Review of forest management systems of tropical Asia

Case-studies of natural forest management for timber production in India, Malaysia and the Philippines

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Foreword

In recent years FAO's Forest Resources Division has undertaken a series of studies on management of tropical humid forests in collaboration with national institutes in developing countries. FAO's Forestry Papers 53 and 55 presented case studies of management systems in India; and in Ghana, Honduras and Trinidad. A Forestry Paper in preparation will review management systems for tropical humid forests in Africa, and a subsequent review of Latin America is planned.

This paper shows that sustained management of tropical humid forests is feasible and economically viable. It further clearly demonstrates that forest management systems cannot be developed in isolation but, in order to be successful, they must be adapted to prevailing economic and social realities of the countries concerned, and carried out with the approval and active collaboration of the local communities.

Although there are considerable gaps in our knowledge of the biology and ecology of the humid tropical forest these do not, per se, prevent initiating management programmes, carried out in parallel with studies and research aimed at improving present-day practices in the future.

The tropical humid forest can survive only if the land itself is seen by the people concerned to be more valuable retained as forest than converted to any other form of land use. Future survival of the forests thus depends on their productive utilization, at the same time ensuring the conservation of genetic resources and the maintenance of the environmental functions such forests perform.

A key factor in forest management is political will to institute effective management programmes. The stakes here are enormous: the quality of life of millions of people will depend on sustainable, productive land use; ecosystem conservation and the conservation and management of genetic resources are inseparably tied to sustainable development; small and large-scale industries in tropical countries, a mainstay of national economies and many local communities, will only contribute to development if they can be assured a continuing supply of raw materials.

FAO will continue to assign highest priority to the conservation and sustained use of tropical forests, in support of national development programmes; and to provide a forum for technical and policy-level discussions furthering the management of this valuable resource.

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CHAPTER I

INTRODUCTION: THE NATURE OF THE PROBLEM

CONSERVATION BY MANAGEMENT

Concern over rapid depletion of the world's tropical forests has become an increasingly prominent theme in the last two decades. It has sparked many conferences, many controversies and still growing literature. One of the issues it has raised is that of the renewability of tropical forests under management for production purposes. The extreme view presented that tropical forests are not renewable is, as a general statement, not correct. Nevertheless, the implication that the utilization of tropical forests for their timber is necessarily incompatible with their conservation, has a considerable and sometimes powerful following.

It is a misconception but one that thrives, despite the fact that timber production management and utilization is an insignificant direct cause of tropical deforestation. Most of the deforestation, it is now generally conceded, is the result of the conversion of tropical forest to agriculture. Of that, a significant proportion, can be attributed, except in Latin America (where clearing forest for cattle grazing predominates), to clearing for subsistence agriculture. This, in turn, is a direct consequence of the failure of economic and social development to provide alternative livelihoods for more than a small fraction of the increasing populations in most of the developing countries in the tropical forest zones. Furthermore, many of the planned programmes for agricultural development based on clearing tropical forest originated in policies aimed at relieving that same poverty pressure.

The conservation of the world's tropical forests thus depends on a solution to the problem of third world poverty. So long as the world community is unable or unwilling to overcome the self-imposed political obstacles to applying what are, by comparison, relatively simple technical solutions to that problem, then no amount of talk, research or exhortation is going to conserve the tropical forests. One thing that can make significant impact in reducing deforestation is to apply forms of forest use under which the rural populations realise that the forest is more valuable to them as forest than as a temporary source of farm land. One possibility for doing that is the sustained yield management of tropical forests for industrial timber production under a natural system of silviculture with full industrial processing of the output close to the point of origin.

Whether that possibility is realistic depends on the several, crucial assumptions implied in it, being true. The one with which this review is concerned is that it is possible and feasible to manage tropical forests on a sustained yield basis, under timber production. That in turn depends on two things:

a) That silvicultural systems for reproducing the particular tropical forest type and maintaining, for the most part the initial ecology (Catinot, 1974) will work in conjunction with timber harvesting, and

b) that the yield which can be sustained in that forest type is adequate in quantity, quality, distribution and economics, to support viable, labour intensive, rurally located forest industries in long term production.

The evidence on these issues is equivocal to say the least (Baur, 1964). Not so long ago, the observation that "Far too little is known about silvics and the silviculture of the different forest communities and thus appropriate silvicultural systems can be confidently prescribed for only a few limited areas" (FAO, 1974) would have been widely endorsed. While the point may be less readily conceded now, there is still a very strong body of opinion that, after more than a century of experience in tropical forest management, there is "little future hope for the managed regeneration of mixed natural high forest" (Duke University, 1965). The essentially economic basis of that judgement is more recently reflected in Spear's (1979) statements in favour of plantations over natural management.

LEARNING FROM ASIA

Yet there are important exceptions to that pessimistic overgeneralisation. For instance, Jabil (1983) points out that the forest industries in Peninsular Malaysia would now be drawing logs from second rotation tropical forests, had those lowland dipterocarp forests not been cleared for agriculture. Obviously then the natural management of tropical forests is considered by some, in some conditions at least, both technically and economically feasible. In fact, in parts of Asia, natural management systems are not only persisted with despite the general approach, but also quite definitely preferred.

The path to that situation has not been easy. Many systems have been introduced, modified, abandoned and replaced as they failed or as conditions changed. Sometimes the failures have come from defects inherent in the system, sometimes from the transfer of the forest type for which the systems worked to other forms of land use.

But out of that experience, a very considerable pool of empirical and fundamental knowledge has been accumulated and it is on that which the policy of natural management is firmly based.

Latin America and Africa now have the most extensive areas of tropical moist forest for which the options are still open. The Asian experience shows that sustained timber production through natural regeneration of native species is an option that should be given serious consideration. The Asian experience, and the knowledge underlying it, represent an informational base accumulated over a century of sustained yield management, and covering a wide range of non-technical as well as technical considerations. It is a source of information on which tropical foresters everywhere should be able to draw on, for the development and improvement of management of tropical forests.

Unfortunately very little of the information is readily accessible. Much of it is in publications dating from a long way back and even more lies unpublished in department files and research reports. Moreover it is, for the most part, whether published or not, presented and stored in compartmentalised blocks as inventory, silvicultural, marketing, economic, utilisation and policy information. Appraisals of results or methods in terms of total management systems are rare and presentations in that form even rarer. Yet it is the integrated form in which the field operational manager has to apply his skills, and it is the sort of knowledge which the practical manager accumulates in his experience but rarely publishes.

THE PURPOSE OF THIS REVIEW

This review therefore aims at taking a first step towards filling some of those gaps. Forest management systems which have been successful or widely used in three Asian countries are reviewed as evolving dynamic total systems. For each country, this has been done collectively or individually by people responsible for the development, administration and application in the field of the management systems analysed.

In attempting this, the country reviews reveal much about the necessarily tentative nature of the processes by which management systems for tropical forests must be developed and of the management systems eventually developed. Two features are of particular relevance at this point. One is that in such brief summaries little more than a glimpse can be given of the wealth of information which lies behind the system in each country, and the painstaking way in which that knowledge has been accumulated. The other is that the idea of a forest management system as an entity in itself, rather than a loose coalition of specialisations, is a very old one, but its development into a practical operational form is not easy and is a long way from complete.

There are therefore some very important and salutary lessons in the experiences outlined here, both for other regions and other parts of Asia and the Pacific region and for the countries from which the experiences have been drawn. The main ones will be considered later, but there are two which are worth mentioning now. These are firstly, the management of tropical forests involves the manipulation of and adjustment to, a much wider set of elements than the forests and their immediate environments, and secondly that these elements are much more complex and dynamic, both in themselves and in their interactions, than even the most successful of present management systems have yet adequately recognized.

This is perhaps not the place to go into what that implies for the management of tropical forests. In any case, the application of systems analysis to the management of complex biological - social systems is too far from an operational status to provide much guidance (Gall, 1977). Nevertheless, some principles can serve as bench marks for the evaluation of how well on-going management systems rate as integrated total systems.

Obviously enough, the managed interaction between forests and their immediate and work environments must be executed in and on the forests. Forest management thus covers what is done to forests and how it is done, to meet certain specified purposes. Those purposes are many and growing, apparently in number and variety, as well as in magnitude. But for working purposes they can be grouped into three broad classes of services and products, which warrant the continued occupation of land by forests. Those groups are an infrastructural group comprising the environmental protection and amelioration influences of forests; a social group comprising those products and services that contribute directly to community welfare and stability and thirdly a commercial group which covers those products which make their social contribution indirectly through local, national and international trade. To be successful a forest management system has to be able to maintain a forest structure and distribution which can supply whatever combination of those requirements that circumstances impose, explicitly or implicitly on the forest. That is no easy matter. Some of the main difficulties arise from the facts that:

a) The combination can rarely be taken for granted or as given, so that it has to be worked out largely within the forest management system itself.

b) It is not simply the combination that currently applies which is important, but, even more so that which will apply in the future.

The failure to get that right, as the country reviews and experience elsewhere show, can distort and misdirect the course of forest management as badly as any deficiencies on the silvicultural side can. The main weaknesses, it is now clear, have been in the anticipation of social changes and their consequences, and it has been difficult for policy-makers in any field to anticipate changes. Nevertheless, in the countries under review, it was on the forests as a land bank that the main impact of unanticipated changes fell, and the effect on the forest resource base has often been devastating (e.g. Wilson, 1983; Joshi, 1983).

FOREST MANAGEMENT WITH SOCIAL PURPOSE

Forestry is based on very long term anticipation and planning. And in fact, forest management systems have always incorporated long-term forecasts of market and, although to a lesser extent, in recent years, non-market demands for wood and other services. Moreover right from the start of forest administration and management in the Asian region, the rights and needs of local communities and watershed protection were accorded high priority (e.g. Ribbentrop, 1900; Stebbing, 1926). Good intentions are not, however, enough. It is what happens in the field that counts and that is not always what it has been decided elsewhere should happen. The discrepancy was noted officially as early as 1894, with the Government of India reprimanding its own forest department for an unduly restrictive interpretation of the National Forest Policy, which was meant to protect local rights and land uses (Taylor, 1981).

Despite that warning, an effective incorporation of social values into forest management systems has been a long time in coming. Forest management has, it must be admitted, been much more concerned with conserving the forests, than with protecting the communities. At times, in fact, protecting the forests was seen as necessitating disruption of the traditional ways of life of local communities. The imbalance eventually back-fired so that management systems are now perforce having to incorporate measures to protect both.

Technically, however, no great change is involved. The reasons for felling the trees may change, and even the choice of trees to be felled but the technical problems remain the same. In a silvicultural phase, the natural management of tropical forests still aims at turning the necessarily destructive harvesting of some trees into mechanisms for replacing them. And for sustained yield, a regulatory phase is still required to ensure that the rate of harvesting and the rate of replacement are properly matched.

That, in principle, is no different from the management of any other type of forest. As far as the regulatory aspect is concerned, there are only three options - to harvest all the increment; less than the increment; or more than it. In the silvicultural aspect, if it has been decided to harvest any increment at all then there are more but still not many options. The proportion of the increment that has been decided to harvest can be met by felling and removing:

a) Isolated trees (Single Tree Selection Systems) or small groups of trees scattered throughout the forest (Group Selection Systems).

b) A proportion of the trees more or less uniformly distributed over a part of the forest (Uniform or Shelterwood Systems).

c) Nearly all of the trees on a part of the forest (Seed Tree, Two-Storied High Forest, Standards Systems).

d) All of the trees on a part of the forest (Clear Felling).

These four spatial distributions of the harvest can be combined with a narrow range of choice, in the vertical dimension, of trees to fell or retain, according to their relative positions in the canopy. Then more possibilities are offered by the form in which regeneration is secured. But when all the conceivable combinations are added up, the possibilities are still relatively limited in total. Even so, workable, let alone optimum, combinations of the silvicultural and regulatory phases for the natural management of any type of forest are not easily found, nor can the solution, once found, be taken as fixed.

The difficulties are compounded many times over in tropical forestry. Fundamentally, the structural and compositional complexity of the ecosystems compared with those in temperate forests and the virtual absence of any short-cuts to the determination of increment would, alone, greatly magnify the technical problems in tropical forest management. However, the tremendous environmental and economic benefits to be derived from proper forest management, supply the rationale and motivation for continued efforts to develop forest management systems, while strengthening institutions and infrastructures in support of them.

CHAPTER II

HISTORICAL OVERVIEW

PRE-TWENTIETH CENTURY

The origins of scientific forest management in the tropics are to be found in India. Dating from the mid 19th Century, they are part of what is now regarded as classical forest management. In fact, one of the tropical systems - the Brandis System - is often included in the classical lexicon (e.g. Jerram, 1935).

The pioneers of that work, were, for the most part, educated in the German forest schools. They brought with them to India a capacity for rational, systematic analysis which was the hallmark of that tradition. The fact that they were applying it to infinitely more complex ecosystems in very difficult social environments, they neither ignored nor were they daunted by it.

Over the years they incorporated the various elements of their scientific approach into an iterative sequence of:

i) Establishing firm administrative control over the forests.

ii) Clarifying and formalising ownership and customary rights.

iii) Defining the physical dimensions of the forest estate so identified.

iv) Investigating the silvical characteristics and behaviour of the main timber species, and their wood properties.

v) Estimating growth rates and patterns, pending the results of more precise further investigations.

vi) Prescribing sustained yield management regimes, which combined yield control and replacement of the forest as it was utilised.

The very important point is that this was no mechanical application of already formalised systems from Western Europe. It was a concurrent development; the approach was imported, not the methods. For any type of forest in any geographical location and any social setting the analytical process must be the same. A range of possible parallels between tropical and temperate systems is therefore inevitable, but the conclusion sometimes drawn from such resemblances, that the limited success with tropical forest management is due to slavish imitation of European modes, is both illogical and superficial.

This does not mean that there was no direct imitation of European models in the tropical forests. It undoubtedly did occur, just as it did in the temperate forests of the new world. But that does not alter the fact that tropical forestry developed largely in its own right, not out of European forestry, but out of a common philosophy.

Eventually the experience from India diffused to other parts of the British Empire, as it then was. The diffusion was, however, direct to a limited extent only. The main channel was through the education and training of foresters for the Colonial Forest Service in the British forestry schools, where many of the teaching staff drew on their own experience in the forests of India.

A similar moulding of tropical forest management in the European scientific philosophy took place more or less simultaneously in what is now Indonesia. There, however, the Dutch foresters tended, it seems, to place more stress on the botany and structural ecology of the various forest types, as a pre-requisite to their management.

In the Philippines, early discouraging results from European-type forest management on the one hand, and structural similarities between the tropical forests and old growth forests in the USA on the other, led to management systems which emphasized the engineering and economic aspects of utilisation.

Thus, the early management systems were grappling with a common problem, which had a number of almost irreconcilable components. Firstly, there was the necessity, as it was seen, to ensure the retention of enough forest to meet future needs for wood and non-wood products and services, while still meeting present demands on the forests for traditional products and uses, for new and growing industrial uses, for exports, for revenue and for land for agricultural expansion. At the same time, there was the need to draw on even those forests which it was felt should comprise the permanent forest estate, to meet current requirements, without impairing their long term productive and environmental protection capacity. And thirdly to do this in forests which are infinitely more complex to study, to monitor and to control than the ones from which forest management has grown and, in physical environments which were almost completely the reverse and in social settings strangely different from those into which the forest management systems had fitted.

It is hardly surprising, therefore, that the early forest management systems developed for the tropics can, in retrospect, be seen as greatly oversimplified. With few exceptions, neither the technial nor the social constraints and difficulties that are now evident received adequate recognition. Nor is it surprising that the systems now in use and in development are tending to converge towards a very similar pattern.

The first step in all instances was to establish some order into the utilisation of those forests foreseen as necessary for the future and some system into the conversion of the remainder to other uses. The extent to which this became a major exercise and subsequently a major part of the management systems varied. Institutional arrangements, therefore, varied with the ways in which the colonial powers imposed their legal and administrative systems on, or merged them with, the local systems. To a large extent, protection of the reserved forests from encroachment by settlers or disposessed poachers came to be a dominant aspect of forest management in India from an early stage. In other countries, where the local situation was either simpler, or simply ignored, such an emphasis either never developed or came much later.

In the three countries covered in this review, the next step in establishing forest management - formalising ownership - had to be taken in the light of very different situations. In India, the rather ambiguous relationships between the British Government and the British East India Company and their relationships with the Indian rulers of the various states and principalities had produced, as far as forestry was concerned, a rather confused and erratic progress towards stabilisation and management. But it was progress all the same, despite a tendency for revenue considerations to over-ride conservation.

With the British Government taking over full responsibility after 1858, surveys, demarcation and registration of ownership and rights became more systematic and uniform. Then, as the railway system expanded, communications became more rapid and reliable and public works programmes, including irrigation, grew. Institutional arrangements for moving more and more land out of subsistence farming into cash crop and commercial agriculture had to be made more effective. The land resources of the emerging forest administrations were both part of this development, and affected by it and its social repercussions.

The end result was, however, a strongly established, demarcated and well protected system of forest reserves across the whole country. Not sufficient in the foresters' opinion, but nevertheless quite extensive and well distributed.

The situation was appreciably simpler in the Malay states and protectorates. Populations were nowhere pressing on resources, there were no natural teak forests on which to build a prosperous export trade and an industry based on timber harvesting, while the growth of commercial agriculture, although rapid and widespread following the successful introduction of rubber, did not seriously erode the total forest estate at this point. Forest reservation nevertheless pushed ahead systematically, if not so urgently, in accordance with the accepted principle of reserving an adequate forest estate.

In the Philippines, three centuries of Spanish occupation and colonisation had left a very distinct institutional mark. Traditional rights and customary laws of the indigenous people had not been recognised in the official pattern of land ownership. Yet it was necessary to legitimise the timber rights which were gradually being introduced. This, it was found, necessitated nationalisation of the more important forest lands and a government forest service to manage them.

Thus with more or less stable and identifiable forest estates on which to base it, management then began with the development of early simple area methods of yield control and empirical investigations of silvicultural prospects. The yield to be controlled was almost invariably considered in terms of industrial wood. For that purpose, very few of the hundreds of the species in the tropical forests were in demand. Teak dominated the Indian scene, strong durable hardwoods the Malayan and early Philippine demand, with fine quality Dipterocarps taking over soon after the American occupation of the Philippines (Roth, 1983). Other species were taken of course and some were highly valued for speciality purposes, but in total the commercial species never amounted to more than a handful of the possibles.

Area control, apart from its simplicity, has the advantage of being not too demanding in its informational requirements. All that is needed is a determination of the area comprising the management unit and an estimate of the rotation. The former came out of the surveys, but the latter could be no more than an educated guess, and applicable to all the commercial species. Commonly, 100 to 120 years was adopted as a first approximation, giving 1/100 or 1/120 of the area of the management unit to be cut over annually.

This might have been a moderately successful initial system if:

a) The composition and size structure of the forest had been reasonably uniform over the management unit.

b) The markets had been relatively static.

c) The prescriptions had been enforceable and enforced.

These conditions, however, rarely applied. Instead, with the extreme variability of the tropical mixed forests, commercial yields from a fixed area annual coupe could vary widely from area to area and from year to year. Meanwhile, the demand for the prime timbers especially, was increasing in local markets in India, and in export markets everywhere. Consequently, political and financial pressures for cutting to match the market were at times quite intense. Forest departments came to be seen as obstinate, insensitive and out of touch with reality in trying to maintain limits which they saw as essential for forest conservation and which, moreover, had been endorsed by their governments.

How successful resistance to such pressures was, depended largely on the character and standing of the heads of the forest departments and their senior officers. Brandis was one of a number, who were quite outstanding in their ability to impose new standards of performance and command the necessary support from above, his name is commemorated in the method of yield control that he devised for Teak in Burma.

In the Brandis method of yield regulation, the number of Teak trees above a specified minimum exploitable size which could be cut was set as a function of the rate at which smaller sized trees could replace the ones to be removed. It was a marked improvement on simple area control and is a successful system as long as the demand can be kept within these sustained yield limits, logging can be confined to the size classes prescribed, and continuous regeneration assured.

