted, which is associated with relatively high costs. To avoid these restrictions, many landowners prefer to keep their holdings "clean", meaning free of forest.

3.2 From the point of view of the technicians

- The forestry curricula of the National Universities do not cover the issue of secondary forests;
- There is general ignorance concerning secondary forests, on the part of both state officials and private forest owners;

Examples:

- 1991: A private forest manager requested permission to exploit "trees on pasture land" from a 12 year old secondary forest, arguing that, apart from the trees he wished to harvest, the forest only contained pioneer species without any commercial value. In actual fact, though, more than 50% of the species possessed commercial value;
- 1997: A forest manager submitted a management plan for a secondary forest containing trees with diameters at breast height greater than 60 cm. In actuality, it was a disturbed primary forest and the forester was unable to tell the difference.

3.3 From the point of view of the general public

- Ignorance and lack of interest on the topic.

4. Technical/ecological aspects

4.1 Research

Various Institutions, which have gained recognition for their research and experience concerning secondary forests, are strongly promoting further research in this field (CATIE, universities, the Tropical Science Centre...
In 1956, Holdridge conducted the first studies on secondary forests. These were followed in 1966 by Budowski, who studied the ecology of young secondary forests (in their first developmental stages);

- Starting in 1986, CATIE analysed the ecology of secondary forests by studying their dynamics and composition in Tirimbina de Sarapiquí, Heredia. Work was done in secondary forests 1.5, 15 and 25 years old, and including trees with diameters greater than or equal to 10 cm. The analyses is still continued today, for the sake of long-term evaluation;

- In 1988, Maria Manta, working through CATIE, conducted a silvicultural analysis of secondary forests older than 25 years in Tirimbina. Working along the same lines in 1989, in the same 15- and 20-year-old forests in connection with a postgraduate thesis at CATIE, Rudy Herrera carried out a thinning operation, to determine potential wood production in the middle canopy (in view of fuelwood extraction);

- In 1989, in 40-year-old secondary forests in Cajón de San Isidro de El General, CATIE established permanent plots in order to analyse the forests’ dynamics, silvicultural treatments, and associated costs;

- In 1991, in a 30-year-old secondary forest located in Florencia de San Carlos, an inventory of trees with diameters greater than or equal to 10 cm was carried out for commercial purposes. In 1993/94, on the same property, 15 hectares of forests were thinned to encourage the growth of commercially valuable trees with diameters at breast height greater than 25 cm. A radius of 7 m for thinning out competition was established around the potential crop trees;

- In 1991, COSEFORMA ascertained the need to study secondary forests in the Northern Zone of Costa Rica during elaboration of the first plan of operations there. This led to the performance of a study on the development and dynamics of secondary forests in the two sub-regions of the Northern Zone, with follow-up monitoring (of growth and dynamics);

- In 1991, the Tropical Science Centre (CCT) worked jointly with universities to map the secondary vegetative cover in Monteverde. The recovery of forested areas was analysed and the species composition of different succession stages studied;

- In 1995, based on agreements between the CCT and universities, an ecological assessment of the pace and quality of regeneration was carried out in Abangares. The findings, obtained within the scope of a master's thesis, indicated that 70% of the area was covered by secondary forest. A model for predicting the quality of the vegetation was also derived;

- In 1996, the Centre of Agronomic Studies at the University of Costa Rica initiated studies of secondary forests dominated by *Vochysia ferruginea* in the Northern Zone of the country, with the aim of developing a site classification system for this tree species in secondary forests of different ages;

- In 1996, CATIE, within the scope of a master’s thesis, analysed the impact of thinning on the growth of a high-elevation secondary forest in the Talamanca mountain range. This forest was approximately 30 years old. That same year, CATIE, also in connection with a master's thesis, carried out inventories in various high-elevation secondary forests in the Cerro de la Muerte mountains;

- In 1997, COSEFORMA, with funds provided by the Tropical Ecology Backup Program (TÖB) of the GTZ, launched a study on the development of secondary forests in dry zones;

- In 1997, the Technological Institute of Costa Rica proposed a research project to study secondary forests in Sarapiquí and possibly also on the Osa Peninsula.

### 4.2 Summary of the knowledge gained from research in the various regions of the country (northern region, Atlantic region, southern region, highlands)

- **Species composition:** Around 50% of the tree species present in secondary forests in Costa Rica are species considered commercially valuable species.

- **Species dynamics:** Already in the first stages of secondary succession, the long-lived pioneer species form the largest group. However, partly shade tolerant species are also already present from the initial stages onward, and increase in quantity over the course of time, ultimately comprising the principal stock of potential crop trees together with the long-lived pioneers.

