ITTO

INTERNATIONAL TROPICAL TIMBER ORGANIZATION

DRAFT PROJECT REPORT

REHABILITATION OF LOGGED-OVER FORESTS IN ASIA/PACIFIC REGION

PREPARED FOR ITTO

BY

JAPAN OVERSEAS FORESTRY CONSULTANTS ASSOCIATION (JOFCA)

YOKOHAMA
16 APRIL 1990
This study was commissioned as a sub-project of study PD 2/87 (F) "Rehabilitation ofLogged-over Forests in the Asia/Pacific Region".

The main contents of the sub-project are as follows:

1. Present status of fieldwork and research on the rehabilitation of logged-over forest

2. Treatments and activities for various types of logged-over forest

3. Proposed programme for the support of research on the rehabilitation of logged-over forest

In the execution of this sub-project, an information review was conducted in eight countries i.e. India, Indonesia, Malaysia, Papua New Guinea, the Solomon Islands, Fiji, the Philippines and Thailand.

This report is a compilation and summary of the information obtained from the studies reviewed separately in the eight countries.

The studies were undertaken mainly by Mr. Alf Leslie (Australia), Mr. Kanayo Karamchandani (India), Mr. Patrick C. Dugan (Philippines) and Mr. H. Aten Suwando (Pt. Aji. Buana Asri, Indonesia), and the compilation and summarization were carried out in full collaboration with Mr. Patrick C. Dugan, Mr. Patrick C. H. Dugan Jr. and Warren Ford.

Grateful acknowledgment is given to the above persons and all other assistants who participated in the execution of this study.

Last but not least, acknowledgment should also be given to the agencies concerned, including the government agencies which provided invaluable assistance with data collection and preparation, as well as instructive suggestions.
Rehabilitation of Logged-Over Forests in Asia/Pacific Region

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1.0 INTRODUCTION

1.1 This report compiles and summarizes information published in separate country studies of the tropical forest resources of India, Indonesia, Malaysia, Papua New Guinea, the Solomon Islands, Fiji, the Philippines and Thailand. Consolidated information from the studies furnishes an overview of current conditions in regard to forest conservation, protection, and rehabilitation. Additionally, gaps in research, planning, field level implementation and other key areas of concern are discussed.

1.2 Because of space limitations, much of the country-specific explanatory material has been omitted from this report. For further details, the reader may refer to the eight (8) country studies which are annexed to this document.

1.3 While each country is unique in its own right, there are problems common to all. In the context of a situational overview, one of the most crucial concerns is often the lack of detailed information, that would provide a reliable and comprehensive description of prevailing conditions. Fortunately, all of the countries covered by this report are continuously gathering new data. Eventually, more extensive information should become available. In the meantime however, there are a number of topics about which little has been officially recorded or published.

1.4 Another commonly-shared problem is the matter of man-to-forest relationships. Each country is faced with the challenge of reconciling local community priorities and the objectives of national programmes. The former usually stem from customary practice, traditional perceptions and population pressures. The latter tend to be based on external factors, such as environmental management, technical issues and law enforcement.

1.5 There is some evidence of attempts to reconcile the day-to-day concerns of people who reside in or near the forests, with the objectives envisioned in national plans drawn up by technical and regulatory institutions. However, many opportunities to resolve conflicts seem to have been overlooked. For example, the formulation of a forest policy has dealt almost exclusively with timber. Very little attention has been given to non-timber crops. The latter are important in the lives of tropical forest communities and could also have great potential from a broader, national perspective. Recent studies in the Amazon suggest that on a per hectare basis, the economic benefits from non-timber crops may exceed the financial returns accruing from timber. Preliminary data from on-going studies in Malaysia and the Philippines tend to support this view. If this subject receives greater attention, it seems likely that many of the conflicts between local communities and technical planners or law enforcement institutions would be minimized.
1.6 On the positive side, one is encouraged by the innovative approaches that are evolving in each of the eight (8) countries, and by the increased commitment of governments, the donor community, private institutions and concerned individuals, to the goals of sustainable management, forest conservation and rehabilitation of logged-over lands.

1.7 Given the varying degrees of degradation that prevail in the eight (8) countries, it seems imperative to broaden the conventional definition of "logged-over" to include all land which was once pristine forest and that can still be rehabilitated in ways that maintain or restore productivity over time. There is no lack of technical methods for achieving this goal. Moreover, the feasibility of appropriate technical methods will be further enhanced by the natural endowments of ample solar energy, rainfall and the relatively even temperature that characterize the tropics.

1.8 With the foregoing potentials in mind, this report seeks to provide an overview of (a) what has been done, (b) on-going activities and (c) matters that need attention, all in the context of forest rehabilitation and redevelopment for the eight (8) countries discussed herein.
2.0 REGIONAL SYNTHESIS

2.1 The combined land area of India, Indonesia, Malaysia, Papua New Guinea, the Solomon Islands, Fiji, the Philippines and Thailand is approximately 685.7 million hectares. Combined population is 1097.7 M equivalent to 22.2% of the total global population. Land area and population data are summarized on Table 1 and illustrated in Fig. 2.

<table>
<thead>
<tr>
<th>Country</th>
<th>Land Area (M ha)</th>
<th>Population (millions)</th>
<th>Land Area/capita (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiji</td>
<td>1.8</td>
<td>0.7</td>
<td>2.57</td>
</tr>
<tr>
<td>India</td>
<td>328.8</td>
<td>817.4</td>
<td>0.40</td>
</tr>
<tr>
<td>Indonesia</td>
<td>191.9</td>
<td>178.0</td>
<td>1.08</td>
</tr>
<tr>
<td>Malaysia</td>
<td>32.8</td>
<td>17.5</td>
<td>1.87</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>46.2</td>
<td>3.7</td>
<td>12.48</td>
</tr>
<tr>
<td>Philippines</td>
<td>30.0</td>
<td>60.5</td>
<td>0.49</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>2.9</td>
<td>0.3</td>
<td>9.70</td>
</tr>
<tr>
<td>Thailand</td>
<td>51.3</td>
<td>56.0</td>
<td>0.92</td>
</tr>
</tbody>
</table>

685.8        1,134.1

2.2 Data on the extent of forests in the eight (8) countries is much less precise than the statistics that quantify land area and population. In an attempt to arrive at a reasonably accurate figure, several macro-scale assessments have been conducted in recent years. In 1982, an FAO study (Lanly) estimated 1,388 million hectares (M ha) of tropical forest on the planet. Of this, 228 M ha (16.6%) was forest fallow. On the other hand, the FAO "Tropical Forestry Action Plan" suggests that the extent of tropical forest is 2,970 M ha.

2.3 In general, figures vary because (a) much of the officially-classified forest land is not tree covered, (b) different classification systems are used and (c) primary data is incomplete. The differences in emphasis and detail between individual country studies suggest a need for regional coordination on data collection and management systems.
Fig. 2 Forestland Per Capita
2.4 The forested lands of Asia and the Pacific included in this study cover about 286 million ha or roughly 42% of the total land area of these countries. There are large disparities in forest cover as a percentage of total land, ranging from a low of 19.5% (India) to a high of 86.2% (Solomon Islands). There are also significant regional variations within countries. A statistical overview is provided in Table 2 (Fig. 3).

Table 2  Forested Land of Asia/Pacific Countries Included in this Report

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Total Land Area (million ha)</th>
<th>Forested Land (million ha)</th>
<th>Forested Land in Relation to Total Land Area (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. India</td>
<td>328.8</td>
<td>64.2</td>
<td>19.5%</td>
</tr>
<tr>
<td>2. Indonesia</td>
<td>191.9</td>
<td>143.9</td>
<td>75.0</td>
</tr>
<tr>
<td>3. Thailand</td>
<td>51.3</td>
<td>14.9</td>
<td>29.0</td>
</tr>
<tr>
<td>4. Papua N. Guinea</td>
<td>46.2</td>
<td>35.0</td>
<td>80.0</td>
</tr>
<tr>
<td>5. Malaysia</td>
<td>32.8</td>
<td>20.1</td>
<td>61.2</td>
</tr>
<tr>
<td>6. Philippines</td>
<td>30.0</td>
<td>6.4</td>
<td>21.3</td>
</tr>
<tr>
<td>7. Solomon Islands</td>
<td>2.9</td>
<td>2.5</td>
<td>86.2</td>
</tr>
<tr>
<td>8. Fiji</td>
<td>1.8</td>
<td>.9</td>
<td>50.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>685.7 ha.</strong></td>
<td><strong>285.4 ha.</strong></td>
<td><strong>41.6%</strong></td>
</tr>
</tbody>
</table>

2.5 As increasing numbers of people seek access to land to produce food, timber or fuel, there is a corresponding decrease in the area of tropical forests. In this century, the rate of decrease has been very rapid, due primarily to slash-and-burn clearing. Additionally, since the end of the second World War, the region has become the world's major source of hardwood timber. For example, it has been estimated that Southeast Asian countries account for 2/3 of the total tropical hardwood exports from all timber producing countries in the world. Exploitation is causing qualitative and quantitative degradation.
Fig. 3 Forest Land vs. Total Land
Fig. 3a  Forest Land vs. Total Land
2.6 On-going deforestation of closed broadleaved forest has been estimated at 1.8 million ha per year, or about 5,000 ha per day. As a consequence, it has been predicted that the closed forest area in the region will have decreased by 12 percent during the 25 year period from 1976-2000. The environmental and socio-economic impacts of such a drastic change are already being felt.

2.7 A significant percentage of the food and fuel requirements for vast numbers of families in developing countries are derived from the tropical forest. Furthermore, the results of botanical surveys imply a large, undiscovered potential for development of new products and crops in the genetic resources of tropical rain forests. These forests contain about half of all known plant and animal species and perhaps seventy-percent or more of all terrestrial species in existence. Additionally, climatic disturbances (e.g. abnormal rainfall patterns) and the "greenhouse effect" have been linked to tropical forest destruction.

2.8 Having realized the dire consequences of tropical forest depletion, many countries have taken steps towards arresting further loss and have invested in rehabilitation programmes. Unfortunately, many of these programmes have floundered because of inadequate attention to the interests and perceptions of people residing in and near the forests. Comprehensive plans and sophisticated technology have often been introduced by organizations that are out of touch with the people who live in daily contact with the forest. Since many rehabilitation programmes are encountering problems, there is now an emerging consensus toward greater participation by local people in the development process.

2.9 Throughout the countries covered by this report, there is a growing realization that local communities must play a major role as the prime managers and beneficiaries of tropical forests. A realistic but demanding solution, this implies major revisions in the processes that have been applied for many decades in the planning and implementation of forest conservation and rehabilitation programmes. Making room for genuine community participation is perhaps the principal challenge in seeking an effective and holistic approach to saving the heritage of the tropical biosphere.

2.10 In all the eight (8) countries, the conventional response to forest resource depletion has been to initiate reforestation programmes. Results have been mixed. But in general, conventional approaches have not been effective. The long gestation time of most reforestation programmes does not respond to the urgent need for short-term benefits and to the demographic pressures that exists in most of the countries covered by this report.

2.11 There are indications that more pragmatic approaches are evolving and that multiple-use concepts will eventually become a standard feature of reforestation projects. For example, interplanting of agricultural crops amongst young trees has been carried out on a limited scale and with favorable results. However, this runs counter to the methods traditionally practiced by professional
foresters. Without substantial input from other disciplines (e.g. agriculturalists and community development specialists), it may be unrealistic to expect a significant modification of these methods in the near future.

2.12 Management policies and research agenda prevalent in the eight (8) countries also tend to reflect a traditional view that a) forests should be managed almost exclusively for timber production, b) that mechanization and economies of scale are pre-conditions to success and c) that clear demarcation lines can be drawn between forestry and agriculture.

2.13 The depleted forest conditions prevailing in most of the eight countries imply that, to be successful, forest managers can no longer rely on traditional stereo-typed assumptions. Fortunately, there is some evidence that rigid policies and perceptions are gradually giving way to more flexible approaches which respond to the highly diverse biological and socio-economic conditions found in this part of the world.

2.14 It is generally accepted that what happens in the current decade will prove crucial to the future condition of tropical forests. The key factor for effective and comprehensive action may prove to be linking people's development with the application of appropriate forest technology. Hopefully, the data provided in this report and the country studies from which it was derived, will help stimulate the political and financial commitment of involved countries and institutions to undertake practical, sustained and adequate action that brings about significant rehabilitation of logged-over tropical forests.
3.0 CLASSIFICATION OF FORESTS

3.1 Forest classification in the eight (8) countries covered by this report, reflects the characteristics of each country's forest resources and the prevailing forest management policies. Hence, descriptive terminologies and other aspects of classification are not standardized. The disparity in description of forest types suggests the need for a simple but comprehensive framework —perhaps several— which can convey an overall picture of regional forest conditions.

3.2 In most cases, forests are classified according to geographic location, biological composition, or kind of systems under which they are managed. Thus forests can be categorized in respect of: nearness to the sea coast, elevation, rainfall, tree species composition, condition of forest growth, selective cutting or clear cutting regimes and so forth.

3.3 Countries with similar climatic conditions like the Philippines, Indonesia and Malaysia do present a fairly common framework for classification although Indonesia has a relatively larger area of freshwater swamp and peat-swamp forests. However, based on currently available data, it is not possible to consolidate the separate classifications by country into a single format. As implied earlier, this situation suggests that a comprehensive and coordinated classification and inventory system could well serve tropical forest management in the Asia/Pacific region.

3.4 Among other parameters, each country has classified forests according to certain utilization objectives. This delineates forest areas for specific purposes and serves as a basis for forest management planning. In the larger countries, classification into productive and protected forests includes specific areas for the conservation of natural flora and fauna. Within their protected forest areas, most countries include national parks and wildlife sanctuaries. For instance, India has set aside (15) fifteen tiger reserves between 1973-1983.

3.5 A helpful overall classification used by the FAO divides forests into the following general categories.

- closed broad leaf forest
- open forest
- shrub land
- forest fallow
- coniferous forests
- plantations

3.6 The foregoing categories provide a broad picture of forest resources. They do not, however, attempt to describe the condition of forest growth within forest types, nor to give an indication of forest composition. To add some qualitative measures, the FAO classification system also focuses on crown density and considers...
80% as dense; 10-40% as open; 2-10% as sparse; and less than 2% as absent.

3.7 General descriptions for each country need to be supplemented by sub-categories based upon biological composition and the condition of each forest type - e.g. whether the forest cover is in its original condition, whether it has been logged-over, or its state of regeneration.

3.8 In most of the countries official (i.e. government) classification of a particular area as forest land does not necessarily mean it is covered with trees. As a general rule, the official classification status indicates the intended land use. In other words, official classification status is usually dependent on prevailing land use policies, not on the degree of forest cover.

3.9 INDIA

3.9.1 Extreme variations in altitude, and the 3,414 km span from North to South in India, result in correspondingly diverse forest types. These range all the way from mangrove and swamp forests on the coast to alpine forests located between 1,800 to 4,000 meters above sea level. Above 4,000 meters, forest cover is negligible.

3.9.2 On the basis of botanical features, India's forests are classified into four major groups; tropical, subtropical, temperate and alpine. These are further broken down into 16 group types and subsequently subdivided into 221 ecologically stable vegetation types. This report deals with the tropical forest types which comprise 81% of the country's forests.

3.9.3 India's forests have been broadly classified as closed or open. Where the crowns are separated by a distance equal to or less than the mean radius of the crown, this is characterized as a 40% crown density and is called a closed forest. If the crown density is less than 40%, the area is described as an open forest.

3.9.4 Table 3 indicates the area of tropical forest by type, crown density and management status. For purposes of comparison, the extent of subtropical, temperate and alpine forests is also included.

3.9.5 Among the various tropical types, moist and dry deciduous forests cover the largest area. They are also the most important source of fuel and timber for local communities. These forests include teak (Tectona grandis) and sal (Shorea robusta) - two of the most important hardwoods of India's natural and plantation forests. The forest types listed in Table 3 are described in the following paragraphs.
3.9.5.1 Wet Evergreen Forests: Tropical wet evergreen forests are distributed throughout the high rainfall zone (exceeding 2,500 mm per annum) except on precipitous slopes and very rapidly draining soils. They are most extensive along the Western Ghats, in Andaman & Nicobar Islands and in the North Eastern States. In structure and physiognomy, there is a little difference between forests in the different regions.