This latter condition is crucial. Ultimately, the success of any management system in which the harvest is made up of the removal of whole trees, depends on the success with which regeneration proceeds. In the long run it could well have been the weakest of the many weak links in the early management systems.

In India, the natural regeneration of Teak was often no major problem. Where it failed or was inadequate, planting, for which techniques had been worked out early in the 19th century, could be used to supplement any deficiency. In fact, so promising were the early Teak plantings that conversion of some tropical mixed forests to Teak plantations eventually became standard practice. With other species there was less success and, in fact, less effort. Contributing to that were a number of ill-advised attempts to apply the Brandis system to forest types, which, unlike Teak, were ill-adapted to its selection silvicultural basis (Jerram, 1935).

Research into silvicultural aspects of the management of the Dipterocarp forests also began at a fairly early stage in the development of the respective forest services. Formalised experiments on growth and regeneration responses to stand treatments date back to the early decades of this century. With statistical science then in its infancy and not part of the normal forestry education, it is unlikely that these early trials would have yielded anything more than quantified observations.

Moreover, taxonomical clarification was a prerequisite for silvicultural research and practice in these complex ecosystems and accordingly took precedence on the biological side. Even so most of the foresters of those days were acute observers and keen experimenters. From their observations and the results of their tests, a working knowledge of tropical forest ecology was gradually accumulated. For some of the important species of the times, that level of information was enough for management to proceed with some confidence, and even allow one or two to be developed as plantation species.

POST WORLD WAR II

However, most of these early systems collapsed at other points of weakness long before the success or failure of the silvicultural aspects could show its effects. The first event that triggered that collapse was the Pacific phase of World War II; the second was the extent, nature and world-wide impact of the post-war recovery and economic boom.

The colonial administrations in the South-East Asia and Pacific, collapsed within the first few months of 1942. This did not mean that forest administration and management necessarily collapsed at the same time. On the contrary, with a well-established tradition of forest conservation and management in Japan, the Military Governments installed in these newly acquired territories, made some provision for conservative utilisation of the forest resources. That phase did not, however, last long. With the reversal in the direction of the war, the military governments were soon forced into uncontrolled deforestation to meet the needs of military engineering, and for fuel wood and for food production.

Thus the end of World War II saw an almost total loss of the research plots and records and of the stands in which the management systems had been applied. A new start, virtually from scratch, had to be made. However, it was well into the 1950's before the forests were free enough of the post-war guerilla activities, for forest management to recommence in earnest and generally. By then, the economic boom was starting to move.

The Indian Subcontinent was not so directly affected by the war. Though Burmese forests and forestry suffered much the same fate as the rest of South-East Asia, the resumption of management after the war was not, however, so long-delayed, so that at independence in 1948, the Burmese forest administration still had a substantially intact forest management system to operate.

In the rest of the Indian Subcontinent, the war was felt, as in the First World War, mainly through the mobilisation of the country's resources in support of the military campaigns. On the whole, research and management records were kept up and management control continued in place, if sometimes dangerously stretched. No completely new start was, therefore, needed after the war and no great delay or difficulty was experienced in the old system resuming its normal role. Even independence and partition in 1947, brought no drastic break with tradition. The Indian Forest Services thus entered the post-war period with a well established forest estate not irreparably damaged by the demands of war, an ongoing set of management systems and procedures, suspended perhaps but not abandoned, and an institutional structure still intact with a staff establishment trained to run it.

However, social conditions to which these institutions were adopted were changing quickly. The population was beginning to grow at a very fast rate, from a base which was already pressing hard on the country's resources. The industrial world was about to take off on 25 years of expanding production and trade, with technological and social developments, that had no historical precedent. These conditions were completely unforeseen and for a while under-estimated, then finally, just as the phase was coming to an end, over-estimated.

The effects of both factors differed widely between developing countries and also within them. Some of these differences depended on how and whence the impact from the developed countries came. This was especially evident in the different directions that forest management took in South and South-East Asia.

Several factors shaped those directions. Amongst them were:

a) The extent to which agricultural and industrialisation programmes absorbed the increasing population.

b) The way in which difficulties in that respect were responded to.

c) The way in which increasing demand for tropical timbers was met.

d) How that response was related to meeting rising domestic demand for wood and land.

The population of almost every country in the region doubled within 30 years of the end of the war. On the whole, neither agricultural reform and resettlement programmes nor industrialisation were able to create farms and jobs to match that rate of increase. In this respect, Malaysia had fewer difficulties than other countries in the region. The official agricultural development and resettlement schemes everywhere, involved quite large scale transfers of forest land to agriculture. To the extent that these and other developments failed to absorb all the population increase, many of those who missed out were forced into illegal clearing of forest land for subsistence. These involuntary shifting cultivators and those for whom shifting cultivation was a traditional way of life, added further to the rate of deforestation; such developments had not been taken into account in management planning.

Either way the result was that the forest estates so painstakingly established in colonial times had to give way. Naturally, the losses through planned clearance took place in the more accessible forests on easy topography. These areas, equally naturally, were those on which the early forest management systems had concentrated and for which they had been devised. Thus in Malaysia, and to a lesser extent in Indonesia and the Philippines, forests for which operational management systems had been worked out and possibly applied, mostly disappeared.

Involuntary shifting cultivation tended on the other hand to be located in less accessible forests where it was less easy to detect and prevent. Efforts to stop it were pressed most strenuously in India, where defence of the forest estate became an almost over-riding pre-occupation (Guba, 1983). Eventually, however, the reality of the poverty driven forces had to be accommodated, and community forestry programmes developed as a partial solution.

In Malaysia shifting cultivation, by those who did not traditionally practice it, did not emerge as a major problem. Nevertheless, the traditional forms under shortening fallow periods did lead to significant deforestation in the uplands, especially in Sarawak. In the Philippines, it was hoped that the timber industry and reforestation efforts would augment rural employment. As in India, however, these forestry contributions to easing the rural poverty consequences of population growth are principally plantation and agro-forestry based. As such, they are not within the scope of this study, although they are amongst the most important outcomes of the situation.

Deforestation arising from such drastic changes in the man/land ratio would alone have forced departures from the forest management systems developed in the pre- and immediate post-war years. For instance, by forcing the permanent resource base for timber production out of the lowland forests of South-East Asia, it:

a) Deprived forest management of a great deal of its information base and information gathering system;

b) Accelerated the introduction of more powerful, highly mechanised logging systems and the construction of much more complex and expensive road networks for harvesting;

c) Thus, eventually raised the issue of conservation of land and water resources in management planning and implementation.

Deforestation was not the only post-war factor to disrupt forest management. Reinforcing its effects and in a way transcending them, was the very great increase in demand for industrial forest products that grew out of the economic recovery and subsequent boom, and the changes in the pattern of that demand.

In the immediate post-war period, the demand was dictated mainly by the needs of reconstruction. The emphasis was, as in pre-war times, in strong, durable species for the rehabilitation of railways, bridges, wharves and civil engineering infrastructure generally. The Malaysian systems of management based on regeneration fellings of several forms were not greatly affected, since they had been developed largely to cater for the supply of these species. Certainly the scale of the operations was greater and the pace more intense, but on the whole it was "business, almost as usual, but brisker". That phase did not last long. The demand for less narrowly specialised timbers soon began to over-take it, as technological advances in wood preservation and developments in concrete, metal and synthetics engineering, eliminated the advantages of natural durability and made high wood density almost a liability. At the same time, other fuels were rapidly displacing wood in industrial and domestic applications.

Export markets for Dipterocarp timbers for sawnwood and veneer had existed before the war. Resumption of trade in them as soon as possible after the war was therefore natural and the gradual increase in demand for them that came with economic recovery in the traditional importing countries was accommodated without much strain on forest management as it then was.

In Malaysia, the Malayan Uniform System evolved out of the regeneration improvement felling procedures in response to the shift in demand from the durable to the utility Dipterocarps. In the Philippines, the change in the pattern of demand neither prompted nor called for any marked change in the utilisation-dominated logger's selection methods. Nor were the Indian systems of management greatly affected, since the large domestic markets for timber and veneer had to a large degree become accustomed to a fairly wide range of general purpose timbers as well as the left-overs from the more highly regarded export woods.

But that comfortable period of easily modified management did not last long. The demand for tropical timbers soon exploded, as the developed countries moved into that period of high and sustained economic growth which characterised the third quarter of the 20th century. In fact, the growth in demand by Japan was so fast and so great that the path of forest development in much of Asia and the Pacific was dictated by the Japanese log market. At the same time, domestic demand in the forested developing countries started to expand under various combinations of economic development, increasing population and urbanisation.

The mass production scale of operations that developed with this rapidly expanding log market, virtually forced the adoption of high investment, mechanised logging systems. The lowland Dipterocarp forests could be utilized by that type of operation but the management systems developed for them did not guarantee regeneration under these conditions. Management by the systematic release of regeneration and advance growth is greatly complicated by the technical and economic requirements of capital intensive logging. Revenue generation, which had always been an important objective in forest administration in the area, became the dominating objective. Where that happened, and that was almost everywhere in the region, established practices and policies of forest management were no longer applied.

There were, however, two significant exceptions: India and Peninsular Malaysia. Not that forest management, in the established form, prevailed. On the contrary, it barely survived. But the causes of the collapse lay more in the internal demands of agricultural expansion than in the external demands of the log export market. In Peninsular Malaysia the adjustment to the growing and changing market for wood products was accommodated by the flow of logs from the planned and systematic conversion of most of the lowland Dipterocarp forest to agriculture. The supply of logs from land clearing was easily capable of meeting the demands of the forest industries built on it and the growing export markets, while at the same time satisfying the economics of large scale logging. The decreased use of the Malayan Uniform System was the result of a drastic change in land use which almost completely eliminated the forest it was designed to perpetuate.

In India the established management systems came under pressures initiated by the enormous increases in population. Land reform and industrialisation proceeded much too slowly and unevenly for them to absorb more than a small fraction of the growing population. Forestry administrations did not fully grasp and anticipate the implication of population growth for their forests and management systems. The retreat from established practices and policies in the face of the rising pressure was reluctant and prolonged, but inevitable.

In a sense, therefore, the last quarter of the 20th century coincides with another phase in the development of forest management in Asia. The management systems evolved over the preceding half century or so, have been successful enough to prove the possibility of managing tropical forests as sustainable ecosystems under timber production. However, by the time that the technical solutions were perfected, the social systems for which they were appropriate were well on the way to being things of the past.

In retrospect, it is easy to see that this was inevitable. Given the biological limits to tree and forest growth, even the adjustment of an ongoing management system to changing conditions cannot be anything but a slow process. The pattern of adjusting forest management in response to changes as they occur, which has characterised the history of forest development in Asia, is a viable proposition only in relatively stable economic and social environments. That is hardly an accurate description of the situation in Asia over the last 40 years or so, and this limitation must also be kept in mind for the future.

With the permanent forest base for most of South-East Asia being forced into the hill Dipterocarp forests, more or less different systems of management are emerging. In general, they seem to be converging on selection systems for natural management. But even in that, reaction to problems that have overtaken the forestry administration seems to be more prominent than anticipation of what that future is likely to bring. Promising, however, are the greater attention being given to the evolution of future domestic and export markets for wood, and the fact that some of the infrastructural services are being taken more seriously into account.

That anticipatory content and the incorporation of social aspects in forest management plans, still needs strengthening. Yet if there is one thing that the historical development of forest management in the region makes quite clear, it is that institutions and planning systems must be based on the realities of the present and future rather than anachronistic assumptions of the past.

CHAPTER III

FOREST MANAGEMENT SYSTEMS IN THE TROPICAL MIXED FORESTS OF INDIA

INTRODUCTION

The growing demand for goods and services in the context of a declining resource base makes forest management extremely complex. This is particularly so in the case of those developing countries in the tropics where land use conflicts are very severe. On the one hand there is an urgent need to utilise forest resources to promote economic development. At the same time it is also necessary that the social and protective values of the forests are not undermined. An understanding of how existing forest management systems in India are geared in such circumstances to fulfill their different objectives could provide valuable information to other countries on their merits and demerits and an indication of the future course of evolution.

On account of variation in climatic, edaphic and physiographic factors, Indian forests present a wide spectrum of variability in terms of structure, phisiognomy, floristics, etc. Man-forest interactions also differ considerably and consequently the type of benefits and their quantum also vary, both in space and time. This chapter opens therefore with a brief account of the most important mixed tropical forests in India and certain salient features of the evolution of management systems now in vogue.

FOREST TYPES AND DISTRIBUTION

A forest type is a natural unit with more or less well defined characteristics, especially as regards physiognomy, floristics, etc. Despite the drawbacks of the type classification by Champion (1936) and Champion and Seth (1968) (Puri, et al, 1983), it continues to be the basis for all forest management purposes. Area under important type groups under the broad category of tropical forests is given in table 1.

Table 1

Area Under Tropical Forests

Major Group		Type Group	Area (in million ha)
Tropical Forest			
(1) Moist Tropical Forests	i.	Wet Evergreen	4.503
	ii.	Semi Evergreen	1.845
	iii.	Moist Deciduous	23.303
	iv.	Littoral and Swamp	0.671
(2) Dry Tropical Forests	v.	Dry Deciduous	29.154
	vi.	Thorn Forests	5.236
	vii.	Dry Evergreen	0.075
Total			64.796

Source: Puri, et al (1983)

Tropical forests thus account for 86 percent of the total forest area in the country[1]. Of these wet evergreen, semi-evergreen, moist deciduous are the most important as regards wood prodution and management of these has a long history. Important characteristics of these forests which have a direct bearing on forest management are discussed below.

Tropical Evergreen Forests

Evergreen forests are found in the high rainfall zone (exceeding 2500 mm per annum) and are distributed in three widely separated regions namely, (1) Western Ghats, (2) Andaman and Nicobar Islands and (3) North Eastern Region (See Fig. 1). Distribution of these forests in these regions is given in table 1.

[1] Total forest area as per official records is 75.351 million hectares. This represents the area that is legally categorised as forests and includes totally barren areas also. Effective forest cover is estimated as only 12 percent of the geographical area of the country.

Table 2

Distribution of Evergreen Forests

Region	States	Area (in mill. ha)
1. Western Ghats	Karnataka Kerala Tamil Nadu Goa Maharashtra	1.19
2. Andaman and Nicobar Islands	Andaman and Nicobar Islands	0.63
3. North Eastern Region	Assam Arunachal Pradesh Nagaland Manipur	2.68
Total		4.50

In structure and physiognomy there is very little difference between forests in the different regions. Trees are generally arranged in tiers with dominants in the top canopy attaining a height of over 40 meters. Tropical evergreen forsts are characterised by the presence of a large number of species and gregariousness is more an exception than the rule. Smooth bark, large buttresses, cauliflory, etc. are some of the notable features of the trees. On account of the multi-tiered arrangement, light availability near the ground level is poor, permitting little or sparse undergrowth.

The tropical wet evergreen forests in India are categorised into two sub-groups, southern and northern. The former consists of forests in the Western Ghats and Andaman and Nicobar Islands while the latter is found in the North Eastern Region (Champion and Seth 1968). Important climatic climax types under the southern sub group are as follows:

Southern Tropical Wet Evergreen Forests

Champion and Seth (1968) distinguish the following climatic climax types:

1.	Giant Evergreen Forests	Andaman and
2.	Andamans Tropical Evergreen Forests	Nicobar Islands
3.	Southern Hill Top Evergreen Forests	Western Ghats
4.	West Coast Tropical Evergreen Forests	" "

The Giant Evergreen Forest is the most luxuriant of the sub-types and occurs on deep alluvial soil with good moisture availability. Important species found inthese forests are Dipterocarpus alatus, D. grandiflorus, D. gracilis, Calophyllum soulattri, Artocarpus chaplasha, Sideroxylong longepetiolatum, Amoora wallichii, Planchonia andamanica, Endospermum chinesis, etc.

The composition of the Andaman tropical evergreen forest is very similar to that of the giant evergreens except that it is less luxuriant. In addition to Dipterocarpus spp., Artocarpus chaplasha, Calophyllum soulattri, Sideroxylon longepejolatum, Myristica andamanica, Planchonia and amanica are the important species. On account of inaccessibility and absence of habitation, forests in the Islands remained in a pristine condition till the latter half of the 19th century. Even now, the biotic pressure is negligible in comparison with the mainland. There are about 200 species of trees of which only 30 are commercially valuable (Bathew, 1983).

The West Coast Tropical Wet Evergreen Forests occur over the entire length of the Western Ghats from North Canara in Karnataka to Kerala and extends to portions of Tamil Nadu in the south and east. Dominant species in the top canopy are Dipterocarpus indicus, Vateria indica, Acrocarpus fraxinifolius,, Calophyllum spp. Cullenia exarillata, Hopea parviflora, Mesua nagassarium, and Dichopsis elliptica. Although gregariousness is an exception, associations are recognised on the basis of dominant trees in the top canopy.

Several edaphic subtypes of the evergreen forests have been described (Champion and Seth, 1968) and their occurrence is primarily guided by soil characteristics which influence moisture availability. Reed and cane brakes occurring in wet pockets are important edaphic forms. Although their contribution towards wood production is very low, they supply valuable raw material to both traditional and modern industries (Nair, 1985). An interesting edaphic subtype is the Andaman Moist Deciduous forest occurring on freely draining slopes in the Islands. Species composition of this is given later.

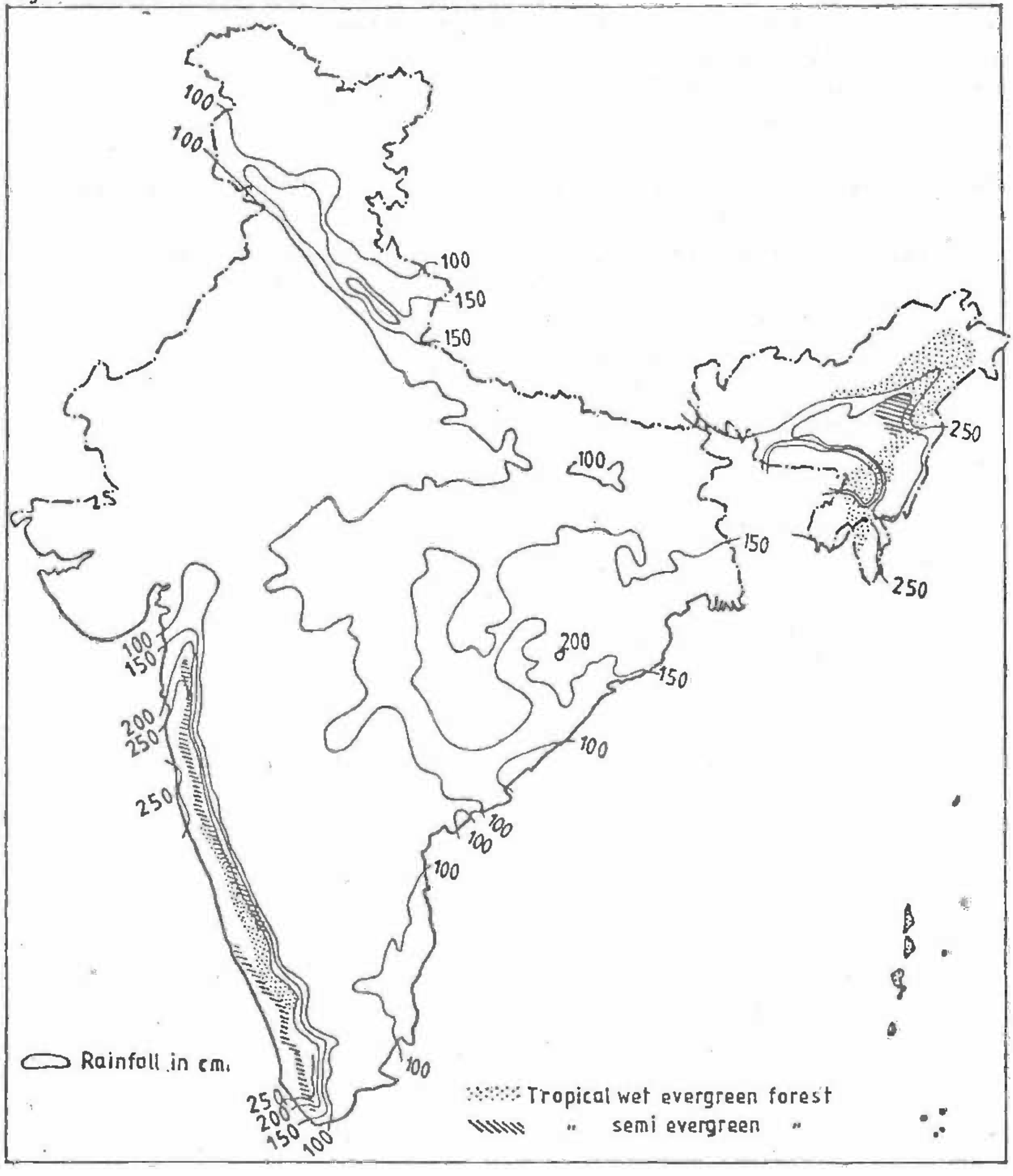
Northern Tropical Evergreen Forests

This type occurs in the North Eastern Region and three sub-types, namely, (1) Upper Assam Evergreen Forest, (2) Cachar Tropical Evergreen Forest and (3) Assam Valley Evergreen Forest, are identified (Champion and Seth, 1968). On account of shifting cultivation and other biotic factors the latter two types are in a highly degraded condition. Upper Assam forests occur in Arunachal Pradesh (Tirap and Lohit divisions), Assam (Dibrugarh, Doomdooma and Digboi divisions) and Nagaland (Mon division). Important species in these forests are Dipterocarpus macrocarpus, Shorea assamica, Mesua nagassarium, Terminalia myriocarpa, Phoebe goalparensis, Hopea spp. etc. One of the distinguishing characteristics of the Upper Assam forests is the gregarious occurence of Dipterocarpus macrocarpus (Hollong) and Shorea assamica (Makai) which together often account for about 80 percent of trees in the top canopy.