- **Factors that influence establishment and development:** Tree seed sources and grazing cattle play a decisive role in the development of secondary forests. Seed sources can vary greatly, a fact which is reflected in the variable composition of the resulting vegetation. In some cases even, stands develop that consist of only a single or a small number of species.

- **Increment:** Recorded data show an increment of the basal area during the first 10 years of between 0.4 and 2.6m²/ha and year, and in the second decade (between the ages of 11 and 20 years) of 0.9 to 2.3m²/ha annually. Only few results are available for older tree stands, e.g. in two isolated cases, one being a 25-year-old forest and the other a 40-year-old forest, growth increments of 1.0 and 0.3m²/ha respectively, were measured.

- **Inventories:** A method involving circular plots exists for carrying out quick inventories (see 5.3.5 below).

- **Management:** Only little experience has been gained so far on the medium- and long-term effects from thinning on secondary forests. Nevertheless, it has been observed that various treatments are suited to
promote regeneration, reduce mortality, and raise both growth increments and yields.

- **Evaluation of the costs and yields of treatments:** Two case studies produced positive results, but these cannot be applied to average conditions within the country.

- **Effect of secondary forest on soil conditions:** As the development of a secondary forest progresses, soil compaction is reduced, which improves the physical and chemical properties of the soil.

- **Yields:** Volume increments of 8 m$^3$/ha/year have been observed in 40-year-old secondary forests. This figure is very similar to the values measured in forests 15 and 25 years old, where rates of 7.6 and 8.2 m$^3$/ha/year respectively were obtained for trees with a diameter at breast height greater than or equal to 10 cm.

- **Wood:** Information has been collected on the wood of several tree species from secondary forests, with positive findings regarding their market potential.

### 5. Promotion of secondary forests within the frame of the COSEFORMA project

**COSEFORMA** ("Co-operation in the Forestry and Wood Sectors") is a Technical Co-operation project in Costa Rica supported by GTZ. Participants of the project are state and private institutions, along with NGOs and companies involved in the forestry sector. The project was initiated in 1990, and is now in its third implementation phase.

The aim of the project is to promote the sustainable use of forestry resources in Costa Rica, whereby the activities concentrate on the northern region of the country and since 1996 also on the Atlantic region.

**Approach:** to attach greater importance to forest resources. Forest resources comprise primary and secondary forests, forest plantations, agroforestry systems, and individual trees on cattle ranches.

Within the framework of the concept, the project began promoting secondary forests as a new forest resource in 1991, and with the aim of offering alternatives for production on abandoned land so highly degraded that it is no longer suited for growing crops or raising livestock. The project's strategy addresses three fundamental aspects: political/institutional, socioeconomic, and technical/ecological.

#### 5.1 Political/institutional and socioeconomic aspects

Confronted with a political environment characterised by an expansion of banana growing and strong incentives to establish forest plantations (both of which have had a negative impact on the development of secondary forests in the past), the project implemented a number of activities to raise the level of awareness of technicians, forest owners and managers, and the general public:

- A letter to the Minister of Agriculture and Livestock Farming that was advertised in the newspaper La Nación in 1991 in order to call attention to the potential of secondary forests as a productive forest resource;
- A pamphlet on the characteristics, development and management of secondary forests (in collaboration with CATIE);
- Distribution of the thesis "Development of Secondary Forests in Abandoned Pasture Areas of the Northern Zone of Costa Rica" and of the "Technical Manual for Rapid Inventory of Secondary Forests in the Northern Zone of Costa Rica";
- Distribution of T-shirts with the imprints "Secondary Forests = Natural Reforestation" and "Without Seed Trees, There Aren't Any Forests";
- Field days for representatives of the state and private forestry sectors (including the vice-president of Costa Rica), technicians and forest owners;
- Organisation of an event to promote secondary forests (also attended by the Minister of Natural Resources, Energy and Mines), at which the project study findings on secondary forests of the Northern Zone (in the sub-regions of Boca Tapada and Guatuso) were presented and a slide show on the development of secondary forests was shown;
- Participation in drafting the new Forest Law of 1996 and its provisions, championing the importance of secondary forests as a new forest resource;
- Elaboration of two project profiles of relevance to secondary forests, for financial co-operation with KfW (for promoting an increase in secondary forest areas and promoting the management of secondary forests, respectively); preparations for the feasibility study carried out by KfW;
- Participation in devising the strategy for the future of Costa Rica's forestry sector; incorporation of secondary forests into the strategy of forest management as a priority issue; presented at the 3rd National Forest Conference in August 1997.
5.2 Technical/ecological aspects

Execution of studies on secondary forests in the Northern Zone of Costa Rica:

- Thesis by Christian Fedimeier: "Development of Secondary Forests in Abandoned Pasture Areas in the Northern Zone of Costa Rica" (1996);
- Thesis by two students on the impact of secondary forests on soils;
- Development of a method for conducting fast inventories in secondary forests;
- Continuation of the annual measurements (of growth and dynamics) in Guatuso and Boca Tapada, the results of which were presented at the 3rd National Forestry Conference in August of 1997.