3.9.5.2 Trees are generally arranged in tiers with dominants in the top canopy attaining a height of over 40 m. These forests are characterized by the presence of a large number of species. Clustering of types is usually not prominent and associations of a single dominant species are exceptional. Smooth bark, large buttresses and cauliflory are some of the notable features. On account of the multi-tiered arrangement, light availability near the ground level is poor permitting little or sparse undergrowth.
<table>
<thead>
<tr>
<th>Type Group</th>
<th>Total Forest Area</th>
<th>Density Covered</th>
<th>Density 10% to 40%</th>
<th>Managed (Working Plans)</th>
<th>Un-Managed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wet evergreen</td>
<td>5.125</td>
<td>5.040</td>
<td>0.090</td>
<td>4.200</td>
<td>0.925</td>
</tr>
<tr>
<td>2. Semi-evergreen</td>
<td>2.642</td>
<td>1.800</td>
<td>0.842</td>
<td>2.500</td>
<td>0.142</td>
</tr>
<tr>
<td>4. Littoral &amp; Swamp</td>
<td>0.405</td>
<td>0.350</td>
<td>0.055</td>
<td>0.205</td>
<td>0.200</td>
</tr>
<tr>
<td>6. Thorn forest</td>
<td>1.649</td>
<td>0.300</td>
<td>1.349</td>
<td>1.300</td>
<td>0.349</td>
</tr>
<tr>
<td>7. Dry evergreen</td>
<td>0.140</td>
<td>0.110</td>
<td>0.030</td>
<td>0.140</td>
<td>-</td>
</tr>
<tr>
<td>Sub-total (1-7)</td>
<td>52.002</td>
<td>28.919</td>
<td>23.083</td>
<td>44.953</td>
<td>7.050</td>
</tr>
<tr>
<td>% Total</td>
<td>-</td>
<td>55.61</td>
<td>44.39</td>
<td>86.44</td>
<td>13.56</td>
</tr>
<tr>
<td>Other Sub-tropical, temperate and alpine types</td>
<td>12.02</td>
<td>7.572</td>
<td>4.630</td>
<td>11.252</td>
<td>0.95</td>
</tr>
<tr>
<td>GRAND TOTAL</td>
<td>64.204</td>
<td>36.491</td>
<td>27.713</td>
<td>56.204</td>
<td>8.00</td>
</tr>
<tr>
<td>% Grand Total</td>
<td>-</td>
<td>56.82</td>
<td>43.18</td>
<td>87.54</td>
<td>12.46</td>
</tr>
</tbody>
</table>
3.9.5.3 Dipterocarpaceae, a very characteristic though not essential constituent, are more numerous and varied in the south east. The most widely distributed genera are Dipterocarpus and Hopea. Other typical components are Guttifera (notably Anacardiaceae, Sapotaceae, Meliaceae, Artocarpus, Syzygium, and Eleocarpus). Dipterocarpus are absent in the northeast whereas bamboos are usually present. Canes, palms and tree ferns are also common. In both the Western Ghats and in the southeast, the wet evergreen forest is found on gneiss or granite though it sometimes extends over metamorphic rocks, shale and limestone.

3.9.6 Semi-evergreen Forests

3.9.6.1 Semi-evergreen forests occur in the transitional zone between evergreen and moist deciduous forests where the annual precipitation varies from 2000 to 2500 mm. Like the wet evergreen type, semi-evergreen forests also have a multistoried structure. The top canopy comprises a mixture of deciduous and evergreen species while the understorey is almost entirely constituted by evergreens. Buttressed stems are frequent; the main canopy is dense and attains a height of 25-35m.

3.9.6.2 The semi-evergreen forest type occurs throughout the moist southern tropics, although it does not occupy large areas. It exists in the Andamans and the Western Ghats, just north of Bombay, near Goa and south of Cochin. It has developed in the moderately heavy to heavy rainfall areas of the northeastern region extending down the east coast of the peninsula to Puri in Orissa. This type generally occurs on low hills and flat plateaus.

3.9.6.3 In the top canopy Hopea, Syzygium, Cinnamomum, and Magnoliaceae are the common evergreen species whereas Terminalia species (T. myricarpa, T. Tomentosa, T. citrina), Tetrameles and Stereospermum are the common deciduous trees. Dipterocarpus also occur frequently. Shorea robusta only retains its footing with burning and other dessicating factors. Among bamboos, Bambusa arundinacea, B. polymorpha, Dendrocalamus hamiltonii, and Melocanna bambusodies are common. The ground flora is very poor and largely made up of Rubiaceae and Acanthraceae.

3.9.7 Moist Deciduous Forests

3.9.7.1 Moist deciduous forests are the most extensive and widely distributed type and play the most prominent role in the production of wood and other products. These forests occur in regions where the annual rainfall ranges from 1,500 mm to 2,000 mm. They are largely closed forests 30-35 m or more in height, with a top canopy comprised principally of deciduous species and the understorey usually dominated by evergreens. Three sub-groups have been identified, namely (1) Andaman moist deciduous, (2) South Indian moist deciduous and (3) North Indian moist deciduous. Within each category, several climax and seral forms are distinguished.
3.9.7.2 In the Andaman Islands, some of the principal species are *Pterocarpus dalbergioides*, *Terminalia bialata*, T. manii, T procrea, *Canarium euphyllum*, *Bombax insigne*, *Lagerstroemia hypoleuca*, and *Chukrasia velutina*.

3.9.7.3 In southern India moist deciduous forest, teak (*Tectona grandis*) is the most important species because of its economic value and excellent development wherever the soil permits. In the teak-bearing areas, its other associates are *Terminalia*, *Pterocarpus* and *Lagerstomia* species. *Adina cardifolia* occurs frequently though tending to indicate drier conditions, and *Dalbergia latifolia* is characteristic. *Xyli Schleicheria* and *Careya* are common in the second storey while bamboos (e.g. *Bambusa arundinacea* and *Dendrocalamus strictus*) appear on relatively dry sites. In the non-teak bearing areas, a variety of moist and occasionally evergreen species occur in mixture. *Terminalias* are common almost everywhere.

3.9.7.4 Just as *Tectona grandis* is ecologically the most important species of the southern moist deciduous forest, so is *Shorea robusta* characteristic of the northern form. Based on the presence or absence of sal (*Shorea robusta*), the North India moist deciduous forests are generally divided into sal forests and mixed forests.

3.9.7.5 Sal forests are characterised by the gregarious occurrence of sal, which sometimes accounts for up to 80 percent of a canopy that is normally 25-40 m high.

As a rule, sal predominates because of the resistance to fire of this species, its coppicing power and its adaptability to various conditions. The associated species are similar to those of the moist teak forest. An important feature of sal is its semi-evergreen nature with a deciduous period of 5-15 days at the beginning of the hot season. Sal forests occur throughout northern India except in the dry north-west and much of the wet northeast.

3.9.7.6 Composition of the mixed forest type is very similar to the sal forests except that sal is scarce or totally absent.

3.9.8 Dry Deciduous Forests

3.9.8.1 Next only to the moist deciduous forests, the dry deciduous forests cover the largest area. They occur in the rainfall zone of 1,000-1,500 mm (occasionally decreasing to 850 mm) characterized by a long dry season extending over six months with little or no rain. These forests are found in the Deccan plateau, the Narmada and Tapti valleys and extend to the plains of the Ganges. Typically, these forests contain fewer species than the moist deciduous type and almost all species are deciduous. Two subgroups, the southern and northern, are recognised in this type.
3.9.8.2 The southern sub-type is divided into two broad categories depending on the presence or absence of teak. Where teak is present its typical associates are Anogeissus latifolia and Terminalia species. In the non-teak bearing forest, the principal genera are Anogeissus and Terminalia associated with Diospyros, Boswellia and Stercula. The most common bamboo is Dendrocalamus strictus.

3.9.8.3 The northern sub-groups are also subdivided into sal bearing forests and mixed forests depending upon the presence or absence of sal (Shorea robusta). Sal is of low quality with a height rarely more than 18 m and with an irregular canopy. Badly-shaped boles and hollow stems are prevalent. Chief associates are Anogeissus latifolia, Buchannia lanzan, Terminalia tomentosa, Emblica officinalis and Lannae coromandalica. In the mixed type, species composition is essentially the same except that sal is absent. Bamboo may or may not occur.

3.9.8.4 Most of the northern sub-group forests are subject to severe biotic pressures, particularly fire and grazing. Productivity is low and removal far exceeds growth rates, resulting in progressive degradation. Firewood is probably the most important product from these forests. In addition, large quantities of bamboo are obtained. Other valuable species include Santalum album (sandal wood), Pterocarpus santalinus (Red Sander) and Diospyros melanoxylon (Tendu leaf tree).

3.9.9 Tropical Thorn forests

3.9.9.1 Tropical thorn forests represent the driest type of vegetation in the arid and semi-arid zones of India. The rainfall ranges between 250-750 mm and can go down to 100 mm. In the south, this type occurs on a wide range of geological (often rocky) formations on flat ground or on low undulating hills and plateaus. The genus Acacia, with a number of species and several other allied genera, is characteristic of this forest type. Fleshy Euphorbias are generally present and form a conspicuous constituent of the vegetation. Capparis is common and Opuntia has become naturalized over wide tracts.

3.9.9.2 In the north, tropical thorn forests occur on flat land in alluvial or aeolian soils but also extend over low hilly country, ravine land and patches of highly saline soil and blown sand. Thorny Mimoseae occur throughout with a number of associated species among which Prosopis cineraria is perhaps the most common. Acacias are widespread and Capparis decidria is one of the most conspicuous trees.

3.9.10 Although 75.18 million ha. or 22.8% of India's total land area is officially classified as forest land, only 64.2 million ha. or 19.5% is estimated to be under forest cover.
3.9.11 In 1948, the officially classified forest land was only 39.94 M ha. By 1987, this had increased to 75.18 M ha. The increase came about due to exercise of local authority under a federal system of government. Authority to administer forest lands, and to decide which areas should or should not be classified as forest land, rests with the 22 States and 9 Union Territories comprising the political structure of the country.

3.9.12 Until recently, the different states and territories did not coordinate on classification parameters or systems. However, coordination has improved with approval in 1980 of the Forest Conservation Act. Nonetheless, to avoid confusion, it should be emphasized that official classification as forest land is no guarantee the area is forested. Similarly, the increase from 39.94 M ha in 1948 to 75.18 M ha. in 1987 does not mean that forest cover expanded. It simply implies that the government exercised its prerogative to reclassify land according to intended land use.

3.9.13 Out of the total officially classified forest land, 66.65 M hectares (88.65%) falls under public ownership. The balance of 8.53 M hectares (11.35%) is owned by local government corporate bodies or private individuals.

3.9.14 Another classification parameter is the official designation of forest lands in relation to intended use. From this perspective, forest land may be subdivided as follows (Fig. 4):

<table>
<thead>
<tr>
<th>Classification</th>
<th>Area</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserved forests</td>
<td>40.18 M ha</td>
<td>53.45%</td>
</tr>
<tr>
<td>Protected forests</td>
<td>21.73 M ha</td>
<td>28.90%</td>
</tr>
<tr>
<td>Unclassed forests</td>
<td>13.27 M ha</td>
<td>17.65%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>74.18 M ha</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

3.9.15 Information on forest areas is not always precise. As indicated above, some 13.27 M ha. have not been further subdivided into reserved, protected or other status. Additionally, not all conversion of forest land to other uses is recorded.
Fig. 4 Forest Classification in India
3.10 INDONESIA

3.10.1 The classification system for Indonesia's forests uses the following framework:

- Mangrove
- Coastal
- Swamp
- Peat-swamp
- Lowland Rainforests
- Hill Rainforests
- Monsoon forests

3.10.2 The lowland and some of the hill rainforests constitute the largest sector of Indonesia's productive forest and are being heavily exploited.

3.10.3 Indonesian forests are very diverse and contain an estimated 10,000 arboreal species. They are second only to the Amazon tropical forests in terms of area.

3.10.4 In addition to general headings in the classification framework, there are classification sub-sections to describe soil, climate types, slope and elevation. Indonesia's classification systems also consider typical species and their distribution throughout the country. Table 4 provides an overview of major forest types and some examples of major species.
<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Soil Type</th>
<th>Climate Type</th>
<th>Elevation Range</th>
<th>Typical Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Littoral</td>
<td>Sandy &amp; Stony</td>
<td>above highest tidal mark</td>
<td></td>
<td>Barringtonia asatra, Terminalia cathaya, Callophyllum, Hibiscus tiliaceus, Casuarina equisetifolia, Pandanus tetorius</td>
</tr>
<tr>
<td>(Coastal)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Swamp</td>
<td>alluvial and humic clay</td>
<td>behind or next to mangrove forest</td>
<td></td>
<td>Palaguium leicarpum, Shorea spp.</td>
</tr>
<tr>
<td>4. Peat-swamp</td>
<td>orgamoxsols with peat layer</td>
<td>Type A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Lowland Rainforest</td>
<td>Podzols, latosols, alluvial</td>
<td>Type A and B</td>
<td>50-250 m.a.s.l.</td>
<td>Shorea spp. Dipterocarpus spp.</td>
</tr>
<tr>
<td>6. Hill rainforest</td>
<td>Latosols, red-yellow podzols &amp; regosols</td>
<td>Type A</td>
<td>400-700 m. a.s.l.</td>
<td>Dipterocarpus spp. Dryobalanops</td>
</tr>
<tr>
<td>7. Monsoon</td>
<td>-</td>
<td>-</td>
<td>up to 1000 m. a.s.l.</td>
<td>Similar to hill rain forest.</td>
</tr>
</tbody>
</table>
3.11 MALAYSIA

3.11.1 Malaysia uses a classification system similar to Indonesia's. Peat swamp is a notable feature of both countries. Malaysian data indicates the prevalence of Dipterocarp species in the lowlands and adjacent hills. Table 5 shows the distribution of major forest types in Malaysia.

Table 5  Distribution and Extent of Major Forest Types in Malaysia (M ha.)

<table>
<thead>
<tr>
<th>Region</th>
<th>Land area</th>
<th>Dipterocarp forest</th>
<th>Peat swamp forest</th>
<th>Mangrove forest</th>
<th>Total forested land</th>
<th>Total percentage of forested land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peninsular Malaysia</td>
<td>13.16</td>
<td>5.62</td>
<td>0.46</td>
<td>0.11</td>
<td>6.19</td>
<td>47.00</td>
</tr>
<tr>
<td>Sabah</td>
<td>7.37</td>
<td>3.98</td>
<td>0.19</td>
<td>0.32</td>
<td>4.49</td>
<td>60.90</td>
</tr>
<tr>
<td>Sarawak</td>
<td>12.33</td>
<td>7.78</td>
<td>1.47</td>
<td>0.17</td>
<td>9.42</td>
<td>76.40</td>
</tr>
<tr>
<td>Total</td>
<td>32.86</td>
<td>17.38</td>
<td>2.12</td>
<td>0.60</td>
<td>20.10</td>
<td>61.20</td>
</tr>
<tr>
<td>Major forest type (%)</td>
<td>-</td>
<td>86.47</td>
<td>10.55</td>
<td>2.98</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5  Malaysia: Extent of Forest Types
3.11.2 Mangrove Forest. In Peninsular Malaysia, the mangrove forests are divided into the following sub types (RICHARDS, 1964; WATSON, 1928):

3.11.2.1 The Api-api Perepat (Avicennia-sonneratia griffithii) type is the pioneer forest in mangrove areas. Avicennia alba and A. marina, are the major species but Sonneratia griffithii is also found on deep mud, rich in organic matter. This forest type normally precedes the gradual evolution to other mangrove types described below.

3.11.2.2 The Berus (Bruguiera cylindrica) type occurs at a higher level than the Aplapi Perepat type and forms a nearly continuous pure belt behind Avincennia forest along the west coast.

3.11.2.3 The Bakau (Rhizophora) type is dominated by Rhizophora apiculata and R. mucronata. This type occurs on land inundated at normal high tides.

Rhizophora forest covers a larger area than any other mangrove forest type. Rhizophora apiculata is more extensive than R. mucronata which prefers relatively wetter sites (i.e. higher rainfall). Associated species include Bruguira parviflora and Xylocarpus granatum.

3.11.2.4 The Lenggadai (Bruguiera parviflora) type may grow as a pure stand in high rainfall areas. It may precede or succeed the Bakau. As a rule, both the Lenggadai and Bakau types gradually merge into the Tumu type.

3.11.2.5 The Tumu (Bruguiera gymnorrhiza) type is the last stage in the development of mangrove forests, and interfaces with the beach forest. Bruguiera gymnorrhiza is the longest-lived of the Rhizophoraceae.

3.11.2.6 In Sarawak, along sheltered coastlines and estuaries, pioneer species like Perepat (Sonneratia), Api-api hitam (Avicennia alba) and Api-api merah (A. marina) rapidly colonize newly formed banks. Gradually the ground becomes stabilized and other species, including Bakau (Rhizophora spp.) establish themselves.

3.11.2.7 Out of the nine major subtypes, five subtypes grow in areas exposed to different levels of inundation. These major subtypes are dominated by one or another of the following species:

- Rhizophora apiculata
- R. mucronata
- Bruguiera parviflora
- B. gymnorrhiza
- B. sexangula
3.11.2.8 In Sabah, the main commercial species of mangrove forests are of the genera *Rhizophora* and *Bruguiera*, with *Avicennia* and *Sonneratia* on the seaward fringe (FAO, 1981). Two types of swamp palm are also included in the mangrove forest type; *nipha* (*Nypa fructicosa*) and *nibong* (*Oncosperma horrida*).

3.11.3 Peat-swamp Forests

3.11.3.1 In Peninsular Malaysia, the common species of the Peat-swamp Forest are the following (WYATT-SMITH, 1963); *Amoora rubiginosa*, *Anisoptera marginata*, *Blumeodendron tokbra*, *Calophyllum spp.*, *Ctenolophon parvifolius*, *Dialium patens*, *Durio carinatus*, *Eugenia spp.*, *Anua otleyana*, *Onystylus ancanus*, *Koompassia malaccensis*, *Intsea randis*, *Hyristica owiana*, *Nessia altissima*, *Parastemon urophyllum*, *Santiria nana*, *Stenonurus capitatus*, *Tetramerista glabra* and *Xylopia fusca*.

3.11.3.2 In certain areas some dipterocarps may be found, such as: *Hopea mengarawan*, *Shorea dealbata*, *S. platycarpa*, *S. rugosa var. uligonosa* and *S. teysmanniana*. This forest type is further subdivided into: Calophyllum tetramerista sub-type, *Cratoxylon arborescens* sub-type, and *Durio carinatus* sub-type.