Semi-Evergreen Forests

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 evergreen forests, these also have a multistoreyed structure. The top canopy comprises of a mixture of deciduous and evergreen species while the understorey is almost entirely constituted by evergreens. Here also, two subgroups, southern and northern, are distinguished. Some of the climax formations under

Fig.1: DISTRIBUTION OF EVERGREEN FORESTS IN INDIA



the southern subgroup are (1) Andaman semi-evergreen forest and (2) West Coast semi-evergreen forest. West coast secondary semi-evergreen dipterocarp forest is an important seral sub-type occurring in the Western Ghats.

In Andamans the semi-evergreen forest occurs in the valleys on well drained alluvial soil. Commercially important species are Dipterocarpus alatus, D. pilosus, Pterygota alata, Pterocymbium tinctorium, Terminalia procera, Albizia chinesis, Albizia lebbek, Pterocarpus dalbergioides, Lagerstroemia hypoleuca, etc. In the Western Ghats semi-evergreen forests are found in Kerala, Karnataka, Goa and Maharashtra. Important species are Haldina cordifolia, Calophyllum tomentosum, Hopea parviflora, Spondias mangifera, Tetramales nudiflora, Terminalia paniculata and Vitex altissimma. Bambusa arundinacea is the most important bamboo species. Reed brakes (Ochlandra spp.) are also found in moist areas, especially along water courses.

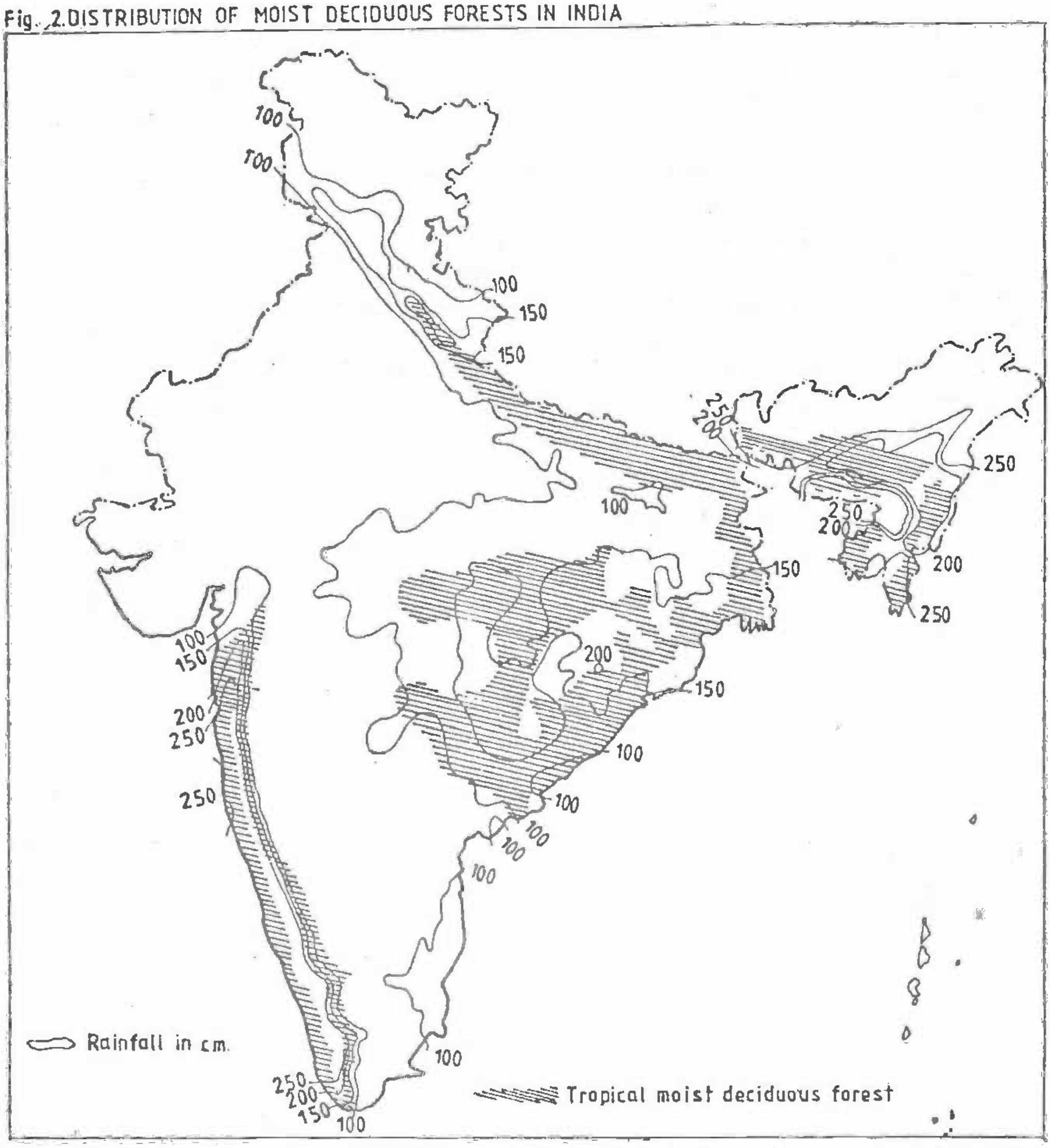
The Northern tropical semi-evergreen forests occur in the North Eastern Region and extend to the moist regions in Bengal and Orissa. In comparison with the Southern form, the flora is poor and less diverse. Important climax types are (1) Assam Valley semi-evergreen forest, (2) Cachar semi-evergreen forest and (3) Orissa semi-evergreen forest. Several seral and edaphic formations are also distinguished and the ecological status of these forests differs considerably. Important species in the northern sub-group are Phoeba goal-parensis, Amoora wallichii, Dysoxylum spp., Chukrasia tabularis, Artocarpus chaplasha, Mesua nagassarium, Michelia champaka, etc.

Considering the small area of the semi-evergreen forests, they are usually grouped for management purposes with evergreen or moist deciduous forests.

Moist Deciduous Forests

Next to the dry deciduous forests, this is the most widely distributed type and plays an important role in the production of wood and other products. Moist deciduous forest occurs in regions where rainfall is in the range of 1500 mm to 2000 mm (See Fig. 2). Typically it is a closed forest with the top canopy comprising mostly deciduous species, while understorey is usually formed by evergreen species. Three subgroups, namely (1) Andaman moist deciduous, (2) South Indian moist deciduous and (3) North Indian moist deciduous, have been identified. Within each category several climax and seral forms are distinguished.

Fig. 2.DISTRIBUTION OF MOIST DECIDUOUS FORESTS IN INDIA



Important species in the Andaman sub group are Pterocarpus dalbergioides, Terminalia bialata, T. manii, T. procera, Canarium euphyllum, Pterocymbium tinctorium, Bombax insignis, Tetrameles nudiflora, Diospyros marmorata, etc. Champion and Seth (1968) point out that this is a stable pre-climax formation occurring on easily drained soils where water stress develops during summer months.

The southern moist deciduous forest is found in the states of Kerala, Karnataka, Tamil Nadu, Andra Pradesh, Maharashtra and Madhya Pradesh. Teak is the most important species and depending upon its presence and dominance this subgroup is divided into moist teak bearing forests and mixed forests[2]. In addition to teak, important species in the Southern moist deciduous forests are Terminalia tomentosa, Grewia tiliaefolia, Lagerstroemia microcarpa, Xylia xylocarpa, Dalbergia latifolia, Haldina cordifolia and Pterocarpus marsupium. The most common bamboo in the moist localities in the south (Kerala and Karnataka) is Bambusa arundinacea while Dendrocalamus strictus occurs in drier regions.

On the basis of presence or absence of Sal, the northern moist deciduous forests are divided into sal forests and mixed forests[3]. The former is characterised by the gregarious occurrence of Shorea robusta (Sal) which sometimes accounts for about 80 percent of the trees. Sal forests occur all along the sub Himalayan belt, from Himachal Pradesh to Assam, in the Gangetic plains, Chotanagpur plateau, Orissa coast, Andhra pradesh and parts of Madhya pradesh. Characteristic species are Shorea robusta, Terminalia tomentosa, T. bellirica, Haldina cordifolia, Madhuca indica, Schleichera trijuga, Ougenia oojenesis, and Mangifera indica. Dendrocalamus strictus is the most common bamboo. Composition of the mixed type is very similar to the sal forests except that sal is scarce or totally absent.

Although floristically the moist deciduous forests are less diverse than and inferior to evergreen forests, they are extremely valuable comercially. Almost all the species are utilised either as timber or firewood. These forests form the most important source of saw logs.

[2]Based on rainfall, teak bearing forests are further subdivided as (i) very moist teak forest, (ii) moist teak forest and (iii) slightly moist teak forests, the last one merging with the dry deciduous formation.

[3]Important climax formations distinguished are (i) very moist sal (ii) moist sal and (iii) moist mixed forests. Under each category several sub types are recognised.

Dry Deciduous Forests

Dry deciduous forests occur in the rainfall zone of 1000 to 1500 mm with a long dry season extending over 6 months. These forests are found in the Deccan plateau, the Narmada and Tapti valleys and extends to the Gangetic plains (See Fig. 3.). Typically this contains fewer species than the moist deciduous type and almost all species are deciduous. Two subgroups, southern and northern are distinguished under this type. Three important climax types under the southern subgroup are (1) teak forests (2) red sander forests and (3) mixed forests. The most common species in the southern types are Tectona grandis, Anogeissus latifolia, Diospyros melanoxylon, Boswellia serrata, Emblica officinales, Acacia leucophloea, Bridelia retusa, Writhtia tinctoria, Pterocarpus marsupium, etc. Apart from teak, some of the valuable species like Santalum album and Pterocarpus santalinus are found in these forests. The most common bamboo is Dendrocalamus strictus.

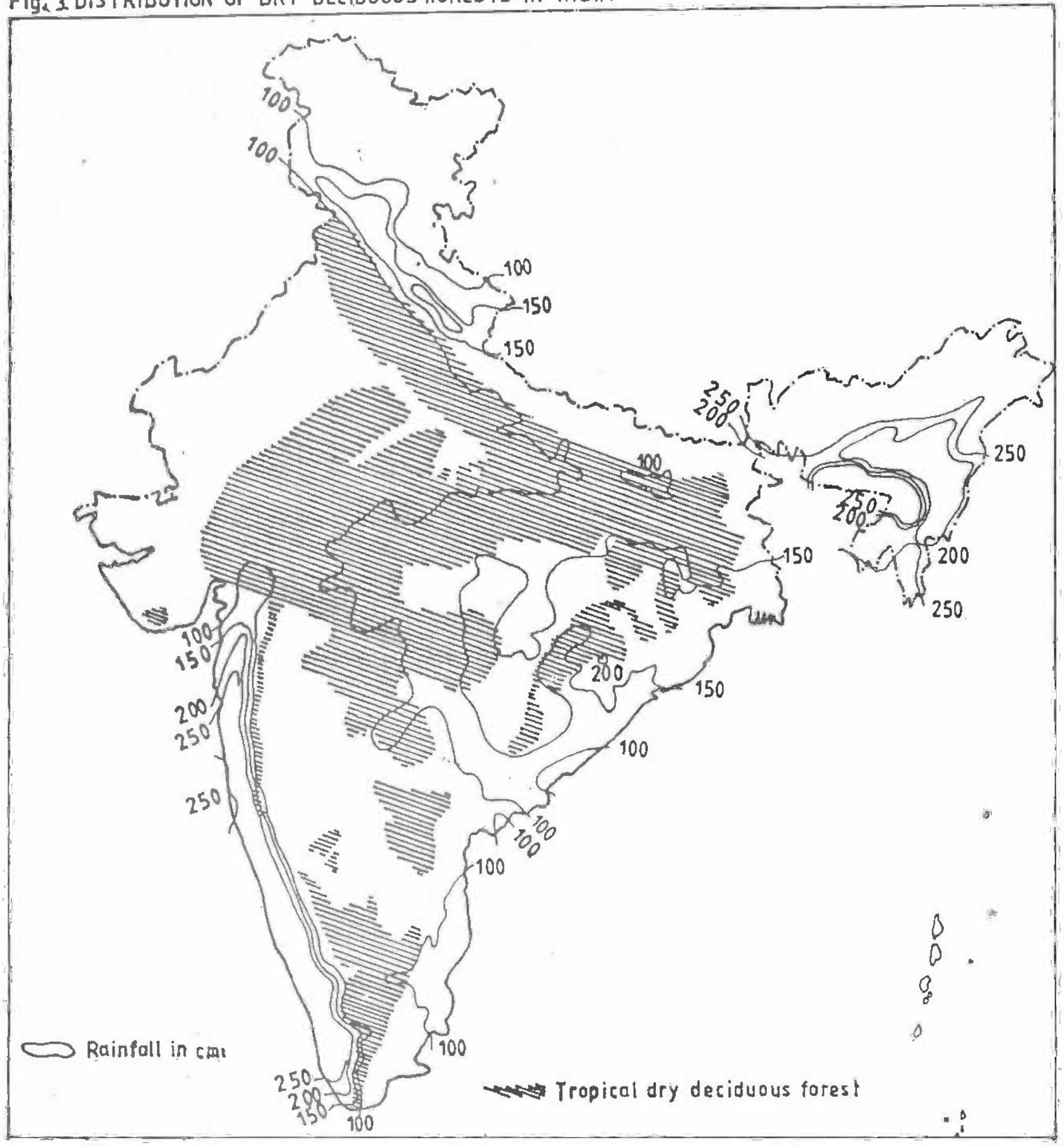
The northern subgroup is divided into sal bearing forests and mixed forests depending upon the presence or absence of sal (Shorea robusta). Sal is of inferior quality and the chief associates are Anogeissus latifolia, Buchnania lanzan, Terminalia tomentosa, Emblica officinales and Lannea coromandalica. In the mixed type species composition is essentially the same, except that sal is absent. As in the case of other forest types several sub types and seral forms have been distinguished, based on floristics and locality factors.

Most of these forests are subjected to severe biotic interferences, particularly fire and grazing. Productivity of these forests is low, but removals far exceed it, causing degradation. Firewood is probably the most important product from these forests. In addition, a large quantity of bamboo is also obtained. Other valuable products include tendu leaves (Diospyros melanoxylon), sandal wood, red sanders, etc.

MANAGEMENT SYSTEMS

Forests can produce a variety of goods and services, singly or in combination, depending upon the type and intensity of management to which they are subjected to. Forest management involves the organised application of any particular silvicultural procedure to regulate and control yield and to ensure restocking of harvested areas to achieve pre-determined objectives. Management is thus an interaction between societal and forest characteristics as depicted in Fig. 4.

Fig. 3 DISTRIBUTION OF DRY DECIDUOUS FORESTS IN INDIA



The forest characteristics include species composition, accessibility, and synecology and autecology of species, while societal factors that influence management are pattern of ownership, objectives of the owner and the socio-economic environment in which the owner has to manage the property. The pattern of ownership of forests in India is given in Table 3.

Fig. 4. Forest - Society Interaction

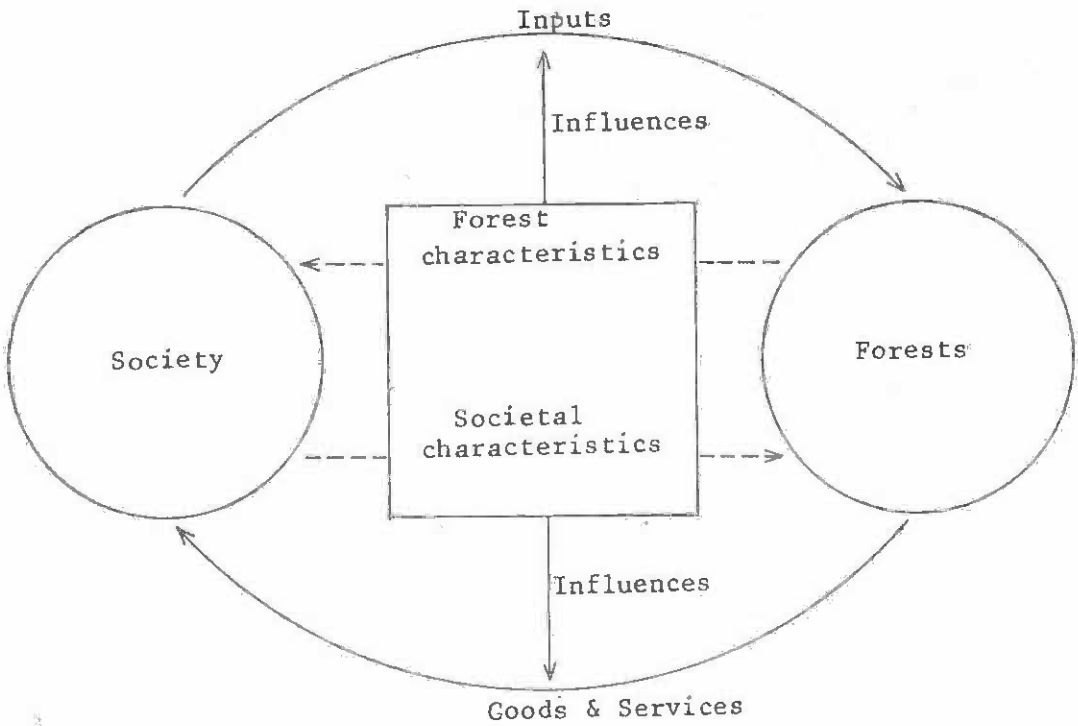


Table 3

Ownership of Forests

Type	Percentage of total area
Government	95.8
Corporate	2.6
Private	1.6

About 52.2 percent of the total forest area is constituted as reserved forests under the Indian Forest Act and here most of the rights have been settled/abolished[4]. Protected forests account for about 31 percent and these are burdened with rights. Often dual control exists in these forests in which land is under the control of the revenue department while protection of tree growth is the responsibility of the forest department. The balance, 16.8 percent, is unclassed forests. Management is effective only in the case of reserved forests which are worked systematically on the basis of regular working plans. About 66 percent of the forest area is now covered by working plans or working schemes (Central Forestry Commission, 1980). In the initial stages, regulating the otherwise uncontrolled felling was the main objective of the working plans/schemes and apart from isolated efforts, very little attention was paid to regeneration. Working plans are usually prepared for a division and areas identified for a specific set of treatments under a given silvicultural system are included in a working circle. Important silvicultural systems applied to different forest types are indicated below.