5.3 Information gained from the project's research

The charts included here present, in summary and on the basis of examples, some of the most important findings from 5 years of studying secondary forests in Boca Tapada and Guatuso in the Northern Zone of Costa Rica. On 32 plots (each comprising 500 m²) established in forests of different ages in both zones, the diameters of all the trees with diameters at breast height greater than 5 cm were measured annually. Based on the recordings, the following values were determined: percentages of commercial and non-commercial species, abundance of species in the various ecological classes, annual growth increments, new trees and mortality rates.

5.3.1 Species composition and dynamics of secondary forests

By way of example, Figure 1 depicts the basal areas of the commercial and noncommercial trees as a function of age during the first 22 years. During the first 12 years, the basal area of both groups of trees grows at much the same rate. Thereafter, the basal area of the trees belonging to commercial species increases distinctly faster than that of the non-commercial tree species. This relationship confirms the productive potential of these forests.

Figure 1: Basal area of commercial and non-commercial tree species in secondary forests at different ages in Boca Tapada

= Basal area (m²/ha); Alter des Waldes = Age of forest; (blue) = Grundfläche der kommerziellen Arten (red) Basal area of non-commercial tree species

Comparing the basal areas of commercial trees in secondary forests of Guatuso and Boca Tapada, the difference between these two sub-regions is conspicuous: as a general rule, the forests of Guatuso exhibit greater basal areas than those in Boca Tapada (Figure 2), owing to the fact that there is less competition of vegetation in Guatuso and the trees therefore achieve greater diameters.
In the forests of Guatuso, the numbers of commercial and non-commercial tree species are roughly the same, with the number of non-commercial species being slightly higher, as shown in Figure 3. The fact that nearly 50% of the species present are commercial ones confirms the productive potential of these forests.

With regard to the abundance of commercial species in the various ecological categories defined by different degrees of shade tolerance (Figure 4), the absence of short-lived light-demanders (= pioneers) with commercial value and the predominance of long-lived shade intolerant species are conspicuous—both of these characteristics are typical of the region’s secondary forests.

Whereas the number of long-lived shade intolerant trees declines as the forests develop, the proportion of partially shade-tolerant trees increases slightly. Management of secondary forests should focus on these two ecological groups.
5.3.2 Increment

Figure 5 shows that diameter increment decreases with age. Non-commercial species, naturally, grow more rapidly during the first six years than the commercial tree species, due also to their greater exposure to sunlight and the intense competition among the trees.

After ten years, however, the opposite situation evolves. The commercial trees grow faster because the non-commercial species have begun to decease or are approaching physiological maturity.

Based on these considerations, a thinning can be recommended in the sixth year, given that the average annual growth increments of commercial and non-commercial species are similar. From this point on, there is intense competition between the two groups. It can also be observed that the growth increments decline if no silvicultural treatments take place.
Figure 6 shows that competition between the commercial and non-commercial tree species continues until the 15th year of age in Guatuso. From this point on, the annual average growth increments begin declining sharply, and consequently it would be advisable to perform a thinning at this time to reduce competition and promote the growth of the commercial trees.

The differences in the growth rates observed in the forests of Guatuso and Boca Tapada, as presented in Figures 5 and 6, illustrate the variation in behaviour that can exist among secondary forests within the same region.

5.3.3 Factors influencing the development of secondary forests

Seed, or mother, trees play a basic role in the establishment of secondary forests and in determining their species composition. As an example can serve the regeneration of the tree species *Otoba novogranatensis*, the seeds of which are primarily dispersed by birds. Figure 7 graphically portrays that regeneration of this species decreases exponentially as the distance from the seed tree increases.
5.3.4 Impact on Soils

Figure 8 shows the degree of soil compaction on pasture land and in primary and secondary forests in Guatuso. It is conspicuous how soil compaction increases at different depths when the land is used for cattle farming. When a secondary forest develops on the land, however, the degree of compaction (N/cm²) lessens, gradually coming once again to resemble that in a primary forest. The degree of compaction is very similar at a depth of 20 cm in both types of forest, owing to the fact that this is the first zone invaded by the roots of the trees. Figure 8 clearly shows the positive effect that the development of secondary forest has on degraded soils of abandoned pastureland.

![Figure 8: Soil compaction (Compactación del suelo) at different soil depths (Profundidad) for three types of land-use in Guatuso (Source: Fedimeier, 1985): upper curve = range land; middle curve = 12 year old secondary forest on abandoned range land; lower curve = primary forest.](image)

5.3.5 Rapid inventory of secondary forests

The method employed involves systematic sampling on circular plots, an approach that reduces the error rate in measuring the basal area as compared to inventories performed on rectangular or square plots. Generally speaking, with this system the error rate fluctuates between 7 and 12%. In addition, the inventory performance can be increased by more than 150% compared with traditional methods.