3.11.3.3 In Sarawak, the three economically important subtypes of the Peat-swamp forest are as follows (BROWNE, 1954, CLARKE 1968):

a. Mixed Swamp Forest grows around the rim of the bog, composed of: *Ramin* (*Dryobalanops bancanusa*), *Jongkong* (*Dactycladus stenostachys*), *Nyatoh* (*Palaquium spp.*), *Keruntum* (*combretocarpus rotundus*), and other characteristic large trees such as *Jelutong* (*Dyera lowii*), *Meranti bunga* (*Shorea uliginosa*), and *Kapur paya* (*Dryobalanops rappa*). The Mixed Swamp forest produces valuable commercial timbers.

b. Mixed Light Hardwood or Alan Batu Forest, consisting of various Meranti (*Shorea spp.*) a.o. Alan Batu (*Shorea albida*). The Alan Batu forest can be considered a transitional zone between Mixed Swamp forest and Alan Bunga (meranti) forest (CLARKE, 1968). Giant trees of Alan Batu are common, but usually their stems are hollow.

c. Alan Bunga (Meranti) Forest. This forest sub-type occupies relatively dry areas within the Peat-swamp forest, where Alan or Meranti Bunga (a variety of *Shorea albida*) attain predominance, forming an almost pure, high density and even upper canopy. The trees are of smaller diameter compared with the Alan Batu forest, but hollow stems are not common.

3.11.3.4 In Sabah, the Peat-swamps are confined to the western and eastern coasts of the state (FAO, 1981). They cover relatively small areas principally on the Klias peninsula. A 1966 report mentioned a total of 65,000 ha. Most of these forests are composed of: *Ramin* (*Dryobalanops bancanusa*), *Jongkong* (*Dactylocladus stenostachys*), *Dryobalanops rappa*, *Shorea platy*
carpa, S. scabrida, S. teysmanniana and Hopea pentanervia. Some of these species also occur on poor padang (kerangas) soils. On the eastern coast, the main species are Shorea scabrida and Hopea pentanervia. Dryobalanops rappa is often replaced by Dryobalanops beccarili.

3.11.4 Lowland Dipterocarp Forest

3.11.4.1 Lowland dipterocarp forests are the richest and the most stable among tropical vegetation types (BROWNE, 1954). The forest is multi-layered, has an uneven upper canopy and is rich in lianas, rattan and epiphytes. The undergrowth is dominated by seedlings, dwarf palms and herbs and members of Zingiberaceae.

3.11.4.2 The larger trees of the upper layer include a high percentage (about 50%) of Dipterocarps (Anisoptera, Dipterocarpus, Dryobalanops, Hopea, Shorea and Parashorea). Other common large trees are: Dyera costulata, Gluta spp., Intsia palembanica, Koempassia malaccensis, Melanorrhoea spp., Palaquium spp., Sindora spp. and Tarrietia spp.

3.11.4.3 In Peninsular Malaysia, the lowland dipterocarp forests are further broken down into the following sub-types (WYATT-SMITH, 1963):

a. Red Meranti - Keruing sub-type, characterized by a high percentage of Red Meranti Shoreas (Shorea acuminata, S. leprosula, S. macroptera, S. ovalis, S. parvifolia) and Keruing (Dipterocarpus spp.) Other large trees include: Anisoptera laevis, Canarium littorale, Dyera costulata, Koempassia malaccensis, Myristica iners, Palaquium maingayi, Santiria laevigata, Sacphium affine and Tarrietia simplicifolia.

b. Balau sub-type, characterized by a high percentage of the Balau or heavy hardwoods of the Shoreas (Shorea atrinervosa, S. exeliiptica and S. Maxwelianiana).

c. Kapus sub-type, characterized by the predominance of Dryobalanops aromatica.

d. Kempas-kedondong sub-type, characterized by the scarceness or the absence of Dipterocarps and the comparative abundance of Koempassia malaccensis (kempas), Canarium and Santiria spp. (kedondong), Dialium patens spp. (keranji), Dillenia spp. (simpoh), Ixonanthes reticulata, Madhuca spp. and Palaquium spp.

e. Merbau-kekatong sub-type, characterized by the dominance of Intsia (merbau) and Cyonometra spp. (kekatong) and the deficiency of Dipterocarps.

f. Keruing sub-type, characterized by the predominance of Dipterocarpus spp. (D. apterus, D. baudii, D. cornutus, D. costulatus, D. crinitus, D. lowii and D. varrocosus) often
associated with Dyobalanops oblongifolia, Hopea mengarawan, Shorea lepidota, Koompassia malaccensis and Palaquium spp.

3.11.4.4 Besides the six sub-types, there are lowland dipterocarp forests dominated by a single economic tree species, such as Balanocarpus (Neobalanocarpus) heimi (chengal), Shorea pauciflora (nemesu) and Shorea kunstleri (damar laut merah).

3.11.5 In Sarawak, the dipterocarp forest constitutes around 78.6% of the total forest area. It occurs from the inland limit of the freshwater peat swamp, to the lower limit of the montane forests*.

3.11.6 In Sabah, there are five sub-types of lowland mixed dipterocarp forest (FOX, 1973):

3.11.6.1 Parashorea malaanonan zwageri forest: P. malaanonan is the most abundant emergent species in the Darvel Bay hinterlands. The forest is a coastal type and Shorea quisu is usually present.

3.11.6.2 Parashorea tomentella/Eusideroxylon zwageri forest: this type is dominant over the north-eastern lowlands.

3.11.6.3 Shorea/Eusideroxylon zwageri forest: this type is found mainly in the southeast;

3.11.6.4 Shorea/Dipterocarpus forest: this type occurs on poorer soil and locally within the proceeding three but is extensive in some areas. Much of the little known interior forest areas are provisionally placed in this type.

3.11.6.5 Parashorea malaanonan/Dryobalanops lanceolata forest: this is the most common association on shale and other non-sandstone hills in the west of the state.

3.11.7 An FAO inventory recorded 606 species (of which 179 were dipterocarps) from 210 genera and 61 families. Non-dipterocarps, which account for roughly 30 percent of net volume, consist of 427 species from 201 genera and 51 families.

With few exceptions, the non-dipterocarps do not occur with sufficient frequency to be considered as commercially important under existing circumstances.

3.11.8 Table 6 summarizes the species composition of the main timber groups encountered during the FAO inventory:

### Table 6 The Species Composition of the Main Timber Groups (Malaysia)

<table>
<thead>
<tr>
<th>Timber group name</th>
<th>Number of species entering group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mersawa</td>
<td>5 species of Anisoptera</td>
</tr>
<tr>
<td>Keruing</td>
<td>28 species of Dipterocarpus</td>
</tr>
<tr>
<td>Kapur</td>
<td>5 species of Dryobalanops</td>
</tr>
<tr>
<td>Chengal</td>
<td>4 species of Hopea</td>
</tr>
<tr>
<td>Luis (Merawan)</td>
<td>14 species of Hopea</td>
</tr>
<tr>
<td>White seraya</td>
<td>4 species of Parashorea</td>
</tr>
<tr>
<td>White meranti</td>
<td>5 species of Shorea</td>
</tr>
<tr>
<td>Yellow meranti</td>
<td>17 species of Shorea</td>
</tr>
<tr>
<td>Dark red meranti</td>
<td>15 species of Shorea</td>
</tr>
<tr>
<td>Red meranti</td>
<td>35 species of Shorea</td>
</tr>
<tr>
<td>Selangan batu</td>
<td>26 species of Shorea</td>
</tr>
<tr>
<td>Resak</td>
<td>1 species of Upuna</td>
</tr>
<tr>
<td></td>
<td>16 species of Vatica and</td>
</tr>
<tr>
<td></td>
<td>2 species of Cotylelobium</td>
</tr>
</tbody>
</table>

#### 3.11.9 Hill Dipterocarp Forest

3.11.9.1 In Peninsular Malaysia, the Hill Dipterocarp Forest occurs on the inland ranges between the altitudinal limits of 1,000 and 2,500 ft. a.s.l. (WYATT-SMITH, 1963). There is no sharp boundary between the lowland and hill Dipterocarp forests. The most common and characteristic large tree species in this forest type is Shorea curtisii (seraya). The following sub-types could be distinguished:

a. **Seraya sub-type**, characterized by the predominance of Shorea curtisii (seraya) in association with Anisoptera curtisii, Artocarpus lanceifolius, Calophylla inophyloide, Hopea beccariana, Myristica gigantea, Tarrietia javanica, Swintonia spp., and Vatica spp.

b. **Balau kumus-Damar Hitam sub-type**, characterized by the predominance of Shorea laeics and S. multiflora.

c. **Balau Laut sub-type**, characterized by Shorea glauca, frequently associated with Shorea maxwelliana and Sindora wallichii.

d. **Balau-keruing sub-type**, characterized by Shorea atriner-vosa, S. foxworthyi, Dipterocarpus costulatus, D. appendiculatus, costulatus, D. penagianus and D. pseudofagineus.
e. Merpaun sub-type, characterized by the predominance of *Switonia specifera*.

f. Keruing-Resak-Mengkulang sub-type, characterized by *Dipterocarpus costulatus*, *D. sublamellatus*, *Shorea acuminate*, *S. dealbata*, *S. curtisii*, *Tarrietia simplicifolia*, *Vatica cuspidata* and *Koompassia malaccensis*.

3.11.9.2 In Sarawak, two sub-types have been identified in the hill dipterocarp forests.

a. Shorea or Selangan Batu forest: This type is found on steeper and higher hills and the most frequent species is *Shorea laevis*.

b. Dipterocarpus/Shorea forest: This type occurs on sandstone escarpments in the east and north, mainly in coastal locations.

3.12 PAPUA NEW GUINEA, SOLOMON ISLANDS AND FIJI

In all three of these countries, forest classification systems are still evolving. While it is well-known that a wide range of types exist (from mangroves to high montane forests), currently available classification data is limited to the tropical lowland forests and whether or not these have been significantly altered. Table 7 (see also Figs. 6 to 8) provides an overview based on the aforementioned classification parameters.
Table 7 General Breakdown of Forests in Relation to Present or Past Use and Area
(Papua New Guinea, Solomon Islands and Fiji)

A. **PAPUA NEW GUINEA**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Est. area (million ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin forest</td>
<td>33.965</td>
</tr>
<tr>
<td>Logged-over (commercial logging)</td>
<td>1.010</td>
</tr>
<tr>
<td>Bush</td>
<td>0.015</td>
</tr>
<tr>
<td>Grassland</td>
<td>0.010</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35.0</strong></td>
</tr>
</tbody>
</table>

B. **SOLOMON ISLANDS**

<table>
<thead>
<tr>
<th>Classification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin forest</td>
<td>2.312</td>
</tr>
<tr>
<td>Logged-over (commercial logging)</td>
<td>0.177</td>
</tr>
<tr>
<td>Bush</td>
<td>0.011</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2.50</strong></td>
</tr>
</tbody>
</table>

C. **FIJI**

<table>
<thead>
<tr>
<th>Classification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin forest</td>
<td>0.774</td>
</tr>
<tr>
<td>Secondary logged-over</td>
<td></td>
</tr>
<tr>
<td>(commercial logging)</td>
<td>0.085</td>
</tr>
<tr>
<td>Bush</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.9</strong></td>
</tr>
</tbody>
</table>
Fig. 6 Papua New Guinea: Breakdown of Forest Types
Fig. 7 Solomon Islands: Breakdown of Forest Types
Virgin Bush
Logged-over Plantations

Forest Type

Fig. 8 Fiji: Breakdown of Forest Types
3.13 PHILIPPINES

3.13.1 The Philippines uses several classification systems. The basic framework takes in all areas classified as forest lands (including non-forested areas) and combines both botanical and current land use features as indicated on Table 8 (and Fig. 9).

Table 8 Total Classified Forest Land and Current Land Use (Philippines)

<table>
<thead>
<tr>
<th>Forest type/Land Use</th>
<th>Area in Hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Mossy Forest</td>
<td>1,137,200</td>
</tr>
<tr>
<td>2 Dipterocarp Old Growth Forest</td>
<td>986,800</td>
</tr>
<tr>
<td>3 Dipterocarp Residual Forest</td>
<td>3,332,800</td>
</tr>
<tr>
<td>4 Pine Forest, Closed</td>
<td>129,600</td>
</tr>
<tr>
<td>5 Pine Forest, Open</td>
<td>107,100</td>
</tr>
<tr>
<td>6 Brushland</td>
<td>2,045,100</td>
</tr>
<tr>
<td>7 Submarginal Forest</td>
<td>535,700</td>
</tr>
<tr>
<td>8 Mangrove</td>
<td>125,700</td>
</tr>
<tr>
<td>9 Other Land Use</td>
<td>7,494,913</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15,894,913</strong></td>
</tr>
</tbody>
</table>
Fig. 9 Classified Forest Land (Philippines)
3.13.2 Over 3,000 arboreal species have been identified in the Philippines. Some are widespread and others are confined to, or dominant in, only a few sites. The forests have developed under a variety of conditions on the thirteen (13) major islands that comprise about 94% of the total land area and some seven thousand (7,000) smaller islands and islets that make up the balance (6%). Given the diversity that is normal in an archipelagic situation, the mix and percentage of species may vary significantly from one island to the next even within the same forest type. In general however, the classifications on Table 8 may be broadly described as follows:

3.13.2.1 Mossy forest, refers to areas from about 800-900 meters a.s.l. and higher where the canopy rarely exceeds 30 meters, and the trees are festooned with various species of moss and epiphytes. Agathis philippinensis, Podocarpus imbrecatus and Quercus spp. are the major commercial timber species, occasionally interspersed with Cinnamomum mercadoi and stunted Dipterocarps. In some areas, the mossy forests are intact and have not been significantly altered but in others there has been extensive disturbance. For example, thousands of hectares of mossy forests north of Baguio City in Luzon Island have been cut down and converted to terraced farms that grow temperate zone crops (e.g. strawberries, carrots, broccoli, beets and cabbage).

3.13.2.2 Dipterocarp old growth forests refer to undisturbed areas that usually interface with the mossy forests. In a few sites however, pine forests may occur between the Dipterocarp old growth and mossy forests. Dominant species include Shorea almon, S. guiso, Parashorea plicata, Shorea negrosensis, S. polysperma and Pentacme contorta. On the lower slopes it is common to find S. kalunti, S. philippinensis, S. polysperma formations and some species from the family Sapotaceae.

3.13.2.3 Dipterocarp residual forests are areas that have been logged-over or have regenerated long after being abandoned by swidden farmers. These forests are similar in character to the dipterocarp old growth forests. However, the percentage of mature non-dipterocarp is usually higher since these were often left in place by loggers because of lower market demand as compared with the dipterocarps. Koordersiodendron pinnatum, Serialbizia acle, Artocarpus blancon, Dracontomelon dao, Intsia bijuga, Diospyros philippinensis and endospermum peltatum are some of the important non-dipterocarp commercial species. Pioneer species tend to proliferate after logging such as Trema orientalis, Macaranga spp. and Nauclea orientalis.

3.13.2.4 Pine Forest, Closed consists of virgin stands of Pinus keysia at high elevation (usually above 900 meters a.s.l.). These forests often lie between the mossy forests and dipterocarp old growth but in some cases extend to the mountain peak. Almost pure stands of Pinus keysia may be found in a few isolated areas. Generally however, patches of rich soil within the pine forest areas are populated by mixtures of Pinus keysia.
and broadleaved species such as mountain oak (Quercus spp.).

3.13.2.5 Pine forest, Open are areas with stands of Pinus keysia or Pinus merkusii that are degraded due to fire, overpasturing, swidden farming, logging or firewood gathering. The open pine forests usually have mixed groundcover including various species of grass (e.g. Imperata cylindrica), shrubs (e.g. Chromalaena odorata) and vines (e.g. Mimosa pudica).

3.13.2.6 Brushland refers to previously forested lands that have been seriously degraded such that trees are no longer the principal vegetative cover. Degradation usually can be traced back to swidden farming, overpasturing and firewood gathering. A wide range of brush species abound in these areas and the trees that remain are usually hardy, fire-resistant types such as Pileostigma malabarticum, Cratoxylum celabicum, and Antidesma ghaesembilla. In sites left undisturbed for 10 to 15 years (i.e. not burned or overpastured) many fast-growing broadleaved species have become established such as Trena orientalis, Macaranga spp. and Alphitonia philippinensis. Wild bananas and bamboo are common.

3.13.2.7 Submarginal forests are usually found in rocky areas at lower elevations and are characterized by a heterogenous mix of bamboo, fast growing pioneer species and the hardy, fire-resistant types mentioned above (3.13.2.6). Gliricida sepium and Leucaena leucocephala are common and Vitex parviflora will usually occur on limestone-derived soils. Most submarginal forests are subjected to continuous degradation brought about by over-pasturing and firewood gathering.

3.13.2.8 Mangrove Forests are dominated by Rhizophora spp., Avicenia spp. and associates. Earlier descriptions of the Malaysian mangrove forests would also apply to the Philippine mangrove forests. In the past, beach forests were considered as a separate type (which in fact they are) but these have practically disappeared and the few that remain are usually included in the areas described as mangrove forests. Terminalia catappa and Casuarina equisetifolia are commonly found along the beaches but these two species also occur inland even at high elevations. In a few rare areas where beach forests are relatively intact, Vitex parviflora, Instia bijuga and Palaquium luzoniense may occur.

3.13.2.9 Other land use is a general term used to describe grasslands, upland farms and pastures that are included among the areas officially classified as "forest lands". This vast area of essentially non-forested terrain is the largest single category (about 7.5 M ha) appearing in the Philippine classification listings.

3.13.3 The data in Table 8 has been derived from several studies that involved aerial photography, satellite imagery and ground studies. The first study was initiated by the FAO (1979). This
study was subsequently continued by the Philippine and West German governments (1981-1988) and is now formally identified as the RP-German Forest Resources Inventory (FRI) Report.