[4]This does not imply that biotic disturbances are absent in these forests. In the North Eastern Hill region, even reserved forests are subjected to shifting cultivation.

Silvicultural Systems

True natural management involves practically no human intervention at the stages of regeneration and growth. When removal is limited to increment, and sufficient time is allowed for natural recovery, a natural management in that pure sense may be possible. With increasing intensity of removal substantial inputs of labour and other resources become necessary to maintain productivity. At what stage management ceases to be natural is, however difficult to determine. For the present study management is considered natural as long as there is complete reliance on natural regeneration, both seedling and coppice for restocking felled areas.

The main components of a silvicultural system applied to natural stands are (i) harvesting the tree growth that already exists, (2) regeneration of felled areas and (3) tending the regeneration till maturity to fulfill pre-determined objectives. A system is distinguished on the basis of the combination and nature of operations carried out during harvesting, regeneration and tending as given below.

1.	Harvesting	1.1 Selective felling	Selective felling in a specified area adopting a felling cycle.
		1.2 Clear felling	i. Clear felling of an area spread over a number of years
			ii. Clearfelling of an area in one operation
2.	Regeneration	2.1 Natural	Seedling or Coppice
		2.2 Artificial	
3.	Tending	3.1 Low intensity	
		3.2 High intensity	

The major silviculture systems developed from this basis and applied to the Indian forests are given together with their important characteristics in Table 4. (See Prakash & Khanna, 1979).

Adoption of the silvicultural system involves therefore the application of certain inputs to the forests at the stages of harvesting, regeneration and tending leading to the generation of specific goods and services. Over time, however, changes are brought to systems in

Table 4

Silvicultural Systems Applied to Indian Forests

Silvicultural System	System Characteristics: Harvesting	Regeneration	Tending	Type of forest to which applied
1. Selection system and selection-cum-improvement felling	Selective removal of valuable species	Natural-mainly seedling origin	Limited to the establishment stage, neglected	Evergreen and semi-evergreen, moist deciduous and dry deciduous forests
2. Shelterwood Systems				
i. Uniform System	Complete felling spread over the regeneration period	Natural-mainly seedling origin	Intensive tending	Moist deciduous forests where regeneration of valuable species is adequate
ii. Irregular shelter-wood system	Complete felling of trees above a specified girth spread over the regeneration period	Natural-seedling origin. Trees below exploitable girth retained as advance growth	Tending and other cultural operations	Evergreen and moist deciduous forests where regeneration can be established with considerable effort

Table 4 (Cont'd)

Silvicultural System	System Characteristics			Type of forest to which applied
	Harvesting	Regeneration	Tending	
3. Clearfelling system	Complete removal of standing growth in one operation	Natural (seedling)	Intensive tending and thinning	Moist deciduous forests where natural regeneration is very profuse
		Artificial	"	Moist and dry deciduous forests where natural regeneration is unsatisfactory or where a change in crop composition is desired
4. Coppice Systems				
1. Simple coppice	Complete felling	Natural-coppice	Tending immediately after felling and thinning	Dry deciduous forests to produce fuelwood and small timber

Table 4 (Cont'd)

Silvicultural System	System Characteristics: Harvesting	Regeneration	Tending	Type of forest to which applied
Coppice Systems Cont.				
ii. Coppice with standards	Complete felling retaining specified number of standards	Natural-mainly coppice	"	"
iii. Coppice with reserves	Reservation by area, species and diameter limits. Felling the rest	Natural-mainly coppice	"	Dry deciduous forests to produce fuelwood and small timber and to improve site conditions

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Table 5

Development of Forest Management in India

Period	Factors Influencing Forestry	Consequences
Prior to 1900	1. Demand limited to high quality timber for railway sleepers, construction etc. Poorly developed accessibility	Adoption of selective felling. Limited extent regenerated artificially. This is mostly limited to teak.
	2. Demand for fuel	Coppice system.
	3. Need to increase land revenue	Transfer of forest land for agriculture, especially where it cannot produce good quality timber
1900-1910	Increasing demand for sawn wood	Accessibility was improved to tap more areas under selective felling
1920-1940	High demand for wood for defence and railways due to war. Setting up of industries. Improved accessibility	In many areas under selective felling, systems of concentrated regeneration were attempted. Adoption of uniform system for Sal. But prescriptions were often set aside to meet war demand
1920-1940	Initially high demand continued, but later slumped due to recession	Adoption of intensive working methods. But slump in demand led to non-observance of working plan prescriptions.
1940-1950	High demand due to war. Expansion of wood-based industries. Improved accessibility shortage of food; land reform acts	Non-compliance of working plan prescriptions and large scale exploitation of easily accessible areas. Deforestation for expansion of agriculture. Vesting of extensive jamindari forests burdened with rights with government
1950-1960	Growth of wood based industries. Development of agriculture	Exploitation of forests to meet industrial requirements. Improvement of accessibility. Consolidation of vested forests. Deforestation for expansion of agriculture

1960-70	Growth of the pulp and paper industry and other wood based industries. Degradation of forests	Expansion of the plantation programme, especially by clearfelling natural forests. Large scale introduction of exotics. Afforestation and rehabilitation programmes. Farm forestry
1970 onwards	Rapid growth of wood-based industries - Emphasis on industrial orientation of forestry. Increasing rural energy crisis	Setting up of forest development corporations to undertake large scale man-made forestry programme by clearfelling the mixed forests. Social forestry programme including farm forestry

response to the changes in societal and forest characteristics. Thus, especially with increasing demand, improved accessibility etc., silvicultural systems have undergone changes as indicated in Figure 5.

Development of agriculture, industry and the changing priorities of government have also greatly influenced forest management and for a large country like India, it is extremely difficult to compress the complex history into a general pattern. Table 5 gives the broad trend in the development of forestry in India.

No reliable data are available on the area under different silvicultural systems in different forest types and for the country as a whole. Areas under different systems in selected states are given in table 6, and from this an indication of the relative importance of the system can be gained.

Table 6

Area Under Different Silvicultural Systems

(Area in Sq. Km.)

State	Selection and selection cum improvement	Shelterwood		Clear-felling and others[1]	Coppice		
		Uniform	Indian irregular shelter-		Simple coppice	Coppice with stds	Coppice with reserve
Bihar	2620	5650	..	4320	..	21720	..
U.P.[2]	5800	5760	..	9040	4160[3]	1910	..
Orissa	20000	NA	..	NA	NA	5000	..
Tamil Nadu	190	..	..	NA	1560[3]	..	..
Maharashtra	18290	3990	..	1480	..	..	13610
Kerala	920	NIL	..	1470	380[3]	..	..
Assam	NA[4]	..	650	350	NA	..	..

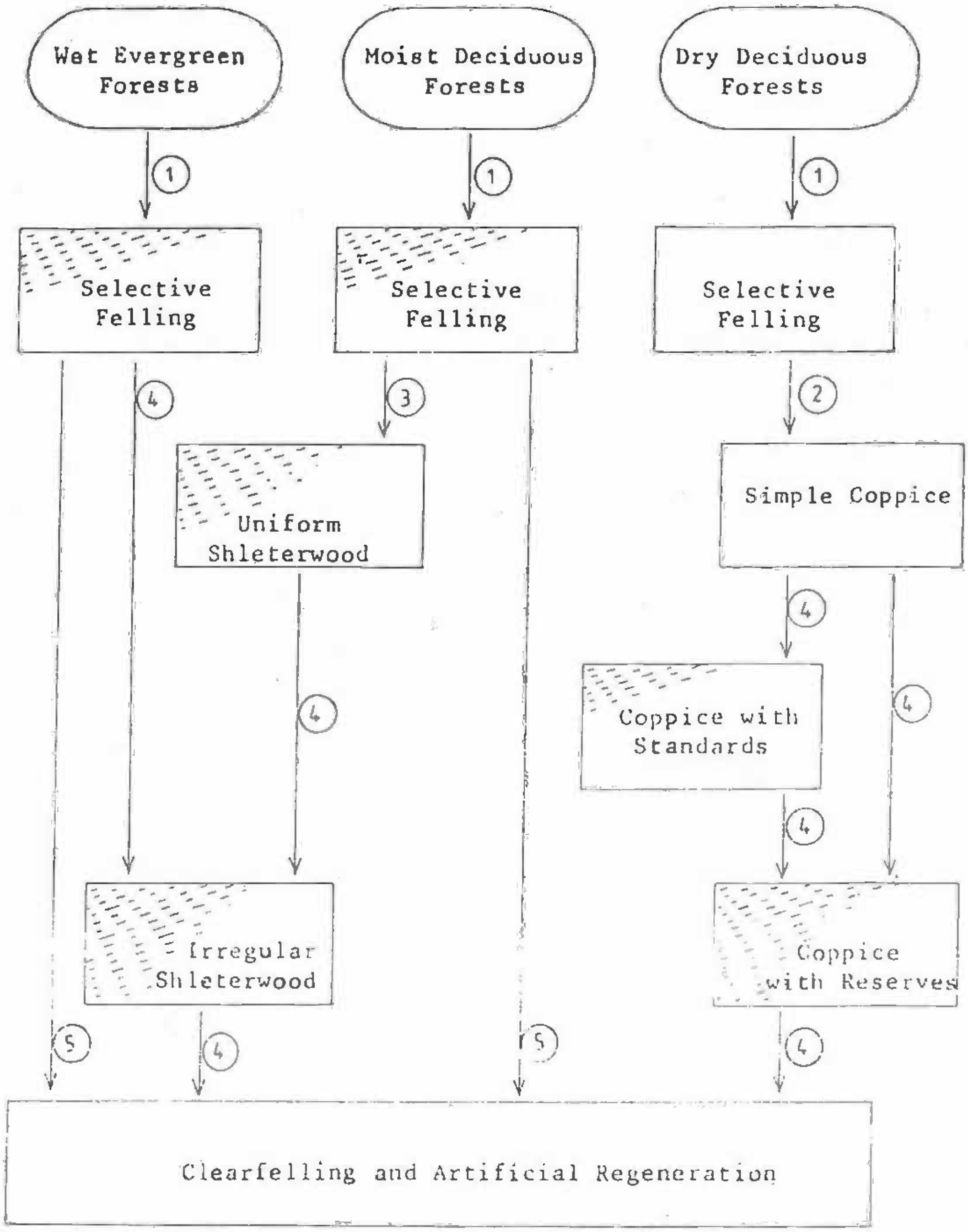
[1] Includes area under rehabilitation and afforestation programmes also. Details of area taken up under clear felling and planting are not available separately.

[2] Includes details pertaining to the coniferous forests also.

[3] In all states eucalypt plantations are managed under simple coppice system. This is also included here.

[4]NA = Information not available.

Fig. 5. Evolution of Management Systems in Tropical Mixed Forests



Indicates - Part of the area remain in the same system

1. Intensive exploitation not feasible due to accessibility, demand or labour constraints
2. High demand for fuelwood and small timber, existence of traditional rights to forest produce
3. Natural regeneration of valuable species feasible
4. Failure or inadequate natural regeneration and forest deterioration
5. Need to change crop composition in favour of species in high demand.

In most states it can be seen that, selection or selection-cum-improvement felling and coppice with standards continue to be the most important management systems.

CONCLUSION:

Diversity of the vegetation coupled with the complexity of socio-economic conditions have led to the evolution of a wide spectrum of management systems. However, what is actually practised seldom fits into the description usually found in silviculture text books and often represents a compromise between conflicting factors. Growing demand for timber and firewood have brought changes in systems over time. Important features of different systems in vogue now are described in the ensuing sections.

SELECTION SYSTEM

The selection system practised in India involves the selective felling of exploitable trees from a given forest area at periodic intervals. It was one of the earliest systems to be applied to the forests and regulating the felling was the main objective. Areas worked under the system are included in the selection (or selection-cum-improvement felling) working circle or the hill working circle. In the case of economically important species distributed widely, working circles which overlap with areas worked under other systems are constituted.

Choice of System

Selective felling is adopted in the tropical mixed forests of India under the following conditions:

i) Low proportion of valuable species: Despite the large number of trees per unit area, the high species diversity necessitates the tapping of a large area to ensure availability of wood to meet specific end uses. This becomes uneconomical except in the case of highly valuable species.

ii) Lack of information on end uses: Properties of a large number of species in the mixed forests are as yet unknown and thus even if extraction is feasible, they cannot be marketed easily. For example, there are more than 100 known tree species in the evergreen forests of Western Ghats, but only about 40 are commercially exploited.

iii) Poor accessibility: This restricts the utilisation of forest, favouring less concentrated working. A large quantity of timber and firewood available cannot be transported economically and as a consequence extraction is limited to logs or sawnwood whose value/bulk ratio is high.

iv) Environmental protection: The system is also adopted where concentrated fellings are inappropriate due to their adverse environmental impacts. In hilly areas, low intensity selective felling ensures an acceptable trade off between protective and productive functions of forests.

Application:

Exploitation of timber from most of the mixed forests in India commenced with selective felling. While in some areas this has been replaced by systems involving more concentrated fellings, in larger areas selective felling is in vogue even now. This is the most widely adopted silvicultural system in India. Table 7 gives the type of forests and states where selective felling is practised (FRI & Colleges, 1961).

Details of application of the system, especially yield regulation and prescriptions related to felling and regeneration, are given below.

Table 7
Selective Felling in India

Forest Type	Species Selectively Removed	State
Evergreen forests	Mostly plywood and matchwood species. Hardwood species are sometimes converted to sleepers depending upon demand.	Kerala Karnataka Tamil Nadu
Moist deciduous	*Shorea robusta, Terminalia tomentosa, Adina cordifolia, Lagerstroemia microcarpa, Tectona grandis*, Bamboo	Uttar Pradesh Madhya Pradesh Bihar, Orissa Maharashtra Andhra Pradesh Assam
Dry deciduous forests	*Santalum album*	Tamil Nadu and Karnataka
	Bamboo	All states
	Boswellia serrata	Bihar Uttar Pradesh Madhya Pradesh
	Acacia catechu	Bihar Uttar Pradesh Madhya Pradesh

Selective felling was in vogue in the evergreen forests of Western Ghats right from the beginning of this century. Extraction was limited to species suitable for railway sleepers (eg. Hopea parviflora, Mesua nagassarium) and ship masts (notably Calophyllum spp.). During the first world war boom, accessibility was improved and in some areas attempts were made to introduce systems of concentrated felling (Champion and Osmaston, 1962). Failure of regeneration and more particularly the slump in demand during the interwar recession led to abandonment of such trials. Growth of the plywood industry during the second world war period and the increasing demand for railway sleepers led to the large scale adoption of selective felling in the evergreen forests of Western Ghats. At present evergreen forests of the Western Ghats are primarily managed to supply veneer logs and railway sleepers. Intensity of management is closely linked to the growth of the plywood industry[5].

Objectives of Management:

The three most commonly stated objectives of management for evergreen forests under the selection system are:

a) maintenance of tree cover to protect the soil and to regulate water yield in catchments

b) increasing the supply of wood and other products and

c) consistent with the above objectives realising the maximum revenue.

Selective removal is considered the most appropriate alternative to fulfill the above objectives under the constraints of poor accessibility and low density of utilisable species. Adoption of low intensity selective felling is primarily determined by economic constraints and is not always an outcome of integrating environmental considerations[6].

[5]The Kerala-Karnataka region accounts for 19.5 percent of the installed capacity of the plywood industry in the country and most of their requirements of veneer logs are met from the evergreen forests (Sivananda and Nagaraju, 1983).

[6]This is evident from the fact that improved accessibility leads to a change in the system of working in favour of more intensive systems (see FAO, 1984) especially when there is no immediate and apparent adverse effects.

Yield Regulation

Under the polycyclic selection system the same area is visited at periodic intervals and trees reaching specified exploitable girth are removed. Factors such as the time taken for trees in the pre-exploitable class to reach the exploitable class, condition of the crop, especially proportion of mature and over mature trees and infrastructural facilities are considered in determining the felling cycle. Where there is a preponderance of harvestable trees, a shorter cycle is preferred to enable their speedy removal. A shorter cycle will, however, enhance the annual area required and involved considerable investment on infrastructure so that this tends to have an overwhelming influence on the cutting cycle. Felling cycles adopted in different forest divisions in the Western Ghat region vary from 15 to 45 years (see Table 8).

Removal from the annual coupe is further subjected to a girth limit check. Exploitable girth is influenced by the nature of demand, the species and the size class distribution of trees. In unworked stands where there is a preponderance of large trees the girth limit is fixed high. Industries respond through technological changes and this often leads to a reduction in the girth limit, especially when an area has to be worked repeatedly. Girth limits for working the evergreen forests in Western Ghats vary between species, felling cycle and locality and range from 120 cm to 210 cm.

A further check is exercised on harvesting by prescribing an upper limit for the number of trees that can be removed from the exploitable class. Smythies safe guarding formula is sometimes used for this[7].

[7]Exploitable number is determined as a percentage of trees in the harvestable class as:

$$Y = \frac{X}{I + X} \times 100.$$

where I = number of trees in the exploitable class

X = f/t (II - 2 of II)

f = felling cycle

t = time taken for class II trees to reach class I

Z = mortality percent

Reliable data are not available on t and Z and consequently approximations are resorted to.

Table 8 gives the felling cycle, exploitable girth and number of trees that can be harvested for some divisions in the states of Kerala and Karnataka.

Some of the important felling rules followed in Kerala and Karnataka are given below:

i. to ensure that felling is not concentrated in pockets it is prescribed that a minimum distance of 20 metres should be kept between two marked trees;

ii. climber cutting is prescribed at the time of marking to minimise damage during felling;

iii. to prevent soil erosion;no felling is to be carried out for a width of 20 metres on either side of water courses

iv. marking is to be carried out in such a way as not to cause any lasting gaps in the canopy and

v. only dead and dying trees are to be marked on steep slopes.

Table 8

Prescription for Selective Felling

Forest Division	Felling Cycle (in years)	Exploitable Girth (in cm. gbh.)	Number Removable/ ha
Coorg (Karnataka)*	45	210	17
Sirsi "	40	183	20
Honnawar "	30	183	NA
Hassan "	30	180	7 to 11
Wynad (Kerala)	15	120-180	20
Nilambur "	20	150-200	10
Ranni "	15	180	20

*Recently in Karnataka, the number of exploitable trees has been reduced to 2 per hectare in response to the growing pressure from environmental groups.

Timber extraction is carried out either by industries (especially plywood and match units) to whom an annual quota of timber is allotted or by the forest department who usually get the work done through the agency of contractors. The system of giving long term lease is not in vogue.

Regeneration

There is complete reliance on natural regeneration. It is assumed that selective removal improves light conditions and thereby facilitates the establishment of regeneration and the growth of trees in the pre-exploitable class to the exploitble class. Important prescriptions aimed to promote natural regeneration are as follows:

i. All broken and completely damaged trees are to be cut back,

ii. A regeneration map is to be prepared for each annual coupe and treatments appropriate to the status of regeneration are to be carried out. Most working plans prescribe gap planting in area deficient in natural regeneration. Nursery raised seedlings of Vateria indica, Dipterocarpus indicus, Dichopsis ellipticum, Artocarpus hirsutus, Dysoxylon malabaricum etc. are to be planted and are to be tended during the first three years.

iii. If required, thinning has to be carried out to relieve congestion in patches of pole crop.

These prescriptions are seldom adhered to. Gap planting, strip planting, etc. undertaken under different schemes cover only a very small proportion of the area felled annually. Although only a few trees are felled, damage to other standing trees is very high[8]. Drastic change in light and moisture conditions encourage the growth of weeds, especially primary colonisers, impeding the establishment and growth of regeneration (Rai, 1979). Prescriptions are neglected due to technical, institutional and financial constraints (FAO, 1984).

[8]Even if only 10 trees/hectare are felled, sometimes this results in opening the canopy to the extent of 50 percent

Selective felling with sufficiently long felling cycles on moderate slopes seldom causes any soil erosion if felling rules are strictly adhered to and sufficient care is taken in laying out roads, extraction paths, etc. However, in practice such prescriptions are not always implemented. Logging contractors (employed both by industries and forest department) are primarily interested in profit maximisation, to the neglect of silvicultural prescriptions[9]. Surface run off and soil erosion tend to be very high during and immediately after harvesting. Very often, logging operations extend for two to three years due to sequential working by different agencies/industries and this aggravates the problem.