5.3.6 Estimation of Yields

The annual increments of the standing volume in the studied areas ranged between 8 and 12 m³/ha/year for trees having diameters greater than or equal to 5 cm. The increments in the basal area of the commercial species varied between 0.62 and 5.74 m²/ha/year. Because most of the forests studied are still young, and none have yet reached the end of a rotation period, it is not yet possible to draw definitive conclusions about their yields.

5.4 The Project’s Strategy for the Future

- Training of governmental and private technical personnel;
- Dissemination of research results;
- Campaigns to raise public awareness;
- Field days for the owners of secondary forests and abandoned pasture land;
- Exchange of information at the national level by way of a working group formed by individuals working in the field of secondary forests.
6. Bibliography (Case Study Costa Rica)


IV Classification Schemes for Secondary Forests

IV.1 Classification by Cause

Formed after the exploitation of largely untouched primary forests with no intermediate clear-cutting or other land-use, moist tropics (Latin America, Asia);

Formed after brief, repeated small-scale agricultural use, moist tropics (Latin America, Asia);

Formed on areas briefly used for agriculture after converting logged-over primary forests for this purpose (Africa);

Formed after large-scale forest clearing and exploitation as pasture, dry regions (Chaco, Latin America and Africa);

Formed after large-scale clear-cutting for timber harvest with no intermediate other land-use, boreal coniferous forest zone (Russia)

IV.2 Classification by Selected Criteria

Biological potential (growth parameters such as climate / vegetation zone, soil conditions) + Time (stage of succession) + Preconditions for regeneration (e.g. distance to seed trees, seeds left in soil, coppices):

Type 1: High growth potential, late (late succession stage), great potential for climax (tree) species;

Type 2: High growth potential, late, no potential for climax species;
Type 3: High growth potential, early, great potential for climax species;
Type 4: High growth potential, early, no potential for climax species;
Type 5: Low growth potential, late, great potential for climax species;
Type 6: Low growth potential, late, no potential for climax species;
Type 7: Low growth potential, early, great potential for climax species;
Type 8: Low growth potential, late, no potential for climax species.

Useful could be to also add socioeconomic criteria - although at the cost of clarity and simplicity - such as:

- Proximity to markets or settlements;
- Legal security;
- Inclusion in planning procedures, e.g. land-use planning (as wooded areas, cropland/fallow, or "wasteland", etc.).

V Ecological Processes in Secondary Forest Development

The reason and circumstances for the development of a secondary forest largely determines the further course of its development. This often - but not always - takes on the form of a "secondary succession". A succession is understood to mean a sequence of biotic communities inhabiting the same area (Burschel & Huss 1984). This usually comprises the development process from pioneer vegetation up to climax-stage vegetation (Jacobs 1986).

"Succession" does not take place if the original species have regenerated directly from root shoots, coppice, and still-present seeds. In these cases, only one, the original forest community simply undergoes a development process. Whether or not succession takes place also depends on the size of the area, the intensity of the disturbance, the distance from surrounding forest, and climatic and site conditions.

When gaps in the canopy are small, autogenous regeneration usually takes place (Oldeman 1980). This means that the open space is occupied by existing or surviving regeneration of climax tree species, or is at least closed very quickly by expansion of the canopy of trees along its edges, coppices and root shoots, germination of tree seeds present in the soil, coppices from parts of trees that have survived, or newly deposited seeds (Corlettr 1995). Since a succession of biotic communities does not necessarily occur in these cases, it has often been proposed that the term "succession" should be limited to processes that take place on areas larger than 1,000 m² (UNESCO 1978; Denslow 1980; Sips et al. 1993).

There is no clear dividing line between the two forms of development (with and without succession). Because succession is a major issue in discussions on secondary forests, the course of a secondary succession is described below.

The force driving succession is competition among the plants, which depends on the site conditions under which they develop. The (micro) site conditions in turn are subject to constant change as the plants develop. A distinction is made between primary succession, which designates the initial colonisation of a site, and secondary succession, which designates the re-colonisation of an area that had already been colonised once before (Burschel & Huss 1984).

Succession is the central process in the development of secondary forests. Since succession also plays an important role in the dynamics of primary forests, it is not surprising to find that there is considerable overlap between the literature on secondary forests and the literature on the succession of (primary) tropical rain forests (Brown & Lugo 1990). The biological mechanisms determining the succession process are the same in both cases.