3.13.4 Classification data is further broken down into national parks, critical watershed reserves, other reservations, productive forests and protection forests. For purposes of comparison, it is also informative to consider a study carried out by the Swedish Space Corporation, the World Bank and the Philippine Government in 1987-88. This study took in the whole country and all types of vegetative cover. For convenience, this study is identified as the SPOT report (Satellit Probatioire d' Observatory de la Terre). The SPOT report compiled interpreted satellite imagery and aerial photogrammetry supplemented by ground observations. The results are summarized hereunder in Table 9.
Table 9 Land Cover Statistics and Classification System
Used in the Spot Project (1987-1985)
(Philippines)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Land Use Type</th>
<th>Area in Hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fp</td>
<td>Pine Forest</td>
<td>81200</td>
</tr>
<tr>
<td>Fy</td>
<td>Mossy Forest</td>
<td>245500</td>
</tr>
<tr>
<td>Fdc</td>
<td>Dipterocarp forest, closed canopy</td>
<td>2434600</td>
</tr>
<tr>
<td>Fdo</td>
<td>Dipterocarp forest, open canopy</td>
<td>4294000</td>
</tr>
<tr>
<td>Fm</td>
<td>Mangrove vegetation</td>
<td>149300</td>
</tr>
<tr>
<td>Es</td>
<td>Cultivated and other open areas in forest</td>
<td>30300</td>
</tr>
<tr>
<td>Eg</td>
<td>Grassland</td>
<td>1812900</td>
</tr>
<tr>
<td>Ec</td>
<td>Cultivated area mixed with brush-land and grassland</td>
<td>10114500</td>
</tr>
<tr>
<td>Ipc</td>
<td>Coconut plantations</td>
<td>1132700</td>
</tr>
<tr>
<td>Ipo</td>
<td>Other plantations</td>
<td>90800</td>
</tr>
<tr>
<td>Ic</td>
<td>Arable land, crops mainly cereals and sugar</td>
<td>4392300</td>
</tr>
<tr>
<td>Imc</td>
<td>Crop land mixed with coconut plantations</td>
<td>3747800</td>
</tr>
<tr>
<td>Imo</td>
<td>Crop land mixed with other plantations</td>
<td>365100</td>
</tr>
<tr>
<td>Ifm</td>
<td>Fishponds derived from mangroves</td>
<td>195200</td>
</tr>
<tr>
<td>Ifo</td>
<td>Other fishponds</td>
<td>10100</td>
</tr>
<tr>
<td>Ne</td>
<td>Eroded areas</td>
<td>600</td>
</tr>
<tr>
<td>Nq</td>
<td>Quarries</td>
<td>8700</td>
</tr>
<tr>
<td>Nr</td>
<td>Riverbeds</td>
<td>81700</td>
</tr>
<tr>
<td>No</td>
<td>Other barren land</td>
<td>10400</td>
</tr>
<tr>
<td>B</td>
<td>Built-up areas</td>
<td>134400</td>
</tr>
<tr>
<td>M</td>
<td>Marshy areas</td>
<td>103500</td>
</tr>
<tr>
<td>L</td>
<td>Lakes</td>
<td>2052000</td>
</tr>
<tr>
<td></td>
<td>Sub-totals Classified land area</td>
<td>29540800</td>
</tr>
<tr>
<td></td>
<td>Unclassified land area</td>
<td>546100</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Siltation patterns in lakes or along the coast</td>
<td>28500</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>352900</td>
</tr>
<tr>
<td></td>
<td>Grand total</td>
<td>30468300</td>
</tr>
<tr>
<td></td>
<td>Distribution in percentage between:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forest : Forest land, classes Fp to Fm</td>
<td>23.7%</td>
</tr>
<tr>
<td></td>
<td>Extens : Extensively cultivated land, classes Es toEc</td>
<td>40.0%</td>
</tr>
<tr>
<td></td>
<td>Intens : Extensively cultivated land, classes Ipc to Ifo</td>
<td>33.2%</td>
</tr>
</tbody>
</table>
3.14 THAILAND

3.14.1 In Thailand, formal classification of lands and forests began when the Department of Lands was established in 1901. Subsequent government decrees and legislation stipulated that 20,528,000 ha., equivalent to 40% of Thailand’s land area, should be reserved as national forests. In reality however, only 14.9 million ha. or 29% of Thailand is forested.

3.14.2 The biological classification of forests in Thailand lists seven (7) different types - Tropical Evergreen, Coniferous, Swamp, Beach, Mixed Deciduous, Dry Dipterocarp and Savanna.

3.14.3 Tropical Evergreen Forests occur throughout the peneplains and mountains where a high amount of rainfall prevails, and are broken down into the following sub-categories:

a. Tropical Rain Forests
b. Dry or Semi-Evergreen Forests
c. Hill Evergreen or Lower Montane Forests

3.14.4 The Coniferous Forests are found in small pockets in the Northwest Highlands and the Korat Plateau from about 200 m to 1,300 m elevation. The composition of the Coniferous forest consists predominantly of Pinus kesiya and P. merkusii.

3.14.5 The Swamp Forests are found in estuaries and along muddy shorelines and are divided physiographically into two general headings: the Fresh Water Swamp Forest and the Mangrove Swamp forest. The Fresh Water Swamp Forest is composed principally of Dyera, Palaquium, Melanorhea, and Scaphium spp. The Mangrove Swamp Forests are found along the coastlines and are usually dominated by Rhizophora spp.

3.14.6 The Beach Forest. Small strips or patches of beach forests occur on the sand dunes, rocky seashores and elevated lands along the coastlines. Casuarina equisetifolia is predominant on sand dunes, often forming a pure stand.

3.14.7 Mixed Deciduous Forest. This type usually contains a diverse mixture of deciduous species. However, in certain localities one species may become predominant, such as teak (Tectona grandis), in which case the area would, for convenience, simply be called a teak forest. The mixed deciduous forest can be further classified into three sub-categories, based on terrain and climatic factors: the Moist Upper Mixed Deciduous, the Dry Upper Mixed Deciduous, and the Lower Mixed Deciduous.

3.14.8 The Dry Deciduous Dipterocarp Forest occurs on the undulating peneplains and ridges, where the soil is either sandy or lateritic, and subject to extreme leaching, erosion, and annual burning. Some important trees in this forest type are Dipterocarpus, Shorea and Pentacme spp.
3.14.9 The Savanna Forest. Savanna can be regarded as the extreme form of deciduous forest, and has usually evolved after frequent and repeated burning. It is prevalent in the Northeastern region where cultivation has been practiced from time immemorial and where precipitation is relatively low (1,000 mm/yr). The Savanna forest is, in essence, a grassland where trees of medium height grow sparsely, forming a very open stand interspersed with thorny shrubs, Bambusa arundinarea and other low-growing species.

3.14.10 Openlands in reserved forest areas are not included in Thailand's classification system. Thus, officially classified forest land that no longer has tree cover is not further subdivided into non-forest land use systems. Royal Forest Department statistics present the functional classification of Thailand's forested areas as shown in Table No. 10.

Table 10 Various Forest Areas by Function in 1985 (Thailand)

<table>
<thead>
<tr>
<th>Number</th>
<th>Area (ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Logging Concessions 621</td>
</tr>
<tr>
<td>2.</td>
<td>National Forest Reserves 1,158</td>
</tr>
<tr>
<td>3.</td>
<td>Pre-reserved Forests 84</td>
</tr>
<tr>
<td>4.</td>
<td>National Parks 52</td>
</tr>
<tr>
<td>5.</td>
<td>Forest Parks 57</td>
</tr>
<tr>
<td>6.</td>
<td>Wildlife Conservation Areas 28</td>
</tr>
<tr>
<td>7.</td>
<td>Non-hunting Areas 38</td>
</tr>
<tr>
<td>8.</td>
<td>Wildlife Parks 2</td>
</tr>
<tr>
<td>9.</td>
<td>Botanical Gardens 5</td>
</tr>
<tr>
<td>10.</td>
<td>Arboretum 42</td>
</tr>
</tbody>
</table>

TOTAL 49,090,637

3.14.11 The official data in Table 10 (above) is not reliable as far as hectarage is concerned. The table would seem to imply that over 95% of the total land area of the country falls within a forest classification. This does not account for cultivated land. Furthermore, it is clear from other data that Thailand's forested area is approximately 14.9 M ha. not 49.09 M ha. as indicated on Table 10. Nonetheless, the table does provide the official nomenclature used to identify functional categories.
4.0 FOREST MANAGEMENT SYSTEMS

4.1 In general, the officially-recognized systems currently in place in all eight (8) countries have been designed to deal with commercial extraction of timber. These systems (and various subsystems) fall within five (5) major categories:

4.1.1 Selective cutting of mature commercial species in the hardwood forests and reliance on natural regeneration of residuals, plus timber stand improvement treatments (T.S.I.) to rehabilitate the timber stand;

4.1.2 Clear cutting of hardwood forests and replacement with plantation forests;

4.1.3 Semi-clear cutting (usually in strips) in mangrove forests;

4.1.4 Clear-cutting that leaves an adequate number of seed trees in place to re-populate the site (primarily in pine forests and occasionally in mangrove forests); and

4.1.5 Coppice management of natural and plantation forests having a predominance of species that respond favorably to coppice treatments.

4.2 Over the past two decades, agroforestry has assumed major importance as an approach to rehabilitation, but not as a management system applicable to natural forests. However, there are indications that agroforestry is broadening in scope to include natural forest management. For example, the Philippines has launched a Community Forestry Program that grants timber concession privileges to local residents and replaces machine logging with labor-based extraction methods.

4.3 Additionally, forest management systems that envision non-timber forest products as the primary source of revenue are being seriously considered. Systems designed along these lines would ban or significantly curtail timber extraction. The main function of forests would be to nurture non-timber crops. Thus, it seems likely that the five (5) major systems mentioned earlier may eventually be augmented by two (2) additional forest management systems:

4.3.1 Agroforestry (i.e. social forestry) that focuses on community ownership and labor-based extraction methods in natural forests, and

4.3.2 Forests managed primarily to supply non-timber products.

4.4 It has generally been assumed that natural regeneration would be adequate for rehabilitation following selective logging operations. This assumption proved valid in some instances where a second rota-
In most cases however, natural regeneration has been aborted because of slash-and-burn destruction of the residuals left in place after selective logging. With the increase in population and demand for wood, natural regeneration has not met expectations. Hence, in recent years, the emphasis has moved towards greater reliance on artificial treatments. Furthermore, as the negative environmental effects of deforestation have become more apparent, there has been a significant shift towards managing forests for purposes other than timber production (e.g. soil and water conservation, minor forest products, parks, watershed protection).

There has been a proliferation of forest management regulations and policies that focus on natural regeneration. By and large however, these have not proven effective in improving the rate and quality of tropical forest regeneration.

Quite often, regeneration treatments which should follow timber extraction were not seriously carried out due to lack of interest, plain disregard of regulations or lack of resources. In other situations, population pressure and inadequate protection of residuals have been the major factors leading to forest degradation. The gradual evolution of the two (2) non-conventional approaches mentioned above (4.3.1 and 4.3.2) may help alleviate these problems.
5.0 PRESENT STATE AND EXTENT OF LOGGED-OVER FORESTs

5.1 Most country-specific data quantifies the area of forest land in need of rehabilitation. However, there is a lack of qualitative data that would indicate relative status of logged-over areas (e.g. severely-degraded, excellent condition, etc). Therefore, one can only describe current status and extent of logged-over lands in terms of the hectarage requiring some form of treatment to sustain or restore productivity.

5.2 Taking in all categories, the aggregate area in need of rehabilitation is estimated to be 66.7 million hectares. This figure is based on a combination of official statistics and reliable (although unofficial) estimates. It probably understates the actual situation, especially insofar as India is concerned. Nonetheless, it does provide some basis for future consideration. Country-specific statistics are reflected hereunder on Table 11.

Table 11 Extent of Logged-Over Forests that Require Rehabilitation

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (Million ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>7.05</td>
</tr>
<tr>
<td>Indonesia</td>
<td>36.00</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>1.01</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>0.17</td>
</tr>
<tr>
<td>Fiji</td>
<td>0.09</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.46</td>
</tr>
<tr>
<td>Philippines</td>
<td>13.59</td>
</tr>
<tr>
<td>Thailand</td>
<td>8.30</td>
</tr>
</tbody>
</table>

66.67

5.3 INDIA

5.3.1 In India, no virgin tropical rainforests remain. This situation underscores the need for comprehensive and effective land use and forestry management. Out of the 52.34 million hectares of natural tropical broadleaved forest, 36.46 million ha. are characterized as productive closed forest. This represents 11.09% of the total land area of the country.
Fig. 10 Extent of Area Needing Rehabilitation
Fig. 10a Extent of Area Needing Rehabilitation
5.3.3 The major causes of forest loss are shifting cultivation, firewood and timber harvesting, grazing, fire, encroachment and conversion to other uses.

5.3.4 Harvesting of timber, especially for firewood, continues to outstrip the regenerative capacity of the forests. Additionally, excessive and unrestricted grazing has contributed to degradation.

5.3.5 Periodic forest fires are estimated to affect up to 50% of the forested areas. Wherever this is done deliberately, the objective is usually to obtain new shoot-growth of forage crops or to facilitate the gathering of minor forest products.

5.3.6 Shifting cultivation and encroachment by people residing adjacent to the forests, affect about 4.42 M ha. Government statistics indicate that conversion of forests to other land uses has been greatly reduced with enactment of the 1980 Forest Conservation Act. All factors considered, an estimated 7.05 million hectares of forest land require rehabilitation.

5.4 INDONESIA

5.4.1 Despite the presence of more than 500 timber concessionaires operating over 55 million hectares, official statistics do not report the extent of forest lands in need of rehabilitation or the state of the logged-over areas. However, it is estimated that low volume forests (less than or equal to 39 cu. m/ha.) cover about 16 million hectares. One can safely assume that all of these areas need various types of rehabilitation treatments.

5.4.2 Since large areas of primary forests have been subjected to commercial logging, the implication is that post-logging treatments need to be seriously carried out. Furthermore, unofficial data indicates that approximately 20 million hectares of grasslands (principally Imperata cylindrica) should be reforested.

5.4.3 In Indonesia, the total area in need of rehabilitation may be summarized as follows:

- Logged-over (commercial logging) 16.0 M ha.
- Imperata Grasslands 20.0 M ha.

Total 36.0 M ha.
Fig. 11 Indonesia: Areas Needing Rehabilitation
5.5 MALAYSIA

5.5.1 The total estimated area subjected to commercial logging is 4,258,600 hectares. Standing volume in residual forests ranges from 60-180 cu.m./ha, indicating that the logged-over areas contain a significant volume of timber relative to other countries. This further indicates that the selective system of management has been effectively implemented so far.

5.5.2 Nonetheless, in three states of Peninsular Malaysia (Pakang, Perak, Kekantan) an estimated 174,000 ha. have reportedly been damaged by encroachments of the predominantly native population (Orang Asli) and need rehabilitation. Furthermore, silvicultural treatments were reportedly carried out on about 800,000 ha. up to 1987. Current T.S.I. targets are about 70,000 each year which is roughly equivalent to the annual logging figures. One may therefore, assume that the area needing rehabilitation would take in all lands previously logged, minus areas already treated and lands earmarked to be cleared for agriculture.

5.5.3 From the above, and assuming that currently available data is reasonably accurate, some 460,000 ha. may require rehabilitation treatments, i.e.

<table>
<thead>
<tr>
<th>Category</th>
<th>Area (M ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas previously logged</td>
<td>4.26</td>
</tr>
<tr>
<td>Less:</td>
<td></td>
</tr>
<tr>
<td>Areas earmarked for Agriculture</td>
<td>3.00</td>
</tr>
<tr>
<td>Areas already treated</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>(3.80)</td>
</tr>
<tr>
<td>Net area for rehabilitation</td>
<td>0.46</td>
</tr>
</tbody>
</table>

5.6 PAPUA NEW GUINEA, SOLOMON ISLANDS & FIJI

5.6.1 In these three countries, the principal areas requiring rehabilitation treatment are forests where commercial logging has been carried out over the last 25 years as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (Million ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Papua New Guinea</td>
<td>1.010</td>
</tr>
<tr>
<td>- Solomons</td>
<td>0.167</td>
</tr>
<tr>
<td>- Fiji</td>
<td>0.085</td>
</tr>
<tr>
<td>Total</td>
<td>1.262</td>
</tr>
</tbody>
</table>
5.6.2 There are undoubtedly other forest lands that have been subjected to slash-and-burn clearing or other forms of abuse. However, in the absence of reliable data, one can only speculate on the amount of rehabilitation that should be implemented on these lands.
Fig. 12 PNG, Solomon Is. and Fiji: Areas Needing Rehabilitation
5.7 PHILIPPINES

5.7.1 In the Philippines, approximately 13.5 million hectares of forest lands have been logged-over and need rehabilitation treatments. The forests have been degraded or destroyed by commercial logging, slash-and-burn farming, overpasturing and other factors. Table No. 12 provides a breakdown of logged-over forests in relation to the type of rehabilitation treatments that are required.