Selective felling does help to enhance wood supply in the short run. Feasibility of long run sustained supply of wood and other products depends on the intensity of exploitation and success of regeneration. Very few forests have been worked continuously over a number of cycles to the same prescription. Between successive cycles, yield is maintained by (1) reducing the felling cycle, (2) reducing the girth limit and (3) removing the species not extracted during the previous cycle. In the absence of regeneration, selective felling at short intervals leads to degradation, seriously affecting wood production in the long run.

The relevance of selective felling has been examined on the implicit assumption that the objectives of management plans truly represent the societal objectives. This assumption may not be always valid. Most often, selective felling is a passing phase and is soon replaced by alternative systems or alternative land uses.

[9] A change in the agency for logging seldom improves the situation. Workers employed for different operations lack sufficient training. Payment to them is made on piece rate basis and out-turn becomes the primary concern rather than adherence to silvicultural prescriptions.

In Moist Deciduous Forests

Although the system of clear felling and artificial regeneration in the moist deciduous forest dates from the 1850's, this was on a small scale and selective removal continued to be the main system applied to both teak and sal forests. Systems of concentrated felling were introduced in some of these forests during the first quarter of this century, primarily in response to the increasing demand for construction timber, railway sleepers, etc. This was, however, restricted to easily accessible areas and where natural regeneration cuuld be relied upon for restocking. In the course of time improved accessibility enabled the extension of those systems and selective felling was mostly adopted in less accessible areas. The need to ensure the protection of steep slopes coupled with techno-economic constraints in undertaking intensive working have led to the continuation of the system in many areas. Table 9 gives examples of divisions where selective felling is still in vogue.

Table 9
Selective Felling in Moist Deciduous Forests

State	Division	Species
Uttar Pradesh	Dehr Dun Haldwani Ramnagar	Mainly Sal
Bihar	Saranda Chambaran	Sal
	Palmau	Sal and other species
Orissa	Kalahandi Angul Rairakhol etc.	Sal and other associates
Madhya Pradesh	Bastar	Teak and Sal
Maharashtra	South Chanda	Teak
Andhra Pradesh	Adilabad Ballampalli	Teak

Objectives of Management

Since the conditions under which selective felling is undertaken in moist deciduous forests are identical to that of evergreen forests, the objectives of management are more or less the same. Some of the most commonly stated objectives are:

i) to protect the hill slopes from erosion and conserve moisture to regulate water supply;

ii) to improve the condition of the crop by encouraging regeneration of valuable species (eg. sal, teak, etc.) and

iii) consistent with the above to obtain the maximum sustained yield of timber (see, Singh, 1979; Maleta, 1976).

Priority given to wood production and revenue maximisation in selection felling is dependent on the overall contribution of selection felling areas to the total wood production and revenue from the sector. When these objectives can be fulfilled from areas managed under more intensive systems, the protective function gets priority.

Yield Regulation and Felling

Here also, yield is regulated by area followed by a girth limit check. Sometimes a further check is exercised by fixing the number of trees that can be removed from the exploitable class either arbitrarily or by using Smythie's safeguarding formula. Felling cycle, exploitable girth and the number of trees harvested per hectare for a few divisions in different states are given in Table 10.

To ensure protection of slopes from erosion, working plans prescribe certain criteria for silvicultural availabiltiy of trees such as:

i) no tree will be marked near the edge of steep slopes, precipitous areas and on erodible and unstable hill sides;

ii) marking should not be carried out for a width of 20 metres on either side of water courses; and

iii) felling of trees should not create permanent gaps in the canopy.

A set of subsidiary silvicultural operations is prescribed and this includes the cutting back of damaged stems, selective weeding to free seedlings and climber cutting. In poorly stocked areas, particularly blanks, artificial regeneration is also recommended.

Table 10

Moist Deciduous Forests - Selective Felling Parameters

Division	Felling cycle (yrs)	Exploitable girth (in cms at bh.) for different species		Selection number
Dehra Dun (Uttar Pradesh)	10	*Shorea robusta*	120	1 tree out of 6 exploitable trees
		Dalbergia sissoo	150	
		Terminalia tomentosa	120	
		Acacia catechu	120	
Haldwani (Uttar Pradesh)	10	*Shorea robusta*	150	Not fixed
		Bombax ceiba	180	
		Acacia catechu	120	
Adilabad (Andra Pradcesh)	20	*Tectona grandis*	120	"
		Terminalia tomentosa	120	
		Pterocarpus marsupium	105	
South Chanda (Maharashtra)	20	*Tectona grandis*	120	"
		Others	135	
Bhandara (Maharashtra)	20	*Tectona grandis*	120-135	"
Kalahandi (Orissa)	20	*Shorea robusta*	105-150	"
Saranda (Bihar)	20	*Shorea robusta*	135-150	1 in 3 to be felled

Critical Evaluation

Implementation of various prescriptions, however, tends to be rather tardy. Whether felling will be actually undertaken or not depends on the importance of the area in relation to the overall sectoral objectives, particularly, wood production and revenue realisation. Cost of selection working is very high and is a major factor that influences the intensity of felling and other operations. The following extreme situations are met with.

i) Yield from selective felling does not significantly enhance income and wood output. This is particularly the case when the same product can be obtained more economically from other forests worked under more intensive systems. Often it may not be possible to get contractors to work such areas. In such situations selective felling may not be taken up at all or carried out only in comparatively easily accessible areas (eg. selection coupes in Saranda Division in Bihar).

ii) The other extreme situation involves intensive working of easily accessible areas ignoring selection principles. Ultimately the area may be completely transferred to other working circles for intensive working[10].

There are no instances where selective felling has been employed to realise a sustained yield from moist deciduous forests. Regeneration of valuable species is poor and gaps created during felling seldom get regenerated. Fire is a major factor impeding regeneration. Gap planting is technically feasible, but institutional and financial constraints prevent its widespread adoption. Probably it is cheaper to undertake intensive regeneration operations under systems of concentrated working. On the whole the system as applied to moist deciduous forests is a passing phase.

[10]In many divisions forests originally worked under selective felling have been included under Shelterwood Working Circle or Plantation Working Circle (eg. Chanda in Maharashtra and Wynad in Kerala).

In Extraction of Bamboos

Traditionally bamboo is used for a variety of household and agricultural purposes and is regarded as a poor man's timber. Also it finds extensive use in cottage industries like mat and basket weaving. Bamboo is one of the most important cellulosic materials and accounts for about 65 percent of fibrous raw material used by the paper industry. Annual output of bamboo is estimated as about 3.23 million tonnes of which about 2 million tonnes are used by the pulp and paper industry (Varmah and Bahadur, 1980). Primarily it occurs in the moist and dry deciduous forests. Bambusa arundinacea and Dendrocalamus atrictus are the most important species. Cephalostachyium pergracile, Dendrocalamus hamiltonii and Ochlandra spp. are also important locally.

Until the pulp and paper industry began to use bamboo as a raw material, it was considered as a minor forest product and worked under the minor forest product working circle. Management was limited to regulating the felling. In regeneration areas, bamboo was treated as a weed and was removed regularly to facilitate the growth of favoured species like teak and sal. This being the case, some of the pulp and paper units could get long term concessions for collection of bamboos at nominal prices. The system of management adopted for bamboo working is known as culm selection-cum-clump improvement (Krishnaswamy, 1957).

Objectives of Management

Regulating felling is still the foremost objective of bamboo management. Working plans do however prescribe other objectives also, such as improvement and augmentation of growing stock through appropriate silvicultural treatments.

Yield Regulation and Felling

All bamboo areas intended for working are included in a working circle, which most often overlaps with other working circles. The felling cycle adopted varies from 3 to 4 years and based on this yield is regulated by area. Important rules prescribed to prevent overfelling are given below:

i) No working is permitted from April to October[11].

[11]Culms grow during June to August and this prescription is aimed to prevent damage to the growing culms.

ii) In each clump all new culms (less than one year old) and 6 to 8 mature culm (over 1 year old) should be retained.

iii) Clumps containing less than 8 culms should not be worked.

iv) Cutting should be carried out between 15 to 45 cm above ground, leaving one internode.

v) In the case of flowered clumps, complete felling is permitted only after seeding is completed.

In some states bamboo forests have been leased out to pulp and paper units and extraction is undertaken by the lessees through contractors. The scattered nature of the work renders effective supervision difficult and felling rules are often violated. Bamboo clumps located in easily accessiblle areas are often clear felled, while those in inaccessible locations are not worked at all. This coupled with fire, grazing and such other biotic factors, has led to the decline of bamboo resources in most states. Yields from successive felling have shown a declining trend[12]. . A felling cycle - of 3 to 4 years is too short to enable the clump to recover from felling damage (Prasad and Gadgil, 1981). Bamboo plantations have been raised in some states in response to the growing industrial and other demand.

In Extraction of Sandal

Sandal (Santalum album) is primarily found in the dry deciduous forests of Karnataka and Tamil Nadu. It is one of the oldest known sources of perfume material and was declared a royal tree long before the concept of reservation of forests came into practice. Oil extracted from the heartwood is an important ingredient in the manufacture of perfumes, medicines and toilet soaps. Sandalwood forms an important source of revenue to the Karnataka and Tamil Nadu forest departments.

Yield Regulation and Felling

Yield is regulated by area. A felling cycle of 6 years was being followed earlier in most divisions. On account of the high mortality due to spike diseases, this has been reduced to 3 years (Joseph, 1970). Within the annual coupe, removal is limited to dead trees only.

[12] Yield per hectare on a three year working cycle varies from 2 to 5 tonnes.

Extraction is carried out departmentally. Trees are uprooted, billeted and after rough cleaning, transported to forest department depots. After removal of sapwood, heartwood is classified on the basis of the size and portion of the tree from where it is obtained[13]. Disposal is through open auctions held at periodic intevals.

Regeneration

Natural regeneration occurs profusely, but, establishment is poor on account of fire and grazing. The spike disease is a major threat and no remedial measures have yet been identified. The disease is spreading rapidly even to areas which were thought to be free from it. Unscientific extraction and illicit removal have also contributed to the depletion of sandalwood especially in states like Karnataka[14]. The technique of artificial regeneration has been more or less perfected and the total area under sandal wood plantations in Tamil Nadu, Karnataka and Kerala is about 3460 hectares. Unless spike disease is controlled, the sandal resource will soon be more or less completely depeleted.

In Extraction of other Species

Khair (Acacia catechu) and Salai (Boswellia serrata) are two important species selectively extracted from the dry deciduous forests. Khair occurs as a seral formation on the river banks (Champion and Seth, 1968) in Uttar Pradesh, Bihar, Madhya Pradesh, Orissa and Gujarat. The heartwood of Khair is used for the extraction of Catechin (Katha) and Catechu tannic acid (Cutch). Catechu is an important commercial product used in dyeing and as a preservative agent and its chief industrial use is for dyeing cotton and silk and for calico printing. Katha is an indispensable ingredient in the preparation of chewing pan. It has a number of medicinal properties and is used as an astringent and digestive (FRI & Colleges, 1972).

All Khair areas are included under the Khair overlapping working circle. Yield is regulated in the first instance by area. A felling cycle of 20 to 30 years is adopted. A further check is exercised by prescribing a girth limit, which varies from 35 to 45 cms. No silvicultural operations are carried out to encourage natural regeneration.

[13]About 18 classes have been recognised in trade. Oil content of the roots is very high and consequently they fetch a very high price.

[14]In some divisions the growing stock has come down by 50 percent during the last three decades (Adkoli, 1977).

Salai (Boswellia serrata) is used primarily for the production of packing cases. It is also used as cellulosic raw material in the pulp and paper industry. Forests with salai are included under the salai overlapping working circle. As in the case of other species, yield is regulated by area following a felling cycle of 20 to 30 years. Selection girth is fixed at 90 to 105 cms. Regeneration is entirely left to nature.

CONCLUSION

Selective felling as a method of working mixed forests has mainly evolved in response to the urban and industrial demand for selected species. Extraction of commercially utilisable/valuable species is the primary objective. Two broad types of selective felling can be identified namely, (1) that undertaken in the initial stages and which will be replaced in a planned manner by more intensive systems in response to techno-economic changes and (2) that attempted as a regular method of working. In the first case improved accessibility and better utilisation of species lead to a more or less planned shift in the management system. The second type of selective felling also tends to change, largely due to unanticipated dysgenic effects. When natural regeneration is insufficient and removal exceeds increment, degradation sets in. Data on growing stock, increment, removal, regeneration, etc., although essential to regulate yield are not readily available and the process of degradation is often imperceptible. Two alternatives available are (1) to exclude the area from the purview of timber production forestry or (2) to introduce intensive management systems like clear felling and planting. With the growing pressure on land, the second alternative has been adopted in many areas.

Selective felling is generally species-oriented and thus completely neglects the complex ecological status of the forests. This has been one of the main factors contributing to the failure of regeneration. The future of natural management of the mixed forests generally in the context of failure of natural regeneration is discussed in the concluding section.

SHELTERWOOD SYSTEMS

Failure of regeneration coupled with the need for intensive exploitation of valuable forests led to the search for an alternative management system. Success with the shelterwood system in Europe led to its introduction to India during the first quarter of this century.

The period commencing from 1910 is in fact one in which remarkable changes occurred in silviculture and management. Knowledge of the silvicultural practices in Europe was primarily responsible for this (Troup, 1916). Stebbing summarises the changes as follows "Having passed the whole of his service in managing forest areas under the so called Selection System by the equally so called Improvement fellings, which, as is now very thoroughly realised, did little more than remove the marketable individuals of a few species from the mixed crop - to such a man, the mere mention of the fact that areas are managed under concentrated regeneration fellings, by taungya or otherwise; under the uniform or shelterwood compartment system either by natural regeneration or by artificial work; or by combinations of this method with strips or groups; under coppice or coppice with standard would convey little. With the fixed ideas engendered during a life's work carried out on the one basis it would prove difficult to visualise the present great advance, to appreciate that at the present day work on as high a plane as anything on the continent of Europe is to be seen in India" (Stebbing, 1926, p.410). Stebbing however hastens to qualify that these methods have been applied to a very small proportion of the forest area.

Under the shelterwood systems, felling of the overwood is regulated to provide favourable conditions for recruitment and establishment of regeneration. A number of variants under the broad category of the shelterwood system exist. The two most commonly adopted in India are:

1) The Indian irregular shelterwood system and
2) The Uniform System

Their salient features are discussed below.

Indian Irregular Shelterwood System

Due to difficulties in getting regeneration, fellings are carried out irregularly under the floating periodic block system. Uncertainty of regeneration has necessitated the retention of trees below a specified girth as part of future crop. The crop so produced is irregular and in many respects the system is very similar to the selective felling system. Table 11 gives the regions/localities where the Indian Irregular Shelterwood System is practised now.

Table 11

Application of Indian Irregular Shelterwood System

Forest Type	Region/Locality
Tropical evergreen forest	Andaman Islands, Assam and Arunachal Pradesh
Moist deciduous forest	Uttar Pradesh (Dehra Dun, Ramnagar, Haldwani) Andamans

The Andaman Islands

In the Andaman Islands timber extraction commenced in 1857 when the first settlement was established. Initially meeting the wood requirements of the settlement was the primary concern of forest exploitation. For a very long time the demand was limited to three species, namely padauk (*Pterocarpus dalbergioides*) gurjan (*Dipterocarpus* spp.) and white chuglam (*Terminalia manii*). Selective felling was in vogue till the 1950s. Although the technique of regeneration under the Andaman canopy lifting shelterwood system - a variant of the Indian irregular shelterwoood system - was perfected about two decades back, it could not, for a variety of reasons be put into practice. Growth of the plywood industry, enhanced utilisation of species not in favour for a long time and improved accessibility have now facilitated the adoption of the Andaman canopy lifting system. This system is applied to both the evergreen and moist deciduous forests. Plywood and match industries form the most important wood based industries in the islands[15]. Although there is large scale migration, settlements are primarily confined to the South Andamans and on the whole the forests are not subjected to severe biotic pressures as in the mainland. Demand from the plywood industry seems to be the most important factor influencing forest management in the islands.

[15]Total quantity of timber extracted in the Islands during 1982-83 was about 143000 of which about 78000 m was utilised by the plywood and match industries (Forest Dept., 1983).

Yield Regulation and Felling

Important objectives of managment are (i) conversion of the irregular forest into a normal forest and (ii) realisation of the maximum yield of timber (Sharma, 1979). A rotation of 100 years is prescribed, but the area of annual coupe is worked out using a conversion period of 75 years to ensure that mature and overmature trees are removed quickly. The system of floating periodic blocks is adopted. Area identified for harvesting and regeneration during the tenure of a working plan is allottted to P'B I. PB I usually comprises of areas which contain advance growth and mature and overmature trees. Here the working plan period is taken as the regeneration period[16]. All the other areas are grouped as PB unallotted.

Yield is regulated by a combination of area, volume and number. Working in a year is confined to the annual coupe. The total volume of trees in the exploitable class is estimated by carrying out a 10 percent partial enumeration. Taking into account market demand, exploitable girth is fixed as follows.

1.	Commercial Hardwoods	-	150 cm
	Softwood	-	120 cm
2.	Non-commercial	-	180 cm

From the total volume estimated, annual availability is calculated. A further check is exercised by limiting extraction to 15 trees per hectare. To ensure that removal does not exceed the prescribed volume, the cumulative volume is worked out as the marking progresses and as soon as the prescribed yield or area is reached marking is stopped. Important marking rules prescribed for working PB I areas are as follows.

i) trees marked for felling should as far as possible be evenly spaced;

ii) no felling should be carried out on steep slopes if sufficient advance growth is not available;

[16] Area to be allotted to PB I is directly proportional to the plan period and is derived as $\frac{A \times P}{C}$ where A = total area allotted to the circle, P = plan period and C = conversion period (75 years).

iii) no tree occurring in blanks with deficient regeneration should be felled;

iv) where regeneration is insufficient, at least 10 sound healthy trees of commercial species will be retained per hectare as seed trees; and

v) no felling will be carried out for a width of 40 metres on either side of large streams.

Rules for felling are, however, not always adhered to, both in the coupes worked departmentally and by lessees directly[17]. Felling damage is high and the whole canopy gets opened. Soil in the Islands is extremely fragile and consequently erosion is a serious problem.

Regeneration

Natural regeneration is generally satisfactory and a series of operations, spread over the first three years immediately following harvesting is carried out to facilitate establishment. All sound trees of commercial species below the prescribed exploitable girth are retained as advance growth and will form part of future crop. The main operations carried out are given in table 12.

[17] All the four major industrial units in the Islands have obtained long term harvesting leases extending over 10 years.

Table 12

Andaman Canopy Lifting System - Regeneration Operations

Year	Month	Operations
1	March - April October	(1) Completion of timber extraction (2) Brushwood cutting (3) Felling of undergrowth and poles up to a height of 10 metres (4) Girdling of trees between 10 to 20 metres
2	April - May September	(1) Broadcast sowing of seeds of commercial species if natural seeding is considered inadequate (2) Weeding (3) Climber cutting and weeding (4) Girdling of understorey trees to permit more light
3	March - April September	(1) Weeding (2) Final felling and girdling of unwanted trees (3) Weeding

Natural regeneration of Dipterocarpus spp. is found to be satisfactory. Although timber extraction leaves the canopy more or less completely open, weed growth is not very dense as in other evergreen forest regions in the country[18]. If weed growth is kept under check during the first one or two years, the light demanding species especially Dipterocarpus spp. are able to grow sufficiently tall to establish.

Light crown thinnings have been prescribed at the 6th, 15th, 30th and 50th years. In an uneven aged crop comprising advance growth of young saplings and poles, thinning becomes an extremely complicated operation and generally tends to be neglected.

[18]The dense forest cover does not permit the growth of weeds. Absence of biotic pressures and the ecological conditions peculiar to the islands are important factors responsible for poor weed growth.

Evaluation

Growing industrial demand is the main factor influencing the management of the forests in the Andaman Islands. Nothing can be said about the sustainability of wood production under the present system of management as no area has yet been worked for the second cycle. However, it is pointed out the yield is expected to decline during the second cycle and may be far less than that obtained during the initial phase of conversion.