The speed, direction and results of succession depend on a number of factors with complex effects. To illustrate these, the course of a succession is described in the following by way of an example.
The "standard succession" described, basically corresponds to the course of succession that takes place after large-scale deforestation in tropical climates, as described by BROWN & LUGO (1990), FINEGAN (1992), SIPS (1993) and CORLETT (1995) on the basis of extensive studies of the literature. The succession can be divided into four phases, depicted below.

V.1 Progression of Secondary Succession o Starting phase

Immediately after deforestation, there is very little biomass left that is capable of regenerating. However, herbs and shrubs appear quickly, which colonise the bare soil.

Early phase

In less than a year, the herbaceous and shrub vegetation is displaced by early pioneer tree species exhibiting the following features: rapid height growth; low wood density; minimal branch formation; large, simply structured leaves; early flowering maturation; production of many small, dormant seeds that are dispersed by birds, mice or wind; short life span (7-25 years); germination in intense light; and a large distribution area.

Due to the early pioneer trees' high light demand, mortality in this succession phase is very high and the trees that mature are roughly even-aged (FINEGAN 1992). Although early pioneers dominate the stands, many tree species typical of subsequent phases also already appear, but are quickly overtaken by the fast-growing early pioneers (GOMEZ-POMPA & VASQUEZ-YANES 1981; KAHN 1982; FINEGAN 1984).

Nutrient cycles develop very quickly (VITOUSEK 1984; VITOUSEK & REINERS 1975; BROWN & LUGO 1990). Minerals, in particular, are absorbed rapidly by the plants, whereas soil nitrogen, phosphorous and sulphur initially increase in the surface humus (JORDAN 1985). Due to the rapid growth and absorption of nutrients, biomass accumulates very quickly. Already within less than five years, a leaf surface index and net primary production rates comparable to those of primary forests are reached (CORLETT 1995). Leaf, root and wood biomass successively accumulate. As soon as the leaf and root biomass is fully developed, the accumulation of wood biomass can be expected to accelerate sharply (BROWN & LUGO 1990). The leaf and fine root biomass achieves levels typical of primary forest after just 5-10 years (UHL & JORDAN 1984). During the first 20 years, net primary production reaches 12-15 t of biomass/ha/year, exceeding that of primary forest by 2-11 t/ha/year (EWEL 1971; TOKY & RAMAKRISHNAN 1983).

The biological processes slow down after about 20 years. This marks the onset of the third phase, the "late phase".

Late phase

After the early pioneer trees reach their maximum height, they die off and are gradually replaced by late pioneers, which also form a homogenous tree story (FINEGAN 1992). The relatively diverse characteristics of late pioneers can be roughly summarised as follows: Although they closely resemble early pioneers while young, late pioneers are taller, live longer (50-100 years), and often have denser wood. Late pioneers are deciduous and have seeds that are dispersed by wind and often remain dormant in the soil for a very long period of time. They can even germinate on very nutrient-poor sites if the light intensity is high enough (GOMEZ-POMPA & VASQUEZ-YANES 1974; LEBRON 1980). The same species of late pioneers belonging to the same genus typically occur within a large geographical area (FINEGAN 1992, KARTAWINATA 1994).

In the late phase, biomass accumulation gradually continues to slow. Only 1-4.5 t of biomass/ha/year are produced in older forests (JORDAN & FARNWORTH 1982; SINGH 1975). After 50-80 years, net primary production approaches zero. As the accumulation of biomass slows, nutrients are utilised more efficiently, because they are now absorbed and recycled to a greater extent. As a result of this, and because of the increase in non-functional nutrients in the surface humus and upper soil horizons, the concentration of nutrients in the biomass declines (BROWN & LUGO 1990). Nutrient turnover in the foliage is much higher than in the previous phase. The climax stage begins.

Climax phase

The late pioneers die off after about 100 years (LIEBERMANN & LIEBERMANN 1987) and are gradually substituted by shade-tolerant species that have grown up under their canopy. These are the climax tree species of the primary forest, which can exhibit very different attributes. They include both commercially valuable tropical woods and many species devoid of any (presently) appreciable commercial value.

A steady-state situation slowly develops, in which dying plants are continuously replaced by new growth. The
basal area and biomass of the original primary forest are reached after 50-100 years (RISWAN et al. 1985), respectively 150-250 years (SALDARRIAGA et. al. 1988). After that point, no additional biomass accumulates. However, it takes 500 years for a situation typical of the autogenous regeneration of moist tropical forests to be achieved (RISWAN et al. 1985).

The standard succession described is a highly generalised example of the very complex, diverse processes involved in succession. Although many successions follow the pattern described, in nature some of the succession stages are often skipped, or else various succession processes appear concurrently in a mosaic-like configuration. A special situation occurs when climax tree species immediately regenerate over the entire area after, or despite, the disturbance that caused its denudation. In this case, the same plant community advances through all phases, and consequently the only changes observed are of a structural nature.