5.7.2 It should be noted that 8.03 M ha. of the total indicated in Table 12 needs to be rehabilitated through agro-forestry (i.e., social forestry). Most of these areas are occupied.
Table 12  Estimated Extent of "Logged-Over Forests" in need of Rehabilitation, Classified by Rehabilitation Objective and Type of Forestland (Philippines)

<table>
<thead>
<tr>
<th>Objective and Type</th>
<th>Hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Forest Conservation and Development</strong></td>
<td></td>
</tr>
<tr>
<td>a.1 Reforestation of brushlands in the public domain</td>
<td>2,045,100</td>
</tr>
<tr>
<td>a.2 Enrichment planting in open pine forests</td>
<td>107,100</td>
</tr>
<tr>
<td>a.3 TSI in dipterocarp residual forests inside timber concessions *</td>
<td>500,000</td>
</tr>
<tr>
<td><strong>B. Others</strong></td>
<td></td>
</tr>
<tr>
<td>b.1 TSI under new management systems in dipterocarp residual forests outside timber concessions</td>
<td>1,427,900</td>
</tr>
<tr>
<td>b.2 Protection and enrichment planting in dipterocarp residual forests not suitable for TSI</td>
<td>1,404,900</td>
</tr>
<tr>
<td>b.3 Agroforestry, tree farm development and pasture improvement on - submarginal forests</td>
<td>535,700</td>
</tr>
<tr>
<td>- other land use</td>
<td>7,494,913</td>
</tr>
<tr>
<td>b.4 Mangrove rehabilitation</td>
<td>79,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13,594,713</td>
</tr>
</tbody>
</table>

*T.S.I. Timber Stand Improvement
Agroforestry Areas (59%)

Dip. (TSI) (11%)
Dip. (Enrichment) (4%)

Brush (Refor.) (15%)

Pine (Enrichment) (1%)

Dip. (Not Reg.) (10%)

Mangrove (1%)

Fig. 13 Philippines: Area Needing Rehabilitation
5.8 THAILAND

5.8.1 As in other Asian countries, Thailand has recorded a dramatic reduction in forested land. Forest cover as a percentage of total land area has diminished from 58% in 1952 to 29% in 1985. This is way below the 40% forest cover target established by the government.

5.8.2 Within the remaining forested area, up to 6.39 million hectares can be considered in need of rehabilitation. If one includes nonforested lands that should be reforested, the total goes up to 8.3 million hectares.

5.8.3 With the recent imposition of a total log ban, depletion due to timber harvesting is expected to decline. However, of greater concern is the pressure exerted by a large population of swidden farmers. Some 6.68 million hectares are estimated to be occupied by one million upland families. Some form of agroforestry therefore seems imperative.

5.8.4 The banning of timber operations creates a large void in forest management. Unmanaged forests will be at great risk unless this void is filled. For example, Philippine experience demonstrates that the rate of forest destruction has increased wherever log bans have been imposed.
6.0 PRESENT STATUS OF FIELD WORK IN REHABILITATION

6.1 Rehabilitation of logged-over lands has been carried out in various ways, all of which would fit within one or another of the following categories:

a. Timber stand improvement (TSI) as a post-logging treatment in natural forests;

b. Removal of residual natural forest vegetation after logging and replacement with plantation species;

c. Reforestation of denuded grasslands, brushlands and scrub forests with plantation species;

d. Mangrove planting on denuded tideflats; and

e. Agroforestry.

6.2 After commercial logging in the natural forests, there has been a tendency to rely almost exclusively on unmanaged natural regeneration to re-establish the forest stands. Quite often, this "hands off" attitude results from an absence of well-defined policies regarding future use of logged-over areas and insecure long term tenure.

6.3 In countries where post-logging management is entrusted to the private sector, insecure tenure has been a disincentive to invest in timber stand improvement, including maintenance, protection of residuals and enrichment planting.

6.4 Where government agencies were expected to assume responsibility, the lack of sustained funding for post-logging treatments, and pressure to convert the land to non-forest uses, have been the principal impediments to rehabilitation.

6.5 With the exception of agroforestry, the absence of interim, short term objectives has been a common deficiency of most rehabilitation programmes. This makes it difficult to encourage sustained commitment to rehabilitation.

6.6 For the private sector, the financial implications of long-term investment to obtain benefits some twenty (20) to thirty (30) years in the future, are not attractive.

6.7 For governments, the inability to provide near-term employment and income-generating benefits from forests has negative political implications. The latter tend to undermine the political will to forcefully pursue rehabilitation over time.
6.8 There are numerous opportunities for combining short and long-term objectives that should be seriously explored (e.g. interim income from non-timber forest products). Some pioneering work has been initiated, but no major effort along these lines has been launched or consistently carried out.

6.9 INDIA

6.9.1 India has a long history of rehabilitation programmes. One of the earliest successful rehabilitation methods was the taungya system through which 31,360 hectares of sal (Shorea robusta) and teak (Tectona grandis) plantations were established over 50 years.

6.9.2 Since independence, plantations of fast-growing species have become a major component of India's rehabilitation programmes. Extensive trials have been carried out with major indigenous timber species and promising exotics. A variety of methods are in use for enrichment planting, plantation establishment and afforestation. The government-owned Forest Development Corporation has established plantations by clearfelling low value forests and replanting these with higher valued sal, teak and eucalypts.

6.9.3 To support its reforestation programmes, India has established seed production centers that are planted with superior strains of natural and plantation forest species. At present, there are 1,000 ha. of these centers that produce high-quality seed from selected cultivars of 32 different species.

6.9.4 Rehabilitation of logged-over natural forests has been carried out primarily through natural regeneration. The specific methods applied are dependent on the type of forest and can include reproduction from seed (selection system), tunnel planting, direct seeding, gap planting, stump planting, coppice and T.S.I. The coppice system is also applied in established plantations.

6.9.5 The total area of man-made forests in India (to 1985) is estimated to be 8,206 M ha. However, the forests under permanent silvicultural management reportedly cover 44.95 M ha. or about 86% of all forests in India. This may be one of the largest areas under management worldwide. There is an apparently high technical capability to implement rehabilitation programmes.

6.9.6 Unfortunately, it has not been possible to obtain reliable data on the categories of plantations or areas covered by forest type (e.g. pulpwood or timber production/moist or dry forests).

6.9.7 As in most other developing countries, there is a high reliance on wood for fuel. Studies conducted in 1975-76 indicate that firewood removal of about 84 million tons during the year, was not officially acknowledged in forestry records. This figure provides some idea of annual demand. The illegal extraction of firewood from forests has stimulated the implementation of
programmes designed to furnish adequate quantities of fuelwood close to settlements. However, there is still a large gap between supply and demand.

6.9.8 Social forestry programmes initiated in the 1980's have helped increase the supplies of fuelwood, fodder and construction timber. These programmes include the establishment of community woodlots, planting of fruit orchards, replanting of degraded forests and wastelands, coastal and desert afforestation. The contributions of social forestry have been very significant. From 1981-1985, social forestry programmes account for an estimated 3.88 M ha. of new forests. This is 83.4% of the national total (4.65 M ha.) for the period.

6.9.9 In response to increasing demand and attractive prices, there has been a noticeable increase in tree planting on private lands. No accurate records are available, but the extent of planting has been large enough to attract attention and create controversy. Articles have been published criticizing the conversion of crop land to tree plantations. Fears have been expressed that grain production will decline. On the other hand, some landowners feel that tree planting will yield higher profits than production of food crops. Most of the private tree farmers grow fuelwood but some have reportedly produced poles for construction and other purposes.

6.10 INDONESIA

6.10.1 Current information from Indonesia indicates that post-logging treatment in natural forests is the principal component of rehabilitation programmes. This is to be expected considering the large areas turned over to timber concessionaires and the scale of on-going timber extraction. For example, it has been reported that Indonesia is now the world's largest producer of tropical plywood.

6.10.2 Nonetheless, it is well-known that development of plantation forests has been a major feature of forest management in Indonesia since the early part of the century. Large areas of teak, Agathis spp. and other timber species have been planted. Rattan plantations established as far back as 1850 now provide significant volumes of this valuable non-timber product. Additionally, there have been a number of successful agroforestry programmes, including the well-documented "Lantorasini" project on Flores Island which has attracted worldwide attention.

6.10.3 Unfortunately, the emphasis placed on logging in recent years seems to have overshadowed the excellent rehabilitation work done in the past. There is a dearth of up-dated information on reforestation, afforestation and reclamation of Imperata grasslands.
6.10.4 Given the concentration on logging, rehabilitation based on natural regeneration methods has assumed major importance. About 16 million hectares of forests have been logged up to 1989, which is about 18 percent of all production forests in the country. The areas logged-over by province are indicated hereunder in Table 13.
Table 13 Logged-Over Forest by Province up to 1989  
(Indonesia)

<table>
<thead>
<tr>
<th>Province</th>
<th>Production forest (ha)</th>
<th>Number of HPH* Units</th>
<th>Logged-over forest ** (ha)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.I. Aceh</td>
<td>1,757,700</td>
<td>20</td>
<td>576,375</td>
<td>32.81</td>
</tr>
<tr>
<td>North Sumatra</td>
<td>2,135,100</td>
<td>14</td>
<td>306,999</td>
<td>14.38</td>
</tr>
<tr>
<td>West Sumatra</td>
<td>1,574,200</td>
<td>12</td>
<td>358,796</td>
<td>22.79</td>
</tr>
<tr>
<td>Riau</td>
<td>7,291,200</td>
<td>62</td>
<td>1,529,216</td>
<td>20.97</td>
</tr>
<tr>
<td>Jambi</td>
<td>1,987,200</td>
<td>25</td>
<td>702,156</td>
<td>35.33</td>
</tr>
<tr>
<td>South</td>
<td>3,643,500</td>
<td>21</td>
<td>447,248</td>
<td>12.28</td>
</tr>
<tr>
<td>Bengkulu</td>
<td>469,700</td>
<td>4</td>
<td>61,587</td>
<td>13.11</td>
</tr>
<tr>
<td>Lampung</td>
<td>573,000</td>
<td>3</td>
<td>59,911</td>
<td>10.46</td>
</tr>
<tr>
<td>West Kalimantan</td>
<td>5,820,400</td>
<td>58</td>
<td>1,337,754</td>
<td>22.98</td>
</tr>
<tr>
<td>Central Kalimantan</td>
<td>12,468,000</td>
<td>112</td>
<td>2,694,104</td>
<td>21.61</td>
</tr>
<tr>
<td>East Kalimantan</td>
<td>13,839,200</td>
<td>105</td>
<td>4,972,904</td>
<td>35.93</td>
</tr>
<tr>
<td>South Kalimantan</td>
<td>1,815,700</td>
<td>16</td>
<td>490,063</td>
<td>26.99</td>
</tr>
<tr>
<td>South Sulawesi</td>
<td>1,417,500</td>
<td>8</td>
<td>194,292</td>
<td>13.71</td>
</tr>
<tr>
<td>Central Sulawesi</td>
<td>2,727,100</td>
<td>20</td>
<td>407,345</td>
<td>14.94</td>
</tr>
<tr>
<td>Southeast Sulawesi</td>
<td>2,195,400</td>
<td>2</td>
<td>10,210</td>
<td>0.47</td>
</tr>
<tr>
<td>North Sulawesi</td>
<td>1,671,100</td>
<td>4</td>
<td>144,563</td>
<td>8.65</td>
</tr>
<tr>
<td>West Nusa Tenggara</td>
<td>642,800</td>
<td>1</td>
<td>36,534</td>
<td>5.68</td>
</tr>
<tr>
<td>Maluku</td>
<td>3,541,900</td>
<td>22</td>
<td>1,003,970</td>
<td>28.35</td>
</tr>
<tr>
<td>Irian Jaya</td>
<td>23,631,200</td>
<td>12</td>
<td>757,117</td>
<td>3.20</td>
</tr>
</tbody>
</table>

Total 89,200,900 521 16,091,145 18.04

Note: * HPH = Hak Pengusahaan Hutan  
(Forest Exploitation Right)  
** Calculated estimate
6.10.5 Post-logging inventories report densities ranging from a low of twenty (20) to a high of two-hundred and twenty six (226) residual trees per hectare in the 20 cm. d.b.h. and up class, and up to 41,570 seedlings per hectare if all diameter classes are included. While the accuracy of many inventory reports has been questioned, it does seem apparent that timber stand improvement (TSI) treatments can produce very favorable results.

6.10.6 Enrichment planting has been incorporated in TSI, pursuant to rules embodied in the Indonesian Selective Logging System (ISFS). Line planting has been the normal practice in areas where ISFS rules are adhered to, with Shorea leprosula, S. smithania and Dryobalanops spp. being among the more frequently-planted species. Rehabilitation of open spots (e.g. skid trails and log landing sites) usually involves the planting of fast-growing species such as Albizia falcataria. In the peat swamp forests, line planting of Ramin has been reported.

6.10.7 Despite the importance of TSI to the long term productivity of Indonesia's forests, there has apparently been no concerted effort to document the number of hectares covered by TSI treatment.

6.11 MALAYSIA

6.11.1 Rehabilitation programmes in Malaysia include post-logging treatment and plantation development. Prior to 1978, post-logging activities were governed by the procedures set forth in the Malaysia Uniform System (MUS) which prescribed cleaning, climber cutting and poisoning of non-commercial or unwanted species as soon as practical after logging. The MUS was later modified to include enrichment planting and poisoning or girdling of all defective or unwanted trees down to 15 cm. d.b.h.

6.11.2 From 1978 onward, the MUS was replaced by the Selective Management System (SMS) which no longer required enrichment planting and emphasized climber cutting. Studies conducted in Sabah (Nicholson, 1979) indicated that the treatment which most effectively promoted early growth increment was the killing of all non-commercial species immediately after logging.

6.11.3 While it is difficult to obtain accurate data, it seems that rehabilitation of logged-over forests has not been uniformly applied. For Peninsular Malaysia, statistics from 1981 imply that about 2.26 million hectares had been logged-over and some 0.48 million hectares had been damaged. In general, "logged-over" status applies to areas logged after 1966 and "damaged" status refers to areas logged prior to 1966 that subsequently deteriorated in quality. The inference is that timber stand improvement (TSI) was implemented in the logged-over sites and enrichment planting in the damaged sites. However, it is well-known that many logged over lands were converted to rubber and oil palm plantations. Moreover, enrichment planting has reportedly been neglected in recent years due to high labor cost.
6.11.4 In Sabah, some 1.2 million hectares had been logged-over by 1980 (FAO) and the intensity of logging has increased since that time. Whereas post-logging treatment regulations prescribed in the MUS and SMS rules were strictly enforced for some years, supervision has reportedly been less than optimum over the last decade.

6.11.5 Statistics for Sarawak are more recent and indicate 0.68 million hectares logged-over by 1985. The general perception is that post-logging treatments have been the exception rather than the rule.

6.11.6 Although quantitative data is difficult to come by, the species that have received priority in post-logging treatments in Peninsular Malaysia have been identified. The major species are: Shorea dasyphulla, S. hemsleyana, S. joherensis, S. lepi-dota, S. leprosula, S. ovalis, S. palemanica, S. parvifolia and S. teysmannian.

6.11.7 In Peninsular Malaysia, rehabilitation has moved ahead rapidly in recent years. Data from the Asian Development Bank (ADB) indicates that T.S.I. treatments were applied on more than 232,000 ha. from 1983 to 1985. The rate of treatment has increased since then and some 822,000 ha. were reported to have been treated by 1987. Additionally, some 35,000 hectares of plantations were established under the Compensatory Forestry Sector Project supported by an ADB loan. About 80-90% of the plantations are monocultures of Acacia mangium. A Phase II loan has been programmed with a target of 45,000 hectares from 1990-1995.

6.12 PAPUA NEW GUINEA, SOLOMON ISLANDS AND FIJI

6.12.1 Rehabilitation methods in these three countries include enrichment planting, line planting, closed plantations and natural regeneration. Enrichment and line planting are carried out primarily on inadequately stocked, logged-over areas. Where residual stands are marginal after logging, natural forest growth is removed and replaced by closed plantations.

6.12.2 Adequately stocked logged-over lands are left to regenerate naturally or are upgraded through line and enrichment planting. No other T.S.I. treatments are reported for logged-over areas (e.g. thinning).

6.12.3 The success of rehabilitation efforts in all these countries has been directly influenced by the status of land ownership. Almost all lands are under customary (i.e. tribal) ownership and many of the owners will not grant permission to conduct post-logging treatment. Therefore, most rehabilitation is carried out on lands where control is effectively in the hands of government agencies rather than traditional (i.e. customary) leaders. One significant exception is Fiji where rehabilitation has been carried out over 42% (37,000 ha.) of the area logged between 1964-88. Fiji's success in this regard is generally attributed to the fact that land owners were closely involved in the various
stages of rehabilitation and perceive a long-term benefit from rehabilitation programmes. By contrast, only 32,000 (9.8%) hectares of plantations have been established in Papua New Guinea and the Solomon Islands or a mere 2.72% of the logged-over areas in these two countries.

6.13 PHILIPPINES

6.13.1 In the Philippines, rehabilitation is carried out to achieve either economic, environmental or social objectives.

6.13.2 Within adequately stocked logged-over dipterocarp forests, natural methods of rehabilitation are practiced. However, timber companies are also required to carry out timber stand improvement (T.S.I.) treatments. T.S.I. involves protection of the residual stand and improvement of growing conditions by the removal of climbers and weed species. In areas where the residual stand is considered to be inadequate, supplemental planting is required. As a general rule however, T.S.I. regulations have been ignored. Un-managed regeneration is widespread.

6.13.3 Rehabilitation in the pine forests is carried out in a manner similar to the dipterocarp forests (i.e. natural regeneration from seeds). However, enrichment planting is usually more intensive than in the logged-over dipterocarp forests. This is because pine forests are often pure stands. More trees are removed per hectare than in the dipterocarp forests but loggers are required to leave an adequate number of seed trees. Post-logging treatments have apparently been carried out more conscientiously in the pine than in the dipterocarp forests. But fire has caused extensive damage to many of the rehabilitated pine forests.

6.13.4 Logged-over mangrove forests are either left to rehabilitate by themselves or artificially regenerated mainly with Rhizophora spp. In recent years, artificial regeneration of mangrove forests has been successfully carried out by many seaside communities.

6.13.5 Rehabilitation on submarginal, brush and openlands has met with limited success. This is due to the fact that most of the land is occupied. Rehabilitation programmes attempted in the past were vague regarding how future benefits would be shared. Hence, most of the successful rehabilitation projects have occurred in areas that had a minimum of occupants.