No attempt has yet been made to assess the environmental effects of heavy fellings in the evergreen forests. As noted the soil is extremely fragile and highly erodible. The change in composition and its long term impacts have also yet to be studied.

In essence, the Andaman canopy lifting system is an intensive selective felling and the canopy gets opened up completely. The intensity and scale of fellings have increased during the last few decades, but regeneration operations have not changed since they were perfected in the 1930's. The question whether the present management system will be able to fulfill the multifarious objectives is difficult to answer.

Assam and Arunchal Pradesh

In the North Eastern region (Assam, Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Tripura and Mizoram) reserved forests account for a very small proportion of the total forest area. Most of the forest is under tribal control and subject to shifting cultivation.

The Upper Assam forests were initially utilised for production of railway sleepers and have been under systematic management since the 1930s. With the growth of plywood industry in the region[19], management is primarily directed at meeting the raw material requirements of the industry (KFRI, 1978). For management purposes the Upper Assam divisions[20] have been constituted into two working circles, namely (1) Hollong - Makai regeneration Working Circle and (2) Hollong plantation working circle. The former consists of good unworked evergreen forests and is managed partly under the irregular shelterwood system and partly under selective felling. The most important objective of management of forests included under the Hollong - Makai regeneration working circle is to supply veneer logs to the plywood industry.

[19]Assam accounts for about 55 percent of the installed capacity of plywood industry in the country,

[20]Important forest divisions aare Digboi, Doom dooma and Dibrugarh.

Yield Regulation and Fellings

In the current working plan (Das, 1974) the rotation has been reduced from 120 years to 84 years while the regeneration period has been reduced from 20 to 12 years. Each felling series is divided into "PB allotted", comprising the area taken up for felling and regeneration during the plan period and "PB unallotted". PB allotted consists of areas with advance growth and mature and overmature trees.

Yield is prescribed for the whole felling series and is obtained from (1) PB I areas by way of regeneration fellings and (2) PB unallotted areas through selective fellings on a cycle of 12 years. In both cases yield is regulated firstly by area and secondly by a girth limit check. In PB I areas the girth limit adopted is 150 cms and all trees below this are retained as advance growth and form part of the future crop. In the PB unallotted a girth limit of 300 cm is followed. However, it is stipulated that if trees above 300 cm are not available, the girth limit can be lowered to 270 cm. Thus the shelterwood regeneration felling is limited to PB I areas and about 65 percent of the prescribed yield is obtained by selective felling in unallotted areas.

To facilitate regeneration in PB I areas felling is carried out in three stages as follows:

1. Initial Stage	(i)	Removal of all trees above the exploitable diameter. If advance growth is absent stems above 180 cm girth are retained per hectare as mother trees.
	(ii)	Removal of underwood leaving sufficient number of trees to keep down weed growth.
2. Intermediate		Periodic removal of underwood and overwood as initial stage regeneration becomes established.

[21]The area of annual coupe in PB I areas is Digboi division is 340 hectares, while that worked annually under selective felling is about 2120 hectares.

3. Final Stage — Removal of underwood and overwood except those retained as part of the future crop.

For the purpose of felling, PB I coupes are categorised as well stocked, medium stocked and poorly stocked[22] and felling is prescribed to be carried out in such a way as not to create a permanent gap in the canopy. Profuse weed growth, especially of <u>Michania</u> sp. is a serious problem in the Upper Assam region. Drastic openings are soon covered by weed growth, totally smothering regeneration.

<u>Regeneration</u>

In PB I areas there is complete reliance on natural regeneration. Further, all Hollong and Makai trees below 150 cm girth are retained as advance growth. Prescriptions aimed to promote regeneration are given below:

i) All marked trees not felled during main fellings are felled or girdled;

ii) Damaged seedlings are coppiced;

iii) Advance growth will be freed and thinning will be carried out in congested groups of poles;

iv) Weeding and climber cuttings are to be carried out for three consecutive years after main fellings. After the third year weeding will be done every alternate year and climber cutting once in three years till the 9th year.

v) Where regeneration is deficient artificial planting should be done in strips by transplanting seedlings of 60 cm and up at a spacing of 50 x 50 cm.

[22]This grouping is based on the stocking of large trees above 150cm gbh. If there are 15 or more large trees the area is considered as well stocked. If it is less than 8 it is understocked. Medium stocked includes areas with 8-15 large trees per acre.

Failure of regeneration in areas worked previously has necessitated artificial regeneration. Degraded forests and blanks have been constituted into a Hollong Plantation Working Circle with the objective of converting these into plantations of hollong and makai on a rotation of 45 years[23]. PB I areas are clearfelled, retaining as advanced growth all hollong and makai trees below 100 cm girth and all miscellaneous species below 40 cm girth and sowing is done in lines at 5 metres apart in worked soil. As in the case of PB unallotted in the regeneration working circle, PB unallotted in the plantation working circle is also subjected to a selective felling on a 15 year cycle.

Evaluation

Management of the Upper Assam evergreen forests is primarily dictated by the growing demand from the plywood industry. Rotation, regeneration period, exploitable girth, etc. have been revised periodically to enhance immediate wood supply. Implementation of regeneration prescriptions has been far from satisfactory. Consequently, most of the forests in the region are in a depleted condition and increasingly the plywood industry has to rely upon resources available from states like Arunachal Pradesh and Nagaland.

Drastic opening of the canopy under the irregular shelterwood system has not facilitated the establishment of regeneration. Although the predominance of hollong and makai in the top canopy is highly conducive for profuse seeding, establishment is hampered by weed growth. Failure of natural regeneration has necessitated the adoption of artificial regeneration. The purpose of introducing shelterwood system seems to have been not fulfilled.

[23] In his plan for Digboi division Das allocated to Hollong Plantation Working Circle an area of 20074 hectares. That allotted to Hollong Makai regenertion circle is 32765 hectares.

[24] For example in Arunachal Pradesh the total forest area is estimated as 51500 km^2. But the area under reserved forest is only 8070 km^2. In Nagaland reserved forests account for only 12 percent of the total forest area.

Forest management in other North Eastern states, especially Arunachal Pradesh, Nagaland and Meghalaya is more complicated. Most of the forests are under tribal ownership and the extent of reserved forest is very low[24]. Shifting cultivation is rampant and consequently forests are in a highly degraded condition. Rapid growth of the plywood industry coupled with depletion of forests in Assam has necessitated the tapping of forests in these states. No scientific management exists in areas outside the reserved forests. There is considerable unauthorised felling, under the pretext of shifting cultivation, and most of the veneer logs are purchased by plywood units in Assam.

Sal Forests of Uttar Pradesh

The irregular shelterwood system is followed in Sal forests in Ramnagar and Haldwani divisions and to some extent in Dehra Dun division also[25]. Due to difficulties in getting regeneration, uniform openings cannot be made and often large trees are retained as part of future crop. In Dehra Dun the rotation followed is 120 years with a regeneration period of 20 years, while in Ramnagar and Haldwani divisions it is 150 years and 30 years respectively. In the latter divisions floating periodic blocks are adopted in view of the uncertainty regarding establishment of regeneration. In Dehra Dun periodic blocks were fixed; but with failure of regeneration, it has become necesary to adopt a floating periodic block system.

Yield Regulation

For the purpose of yield regulation, PB I area is divided into (i) areas with woody but unestablished regeneration and (ii) areas with deficient regeneration. Yield is prescribed only with respect to areas belonging to the first category and is regulated by a combination of area and volume checks. Annual volume yield is established as:

$$Y = \frac{V + (I \times 0.5)}{P}$$

where Y = annual yield
V = Volume of growing stock above 120 cm girth
P = Regeneration period
I = Increment put on during P

As in the case of Upper Assam forests, a selective felling is carried out in the PB unallotted in Haldwani and Ramnagar divisions.

25 The system followed in the case of Dehra Dun is described as conversion to uniform system in the working plan. But strictly speaking, what is followed is Irregular Shelterwood System (Singh, 1979).

Regeneration

A set of rules for felling and regeneration is prescribed depending upon the status of regeneration. Where regeneration is deficient, only dead, dry and diseased trees in the canopy are to be removed. Where regeneration is present, but not established, more light will be permitted by removing the under storey trees. Complete overwood will be removed in areas where regeneration is well established. In Ramnagar and Haldwani divisions all healthy and well grown sal trees up to 120 cm girth are retained as part of the future crop.

In category (ii) areas the main objective is to induce natural regeneration through intensive cultural operations. Canopy manipulation involves the removal of all dead, dry and diseased trees and felling of mature and overmature trees is carried out where canopy is very dense. Shrub cutting, burning, soil working, fencing, etc. are some of the important operations for getting *de novo* regeneration. Since the introduction of the shelterwood system, forest managers have been making earnest efforts to regenerate the felled areas, and the techniques for *de novo* regeneration have almost reached a stage just short of planting. However, in most of the areas regeneration continues to be an intractable problem (Sen, 1965; Anon, 1967; Srivastava, 1969). Consequently, planting of nursery grown seedlings or sowing is being resorted to.

Evaluation

No doubt the irregular shelterwood system has played an important role in enhancing wood production in the short run. However, its long term sustainability is undermined due to failure of natural regeneration. Regeneration of species like sal has been one of the major focus of research in Indian forestry, but so far no reliable techniques have been developed. Thus, like the selective felling system, the irregular shelterwood system also seems to be destined to be replaced. In the case of the former, regeneration was almost neglected, while in the case of latter, efforts were made, but did not succeed.

Uniform System

The Uniform System is adopted in the moist deciduous forests with a preponderance of high value species like teak and sal. Management of these forests is geared to meet the national and regional demand, especially for defence, railways, general construction, etc. Application of the system involves the creation of uniform openings in successive fellings and is usually followed where regeneration is satisfactory. Often all overwood is removed in one clearfelling operation and the area gets restocked by natural regeneration. The true uniform system in which successive fellings are carried over a number of years and regeneration is gradually nurtured to the established stage is not in vogue in any of the mixed tropical forests in India. What working plans describe as uniform systems are in fact close to the clearfelling system in most respects. Table 13 gives examples of the so called uniform system.

Table 13

Practice of Uniform System in India

State	Division	Species
Uttar Pradesh	Dehra Dun	Sal
Bihar	Saranda	Sal
Madhya pradesh	Raipur	Sal
	Hoshangabad	Teak
Maharashtra	Allappalli	Teak

Yield Regulation

Yield regulated by area with a volume check. Rotation, regeneration period, etc. adopted for the two principal species in different divisions are given in table 14.

Table 14

Uniform System - Rotation and Regeneration Period

Division	Species	Rotation (in years)	Regeneration period (in years)
Saranda	Sal	120	20
Dehara Dun	Sal	120	20
Raipur	Sal	180	20
Hoshangabad	Teak	120	20
Betul	Teak	100	20
Allappalli	Teak	100	20

The system of fixed periodic blocks is followed and areas earmarked for felling and regeneration are included in PB I. In addition to area check a volume check is also exercised for yield regulation. In Saranda, yield is prescribed in volume units and marking for felling is stopped as soon as the prescribed area of volume is reached.

Regeneration

In sal forests worked under uniform system, there is complete reliance on natural regeneration. Intensity of felling in the overwood depends on the status of regeneration. Where regeneration is abundant, existing growth is completely removed (eg. Saranda). However, groups of poles are often retained as future crop[26]. In South Raipur (Madhya Pradesh) the annual coupe is thoroughly perambulated and a regeneration map is prepared. Where established regeneration is present, clearfelling is carried out, while in areas where regeneration has not established, some of the suppressed and dominated trees are retained to control weed growth. Steep slopes and eroded areas are not clearfelled. To promote regeneration a number of subsidiary silvicultural operations are prescribed. This includes cleaning, climber cutting and thinning.

[26] In Dehra Dun all trees up to 90 cm girth are retained as advance growth.

Silvicultural treatments are prescribed for other periodic blocks also. Treatments in unconverted areas aim at encouraging regeneration and often a light crown thinning is prescribed. In regenerated blocks weeding, thinning and tending are prescribed. In Saranda climber cutting is done for the first five years after the main felling. At the 5th year a preliminary thinning is carried out during which all injured, unhealthy and malformed stems are cut back. At the 10th year a systematic thinning is carried out to a spacing of 2.4 x 2.4 m. The second thinning i. carried out at the 20th year and subsequent thinnings are carried out at 20 year cycles.

In teak areas there is much less dependence on natural regeneration (Dubey, 1967). Where it occurs, advance growth is retained. In other areas artificial regeneration through stump planting is the standard technique and the overwood is clearfelled in one operation.

Evaluation

The so called uniform system has been consistently applied to some of the good teak and sal forests in the country managed to produce large sized timber. Since the process of conversion to a normal forest has not yet been completed, no indication can be given on the outcome of past management. The system may continue to be adopted where natural regeneration is abundant, and pressure from alternative uses is negligible. Where natural regeneration is difficult, artificial regeneration becomes essential. High investment necessary for artificial regeneration compels a reduction of rotation. This seems to be the case in most of the teak areas. In sal areas the more profitable teak is being planted.

Conclusion

Shelterwood systems have been introduced primarily in the valuable evergreen and moist deciduous forest and the main objective of management continues to be the production of large sized timber. Both irregular shelterwood and uniform systems are oriented towards one or a few species. Where the system has been in vogue for a long time and regeneration is not a problem, there is unlikely to be any change. In the case of evergreen forests in the North Eastern Region and Andamans, management is primarily aimed to supply veneer logs so that developments in the plywood industry have a direct bearing on management. Rapid development of the industry in the Assam region has led to instability in management due to frequent changes in rotation, regeneration period, etc. and it is evident that the system is not capable of fulfilling the protection and production objectives.

In the case of sal, the end product is not specifically aimed at a particular industry, and substitutes are available. Consequently increase in demand has not led to an appreciable change in the management. These forests are also not subjected to serious biotic pressures and as long as natural regeneration is satisfactory, there will not be any serious compulsion to switch over to other systems.

Teak forests managed under uniform system face slightly different conditions. Here natural regeneration is patchy and uncertain. Rather than manipulating felling to promote natural regeneration, it is much easier to resort to artificial regeneration. Thus in most teak areas natural regeneration is not being relied upon. With the increasing possibility of getting good prices for small sized logs and the need to take economic feasibility into account, the rotation for teak has been reduced considerably.

COPPICE SYSTEMS

Management under coppice systems also relies upon natural regeneration. However, unlike other systems where regeneration is primarily of seed origin, coppice systems, as the name indicates depend on shoots emerging from the cut stumps. Variants of the system are widely applied, especially to the dry deciduous forests and plantations of species like eucalypt.

Application of Coppice Systems:

Conditions under which coppice systems are adopted are as follows:

i) When the objective of management is production of firewood and small timber coppice systems are more appropriate.

ii) Coppicing ability is another important consideration in adopting the system and it cannot be followed in the case of species, which are poor coppicers. With increasing age, coppicing ability declines and this necessitates the adopting of a shorter rotation.

iii) One of the main advantages of coppice systems is the low investment requirements. Returns are generally quicker than high forest systems and this seems to be an important reason for their widespread application.

iv) The systems are highly flexible and a number of objectives can be incorporated. Thus, production of large sized timber can be achieved by retaining standards and soil and water conservation objectives can be fulfilled by reservation of areas and reservation of trees.

Important variants and their application are given in table 15.

Table 15
Application of Coppice Systems

	System	Forest Type	States
1.	Simple Coppice	Dry deciduous forests Eucalypt plantations	Tamil Nadu All States
2.	Coppice with standard	Dry deciduous forests and moist deciduous forests	Bihar, Orissa, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh
3.	Coppice with reserves	Dry deciduous forests	Madhya Pradesh, Maharashtra, Uttar Pradesh, Orissa

Simple Coppice Systems

The system is being followed in the dry deciduous forests of Tamil Nadu which are worked primarily for production of firewood. Also simple coppice system is adopted in the case of eucalypt plantations throughout the country for the first three rotations after artificial regeneration.

Yield Regulation

Yield is regulated by area. Usually the rotation followed varies from 30 to 40 years for fuel working. After demarcating the annual coupes, the entire tree growth is felled either departmentally or by purchasers. Felling operations should be completed before the commencement of the growing season. After felling the area is closed to grazing and protected from fire. Cleaning, involving removal of excess coppice shoots, climber cutting, etc. is prescribed.

Regeneration

Since the coppice shoots grow quickly, no weeding is usually required. Over time, however, coppicing vigour declines and mortality of stumps tends to increase. If protected from fire, grazing and other factors, the seedling regeneration that comes up does help to compensate for stump mortality. Most of the coppice forests however, are subjected to severe biotic pressures and consequently seedling regeneration is absent. With increasing stump mortality, degradation sets in over time. On account of this Tamil Nadu has temporarily suspended the felling of fuel coupes.

Coppice with Standards (CWS) System

The coppice with standard (CWS) system involves the retention of a fixed number of overwood trees, mostly of seedling origin, and extracted on a rotation which is usually a mulitple of the coppice rotation. A forest worked under the CWS system thus has two tiers, an upper one consisting of the standards usually producing timber, and a lower tier primarily aimed at the production of firewood and small timber. The standards also protect the coppice crop from adverse climatic factors and form a source of seeds for restocking the area and thus help to overcome the decline in productivity due to stump mortality.

The main objective of management is production of firewood and small timber. CWS is one of the most widely adopted systems in the country. Most of the coppice forests are located close to habitations and are burdened with rights[27].

[27]This is particularly the case of the former zamindari forests which vested with the government under the enactment of land reform acts. They have been constituted as protected forests and the local people continue to enjoy certain rights.

Yield Regulation and Felling

Yield is regulated by area. The rotation varies from 30 to 60 years and is fixed taking into account the condition of the crop and the extent of local demand. Where stocking is good and demand is low, usually a longer rotation of 60 years is adopted[28]. The rotation of the standards is usually a multiple of the coppice rotation and usually they are retained for two coppice cycles[29]. The number of standards retained and the preferred diameter class also vary between different categories of areas (eg. Dhalbhum Division - Bihar) as given in Table 16.

Table 16
Coppice with Standards System in Bihar

Category	Characteristics	Rotation	No. of stds. per hectare	Preferred diameter class (cm)
A	Good soil - Low biotic pressure	60	20-30	20-25
B	Deteriorated soil - High biotic pressure	40	30-40	15-20
C	Highly deteriorated and eroded soil. Very high biotic pressure.	30	40-50	10-15

Marking rules indicate details regarding the retention of standards. Apart fromthe standards, all fruit bearing trees like Mahua (Madhuca indica) Mango (Mangifera indica), Amla (Emblica officinales) and Bahera (Terminalia bellirica) are also retained. The total number of trees retained in a coupe as standards and reserved trees should not exceed 50 in the case of category A and B areas and 62 in the case of category C areas.

[28]The condition of the crop is directly related to the demand; where demand is high a large quantity of wood is removed, often unauthorisedly, and this is an important factor in the deterioration of the condition of the crop.

[29]Where demand is very high, the standards seldom reach the prescribed rotation.

After demarcating the annual coupe, a portion is set aside to meet the traditional rights or nistar. In Bihar the coupe is divided into four sections. To begin with, one section is opened to right holders to collect the material required by them on the basis of the recorded rights. If all the requirements of right holders could not be met from the first section, wood collection is permitted from the second section also. The residual material available from the right holder's sections plus the unworked section, leaving the standards and reserved trees, is sold in open auction and removed by contractors[30]. With the introduction of state trading, felling and transport is undertaken either by the department or by the forest development corporations who finally sell the material from the depots. Yield per hectare varies from 10 m^3 to 25 m^3, depending upon the condition of the crop which is primarily dependent on biotic pressures. In most cases, there is a declining trend in yield between successive rotations.

Regeneration

After felling a number of subsidiary silvicultural operations is undertaken to promote coppice regeneration.

These include:

i) dressing down stumps higher than 15 cm above ground level,
ii) coppicing of damaged trees,
iii) tending of seedlings by climber cutting, weeding etc.,
iv) cutting back of malformed seedlings and reducing coppice shoots to 2 to 3 per stump,
v) soil working in unproductive blanks and sowing of seeds of sal and other valuable species and
vi) strict fire protection.

In Bihar thinning is carried out as per the cycle given in table 17.