V.2 Economic and Ecological Comparison of Various Stages

The individual development phases exhibit differing economic and ecological potentials. The following parameters in particular vary over time:

Species diversity

A basic axiom that applies is that species diversity in the tropics increases with a forest's age. Accordingly, stands are dominated by just a few tree species in the early phase. The original species composition is not restored until the climax forest stage, following a long period of development.

Wood properties

The wood of early pioneer trees is not very usable, nor does a commercial promotion seem promising, while the wood of many late pioneers is judged favourably (FINEGAN 1992; KARTAWINATA 1994). The valuable climax tree species for which the forest was, in many cases, originally exploited do not reappear until after a very long time. This group also includes many less usable woods as well, however.

Dimension

Greater stem diameters can not be expected until after many years of growth. In accordance with the unit-volume law, the dimension influences harvesting costs and is also an important criterion for the suitability of wood for many uses, such as larger dimensions for sawing into lumber or veneer production.

Steering possibilities

The younger a tree, the more sensitive it is to silvicultural treatments. Wood quality (e.g. amount of branches) and growth are easier to influence in younger stands. A stand's species composition and phytosanitary condition can also be more easily controlled when the trees are young.

This illustrates the significance of time as a factor in analysing the potential of secondary forests.

VI Factors influencing the Development of Secondary Forests

VI.1 Ecological Factors

As with all forests, the characteristics and development of secondary forests also depend on their specific growing conditions. The characteristics include not only the development of height increments and standing volumes, but also the structure and composition of the stands. The growing conditions are determined by major climatic influences (climate, vegetation zone) and regional conditions, and by the forest's characteristics and development themselves.

VI.1.1 Site Conditions

The forest formation (climax-stage vegetation) corresponding to a given climate zone pre-describes the
attributes a secondary forest will eventually exhibit, because the secondary forest will increasingly come to resemble this climax vegetation over the course of time - provided, of course, that genetic resources have not been lost.

Continents exhibit differences within the same vegetation zones, owing to their respective histories. Where site conditions are similar, however, species groups resembling one another have developed. For instance, the species belonging to individual succession phases exhibit very similar characteristics on every continent. The proportion of commercially exploitable tree species varies, however, in some cases considerably. The lowland dipterocarp forests of the islands of Southeast Asia, for instance, contain more valuable tree species than other tropical forests, and have therefore been more heavily exploited (KARTAWINATA 1994). This example illustrates that regional differences can also strongly influence the development and potentials of secondary forest (BROWN & LUGO 1990).

Climatic differences within a vegetation belt (e.g. temperature and precipitation) also affect the course of succession. In the tropics, for instance, coppicing plays a greater role in the reforestation of clear-cut areas where the climate is drier and cooler (SUDGEN el al. 1985; STRIMGAARD 1986; NYERGES 1989). In most logged-over dry forests, regeneration takes place nearly exclusively through coppice and root shoots (BROWN & LUGO 1990). The pioneer stage is skipped completely at high elevations in the tropics, with climax forest tree species directly colonising such areas (CORLETR 1987).

The microclimate (light, radiation, wind, moisture and temperature conditions) is strongly affected by the vegetation remaining after a disturbance. This has a critical impact on regeneration. For instance, high light intensities and fluctuating radiation and moisture conditions create a favourable situation for natural seeding of early pioneers, while low light intensities are necessary for the growth of shade tolerant climax tree species that can only dominate and thus grow well when shaded.

Another important ecological factor for succession is soil fertility (FINEGAN 1992). Succession proceeds much more slowly on poor soils than on rich soils. Thus, early pioneers may need decades to colonise sites with extremely poor soil, and the colonisation process can be very irregular. Yet even less fertile soils have considerable potential for re-colonisation, provided that no further site degradation occurs (UHL et al. 1988). It is common to find some slow-growing tree species with denser wood on such soils, representing the climax vegetation typical of these Sites (CORLETT 1991; Sim et al. 1992). The poorer the soil is, the greater is the impact of interventions (disturbances) (SANCHEZ 1976). Human activity causing major disturbances can lead to degradation processes so severe, that natural redevelopment of forest takes decades or even centuries (CORLETT 1995).

VI.1.2 Regeneration Resources

In addition to abiotic growth conditions, the development of secondary forest also depends on the density and composition of the flora and fauna relevant to regeneration. Significant here are the vegetation remaining in a secondary forest area after a disturbance - which depends primarily on the type of disturbance - and the distance from remaining (primary) forest.