6.13.6 The first officially-recorded reforestation project in the Philippines was launched in 1916. As of 1985, an estimated 350,000 ha. were reported to have been reforested by the government and approximately 240,000 ha. by private timber companies, or 590,000 ha. overall.
6.13.7 Prior to 1988, however, official reforestation statistics were never subjected to independent audit or verification and the reliability of official data was questionable. In 1988, the Philippine government's Department of Environment and Natural Resources (DENR) entered into agreements with seventeen (17) forestry colleges and universities to conduct a nationwide performance audit of government-implemented reforestation projects.

6.13.8 Concurrent with the aforementioned performance audit, the Asian Development Bank (ADB) and the Overseas Economic Cooperation Fund (OECF) of Japan, approved a US$240 million loan to the Government of the Philippines (GOP) to finance reforestation, social forestry, T.S.I., watershed management rehabilitation and other forest development activities. Collectively, these activities are identified as the National Forestation Program (NFP).

6.13.9 Most of the ADB-OECF loan funds are being used to finance reforestation contracts implemented by families residing in the uplands, by community associations or by non-government organizations (NGO's) and corporations. As of December 1989, some 10,000 contracts had been awarded, covering approximately 70,000 hectares.

6.13.10 Preliminary results of the performance audit mentioned above (6.13.7) were compiled in January 1990 and indicate that of the 350,000 ha. reported to have been reforested by the government (para 6.13.6) only 73,500 ha. (21%) can be considered successful. Most of the balance has succumbed to fire, poaching and other forms of damage. Meanwhile, private sector reforestation has been validated to be around 180,000 ha. Thus, excluding new plantings financed by the ADB-OECF loan, mature reforestation projects currently cover about 253,000 ha. (180,000 ha. private sector plus 73,500 ha. government).

6.13.11 Meanwhile, updated statistics collected as part of NFP implementation indicate that social forestry projects have been successfully carried out in cooperation with around 100,000 families who have rehabilitated approximately 80,000 ha. of denuded grasslands. The principal treatments have been terracing, planting of erosion control hedgerows, construction of small-scale water impoundment structures, reforestation with timber and firewood species, and establishment of orchards.

6.13.12 Reforestation has increased significantly under the ADB-OECF-assisted National Forestation Program (NFP). End of the year statistics (Dec 1989) indicate that some 140,000 ha. of denuded lands have been reforested thus far under the NFP.

6.13.13 Combined statistics from the various sources mentioned above indicate that rehabilitation has been carried out on a total of 473,500 ha. A detailed breakdown is provided in Table 14.
Table 14 Rehabilitation Accomplishments in the Philippines as of Dec. 1989

<table>
<thead>
<tr>
<th>Category</th>
<th>Area (ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Previous reforestation by the government up to 1986 (per performance audit)</td>
<td>73,500</td>
</tr>
<tr>
<td>2. Previous private sector reforestation (Up to 1986)</td>
<td>180,000</td>
</tr>
<tr>
<td>3. New reforestation, under the ADB-OECF assisted NFP</td>
<td>140,000</td>
</tr>
<tr>
<td>4. Social Forestry</td>
<td>80,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>473,500</strong></td>
</tr>
</tbody>
</table>

6.14 THAILAND

6.14.1 Forest rehabilitation programmes in Thailand include community settlements, issuance of "right to farm" licenses, reforestation by government agencies and, until lately, reforestation by timber companies.

6.14.2 Encouraged by government incentives, private sector forest plantations have expanded but reliable data on private lands reforestation is not available. Some statisticians include Thailand's 1.4 million ha. of rubber plantations in their reforestation data.

6.14.3 Current targets of the Thai government indicate an annual reforestation goal of 112,000 hectares. The area successfully reforested has reportedly increased from around 8,000 ha. in 1961 to 593,391 ha. in 1986. Partial statistics up to 1983 are provided in Table 15.
Table 15: Reforestation Accomplishments as of 1983 (Thailand)

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantings to Improve degraded forest (i.e. enrichment planting)</td>
<td>87,643</td>
</tr>
<tr>
<td>Teak Plantations</td>
<td>63,983</td>
</tr>
<tr>
<td>Other Hardwood Plantations</td>
<td>54,773</td>
</tr>
<tr>
<td>Watershed Replanting</td>
<td>139,850</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>346,249</strong></td>
</tr>
</tbody>
</table>

6.14.4 "Right-to-farm" licenses issued under the Sor Tor Kor (STK) programme are assuming major importance in forest rehabilitation planning. STK can be generically described as an agro-forestry (i.e. social forestry) initiative and is said to involve some 174,295 households occupying about 260,055 ha.

6.14.5 In addition, the Forest Village Establishment programme has settled 23,135 families in 144 villages covering 28,647 ha. Some 4,871 of these families are occupying living space without an allocation of farmland. It is presumed they are employed in government forestry projects.
Fig. 14 Thailand: Types of Rehabilitation
7.0 PRESENT STATUS OF RESEARCH ON REHABILITATION OF LOGGED-OVER FORESTS

7.1 Overview

7.1.1 In all eight (8) countries, afforestation and reforestation have been the principal focus of rehabilitation research. Next in priority have been research projects that deal with silvicultural treatments after commercial logging in residual natural forest stands. Mangrove forests have also received attention and agro-forestry has been a major area of research in recent years. Non-timber forest products have been studied, but not extensively.

7.1.2 The range of topics investigated to date is very broad, and includes both basic and applied research. Similarly, the historical background of formal research extends from as far back as the nineteenth century in India, Malaysia and Indonesia to the recently-proposed establishment of Papua New Guinea's first forestry research organization (i.e. the Forest Research Institute).

7.1.3 All of the countries, except Thailand, have been colonies of temperate-zone powers. In some cases, the colonial period covered several centuries. Colonialism invariably influenced the earlier course of research, and priorities established during the colonial era still seem prevalent to this day. This is illustrated by the large body of research dealing with conifers, eucalypts, establishment of mono-culture plantations and timber species important to the export trade.

7.1.4 There is a relatively meagre bibliography describing customary forest management regimes and day-to-day multiple-use production systems. This further demonstrates the carry-over of colonially-influenced priorities and insufficient attention to topics that touch the lives of millions of forest dwellers in the Asia-Pacific region.

7.1.5 Fragmentation and the lack of sustained funding for research seem to be major operational constraints in all of the eight (8) countries. However, excessive centralization (the opposite of fragmentation) has also been a problem in that centrally-formulated research agenda often overlook site-specific issues which ought to be studied.

7.1.6 In most of the eight (8) countries, there is an adequate pool of trained researchers, many of whom are graduates of internationally-recognized universities. There is also a growing realization of the need to intensify research and develop new procedures and technology that will help close the large gap between on-going deforestation and forest land rehabilitation.

7.1.7 Prevailing forest management policies significantly influence the type of research that is carried out. Thus, in timber-rich countries (e.g. Indonesia) the research agenda is dominated by
studies that relate primarily to utilization and somewhat indirectly with rehabilitation. In timber-poor countries, such as India and the Philippines, research is moving away from utilization and more in the direction of rehabilitation treatments, chemistry and microflora/micro-fauna on logged-over lands, gene pool inventories and demographic issues pertinent to rehabilitation.

7.1.8 Given the large number of research studies conducted over the years and the varied country-specific agenda, it is not practical to present a detailed description or comprehensive listing of the research already accomplished or underway. Information on these matters is provided in the country studies annexed to this report and through national and international research institutions. However, it is feasible to describe the research situation in general, and to provide illustrative examples of ongoing work. The succeeding paragraphs in this section of the report summarize current conditions in this regard.

7.2 Completed Research

7.2.1 Research is a continuing process and there is always the potential to generate useful new information on most topics. However, research that has already developed practical methods which may (or are being) applied in rehabilitation programmes can, from that perspective, be defined as "complete" (sometimes described as "mature") technology.

7.2.2 From basic studies, experimentation and extensive field trials, research can be characterized as "complete" in respect of plantation establishment for a large number of species. This is particularly true in the case of exotic (i.e. introduced) species such as Eucalyptus spp., Swietenia macrophylla, Pinus caribea and Leucaena leucocephala. Plantation methods are also well-developed for a number of indigenous species such as Casuarina equisetifolia, Tectona grandis (Teak), Shorea robusta (sal), Arucaria spp., Azadirachta indica (neem), Pterocarpus indicus (narra) and Intsia bijuga (merbau/ipil). Additionally, species endemic to some countries of the Asia-Pacific region and introduced in others (e.g. Gmelina arborea) have been extensively researched with the results broadly applied in rehabilitation programmes.

7.2.3 Biometric evaluation of natural forest regrowth after logging has been a major item on the research agenda of all eight (8) countries. Research output in this area has provided inputs to the formulation of cutting regimes and rehabilitation initiatives pursued through natural regeneration methods (e.g. timber stand improvement). Relatedly, a large number of completed studies discuss changes in microflora, microfauna, nutrient status, water holding capacity and physical properties of tropical soils at various stages in the rehabilitation cycle.
7.2.4 Soil and water conservation methods, both vegetative and structural, have been well-developed and, in some cases, extensively applied. The downstream impacts of deforestation have been studied quite thoroughly, especially in countries where denudation is widespread (e.g. India, Philippines, Thailand). A great deal of effort has been devoted to quantifying the off-site financial losses caused by deforestation. The figure derived from these studies has been used to support investment proposals for watershed management and rehabilitation programmes.

7.2.5 Research on pests and diseases which affect rehabilitation programmes has been another important area of study and published results are available on a broad range of topics. Damping-off and other pest/disease-related problems in seedling production have received considerable attention and methods have been developed to cope with these problems. Furthermore, through applied research, seedling production technologies have been perfected for many different species and in a variety of methods. Some examples are production of stump planting materials for Tectona grandis, bareroot seedlings of Eucalyptus spp., cuttings of Morus alba and Gliricida sepium, preparation of Dipterocarp wildlings, bamboo marcots and so forth.

7.2.6 Germination techniques have been developed to break the dormancy and hasten sprouting of seeds that were formerly considered difficult to propagate such as Endospermum peltatum and some species of rattan.

7.2.7 Agroforestry research has provided input for the design of appropriate, multi-storey planting systems applied in a variety of site-specific conditions. Low-cost methods have been developed for organic fertilization, zero-tillage planting systems, construction of check dams and water impoundments, establishment of erosion-control hedgerows and stall-feeding technology for backyard animal husbandry.

7.2.8 There has been considerable research into mangrove ecosystems such that efficient planting methods for several important genera (e.g. Rhizophora spp., Nypa fruticans) are well-developed and widely-applied.

7.2.9 Extensive biomass production studies have been conducted in mangrove forests and there is a large body of literature on this subject. Some of the important marine fauna that reside in (or are nurtured by) the mangroves have been studied as part of biomass research (e.g. Penaeus monodon and Chanus chanus). Production of animal protein often provides the financial rationale for investment in mangrove reforestation.

7.2.10 A few non-timber forest products have been the subject of research. Mature technology is now available for growing rattan, bamboo, pandanus and palms. Some of the important sources of extracts have been quite thoroughly studied and the results applied (e.g. *Derris* spp.). Other non-timber species research
which dealt primarily with utilization has also produced information that is pertinent to rehabilitation (e.g. development of planting methods for *Lygodium* spp. used in forest-based handicraft industries).

7.2.11 By and large, the centerpiece of completed research has been studies that relate to the major broad-leaved timber species important in the export trade and for domestic consumption.

7.2.12 Updated bibliographies are not available for all the eight (8) countries covered by this report. However, the most recent compilation of the Philippine and Thailand abstracts does indicate that some 260 and 200 rehabilitation studies respectively, have been completed in these two countries.

7.3 On-going Research

7.3.1 Most of the research currently underway deals with the same topics described in the previous section of this report (7.2). In general, on-going research is directed toward obtaining further improvements in rehabilitation technologies for logged-over lands and forests. There are however, several new areas of research that deserve special mention.

7.3.2 In the Philippines, research is moving ahead rapidly on mychorrizae associated with species commonly-grown in reforestation projects. A number of strains have been isolated. Several have been made available in tablets that simplify inoculation as part of reforestation programmes. Preliminary results have been very promising, often enhancing initial growth rates by as much as 200% over control plots. Three million (3.0 M) trees will be planted with mychorrizal tablets in 1990 and researchers monitor performance.

7.3.3 Thailand is conducting research on the financial and biological implication of agricultural intercropping as a standard operating procedure in reforestation projects. This builds on earlier small-scale studies that indicated very positive results. This research is not to be confused with the well-known taungya system since it deals with rehabilitation of non-forested lands (especially grasslands).

7.3.4 Intercropping research in Thailand seeks to develop appropriate technology that is consistent with the principles of multiple-use management. Anticipated results from this research are the design of perennial-annual crop mixed-planting designs that are compatible with timber production and that furnish valuable short-term benefits. Early indications point out the potential to recover tree planting costs and initial maintenance expenses in less than five (5) years, thus substantially increasing the financial viability of reforestation projects.

7.3.5 Indian researchers continue to move forward on identification of superior clones and cultivars of commercially important endemic trees, and the development of seed orchards.
7.3.6 In recent years, commercial application of products derived from Neem (Azadirachta indica) have stimulated planting of this species throughout the tropics. Neem-based insecticidal powders and toothpaste produced in India, are some examples of this synergistic relationship between market forces and rehabilitation.

7.3.7 Further on the subject of seeds and seed orchards, the Philippine government has just awarded a contract to a leading fraternity of professional foresters who will identify superior provenances of seventeen (17) endemic species, collect and deliver seeds accordingly and assist in nationwide seed dispersal to private sector reforestation contractors. This will lay the groundwork for large-scale follow-on adaptability and growth trials. Approximately 20 million trees grown from selected seeds and phenotypically superior sources are scheduled for planting in 1990.

7.3.8 Reports from Malaysia indicate significant progress in determining the financial viability of rehabilitation programmes that focus primarily on non-timber products grown in association with forest trees. Preliminary studies indicate that non-timber products may account for up to twenty-five percent (25%) of potential commercial value per hectare in natural forests. This implies the likelihood of even higher value if non-timber crops are deliberately cultivated.

7.3.9 In fragile lands where steep slopes and other factors mitigate against commercial logging, the development of non-timber forest products planting regimes could provide significant financial benefits. This may help encourage swidden farmers to conserve forests as a perennial source of income from non-destructive harvesting. While swidden is not a serious problem in Malaysia, the neighboring countries of Thailand, Indonesia, India and the Philippines could benefit substantially from Malaysian research on this topic.

7.3.10 In Indonesia, research on growth rates after logging are not new, but current studies take on increased significance considering the rapid expansion of commercial logging operations over the past 10-15 years. If combined with (or influenced by) on-going Malaysian research dealing with non-timber products, there may be a potential to develop financially-viable multiple-use systems that would reduce the incidence of swidden farming and other conversion of recently logged-over forests to non-forest land use systems.

7.3.11 Papua New Guinea (PNG), the Solomons and Fiji are all in the process of broadening their research horizons and this should be further stimulated by the forthcoming establishment of the PNG Forest Research Institute. Meanwhile, it seems that officials in the PNG and Solomon Islands governments are beginning to study socially-oriented approaches to rehabilitation on customary lands.
7.3.12 If one were to identify a single subject matter area for research that all eight (8) countries have prioritized, it would (at this point in time) seem to be agroforestry (i.e. social forestry)—broadly defined.

7.3.13 Stimulated largely by forest development programmes financed by bi-lateral and multi-lateral donors, all of the eight (8) countries have initiated or further expanded research that examines the relationship between forests and local communities. This is not a new topic particularly in India, the Philippines, Thailand and Indonesia where agroforestry programmes have been underway for some 10-15 years. However, it is only lately that initial investments in agroforestry have started to yield quantifiable results.

7.3.14 In India for example, some 3.88 M ha. or about 83.4% of the 4.65 M ha. reported to have been reforested between 1981 and 1985, is said to have been achieved through agroforestry programmes.

7.3.15 In the Philippines, agroforestry approaches have been successfully applied in many areas where conventional systems failed in the past. Improved environmental conditions and higher rural income in these areas have attracted the attention of decision makers. This has facilitated the allocation of additional funding for agroforestry research and implementation.

7.3.16 Along with agroforestry, there is a noticeable shift towards natural regeneration methods to reestablish forests in grasslands. Broadly described in international symposia as "restoration ecology", this new approach has been given various local labels (e.g. Assisted Natural Regeneration in the Philippines, Accelerated Natural Regeneration in Indonesia and abbreviated as "ANR" in both countries).

7.3.17 While long accepted as a normal practice in residual forests, the deliberate nurturing of natural plant succession in grasslands (i.e. ANR) has not received significant attention in the past. Recent interest in this subject has been attributed to several demonstration projects that re-established woody perennials as the dominant vegetation in former grasslands within less than three (3) years.

7.3.18 Several well known researchers (notably Sajise and Dalmacio of the Philippines) are active in implementation of rehabilitation programmes that rely on plant succession dynamics and are documenting the transformation of grasslands into tree-dominated ecosystems over time.

7.3.19 To conclude this summary of on-going research, it is apparent that many new studies are underway which focus on mangrove ecosystems. Most of these studies are designed to enhance the success of Rhizophora planting programs by identifying the appropriate planting sites for various species within this genera. For example, some Rhizophora spp. seem better suited for
planting close to the shoreline while others should be planted on
the seaside fringe. The latter seem not to attract various
shellfish that attach to and deter the growth of certain
Rhizophora species. Researchers are also attempting to develop
simple propagation techniques for Avicennia spp. and Sonneratia
spp.