[30] A major portion of the firewood so sold goes to meet the urban demand. Sometimes firewood is transported for a distance of over 1000 km.

Table 17
Thinning Cycle Under CWS System

Rotation (years)	Thinning Cycle (years)
60	15,30,45
40	15,30
30	15

Evaluation

In theory the system is quite suitable for meeting the demand for fire wood and small timber. Retention of standards incidentally helps seedling regeneration, and thus to compensate for the stump mortality.

The system is however unable to meet the growing demand for timber and firewood. Areas close to habitation particularly suffer from illicit removal, and this in turn undermines the productivity of the system. In response to the growing demand, an attempt has been made to enhance supply by reducing the rotation. This is particularly the case for forests adjoining villages. Reducing the rotation has,however, failed to be a realistic solution, because already the biotic pressure on these forests is very high and a reduction in rotation only increases the frequency of removal and thereby the process of degradation is accelerated. Degradation has gone to such an extent that it has become necessary to take up large scale planting in these areas. Areas originally under CWS working circle have been reallocated to rehabilitation or plantation working circle (Anon, 1974). In states like Orissa some effort is being made to introduce coppice with reserve system.

There is nothing inherently wrong with the system. Where biotic pressures - fire, grazing firewood collection - are not high, the system is able to thrive well and regeneration is quite satisfactory[31]. In fact some of the areas worked under coppice system in Dehra Dun has been later put under conversion to uniform system.

Coppice with Reserve (CWR) System

The coppice with reserve system has evolved in the former Central Provinces, now consisting of portions of Maharashtra and Madhya Pradesh. As in the case of other coppice systems, the main objective is to produce firewood and small timber, partly to meet the traditional rights (nistar) and regeneration is primarily of coppice origin. One of the main objectives of the system is prevention of site deterioration. This is aimed to be achieved by a combination of treatments appropriate to the condition of the crop. Also it attempts to see that species with high coppicing power do not form a pure crop and cause site deterioration. Reservation thus involves the exclusion of specified areas, species and trees above a prescribed diameter from felling. In effect it is a combination of different elements in different systems applied to the same coupe. The system was first introduced in 1927 by Trevor as 'modified simple coppice'. It was later developed and improved by Datta and Sagreiya (Tiwari, 1968).

The system is now applied to the dry deciduous forests of Madhya Pradesh and Maharashtra. In States like Orissa, CWR system is being introduced in areas worked under CWS system to improve the condition of the crop and to prevent degradation (Mahapatra, 1980). The main objectives of management under the CWR system are,

i) to meet the increasing demand for small timber, poles and firewood, and

ii) to improve the stocking and quality of the crop by scientific management.

[31]For example stocking and regeneration in some of protected forests worked under CWS system in Gua range in Saranda division is as good as the adjoining areas worked under conversion to uniform system. Absence of biotic pressures seems to be the main factor.

Yield Regulation

Yield is regulated by area. On account of the varying intensity in felling, equal annual yield is difficult to realise. Often equiproductive areas are demarcated to ensure equal annual yields. Rotations under CWR system vary from 30 to 60 years and as in the case of CWS system a shorter rotation is followed in areas where the demand for firewood is very high.

After demarcating the annual coupe, a treatment map is prepared identifying the following types of areas.

i) Protection areas: No felling is carried out in these areas which usually include understocked portions with a density of 0.4 or below, eroded areas or areas subject to erosion and strips on either side of water courses where retention of vegetation is essential.

ii) Areas requiring enrichment

iii) Areas fit for felling, and

iv) Those fit for raising plantations.

Even in areas earmarked for felling, certain species as well as certain trees above specified girth limits, are reserved. All species yielding fruits and other minor forest products - eg. Madhuca indica, Emblica officinales, Mangifera indica, Buchnania lanzan, Diospyros melanoxylon, Syzygium cuminii, Acacia catechu, Boswellia serrata, Terminalia chebula and Terminalia bellirica, are retained. All advance growth up to 24 cm girth is reserved. In addition healthy trees of valuable species like Tectona grandis, terminalia tomentosa, Dalbergia latifolia, Gmelina arborea, Chloroxylon swietenia are reserved to act as seed trees. Reservation of species and trees ensures that the mixed character is not lost during successive coppicing.

Regeneration

Although regeneration is primarily from coppice, the large number of trees reserved ensures adequate seeding and natural restocking. To encourage seedling and coppice regeneration, subsidiary silvicultural operations are carried out in the year following felling. These include cleaning, cutting back damaged stems, and climber cutting. The number of coppice shoots is reduced to 2 or 3 per stool. Artificial regeneration is carried out in blanks by sowing or planting. Thinning is prescribed in the case of pole crops.

Evaluation

The coppice with reserves system represents a unique attempt to adapt silvicultural treatments to suit the varying conditions obtaining in a mixed forest. The system is highly flexible and takes into account varying site conditions.

Two factors, however, seem to affect the effectiveness of the system. Firstly, CWR is a highly skilled intensive system requiring a good understanding of the interaction between different species. The type of intensive silviculture necessary is not being practised. Secondly, as in the case of CWS system, excessive demand has led to unauthorised removal causing serious deterioration in areas close to habitation.

Conclusion

Coppice systems are primarily adopted in the case of the dry deciduous forests where the main objective is the production of firewood and small timber. Performance of the system largely depends on the socio-economic conditions of the immediate environment. Where demand is low and biotic pressures minimal, coppice systems do contribute significantly to the production objective. Where biotic pressure is high, the system has been found to be unsuitable. Excess removal, often unrecorded, coupled with fire and grazing has led to degradation, and it has become necessary to tackle these wastelands with artificial regeneration under rehabilitation schemes.

CLEARFELLING SYSTEM

The Clearfelling system has a long history in India, and it is adopted with the objective of changing the crop composition in favour of commercially and industrially more valuable species. Restocking of felled areas is accomplished either naturally or artificially. Artificial regeneration is necessary when new species are to be introduced or the composition of the crop is to be significantly improved. Both methods of regeneration are followed in India and the choice is determined by a number of factors. Dependence on natural regeneration to restock clearfelled areas is however on the decline and is restricted to those areas, where regeneration comes up profusely.

Clearfelling is adopted in almost all states in India, with the following objectives:

i) To enhance the proportion of valuable species, especially in the mixed moist and dry deciduous forests and to improve the condition of degraded ares (eg. planting of teak in Kerala, Karnataka, Tamil Nadu, Madhya Pradesh, Maharashtra, and Andhra Pradesh. Planting of padauk in the moist deciduous forests of Andamans, etc.).

ii) To drastically change the crop composition by introducing species outside their natural habitats (eg. introduction of teak to the sal zone in Uttar Pradesh, Bihar and West Bengal, and eucalypt and tropical pines in different states).

Yield Regulation and Felling

When managed on the basis of working plans, yield is regulated by area and the extent of the annual coupe is derived on the basis of rotation and area under the felling series. The rotation varies between species and between regions for the same species. Table 18 gives some of the typical rotations applied for some of the species commonly managed under clear felling.

Table 18

Rotation for Plantations/Natural Regeneration

State	Division	Species	Rotation (in yrs)
Kerala	Nilambur	Teak	55
	Konni	Teak	70
Maharashtra	Allappalli Plain FS	Teak	120
	Allappalli FDC Plantation	Teak*	50
Madhya Pradesh	Hoshangabad	Teak	80
Uttar Pradesh	Haldwani	Teak	50
	"	Sal	90
	"	Sissoo and Semul	60
West Bengal	Jalpaiguri	Sal	80
		Teak	70
All States	..	Eucalypts	7 to 15

*The objective of management of FDC plantations is to produce poles and small timber and hence a low rotation of 50 years.

Although the rotation remains still very high for most of the hardwood species, there is a trend towards reducing it. (Ghosh and Singh 1981). Partly this depends on saleability of the produce, and a declining trend is particularly evident in the case of high value species like teak.

Regeneration

Examples of natural restocking with clear felling are Saranda in Bihar and Raipur in Madhya Pradesh for sal and Hoshangabad in Madhya Pradesh and Chanda in Maharashtra for teak. In the case of sal forests of Sranda, regeneration comes up profusely immediately after clear felling[32]. Such a situation, however, seems to be an exception. In Saranda itself the mixed forests are regenerated artificially with teak. In the teak areas of Madhya Pradesh and Mararashtra dependence on natural regeneration is very partial. Compact blocks of not less tha 0.8 hectares containing more than 750 saplings per hectare over 1.5 metres are retained and damaged and malformed saplings are cut back. Also poles up to 76 cm gbh are retained as advance growth. In other areas artificial regeneration is the usual practice.

[32]Details have been given in Chapter 3. Strictly the system adopted in Saranda is clearfelling with natural regeneration. But management plans refer to this as conversion to uniform system (Rajhans, 1976).

Natural regeneration is taken advantage of in restocking final felled Wattle plantations (Acacia mearnsii) during the second and subsequent rotations in Nilgiri and Palni hills in Tamil Nadu. Wattle is worked on a 10 year rotation for pulpwood and bark. After final felling the area is control burnt and this helps to end the dormancy of seeds. Natural regeneration comes up profusely and after 2 or 3 years thinning is done to remove excess number of saplings. Artificial regeneration is resorted to in failed areas and new areas only.

Conclusion

No systematic evaluation has yet been carried out of the multifarious effects of clearfelling systems, despite the very great expansion of clearfelling followed by artificial regeneration that has taken place in the 1970s. There is however a growing awareness of its possible adverse social and environmental effects but the future of the system will depend also on a number of other factors. One of the justifications for clear felling, is for instance, to make the land available for the plantation programmes geared to meet industrial and domestic wood requirements. However, this could be undertaken on the extensive degraded land already available (Bentley, 1984). Probably, the contribution of clearfelling towards revenue will also continue to provide a strong compulsion for continuance of the system. Another factor that will necessitate clear felling will be the need to supply wood to industries like sawmilling. Most of the plantations belong to the younger age classes and output from them will not be available in time to replace timber obtained from natural forests. Further, most of the plantation programmes have focused on a few species, while no attempt has been made to raise those required for ordinary purposes. Considering all these, it is difficult to predict the future direction. The system may continue to be used, but on a much reduced scale.

SOCIETY, FORESTS AND FOREST MANAGEMENT

Society-forest interaction as reflected in the management system undergoes changes in response to changing characteristics of society and forests. Management systems, therefore, seldom remain static and what is appropriate at a given time may not remain so later. The future of natural management of mixed tropical forests in India depends on a number of factors. To get a picture of emerging trends, it is imperative to analyse how developments in biological, technical, organisational and managerial sciences have influenced current management systems.

Technical Changes

Developments in biological and technical sciences related to forestry can be grouped as (1) those which improved management and utilisation of natural forests and (2) those that contributed to better management of man-made forests. Identification, and cataloguing of species and research on forest utilisation were largely aimed to enhance the use of natural forests. Forest botany and forest products research were the major areas that got attention during the early stages of forestry research. Extensive exploration was undertaken with the objective of identifying commercially valuable species. Research on forest products, particularly wood anatomy, timber mechanics, wood seasoning and preservation, etc. was also taken up simultaneously.

Cataloguing and classification led to forest type classification, an important field in forest ecology. Autecological studies were initiated in response to the need for regenerating some of the commercially valuable species like teak and sal. Initially there was complete reliance on natural regeneration and most of the techniques were standardised by way of trial and error. Sal was one species whose regeneration received considerable attention. Sal forests can be broadly grouped into those where regeneration is satisfactory and those which are difficult to regenerate. A lot of effort was directed to promoting regeneration in the latter, involving operations like canopy manipulation, shrub cutting, controlled burning, fencing and soil working. To identify the factors that inhibit regeneration, investigations were undertaken covering geology, soil, climate, biotic factors, ecological status of the forests, competition for light and moisture and so on. No doubt, these studies improved the understanding of sal ecology; but natural regeneration continued to remain an intractable problem. Artificial regeneration, often with species other than sal, had to be resorted to in many areas.

Growth and yield studies of important commercial species also received considerable attention. This led to preparation of volume and yield tables and a better understanding of the growth response to various treatments.

Synecological studies on tropical mixed forests are at best partial and most often limited to a small segment of the complex processes such as nutrient partitioning, biomass distribution, etc. (Nair, 1984). No research has been carried out to understand the intra and intersystem flows, fractioning of energy and matter, processes of succession and the impact of different intensities of harvesting in representative forest ecosystems over a sufficiently long period to generate reliable data required for developing appropriate management practices.

Neither have researchers attempted to address management objectives, nor have managers tried to adopt research findings. Consequently, management of natural forest continues to be unscientific and managers often act arbitrarily in response to immediate compulsions. Thus, when there is an increasing pressure from wood based industries, large areas are exploited heavily, disregarding long term sustainability of wood supply. Response in the opposite direction is also seen, often leading to the total stoppage of felling due to pressures from environmental groups.

An outcome of the emphasis on exploitation of natural forests is the high priority given to forest resource inventory and the attempt to improve logging techniques. Resource surveys focussing entirely on wood availability have been undertaken in most of the forest areas. This information has been utilised for management plans and particularly for taking up forestry projects by the forest development corporations. A considerable effort has been made to improve logging techniques, but on a national scale the impact has been marginal. This is partly attributed to the prevalence of the contract system (Govt. of India, 1976). However, even in states where the contract system of timber extraction has been abolished, no significant improvement is noticeable.

Most of the recent developments in forestry are directed at creation and management of man-made forests and are therefore not relevant to this review.

No doubt, the inherent complexity of forest ecosystems limits the adoption of techniques appropriate to simple ecosystems like agriculture. But other factors have also contributed to such a situation. Firstly, a large proportion of timber continues to be obtained from natural forests with practically very little investment or re-investment. The assumption that forests are inexhaustible continues to influence the thinking of both people and decision-makers. Secondly, low prices for wood and other products provides little incentive for high investment. Industrial wood supply is highly subsidised and most consumers of wood regard it as a free good. Finally, the long gestation period of forestry investments acts as a disincentive, especially to the private sector. With the introduction of short rotation crops, this is, however, changing.

Development in the field of wood utilisation has been quite impressive, and partly due to the necessity to use lesser known species arising from the unavailability of conventional species. However, developments in silviculture and management are limited to a few well known indigenous species like teak, sal, sissoo and semul or exotics like eucalypt and tropical pines. Easy availability of information on management practices of exotics has been primarily responsible for their large scale introduction[33]. Despite the long history of trials, information on many of the indigenous species continues to be inadequate, especially for those which are of local importance only.

Institutional Changes

Introduction of organisational and managerial developments has also been extremely slow. In fact, so slow that it seems to have seriously hampered the development of forestry. Structure and organisational patterns of forest departments have undergone little change since their establishment. Policing the forests continues to be the main function and the function as land manager has been neglected considerably.

Attempts have been made to separate the different functions of forest services. Such organisational changes are mostly internal, like creation of separate wings, or divisions for logging, afforestation, sale of timber, collection of minor forest products, social forestry, etc. The establishment of autonomous forest development corporations is a further step in the direction of giving more emphasis to the land management function. As pointed out earlier, forest development corporations were formed to ensure better operational flexibility necessary in land management and to utilise institutional finance for forest development. Activities undertaken by forest development corporations can be categorised as follows:

i) Harvesting natural forests and collection of commercially valuable minor forest products like tendu leaves, sal seeds, etc.

ii) Raising plantations of species like teak, eucalypt, and tropical pines and

iii) Cultivation of cash crops like oil palm, tea, rubber, coffee and cardamom.

Since commercial profitability is the main consideration, none of the corporations has taken up management of natural forests. Further, the activities of most of the corporations have centred on well stocked natural forests from where a substantial quantity of timber can be obtained by way of clearfelling. In many instances, treating the yield from clearfelling as a project benefit has enhanced the financial profitability of the projects.

[33] A number of international institutions, including aid agencies, and research institutions, has played an important role in the introduction of exotics like eucalypts and tropical pines.

Organisation and management of forest research and education have undergone little change during the last few decades and this has been an important factor impeding the development of forestry. The training of forestry personnel has been one of the most important functions of existing institutions, and institutions geared to the development of forestry science are poorly developed.

Natural Management: Future Trend

Necessary conditions for natural management to be successful are (1) adequacy of natural regeneration, (2) negligible biotic factors which could adversely affect recruitment and establishment of regeneration and (3) low and stable demand for wood and other products. The extent to which fulfilment of the above conditions will affect natural management in important forest regions are examined below.

Tropical Evergreen and Semi-Evergreen Forests

(1) Andaman and Nicobar Islands:

Natural regeneration is satisfactory. Due to the low population density, biotic factors like fire, grazing etc. are not serious. Currently, timber is obtained from harvesting unworked near-virgin stands. Even if regeneration is good, a decline in yield during the second rotation is anticipated. Scarcity of veneer logs in the mainland will lead to over-exploitation. Another important factor that could affect forest management is the diversion of forest land for non-forestry purposes, particularly for cultivation of cash crops like rubber and oil palm. Already the forest development corporation in Andamans has taken up an oil palm project in Little Andamans. There could also be an expansion of oil palm cultivation in order to reduce the growing foreign exchange drain through import of edible oil. This could drastically change the land use pattern affecting natural management.

(2) North Eastern Region

The north eastern region presents another extreme situation. Industrial capacity and wood resources are unevenly distributed between different states. Rapid growth of the plywood industry has led to over exploitation of all easily accessible forests. Natural regeneration is unsatisfactory and areas degraded due to past working are being restocked artificially. A large proportion of the forests is under tribal control and subject to shifting cultivation which rules out the possibility of any long term sustainable management for wood production.

(3) Western Ghats

Natural regeneration is unsatisfactory. Adverse biotic factors such as fire and encroachment are serious. Further, the demand for timber, especially veneer and saw logs, is increasing. Most often demand is met by reducing exploitable girth and felling cycle and increasing the number of trees harvested per hectare[34]. The felling cycle is often unrealistically low inhibiting natural recoupment. Also there is growing pressure to divert forest land for non-forestry purposes. One cannot, therefore, be optimistic about the feasibility of natural management in the Western Ghat evergreen forests.

As can be seen, evergreen and semi-evergreen forests in all the three regions are exploited primarily to supply veneer logs. Future management of those forests is essentially linked to the growth of plywood industry and the availability of raw material from alternative sources. Imports could be helpful to relieve the pressure for the time being. But in the long run, there has to be reliance on man-made forests. Adoption of coppice with standards system in eucalypt plantations under which the standards harvested after 3 or 4 coppice rotations to supply veneer logs, is an appropriate alternative. Failure to find alternative sources of veneer logs will lead to intensive, and often uncontrolled exploitation causing total degradation.

Even if the problem of wood raw material to the plywood industry is resolved, future management of evergreen forests will depend on the changes in overall land use. Climatic and soil conditions are apparently favourable for alternative land uses, especially for cash crop cultivation and the process of diversion for non- forestry purposes is continuing. How far this will continue depends on a large number of factors, particularly population growth, the pace of economic development, the dependence on land as a source of income and government policy on land use. Changes to agricultural land tenure are likely to have significant effect. Although land reform legislation has been enacted in most states, their implementation is tardy and consequently feudal relationships persist in many areas.

Implementation of land reforms could reduce the pressure on forest land, especially that due to migration of landless to forest areas. Better income could also reduce the need for collecting firewood.

[34]Recently a change in the opposite direction is seen. For example in Karnataka the number of trees allowed to be harvested has been reduced to 2 largely due to the pressure from the environmental groups.

Although there is growing awareness of the productive, protective and social functions of evergreen forests, diversion for non-forestry purposes may continue for some more time, consequently increasing the pressure on the remaining forests. Natural management has very limited scope under such conditions.

Moist Deciduous Forests

(1) Sal Forests

Natural management can be considered as successful only in a few areas like Saranda in Bihar and Raipur in Madhya Pradesh. Adequacy of natural regeneration seems to be the most critical factor. In most of the valley, plain and hill sal tracts (parts of UP, West Bengal, Bihar, Assam, Orissa and Madhya Pradesh) despite earnest efforts, regeneration continues to be problematic and artificial planting is being resorted to, often involving replacement of sal with teak, eucalypt, etc. In theory, selective felling, in which intensity of removal is low, relies upon natural regeneration. However, no study has been carried out on the long term impact of selective removal in sal forests. Also selective felling as practised now, cannot be strictly regarded as a management system.