The existing capacity for natural regeneration - in the form of coppices, root shoots and remaining seeds in the soil - greatly influences the course of a succession (RICHARDS 1964; BOERBOOM & SCHOUTEN 1971; BOERBOOM & WIERSUM 1983; BERNAL & GOMEZ-POMPA 1976). If the existing regeneration potential is exhausted or destroyed, then natural seeding assumes great importance. In such cases, the distance, structure and species diversity of adjacent primary or older secondary forests play a large role (MACMAHON, 1981; DORP 1985; ROTH 1987; KARTAWINATA 1994). In these cases, fauna - as the most important means of dispersing seeds of climax tree species - also plays a crucial role (CORLETT 1995). If the seeds cannot be dispersed by animals, climax species with heavy seeds can only regenerate in the immediate vicinity of mother trees.

VI.2 Human Influence

VI.2.1 Wood Utilisation

Logging has a great impact on flora and fauna as well as on the microclimate and soil. Fauna is affected indirectly by the destruction of habitat, and directly by hunting. The impact of logging depends on its intensity and frequency.
In general, it can be said that felling more trees on a larger area improves the regeneration conditions for early pioneers while decreasing the diversity of available seeds and thus the number of species that can participate in the succession. At the same time, the risk of soil degradation increases with the intensity of the disturbance. Based on this, steadily increasing impacts can be observed when moving up the scale from selective logging methods to clear-cutting.

VI.2.1.1 Selective Cutting

Selective removal of a relatively small number of trees leaves a forest's species diversity largely intact. Resulting gaps in the vegetation are usually closed as adjacent trees grow. But selective logging can also, especially in areas with a low density of climax tree species with heavy seeds, or when re-colonisation potential is lacking due to severe deforestation of the surrounding areas, lead to a pronounced segregation of species that can range in degree all the way up to the regional extinction of one or more tree species. When nearly all commercially valuable trees are logged in an area (even if selectively), which is mostly the case, forests' economic potential decreases considerably as their species diversity declines.

Selective logging also largely preserves soil structure and available nutrients, thus enabling rapid re-colonisation (CORLETT 1994). Near logging roads the soil can be more severely damaged by greater soil compaction, with the risk of erosion (JOHNS 1992). The impacts of selective logging operations can therefore only be evaluated fully if the indirect effects are also taken into account. For instance, accessing a forest for selective logging and removing large-diameter stems greatly facilitates subsequent use of the area for other purposes (e.g. for farming) (BULTE & DAAN 1995). This reduces the chances of preserving the forest or reforesting the area.

If a forest is selectively logged repeatedly over a longer period of time, the proportion of valuable tree species decreases, nutrients are depleted, and the stand is progressively thinned and opened. All of these factors decrease a site's long-term performance.

VI.2.1.2 Clear-cutting

In clear-cutting, all available species are removed. The soil structure and available nutrients are destroyed so thoroughly that the site is then mainly re-colonised by species from outside the area (CORLETT 1994). In this case, the availability, distribution and frequency of potential species has significance for the succession process (FORMAN & GODRON 1986; TURNER 1989). As a result of the large-scale, complete elimination of vegetation inflicted by clear-cutting, the secondary forests that develop afterwards are generally relatively poor in species, and often no longer include any tree species from the climax tree community (CORLETT 1994). Usually a few pioneer tree species will dominate the area, which would also appear for re-colonisation in larger gaps of climax forests. If the site is isolated from sources or dispersers of seeds, then reforestation either cannot occur at all, or else the succession grinds to a halt. However, depending on the tree species, seeds can be carried over hundreds of Metres by wind, or they can remain dormant in the soil for many years.

Soil compaction caused by the extensive use of machinery often has a long-term negative effect on the accumulation of biomass (FINEGAN 1992), which in poor soils in particular plays an important role as a nutrient reservoir (POELS 1982). Re-colonisation takes longer on compressed soil. Cleared areas and roads are starting points for erosion, which can lead to large-scale soil loss, especially on slopes. With progressively complete removal of trees, degradation also becomes more severe. After large-scale clear-cutting, soil erosion and nutrient depletion play a major role.

The distinction between selective utilization and clear-cutting becomes blurred when forests are logged more frequently but less completely. Even single (wide-spaced) trees left behind can have a very positive effect on the speed of re-colonisation and the species composition of the new forest (FEDLMEIER 1996).

VI.2.1.3 Additional Fire

Additional fire, not uncommon in areas with pronounced dry periods, amplifies the effects of clear-cuts described above. Fires further diminish the available regeneration potential by eliminating surviving seedlings and reducing the ability of tree remnants to coppice (UHL et al. 1990). Repeated burning can even lead to permanent degradation by completely eliminating root shoots and coppices and destroying the germination potential of seeds of pioneer tree species in the ground (HARTHORN 1980). In the moderate tropics, repeated forest fire or deliberate burning can steer the succession towards the development of fire-resistant species (GOLDAMMER 1995).