7.4 Research Gaps

7.4.1 The issue of research gaps has two (2) major dimensions. One is
the need for a more thorough understanding of the basic dynamics
of forest ecosystems. For example, why do forests develop in
certain ways and what stimulates the various phenomena that occur
from time to time? Up to now, it is not even clear what triggers
the fruiting and seed production of certain Dipterocarpaceae, one
of the most important families of tropical forest trees.

7.4.2 Tropical forests are the most diverse of all terrestrial eco-
systems on the planet. This clearly suggests that it will not be
easy to find answers to some of the basic questions of tropical
forest ecology. Oversimplified, one could say that there are
almost as many gaps as there are kinds of trees, and Indonesia
alone has an estimated 10,000 arboreal species.

7.4.3 The other major dimension to research gaps relates to operational
issues. One vivid example is the failure to incorporate mature
technology from agriculture into research, planning and implemen-
tation of agroforestry and reforestation programmes.

7.4.4 For instance, planting of leguminous cover crop (e.g. Centrosema
pubescens, Pueraria javanica) has a long history in agricultural
plantation establishment (e.g. rubber, oil palm, coconuts).
However, there has been little if any adaptive research to extend
application of this treatment to reforestation of degraded
grasslands. Additionally, technology developed in the orchard
industry has not been deliberately adapted to suit the require-
ments of agroforestry.

7.4.5 Insufficient attention to endemic species is perhaps the most
noticeable gap in forest rehabilitation research. All-to-often,
there has been a tendency to plant exotics as the major species
in reforestation and watershed management programmes. Many pro-
ject managers have ready access to information on fast-growing
exotics. But they search in vain for data on the germination and
planting methods suitable for many fast-growing endemic species.
The same holds true for several of the premium timbers such as
Toona kalantas and Dipterocarpus grandiflorus.

7.4.6 Sociological research that can help rationalize the formulation
of forest policy is another area of study that needs further
attention. The comparison between reforestation programmes in
Fiji, and similar programmes in Papua New Guinea and the Solomon
Islands, illustrates the beneficial results that can accrue from
careful study of local customs, traditions and perceptions.
7.4.7 In Fiji, customary owners are fully involved in the design and implementation of reforestation projects. Although much smaller than Papua New Guinea and about forty percent (40%) smaller than the Solomons, Fiji has reforested 37,000 ha. while the other two countries combined have only reforested some 32,000 ha. Independent appraisals of this situation point out that PNG and the Solomons have not effectively involved customary leaders in programme implementation. This implies a void in understanding that can be significantly minimized if appropriate sociological research is carried out and the results applied.

7.4.8 The technical and financial feasibility of upland irrigation systems that can expedite reestablishment of forests on hilly lands, is another important topic that has been overlooked in research. For example, while sophisticated drip irrigation methods are widely used in lowland orchards, reforestation research has yet to explore even the most rudimentary forms of drip irrigation (e.g. conveyance in bamboo tubes or cheap plastic pipes).

7.4.9 Many upland reforestation sites have springs that could be (but are not being) tapped to irrigate newly-planted trees. Lack of water during the dry season is the principle limiting factor to rapid re-establishment of hilly land forests on degraded grassland. However, practical solutions to this problem have not been tested. Similarly, the financial feasibility of using water absorbent polymers to increase rainfall retention has yet to be seriously examined by reforestation researchers in the region.

7.4.10 Recent interest in the application of plant succession dynamics for grassland rehabilitation (i.e. Assisted/Accelerated Natural Regeneration) has exposed another major gap in forest research. With few exceptions, this study area has been ignored for decades.

7.4.11 It also seems imperative to conduct more research on the financial viability of non-timber crops. In most of the eight (8) countries, demographic pressure and budgetary constraints seriously impede progress of rehabilitation programmes. More emphasis on non-timber crops can help address these problems, in the same way that agricultural intercropping can increase the chances for success in reforestation.

7.4.12 The range of non-timber crops compatible with tree-dominated ecosystems is very extensive but largely unexplored. For example, preliminary estimates in the Philippines indicate that about 2.5 ha. planted to thirty percent (30%) bamboo, rubber and spices, and the balance planted to timber species, can support a family of six (6) persons.

7.4.13 The approximate land-to-man-ratio indicated above (7.4.12) is typical of many tropical countries including several covered by this report. There is an urgent need for research along lines that identify practical opportunities to maximize the use of labor.
and create more gainful sustainable employment per hectare than can be provided through traditional forest management approaches.

7.4.14 Finally, there is an acute lack of reliable data on the extent of deforestation and the area covered by reforestation programmes. This demonstrates the need for research that will provide a reliable overview of current conditions. Faulty, inaccurate and incomplete data have been impediments to government and donor-assistance investment in the rehabilitation of logged-over lands. If this problem is not addressed, forestry cannot compete successfully with other sectors for the financing needed to support rehabilitation programmes.
8.0 GAPS BETWEEN RESEARCH AND ON-SITE REHABILITATION

8.1 Earlier sections of this report made reference to the relatively under-developed status of research in Papua New Guinea, the Solomon Islands and Fiji. On the other hand however, the linkage between research and the application of research results, is very strong in all of these countries. Research is conducted to solve clearly-identified problems. There is virtually no gap between study and implementation. Elsewhere in the region, there are significant gaps.

8.2 As cultures become more diverse and sophisticated there is a natural tendency to specialize. Quite often in forestry, specialization has been carried out to such an extent that researchers and field implementors rarely communicate or understand one another's problems.

8.3 With the exception of the three countries mentioned above, the gap between research and on-site rehabilitation is quite apparent from the country studies that provided the background for this report. Much of the published research never reaches the field and even when this problem is overcome, there is still a serious lack of communication.

8.4 Research terminology appropriate for academics is not likely to be understood by the average implementor whose vocabulary rarely includes the phrases preferred by professional researchers. Similarly, when the implementor describes his problems, the average researcher will often misunderstand what is needed or may misinterpret the information he receives.

8.5 Indeed, most of the gaps between research and on-site rehabilitation can be traced back to lack of communication and ineffective dissemination. Other gaps can be attributed to either policy or institutional constraints.

8.6 Operationally, some of the more obvious gaps relate to basic problems in the field. For example, seed storage methods that are suitable in a laboratory are rarely applicable in a reforestation project site. Refrigeration and controlled humidity are not available in most of the hinterlands. Researchers accustomed to these sophisticated facilities have often failed to develop seed storage technology that is effective under field conditions.

8.7 Improvement in site preparation methods receives very little attention from the research community, but can often spell the difference between failure and success in a reforestation project. This is a promising area for research that continues to be ignored.

8.8 In agriculture, thorough site preparation is considered essential and technology is available for a variety of conditions. But this technology is seldom disseminated to reforestation and agroforestry
project managers. Moreover, without the academic stamp of approval, financial managers often hesitate to approve budgets that deviate from traditional reforestation norms. Additionally, agricultural intercropping will not be feasible if the establishment of reforestation plantations fails to include adequate site preparation.

8.9 Another serious gap is the failure to communicate vital information in a timely manner. For example, Canker infestation in Albizia falcataria plantations was apparent as early as 1979 in the southern Philippines. But it was only in 1989 that tree farmers were advised to shift from A. falcataria to other fast-growing species.

8.10 Much of the research conducted in recent years has focused on exotics. Where there is no appreciable difference between conditions at field sites and research stations, favorable results in planting exotics can be replicated successfully. Unfortunately, replication over a large area without interim field trials has occurred, and there have been serious negative consequences. Obviously, another major gap is the failure to move systematically from technology generation to adaptability trials before proceeding with broad scale application.

8.11 On the matter of regeneration in logged-over residual forests, gaps have been brought about by a pervasive reliance on un-assisted natural methods to re-establish commercial stands. Researchers have developed appropriate treatments for expediting restoration of second-growth forests while still retaining the basic characteristics on undisturbed forests. However, forest managers have generally neglected to apply these methods.

8.12 The principal impediments to implementing natural regeneration in residual forests have been insecure tenure and lack of financial incentives to maintain the residual stands until such time that a subsequent harvest is feasible. In this case, the gap between research and appropriate policies and failure to develop and legitimate multiple-use methods that can support rehabilitation expenses which accrue between timber harvest rotations.

8.13 Unreliable access facilities have been identified as a serious gap in many locations. For example, acidic soils in degraded grasslands can readily be improved by applying lime in amounts easily quantified by researchers. However, lack of roads, trails and transport facilities makes this impractical.

8.14 The gaps between research and field application are numerous and it is unlikely that this situation will change unless the basic problems of communication are minimized. It would be unrealistic to assume that researchers will develop the communication skills required to effectively disseminate results of their studies to field implementors. Similarly, one cannot expect that implementors will learn how to communicate effectively with research institutions.
8.15 Bridging the information gap poses challenges to the agencies and individuals whose principal area of expertise is communications. This situation also demonstrates that forest researchers, forest managers, and forestry planners need to reach out and enlist skills they have not previously mobilized to address the problems of forest rehabilitation.
9.0 RESEARCH PRIORITIES FOR THE FUTURE

9.1 Given prevailing conditions in the eight (8) countries, and looking ahead to the future, it seems clear that research will need to be prioritized in at least five (5) key areas: policy, field operations, sociology, financial viability and communications.

9.2 Policy Research:

9.2.1 Many of the impediments to rehabilitation of logged-over lands relate directly to policies that are unrealistic, inappropriate or lack the scope required to address basic issues. For example, in response to public pressure, many countries (including two covered by this report) are considering, or have imposed, a total ban on logging. On the surface, this may seem to be a direct and rational way to stop deforestation. But it ignores the reality that wood is an essential commodity.

9.2.2 If wood is not provided legally, the demand for this commodity will most likely come from illegal sources. Legally-cut wood is derived from managed forests and illegally-cut wood implies that forests are not being managed. Seldom are rehabilitation programmes successful in un-managed forests.

9.2.3 All past experience demonstrates that where there is high population density, un-managed forests are rapidly converted into marginal forests and then into deforested lands. Logging bans may exacerbate the rate of forest loss.

9.2.4 Policies that bring about better enforcement of logging regulations and induce voluntary application of sustained-yield management (or both), would seem to be more appropriate than log bans. Carefully-targeted policy research can examine various options.

9.2.5 The whole range of issues that pertain to multiple-use may also need to be addressed through policy research. For example, would labor-intensive logging methods be more appropriate than the systems currently applied if they were combined with more frequent cycles and optimal utilization of non-timber products? Perhaps this multiple-use approach, or something similar, would provide a policy environment conducive to community management of forests or community partnership with timber corporations.

9.2.6 Many of the prevailing policies assume that capital-intensive systems are a pre-condition to efficient management of forests. It is clear however, that these systems effectively prevent rural communities from participation in the wood industry. This situation creates disincentives to community involvement in forest conservation. Slash-and-burn destruction is often attributed to lack of forest-based livelihood opportunities for upland communities.
9.3 Field Operations

9.3.1 Research abstracts and bibliographies do not provide any indication that rehabilitation has been seriously studied from the perspective of a field implementor. There are undoubtedly many experiential lessons from the field that should be incorporated in forest rehabilitation technology, procedures and planning. The relative efficiency of different types of tools and various site preparation methods are two examples. Others could include agricultural intercropping, establishment of piece-work rates that encourage efficiency, provision of health services, and so forth.

9.3.2 Informal interviews with field workers often reveal their lack of enthusiasm over rehabilitation plans and procedures they perceive to be illogical, but with which they are required to comply. Surely, the man who wields the machete in T.S.I. operations, or handles the shovel in reforestation has many lessons to share.

9.4 Sociology

9.4.1 The increasing importance of social forestry (often called "agroforestry") makes it imperative to learn more about the dynamics of what will work and what should be avoided in rehabilitation programmes that involve rural communities. For instance, the entry points for some of the more successful social forestry programmes have been construction of trails and water systems, provision of health services and fielding of veterinarians. Work in these areas established credibility and provided insights that eventually enhanced performance in tree planting, soil conservation and other social forestry endeavors.

9.4.2 Studies with a sociological perspective may also indicate where it would be worthwhile to consider policy reforms or new approaches that could stimulate community-implemented rehabilitation. It also seems likely that delivery of technical services would improve if social forestry managers know which crops are most important to their clients, what production problems need to be addressed and what risks might be involved if new technology is introduced.

9.5 Financial Viability

9.5.1 All-too-often, reforestation plans fail to address the issue of financial viability, without which rehabilitation programmes may not be sustainable. The potentially positive impacts on financial viability of agricultural intercropping and planting of non-timber crops, have been mentioned earlier. These seem to offer excellent opportunities for carefully-targeted research.

9.5.2 Furthermore, there are apparently good prospects for modifying the regulations governing timber stand improvement such that T.S.I. can be converted from a cost center into a modest profit center. Processing of tops, branches, buttresses and culled
trees into saleable commodities should probably be considered and encouraged. If post-logging treatments can at least yield sufficient income to offset costs, this should stimulate more consistent application of T.S.I. in logged-over residual forests.

9.5.3 The long-term planning view that is normal in forest management and rehabilitation, should not disregard the need for interim benefits. The latter can provide the financial capability to sustain enthusiasm and defray costs until such time as rehabilitation investments mature.

9.6 Communication

9.6.1 As mentioned earlier in this report, the gaps between research and implementation will be difficult to overcome if communication linkages are not improved. The conventional view that development of appropriate technology should be prioritized is undoubtedly valid. But without reliable feedback how does one determine whether or not a specific technical treatment is really appropriate?

9.6.2 Over the years, communication has evolved into something that is more than an art, not quite an accurate science, but still containing many features of both. Unfortunately, the importance of good communication has rarely been emphasized in rehabilitation programmes. It would seem appropriate to study how the communication disciplines can be effectively applied in the years ahead.

9.7 There are many other research priorities that could be mentioned, primarily in the biological field and related disciplines. However, research has traditionally moved in these directions and will undoubtedly continue to do so. The proposed priorities suggested above highlight certain issues which have not been adequately addressed in the past and that should receive attention in order to improve overall performance in rehabilitation programmes.
10.0 A PROPOSED RESEARCH PROGRAMME

10.1 Among others, Sections 7 and 8 of this report deal with constraints and gaps that impact on rehabilitation programmes. Section 9 suggests general directions for research in several areas that were previously ignored, overlooked or not prioritized. This section of the report provides a specific list of research topics that would address major problems and/or create new opportunities to enhance rehabilitation of logged-over forest and forest lands.

10.2 Assisted/Accelerated Natural Regeneration (ANR)

10.2.1 Initial trials in the Philippines and Indonesia provide convincing evidence that ANR methods will significantly reduce the costs incurred to rehabilitate degraded grasslands. Moreover, replacement of grass with woody perennials and establishment of stable plant populations is faster when compared with the results obtained through conventional methods.

10.2.2 Although based on plant succession dynamics which evolved over millions of years, the deliberate implementation of ANR is relatively new. There is a need to develop ANR implementation procedures that are easy to explain, simple to demonstrate and not difficult to monitor.

10.2.3 ANR begins with the liberation (through ringweeding) of woody vegetation suppressed by, or in competition with, grass. It is sustained by additional liberation treatments, pressing down the grass and fire prevention. When the population of naturally-occurring woody species is sparse, some enrichment planting may be required. On the other hand, it is also probable that additional woody growth will emerge from dormant seeds that sprout when grass competition becomes less intense because of frequent pressing. Furthermore, natural dispersal of new seeds (by birds, wind, etc) may occur, thus reducing or eliminating the need for artificial enrichment.

10.2.4 Research can help determine when and whether enrichment planting is required, under what conditions, at what cost and the species that should be introduced. The appropriate answers to all of these questions will be dependent on the objectives of rehabilitation, programme schedules, site characteristics and other variables. Additionally, it should be feasible to determine whether direct seeding should be carried out as part of an enrichment strategy in order to further reduce costs.

10.2.5 Species compatibility studies will be important, especially when premium hardwood species are introduced amongst natural pioneers to convert a site into a production forest.
10.3 Financial Viability in Timber Stand Improvement

10.3.1 As implied in Section 9, it may be feasible to encourage more active implementation of T.S.I. if opportunities for commercial use of thinnings, tops, branches, etc. are made available. However, the temptation to deliberately harvest trees that ought to be retained must be considered. Practical methods to prevent this from occurring need to be developed. For example, complete (100%) inventories prior to T.S.I. would provide a means to check performance. The costs for conducting complete inventories should be established and this requires field trials under various conditions.

10.3.2 Processing of raw material produced in T.S.I. operations will undoubtedly pose new challenges to researchers. Raw materials would be very heterogenous in size, quality and other characteristics. Processing methods and equipment would have to be designed accordingly. Portability may be an important consideration and two stage-processing might be required to reduce materials-handling costs (e.g. rough squaring in the woods and final processing elsewhere).

10.3.3 Frequency of T.S.I. treatments will impact on financial viability and on effectiveness (i.e. enhancing quality of the residual stand). Appropriate schedules will need to be determined that consider financial viability, effectiveness and variable conditions in logged-over forests.

10.3.4 Under certain conditions, financial viability may be further enhanced by temporary intercropping with shade tolerant crops (e.g. ginger) on skid trails or other areas where the soil has already been disturbed. In some cases, semi-perennials that do not detract from long term timber production objectives may be planted (e.g. Musa textilis). Where markets are available, the potential for growing ornamentals could also be explored (e.g. orchids, decorative ferns and palms). Intercropping timber species and rubber could also be considered.

10.4 Market Studies

10.4.1 Two recent developments may have far-reaching effects on the market for tropical timber. One is the proposed ban on tropical wood imports in some European countries. The objective of this ban would purportedly be to help discourage logging of natural forests. However, another impact might also be that potential investors will no longer proceed with plans to establish forest plantations. Investors need to better understand the parameters that will be applied if import bans are imposed. It will also be important to determine which species, if any, will be excluded from the proposed ban. In this case, advocates for the ban would presumably be confident that these species are produced in plantations and not harvested in the natural forests. All of this information will be vital in order to encourage continued investment in forest plantations.
10.4.2 Another development is the perceptible shift toward light-colored wood in certain markets (e.g. furniture). If this is the emerging trend, reforestation programmes should be designed to include more light-colored woods. Traditionally, the tropical wood market has been dominated by red and dark red timber.

10.5 Endemic Species

10.5.1 While thousands of timber species are endemic to the tropics, probably less than one hundred are being planted in rehabilitation programmes. Very little is known or recorded regarding pheno- nology, germination procedures and appropriate planting methods for endemic trees. Research in these areas can open up new opportunities in reforestation and in programmes that are directed towards conservation of endemic species.

10.5.2 Greater utilization of lesser-known species is another area of research that may provide significant benefits. Among others, broader use of lesser-known species might reduce the pressure on valuable species that are becoming scarce or endangered.

10.6 Non-timber Crops

10.6.1 The commercial utilization of non-timber crops in tropical forests is confined to very few species (e.g. rattan, bamboo, *Lygodium* spp., etc.) But it is well known that indigenous cultures use a broad range of non-timber forest species. For example, a monograph on the Aeta tribes of Zambales, Philippines identified 250 species of plants used in that culture (FOX, 1950). Research may uncover a potential to develop commercial application of these plants or products thus increasing their value to upland communities and providing incentives for forest conservation.

10.6.2 Relatedly, research should be conducted on planting regimes for non-timber products. Very few agronomic studies have been carried out for non-timber species.

10.6.3 Research on this subject should also address the policy constraints to organized commercial use of non-timber by tribal communities. Rules, regulations and procedures are usually formulated along lines that reflect the views of urban-based technocrats. If tribal communities are to benefit from non-timber crops, rules suitable for their culture need to be drawn up and officially promulgated. This will not be possible without careful research.

10.7 Labor-based Timber Production Methods

10.7.1 In the rush toward modernization, many governments in tropical countries have overlooked the potential to satisfy timber demand by relying on centuries-old methods that do not require machinery and which provide badly-needed employment. Research on this topic should consider the relative environmental impacts of
labor-based versus machine logging systems.

10.7.2 Negative environmental impacts caused by logging must be overcome by investments in rehabilitation. If negative impacts are minimized, rehabilitation costs can be reduced. It is universally recognized that labor-based timber production methods are significantly less destructive than machine logging but the relative degree of damage has not been formally studied.

10.7.3 Financial viability is another dimension to be examined in respect to labor-based systems. For example, hand-sawn lumber can often be purchased at much lower cost than lumber produced by timber corporations. However, hand-sawn lumber is usually produced surreptitiously because official license to produce lumber from natural forests has normally been granted to organized companies, rather than to village residents. Thus, there is a dearth of formal studies that compare the financial viability of labor-based methods and machine-based methods. The policy implications of such studies could be quite significant.

10.7.4 Additionally, studies that explore the potential to combine labor-based production of raw materials by villagers, with sophisticated down-stream processing by the formal business sector, could provide insights that would help reduce the on-going conflict between villagers and timber companies. The agricultural sector has made great strides in this direction by developing contract-growing systems. Something akin to this approach would seem appropriate and perhaps imperative in forestry.

10.7.5 As implied earlier in this report, it would also seem worthwhile to re-examine some of the basic precepts of sustained-yield logging. All of the formal systems currently in place envision harvest of growth increment accumulated over 30-40 or more years, with no interim harvesting between cycles. Perhaps these systems should be revised so that a smaller percentage of growth increment (or natural standing stock) should be removed at each harvest cycle under systems that envision more frequent harvest cycles. For example, if the harvestable stand (i.e. trees 60 cm. d.b.h. and up) is 50 cubic meters per hectare, perhaps 5 cu.m. should be removed in each of 10 cycles spaced at 5 yr. intervals. If combined with labor-based methods, this would respond more effectively to the need for sustained employment in tribal villages. Moreover, the wide gaps in crown cover created by more intensive harvesting (with machines) at longer intervals would be avoided. Reduced damage at any point in time can enhance the effectiveness of natural regeneration methods and T.S.I.

10.8 Impact of Logging Bans

10.8.1 Tropical forest depletion has become a major environmental issue often charged with high emotion. Log bans have been suggested as one solution to this problem and several bans have been imposed. The impact of these bans needs to be studied and documented by researchers that have impeccable credentials. Early indications
are that the rate of forest loss increases wherever log bans have been imposed. This has very serious implications. It does seem clear that most of the decisions on this matter have been influenced by people and organizations that mean well but have little if any intimate knowledge of the dynamics at play in tropical forests.

10.8.2 If previous negative experiences with log bans are repeated, (and this seems likely) it will be essential to promptly re-examine the concept and change directions. However, log ban advocates are very influential and will probably remain adamant unless convinced by valid, verifiable evidence presented by impartial highly-respected researchers. Studies in this area should be linked with research on labor-based methods.

10.8.3 The demand for wood cannot be expected to diminish. Therefore, socially-acceptable systems for supplying this demand need to be formulated. Community-owned/labor-based approaches would be one logical response. For very valid environmental reasons, it is doubtful that logging ban advocates would accept resumption of machine-based logging. At the same time, it seems clear that log bans will result in totally un-managed forests. This must be avoided.

10.9 Technology Upgrading

10.9.1 As implied earlier (Sec. 7, 8 and 9) there are many opportunities to improve efficiency in rehabilitation programmes. Some research areas have already been mentioned (e.g. ANR, endemic species, agricultural intercropping, etc.). But there are many others that should be considered.

10.9.2 In many countries, tree planters use inefficient tools. Research and development directed toward production of better tools could be very beneficial.

10.9.3 Adaptive forestry research to apply the lessons from previously-completed agricultural research is long overdue. Some interesting topics would include upland irrigation systems; cover-cropping and other site amelioration treatments; the use of water-absorbent polymers to enhance moisture retention capability; development of seed storage methods that do not rely on sophisticated facilities; and tree improvement programmes (e.g. breeding, mass-production methods for vegetative propagation of superior clonal planting material).

10.10 Policy Studies

10.10.1 Tenure and land use issues would be important topics for policy studies. Many of the regulations currently in place do not consider traditional tenure systems but merely initiate systems in vogue elsewhere. This is illustrated by the absence of policies and procedures that envision multiple-use forest management implemented by upland communities. Government agents are
often expected to enforce laws that conflict with long-standing traditions and indigenous cultures. Rarely do tribal groups sincerely acknowledge central government authority to dictate how lands and forests are used. Regulations are grudgingly accepted out of fear, or actively-resisted. Bloodshed and loss of lives are not uncommon. If realistic, pragmatic policies are formulated and installed, much of this conflict can be avoided.

10.10.2 Policy studies could also address the matter of community organization. Many extension agents who work in this area are required to follow strict guidelines that prescribe the structure of community organizations or village associations. Quite often, these guidelines are conceptualized without considering traditional structures already in place which have served villagers well in the past. Research which analyzes the features of traditional structures should reveal how government guidelines can be drawn up to conform with village norms rather than expecting villagers to re-arrange their lives along lines envisioned by outsiders.

10.10.3 Malaysia and the Philippines have revised their implementation procedures to include contract reforestation implemented by the private sector. Results have generally shown this to be a better approach than reforestation by government agencies. Other countries in the region may benefit from studies that examine the Malaysian/Philippine experience to determine whether this system would be suitable for inclusion in their rehabilitation programmes.

10.11 Genetic Resources: The rich biosphere of the tropical forests has never been fully studied. Research on this matter needs to be expedited for a number of reasons including (a) the potential to develop new medicines and other products (b) conservation of endangered species.

10.12 Data Collection: Data collection and recording systems have not kept pace with information requirements. This is obvious from the numerous data gaps mentioned earlier.
11.0 TREATMENT AND ACTIVITIES FOR VARIOUS TYPES OF LOGGED-OVER FORESTS

11.1 The eight (8) country studies suggest a variety of treatments that may be applied to enhance rehabilitation of logged-over forests. The principal features of these treatments are summarized hereunder excluding however, methods for conversion of marginal residual forests to plantations. The latter are already well-covered by standard forestry literature.

11.2 T.S.I. in Dipterocarp Residual Forests:

a. Complete (100%) resource inventory and preparation of development plans;

b. Selective cutting and sale of mature but defective trees using labor intensive methods;

c. Release cutting to promote the growth of premium crop trees (PCT's);

d. Enrichment planting;

e. Fire prevention, including establishment and maintenance of firebreaks;

f. Assisted natural regeneration (ANR) in fragile areas;

g. Planting of rattan, bamboo and useful vines;

h. Agroforestry in occupied lands

11.3 T.S.I. in Pine Forests:

a. Complete (100%) resource inventory and preparation of development plan;

b. Greenbelt establishment with fire-resistant species (e.g. Alnus spp., wild sunflower);

c. Where adequate seed trees are available: controlled burning between greenbelts timed to coincide with the appropriate months for seed scarification;

d. Enrichment planting in the absence of an adequate number and distribution of seed trees, using site preparation treatments "e", "f" and "g" hereunder;

e. Suppression/elimination of fire prone grass by plowing on slopes less than 18% and by covercrop planting, herbicide, frequent brushing and pressing wherever plowing is not feasible;

1) Further amplified in Sect. 11.4
f. Excavation of planting pits before onset of the dry season preceding the planting months;

g. Soil improvement in the planting pits including placement of moisture retention additives, mychorriza innoculants, basal fertilizer application and organic matter (e.g. grass and/or manure gathered on site);

h. Planting of pine and endemic broadleaf species;

i. Agroforestry on occupied sites.

11.4 Rehabilitation of Sub-marginal Forests:

a. Complete (100%) resource inventory and preparation of development plan;

b. ANR treatments;

c. Enrichment planting with appropriate species (e.g.) bamboo, *Vitex parviflora*, *Gliricida sepium*, *Meliaceae spp.*, *Swietenia macrophylla*, *Pileostigma malabaricum*, *Leucaena diversifolia*;

d. Fire prevention, including establishment of firebreaks;

e. Agroforestry in occupied areas.

11.5 Reforestation in Grasslands and Brushlands with no Occupants:

a. Delineation of areas for development of production forests and protected forests;

b. Suppression and/or eradication of fire-prone grass species (e.g. *Imperata cylindrica*) by plowing, herbicide treatments and pressing;

c. Planting of perennial leguminous covercrop vines;

d. ANR treatments;

e. Wherever feasible ... complete plowing on slopes from 0-18% slope and strip plowing on slopes from 19-50%;

f. Excavation of planting pits before onset of the dry season preceding the planting months;

g. Soil improvement in the planting pits including placement of moisture retention additives, lime as needed, basal fertilizer application, mychorriza innoculants and organic matter (e.g. grass and manure gathered on site);

h. In all production forest sites: planting of nurse species and shade tolerant intercrops to provide food for the labor force (e.g. *Cajanus cajan*, bananas, taro, ginger, chili pepper);
i. Reforestation of protected forest sites with a diversified mixture of endemic trees, bushes, palms, bamboo, useful vines and occasional fruit/nut producing trees;

j. Reforestation of production forest sites with suitable premium tree species (endemics and exotics) planted amongst the nurse species;

k. Planting of bamboo and Pandanus spp. along all streams and gullies which have adequate moisture;

l. In gullies and waterways, construction of low-cost brush dams and check dams at vertical intervals of approximately 15-20 meters;

m. Planting permanent vegetative barriers across gulleys or waterways (e.g. double and triple rows of Gliricida sepium, bamboo or Pandanus spp);

n. Establishment and maintenance of firebreaks not less than 10 meters wide at intervals not exceeding 200 meters.

11.6 Rehabilitation of Grasslands/Brushlands Occupied by Settlers:

a. Consultation with settlers to determine acceptable interventions;

b. Preparation of development plans based on consultation;

c. Labor-based construction of access trails implemented by occupants, paid for by the government and supervised by competent project managers;

d. Communal planting of trees, bushes and perennial leguminous vines on both sides of access trails;

e. Construction of box springs;

f. Building on the organization of work teams as a result of "c", "d" and "e" ... encourage work teams to establish vegetative erosion control hedgerows at vertical intervals of approximately 1.5 to 2.0 meters, using woody perennials suitable for pollard management (e.g. Gliricida sepium, Leucaena diversifolia, Flamengia congesta, Cassia spectabilis, Morus alba, Alnus japonica). To the maximum extent possible, rely on volunteer labor of work teams rotating from farm to farm, and limit project inputs to planting materials, tools and extension. If volunteer labor is not feasible, provide partial subsidies (e.g. pay labor at 50% of normal rates and/or supply food-for-work);

g. Encourage farmers to practice contour plowing between vegetative hedgerows and plant annual crops, fruit trees or other perennials;
h. Where plowing is not feasible, encourage the planting of perennial leguminous vines that can be pressed down periodically and interplanted with annuals or perennials using zero-tillage methods. Furnish the farmers with seeds of leguminous vines and seedlings of perennials;

i. Analyze soil and apply lime (preferably dolomite) wherever necessary. Furnish the farmers with lime in exchange for maintenance work implemented in the access trails (i.e. payment in kind);

j. Encourage farmers to practice pollard management of erosion control hedgerows and use trimmings in cut-and-carry livestock feeding operations, or apply the cuttings as green manure on the croplands between erosion control hedgerows;

k. Implement reforestation under contract with the farmer work groups on lands the occupants agree to set aside for forest development. Apply ANR methods and subsequently interplant with perennials that can produce useful commodities via non-destructive harvesting (e.g. fruit trees);

l. Introduce compost pit and basket composting technology in the areas reforested under contract to encourage by demonstration the on-farm adoption of these technologies;

m. Through project nurseries, introduce high-value perennials not previously available to the farmers (e.g. black pepper, cinnamon);

n. Introduce improved fallow systems on idle lands farmers intend to plant in the future by planting semi-perennial herbaceous legumes (e.g. Crotolaria juncea, Centrosema pubescens, Pueraria javaniza, Styllosanthes spp., Calopogonium);

o. Ensure sustained maintenance of access trails to encourage frequent visits by extension agents and to facilitate marketing and the delivery of social services;

p. Establish and maintain firebreaks and organize communal fire prevention teams.

11.7 Rehabilitation of Degraded Pastures:

a. contour plow wherever feasible (i.e. gradual slopes) and plant improved grasses and perennial leguminous forage;

b. where plowing is not feasible ... eliminate fire-prone grass species (e.g. Imperata cylindrica) by applying systemic herbicide (e.g. Glyphosate) and introduce improved grasses/ legumes;
c. Establish brush and tree forage by planting hardy, fire-resistant species such as *Pileostigma malabaricum*, *Acacia spp.*, and *Gliricida sepium*;

d. Reforest all slopes greater than 50% applying ANR methods and implement enrichment planting with species not attractive to livestock (e.g. *Pithocelobium dulce*, *Acacia farnesiana*);

e. Establish vegetative erosion control hedgerows with species suitable for pollard management to produce forage, and adopt a cut-and-carry system;

f. Establish and maintain firebreaks and strictly enforce fire prevention rules and methods;

g. Practice rotational grazing and delineate paddocks by planting closely spaced trees that can be established with hi-stump planting stock (e.g. *Gmelina arborea*) or large branches (e.g. *Erythrina orientalis*);

h. Where feasible, change over from free grazing methods to cut-and-carry methods.

11.8 Logged-Over Mangroves:

a. Carry out appropriate consultation meetings and community organization work;

b. Delineate planting blocks and assign to work groups of coastal dwellers;

c. Award reforestation contracts to the families/work groups with provision for eventual conversion of contracts to long-term lease and utilization permits;

d. Plant mature propagules of *Rhizobia* spp. at intervals of 1 x 1m in planting holes prepared by thrusting a metal bar or hardened stick into the soil;

e. Time planting to avoid egg laying season of major shellfish species that produce spats which would attach to the propagules;

f. Time planting to avoid wave-action caused by prevailing winds;

g. Wherever necessary, construct brush piles to provide temporary protection against waves (e.g. piles of coconut fronds, bamboo branches or any other available materials);

h. In addition to *Rhizobia* spp. ... plant other species that can be propagated in nurseries (e.g. *Avicennia marina*);

i. Guard against damage by stray animals;
j. Periodically thin to lower planting densities over time;

k. Wherever feasible, set aside part of the site for planting seagrass and seaweed species.
12.0 CONCLUSION

12.1 One of the lessons of the latter half of the 20th century has been the finiteness of life systems on earth. No longer can the resources be treated as something that will always be there when needed. Clearly, growing concern for tropical forests reflects a realization that action must be taken soon to arrest and reverse the trends of forest loss.

12.2 Yet appropriate measures cannot be effectively organized without reliable qualitative and quantitative information regarding the tropical forests. The country reports indicate the need for a more comprehensive assessment and rational presentation of forest resource data. They also point to a need for greater understanding through research of the internal and external dynamics of the tropical forests in order to determine the proper approaches and directions of rehabilitation.

12.3 People who live within and near tropical forests, especially upland tribal and settler communities, must play a leading role in conservation, restoration and rehabilitation of tropical forests. Appropriate technologies for forest care, use and regeneration can be improved and disseminated. Policies and procedures can be designed to promote these thrusts.

12.4 Perhaps the beauty and richness of tropical forests and the tragedy and dire consequences of their loss will unite people and governments in the region beyond the limits of political ideology.

12.5 If mankind is convinced of the importance of tropical forests for life on earth, then reducing inequity and promoting simpler, less wasteful life styles in developed countries - without implying a less fulfilling life - becomes a matter for reflection. Development and the future of tropical forests relate closely to the way we think and live. Assumptions about the endless capacity of earth to provide whatever we desire can be critiqued and changed.