The increased availability of nutrients after fire can last for up to 3 years (JORDAN 1985), an effect which is
taken advantage of in shifting cultivation. The total supply of nutrients is steadily diminished by leaching and conversion (FINAGAN 1992). Erosion and soil compaction also play an important role. How heavily a site is degraded by fire not only depends on the soil characteristics and micro- and macro-site conditions (slope, exposition, precipitation, temperature), but on the type and extent of the disturbances in particular.

**VI.2.2 Agriculture**

Selective utilization, clear-cutting and/or fire often precede intermediate agricultural utilization of the land. All of the effects described above therefore also apply to sites utilised in this way. Even light cultivation enormously decreases the regeneration potential by eliminating existing seedlings and decreasing the potential for coppice (CORLETT 1995). Re-colonisation then relies completely on the surrounding vegetation. When the development of a secondary forest has been preceded by agroforestry use (e.g., trees planted to shade coffee or to meet subsistence agricultural needs, which usually have poor stem shapes and a low wood volume), these planted trees often determine the forest's species composition during the early phases of its succession (WEAVER & BIRDSF 1982; ditto 1986). Within the scope of traditional shifting cultivation systems, the species composition of the emerging forest itself is greatly influenced by measures ranging from the planting of long-lived fruit trees to the design of artificial succession communities (EWEL 1986; DUBOIS 1990; GODOY & TAN 1991; JONG, 1993).

Because the more productive sites are usually used for agricultural purposes, forests are usually pushed back to marginal sites. Often even these marginal sites are fanned, for instance in the form of shifting cultivation systems. Cultivation induces greater nutrient mobility, but the vegetation is unable to absorb the released nutrients quickly enough. As a result, nutrients are washed away, and, mainly with large-scale intervention and delicate site conditions, soil erosion takes place. This degradation slows the succession considerably. For instance, areas studied in Venezuela that had not been subject to intermediate agricultural utilization had three times as many woody species, much denser forest cover, and 30% more biomass than areas that had been cultivated but abandoned again as long as five years back (UHL 1987). The extent of the degradation depends on the intensity and duration of use. Longer periods of agricultural utilization without fertilisation soon lead to a rapid deterioration of soil conditions. For instance, signs of nutrient deficiency often appear in poor Oxisols and Ultisols and in some volcanic soils (NIA7-ZORINO et al. 1988) after fewer than 5 years. After 8 years, aluminium exchange rates of up to 100% can be measured (SANCHEZ et al. 1983). In contrast to lightly utilised sites, in such cases no significant concentrations of P, K, Ca or Mg are left (BUSCHBACHER et al. 1988; UHL et al. 1988).

In the tropics, cases of intermediate agricultural utilization lasting longer than 5 years cause greater site degradation. Natural seeding of many tree species is inhibited, because tilling the soil destroys existing regeneration potential or radically changes the composition of mycorrhizae, which play a crucial role in the ability of tree species to compete (JANOS 1980). Longer or more frequent cultivation and the associated degradation can culminate in a semi-climax stage that is very different from the original forest (CORLETT 1995). Bamboo (WHITEMORE 1984), Imperata-grass (KARTAWINATA 1994) or grassland (Central America) can inhibit reforestation indefinitely. In extreme cases, such changes can lead to the formation of permanent brushland (Sips 1993).

**VI.2.3 Pasture Management**

Pastures are usually abandoned when their conditions no longer support grazing. These conditions can include the withdrawal of land-use rights, veterinary problems that threaten the health of cattle, economic constraints that make cattle farming unprofitable, and declining soil fertility.

The germination potential after a clear-cut exists longer when land is utilised for grazing than when crops are cultivated (NEPSTAD et al. 1990). In addition, more organic material remains in this case, than, for instance, if the land is transformed into a coffee plantation (WEAVER et al. 1987). Often grassland even contains more organic material than primary forests (BROWN & LUGO 1984; LUGO et al. 1986). However, grass can pose a direct or indirect obstacle to forest succession, because it provides a habitat for seed-eating animals, hinders seeds in reaching the soil, competes with woody plants for nutrients and light, intensifies water shortages during dry seasons, and increases the risk of fire. On the other hand, the grasslands of the temperate tropics and moist tropical lowlands will mostly disappear unless periodic burning takes place (GOLDMAMMER 1995). Erosion and soil compaction are also greater when land is utilised for growing crops than when it has a permanent grass cover.
* The responses, however, were not based on a consistent definition of secondary forest. The definition of secondary forest given in the survey was the same as the one applied in this study. Simultaneously, though, the definition constituted part of the survey in that it was presented for discussion. A few of the respondents suggested modified definitions, to which their further responses then referred to.


2Charral = first succession stage of a secondary forest; Tacotal = second stage.