(2) Teak Forests

Dependence on natural regeneration to restock teak forests is limited to some areas like Chanda, Hoshangabad, etc. Even here, uncertainty of natural regeneration has led to its replacement by artificial regeneration, although this is known to cause site deterioration by way of soil loss (Seth and Kaul, 1978). Status of natural regeneration is unsatisfactory in selection felling areas.

(3) Mixed Forests

Natural regeneration of valuable species is unsatisfactory. Further most of these forests are subjected to fire, grazing and such other biotic pressures. Traditionally the objective of management has been to enhance the proportion of valuable species and inevitably artificial regeneration is resorted to.

(4) Dry Deciduous Forests

Most of the dry deciduous forest are managed under coppice systems. Production of fuelwood and small timber is the main objective of management and these forests primarily cater to the local demand. Coppice regeneration is satisfactory, but most of these forests are subjected to severe biotic pressures, especially fire and grazing, leading to degradation. Illicit removal of wood is also a serious problem and is an indication of the growing demand. Natural management is almost impossible under such circumstances. consequently most of the degraded areas are being restocked artificially.

A similar situation exists in the case of forests predominantly used for production of bamboo, salai, sandalwood, etc. Especially when the same forests are utilised for producing more than one product, incompatibilities arise and operations intended to benefit one become deterimental to the other. For example to induce production of coppice shoots in <u>Diospyros melanoxylon</u> (Tendu) burning is resorted to. No doubt this increases the availability of tendu leaves (which is an important source of revenue to forest departments in many states) but adversely affects natural seedling regeneration of a large number of species. Similarly collection of sal seeds could have serious implications on natural regeneration, especially during poor seed years (Verma and Sharma, 1978). Biotic pressures like fire, grazing illicit removal and non-compliance with silvicultural prescriptions have adversely affected both growing stock and increment. Realisation of long run sustainable supply under existing systems of management is impossible.

<u>Forest Management - Future Options</u>

Although India has about 75 million hectares of land legally classified as forests, the growing stock and increment are very low. The average growing stock is estimated as 26 m^3/hectare. This is unevenly distributed with easily accessible areas exhibiting poor growth. Total demand for wood by 2000 AD is projected as 289 million m^3 (Govt. of India, 1976). With a low mean annual increment of 0.5 m^3/hectare this demand cannot be met. A radical change in the direction of forestry development is essential to ensure that forestry fulfills the multifarious requirements of society. The present phase of forestry is characterised by

1) high dependence on natural forests to meet industrial and domestic demand.

2) deforestation to meet the demand for land for alternative uses and

3) low investment in forestry.

An alternative and more desirable scenario will be one in which:

1) the dependence on natural forests is minimal,

2) very little diversion of forest land for non-forestry purposes and

3) high investment on forestry, especially on plantation development.

Under this alternative, most of the wood requirements may be met from plantations raised in the degraded and waste lands. Natural forests, especially those in hilly areas, can be utilised to fulfill the protective and social functions, to supply a small quantity of high quality timber and to balance the cyclic fluctuations in wood demand. There are some indications of a change including (1) a general opposition to clearfelling natural forests for conversion to monoculture plantations, (2) growing environmental awareness and resultant closer scrutiny of developmental projects, especially those implemented in forest areas and (3) assigning a high priority for social forestry and development of wastelands through afforestation. The Government has initiated an ambitious wasteland development programme and proposes to afforest 5 million hectares annually. To undertake this, a Waste Land Development Board has been constituted. Successful implementation of this programme will result in a radical change in forestry and the dependence on natural forests for meeting wood requirements will be reduced significantly. A balanced multiple use of mixed tropical forests requires the creation of intensively managed plantations on land which contains no tree growth now. Failure to pursue such a policy would result in heavy exploitation of natural forests, seriously jeopardising the realisation of many different values in the long run.

Constraints in the pursuit of a rational forestry programme have been indicated elsewhere (FAO, 1984). The new approach would require formulation of a forest policy as a component of an integrated land use policy, creation of appropriate institutions for implementation of such a policy, and provision of a suitable legal framework (Nair, 1984). Institutions involved in education, research and extension would need to be remodelled and strengthened to overcome the information gap, communication gap and adoption gap. With the involvement of Universities in forestry education and research, development of forestry science is expected to gain considerable momentum.

Conclusion

Society has treated forests as a God given asset and hence a freely available resource. The uncontrolled exploitation that this has led to still continues. Applications of developments in biological and technical sciences are all primarily directed at the accelerated exploitation of natural forest. Organisational changes in forest administration have been marginal and have not brought about any significant change from the traditional policing role.

As long as such a situation persists, sustainable natural management of the tropical mixed forests will not be possible. Analysis of existing management systems indicates the limitations of present approaches. The creation of intensively managed plantations on barren land to meet most of the wood requirements seems to be the only alternative. Indications are that Indian forestry is entering a transition phase during which current practices will be critically examined and a more rational approach to land use, in particular forestry, will have to be pursued.

CHAPTER IV

FOREST MANAGEMENT SYSTEMS IN MALAYSIA

THE BACKGROUND TO MANAGEMENT

Location and Environment

Malaysia is located within latitudes 1° to 7° north and longitudes 100° to 119° east. The country has an approximate land area of 33 million hectares, comprising 13.1 million hectares in Peninsular Malaysia, 7.4 million hectares in Sabah and 12.5 million hectares in Sarawak as shown in Figure 6. Peninsular Malaysia is separated from Sabah and Sarawak by about 750 kilometres of the South China Sea giving the country a coastline of about 4,800 kilometres much of it exposed to the monsoons. The topography is characterised by coastal lowlands with hills in the interior, culminating in Mount Kinabalu at 4,100 metres in the State of Sabah. The rivers are fast-flowing; most Malaysian soils are easily eroded.

The climate is typically tropical and is characterised by year round high temperature and seasonal monsoon rain. The mean temperatures during the day and night are 32°C and 22°C respectively. The average monthly temperature variation is about 2°C while diurnal temperature variations for inland and coastal areas are 8.5°C to 11°C and 5.5°C to 8.5°C respectively. The average rainfall is about 2,540 mm per year with a maximum of 5,080 mm and a minimum of 1,650 mm. Humidity is always high and ranges between 70 to 98%.

The population of Malaysia comprises predominantly Malays and other indigenous races, Chinese and a substantial proportion of Indians. The population in 1980 was 13.7 million and is expected to reach 15.5 million in 1985, growing at an average rate of 2.5% per annum over the period 1981-1985. The geographical distribution by 1985 is expected to be 82.8% in Peninsular Malaysia, 7.7% in Sabah and 9.5% in Sarawak. Notable features of the population distribution are the preponderance of Malaysians living in the rural areas and the age structure which was estimated at 37.8% within 0-14 years, 58.5% within 15-64 years and 3.7% over 65 years. A New Population Policy for increasing the country's population to 70 million by the year 2100 is currently being formulated.

Figure 6

Malaysia and Adjacent Territories

Constitution and Legal Provisions

Malaysia is a federation of 13 States of which 11 are located in Peninsular Malaysia. Under the Malaysian Constitution, land is defined as a State matter and is thus within the jurisdiction of the respective states. As such, each is empowered to enact laws on forestry and to formulate forest policy independently. The executive authority of the Federal Government only extends to the conduct of research and maintenance of experimental and demonstration stations, training and the provision of advice and technical assistance to the States.

In order to facilitate the adoption of a co-ordinated and common approach to forestry, the National Forestry Council (NFC) was established on 20th. December, 1971 by the National Land Council (NLC). The NLC is empowered under the Malaysian Constitution to formulate national policies for the promotion and control of the utilization of land for mining, agriculture and forestry. The NFC serves as a forum for the Federal and the State Governments to discuss and resolve common problems and issues relating to forestry policy, administration and management. All the decisions of NFC have to be endorsed by the NLC. The responsibility for implementing the decisions of NFC lies with the State Governments unless it is specifically within the authority of the Federal Government.

Currently, the legal basis for law enforcement and management in the forestry sector are the various Forest Enactments and Rules of the respective States. These are now obsolete and limited in terms of scope and objectives. As they do not have sufficient provisions to meet the present and future needs of the forestry sector, a comprehensive National Forestry Act, 1984 has been promulgated which will ensure effective forest administration, utilization, management, harvesting and reforestation in accordance with the concept and principles of sustained yield. This Act will be supplemented by the Wood-based Industries Act, 1984 which will regulate and ensure the rational development of wood-based industries.

Forestry Sector Contributions

The forest resource in Malaysia is an important renewable asset which plays an important role not only in contributing towards the socio-economic well-being of the country but also in the impovement of environmental conditions which are essential for optimum development of the agricultural and other sectors of the economy and ultimately for upgrading the quality of life.

In 1983, the total forest revenue collected by the various State Forestry Departments in Malaysia amounted to M$1,394.4 million while the total roundlog production was 32.7 million m^3 with an export of 23.0. million m^3. of timber and timber products. This represents 14.1% of the total gross export earnings and 6.8% ofthe total Gross National Product ranking second to petroleum and petroleum products.

During that year, the forestry sector in Malaysia provided employment for 9,484 people in the forestry services and agencies which are responsible for forestry administration and for management and development of the forest resources while another 121,000 people were employed directly in the forest industries for timber harvesting and processing. Employment opportunities in the sector are expected to increase substantially in view of the priority accorded to the expansion of the forest resource base through intensive forest management and development and the establishment of fast-growing tree plantations, as well as to the modernisation of forest industries to produce higher value-added products. As most forestry workers are semi-skilled to highly skilled, they tend to earn higher wages than those employed in other sectors. Consequently, as most forestry jobs are located in the rural areas, the development of the forestry sector will not only contribute significantly to socio-economic development in the rural areas but also effective transfer of skills and expertise to those areas.

Forest Resources

Malaysia is fortunate to be endowed with extensive areas of valuable natural tropical rainforests with the proportion of forest land being higher in Sabah and Sarawak than in Peninsular Malaysia. These tropical rainforests are extremely complex ecosystems and are richer in tree species than in similar areas of Africa and South America. They are, in fact,the most species-rich plant communities known anywhere in the world (Whitmore, 1975). In Peninsular Malaysia alone, the flora is estimated to comprise 7,500 species of seed plants of which 4,100 are woody. An estimated 2,900 species reach a diameter of 10 cm. at breast height (dbh) while about 1,680 species in 375 genera are trees i.e. they reach a diameter of 30 cm. dbh. (Whitmore, 1975); with 890 of these species reaching exploitable sizes of at least 45 cm. dbh. Of these 890 species, a total of 408 have been introduced at one time or another to the international markets under the Malayan Grading Rules.

In numerical terms, in a 10 ha, survey at Pasoh Forest Reserve (a lowland dipterocarp forest) a total of 5,907 trees of 10 cm. dbh and larger belonging to 460 different species was identified (Ashton, 1971) About 80% of these trees are in the 10-29 cm. diameter class while about 10% are with diameter greater than 40 cm. The Dipterocarpaceae constitutes about 7 - 14% of the total number of trees while Euphorbiaceae accounts for about 5 - 16%.

Tang (1976) in a study in Terengganu found that the average stocking of trees with diameter greater than 5 cm. in a virgin stand was 934 ± 121 per ha. with 80% of these in the two smallest diameter classes and less than 2% in the 60 cm. dbh and larger class. The average basal area was about 30 m^2/ha.

The average yield from the forest is estimated to be 52 m^3 per ha. and this is roughly about 30% of the total standing volume (FAO, 1973). Current logging practices account for less than 100 (or 15%) of the total 700 species of merchantable timber trees (Soepadmo and Kora, 1977). Based on this approximation, the forest is then potentially capable of yielding about 177 m^3 per ha. A 42 year old mixed meranti stand at the Forest Research Institute which was felled in 1978 gave an estimated net return of 140.4 m^3 per ha. (Wan Razali and Daljeet, 1981). The yield from a good stand of Kapur forest is estimated to be 142 m^3 per ha. and a figure of 284 m^3 per ha. has been reported to be the upper limit (Lee, 1977).

In recent years, these forests have contributed significantly to industrial development, of foreign exchange earnings, and the improvement of socio-economic conditions, particularly in the rural areas. The forests also play a vital role in environmental management and conservation of soil, water, wildlife and genetic resources which are essential for successful agricultural and rural development as well as for enhancing the quality of life for both the rural and urban population. As a consequence of the country's policies for sustained yield and conservational management, forests still cover about 20.6 million hectares or 62.3% of the total land area. The location of the forest resources by regions is as shown in Table 19.

Table 19

Area Under Forest, Malaysia

(million ha.)

Region	Land Area	Forest Area	Percentage of Land Under Forest
Peninsular Malaysia	13.17	6.54	49.7
Sabah	7.39	4.61	62.4
Sarawak	12.45	9.43	75.7
Total	33.01	20.58	62.3

The forests of Malaysia have been variously classified according to their ecological and physical distribution but for the purposes of management they can be classified broadly into the Dipterocarp, Freshwater Swamp and Mangrove Forests. The estimated extent of these forest types by regions at the end of 1983 is as shown in Table 20 below:

Table 20

Distribution and Extent of Major Forest Types, Malaysia

(million ha.)

Region	Dipterocarp	Freshwater Swamp	Mangrove	Total
Peninsular Malaysia	5.97	0.46	0.11	6.54
Sabah	4.12	0.17*	0.32	4.61
Sarawak	7.78	1.47	0.17	9.42
Malaysia	17.87	2.10	0.60	20.57

*Estimated

On the plains, the tropical forest forms an almost unbroken canopy, but in the higher mountains it tends to thin out and exhibits considerable variation in flora. In the swampy areas, the high forest is replaced by a swamp flora terminating in mangroves. The Dipterocarp forest which represents 86.9% of the total forested land, is characterised by the predominance of the family Dipterocarpaceae with many of the species of the genera Anisoptera, Dipterocarpus, Dryobalanops, Hopea, Shorea and Parashorea.

Although this rich timber resource is still subjected to rapid depletion as a result of the large scale forest land clearance for agricultural and urban development, a total of 13.8 million ha. of forested land has been earmarked as Permanent Forest Estate (PFE) to be managed under sustained yield. The information here is aggregated into two broad categories as details vary from State to State. Protective forests include all forested land designated as National Parks, Wildlife Reserves, etc. Hence, approximately 9.1 million ha. of the proposed Permanent Forest Estates have been identified as productive while the remaining 4.7 million ha. as protective forests. The extent of the proposed Permanent Forest Estates in Malaysia is shown in Table 21 below:

Table 21
Extent of the Proposed Permanent Forest Estates
(million ha.)

Region	Protective Forest	Productive Forest	Total
Peninsular Malaysia	1.90	2.85	4.75
Sabah	0.35	3.00	3.35
Sarawak*	2.42	3.24	5.66
Malaysia	4.67	9.09	13.76

*Estimated

The bulk of the PFE will be located in the hilly and mountainous interior with most of the forests covering sensitive environments and critical watersheds. Intensive forest inventory and relevant integrated forest management and operational studies as well as some basic research and development will therefore be imperative to determine more precisely the timber production areas.

Due to the absence of regular and up-to-date forest inventories; the complexities of the tropical rainforests; and the lack of standardisation in format and uniformity in terminology concerning forest and timber resources there is no overall estimate of the growing stock in Malaysia. The issue is further confused by the great variation in the stocking of similar forest types and the level or intensity of utilisation in the various States. Under the circumstances, the total growing stock cannot be determined precisely but a conservative estimate based on past forest inventories suggest a total volume in excess of one billion (10^9) cubic metres. In addition, recent estimates also indicate that substantial volumes of currently under-utilised timbers would be available if appropriate uses, technologies and markets could be found.

In recent years, Malaysia has recognised the urgent need for forest plantations to meet domestic requirements in Peninsular Malaysia and to sustain timber exports in Sabah. Ambitious programmes for the establishment of plantations of fast-growing tree species, such as _Acacia mangium_, _Gmelina arborea_, _Paraserianthes falcataria_, _Eucalyptus deglupta_ and _Pinus caribaea_, have been formulated and some have been implemented which could eventually cover as much as 500,000 hectares. Programmes which are being implemented include those of Sabah Softwood (61,000 ha.); Sabah Forestry Development Authority (100,000 ha.); Sabah Forest Industries (48,150 ha.) and the Compensatory Plantation Project in Peninsular Malaysia (188,000 ha.) which will initially involve the States of Johore, Negeri Sembilan, Pahang and Selangor.

FOREST MANAGEMENT SYSTEMS

Perspective

The first forest service in Malaysia was established in the Straits Settlements in 1883 with its first Chief Forest Officer being appointed in 1901 while the first Conservators of Forests in Sabah (North Borneo) and Sarawak were appointed in 1915 and 1919 respectively (Menon, 1976) when most of the country was forested and demands on the forest were few. The removal of forest produce to satisfy domestic basic needs had an insignificant impact on the forest environment which had an immense capacity for regeneration. Under these circumstances, the main activities were exploration, reservation, legislation and administration, as management in the strict sense was hardly necessary. Traditional working plans based on area control were more than adequate for operation and regulation.

Malaysia has been able to conserve the country's abundant and rich natural forest resources by adopting relevant policies to ensure balanced and beneficial utilisation of these resources consistent with the concept and principles of sustained yield management. As a developing country with a relatively small population and chronic under-development in the past, Malaysia is committed to a comprehensive socio-economic development programme in which land development has a major role. Hence, after independence in 1957, ambitious plans were formulated for socio-economic development, particularly in the rural areas. Large-scale land development programmes were launched by the conversion of land under natural tropical forest which produced an abundance of high quality logs. This coincided with a rapid increase in world demand for tropical hardwoods which stimulated a tremendous expansion of wood-based indusries in Malaysia. The unprecedented growth in demand for tropical hardwoods combined with clearing for agriculture development resulted in accelerated depletion of tropical forest to the present level at which rational management has become imperative. However, the relevance and soundness of the forest resource utilisation and management policies in Malaysia should be evaluated in perspective, particularly in the light of the different needs, aspirations and conditions prevailing in the respective States concerned.

A "Forest Management Policy and Strategy for Peninsular Malaysia" was proposed in 1976 and subsequently accepted as supplementary to the National Forestry Policy. The policy was formulated to ensure fuller utilisation of the forest resource; sustained yield in perpetuity; maximum social and economic benefits; and environment stability. The explicit forest management policy is:

i) to manage and utilise the forest for maximum benefit based on the inherent capability of the forest and its optimal use;

ii) to manage the utilisation of the forest resource based on comprehensive forest land use and management plans;

iii) to determine potential yield on the basis of systematic and in-depth appraisals of the forest resource base, its growth potential and of the relevant factors;

iv) to regulate log flows based on a careful balance of supply and demand and maximum utilisation prospects and constraints;

v) to harvest the forest resource conservationally by selective felling and retention of adequate natural regeneration, consistent with economical harvesting, to ensure the sustainability of the forest resource base; and

vi) to apply optimal forest management regimes developed on the basis of information generated by systematic integrated forest management and operations research.

In Sabah, the basis for rational future management of the forests has been considered to be as follows:

i) intensive management of the permanent forests with extensive liberation treatment based on forest sampling/inventory to determine species and size class distribution for prescribing treatment of the growing stock,

ii) special provisions in logging licences and concerted efforts to curtail logging damage,

iii) mulitple-use management through strict regulation of logging in forest reserves with protective functions and incorporation of agro-forestry in suitable areas,

iv) development of forest tree plantations to an appropriate extent, and

v) reduction of export of logs and promotion of local processing.

In Sarawak, the broad objectives of forest management are as follows:

i) optimum utilisation of the resource potential;

ii) regulation of the harvest in accordance with the sustained yield concept;

iii) rehabilitation and protection of the forest after harvest; and

iv) development of the forest estate as a permanent resource base for industry or other uses and maximising revenue and socio-economic benefits in as far as it is compatible with the dominant use of the forest.

The overall management strategies for the forestry sector in Malaysia are as follows:

i) forest land which is scheduled for conversion to agriculture will be released for clearance in a properly planned and controlled manner so as to ensure a regulated and reliable flow of logs, together with the maximum possible utilization of the available wood supply. Plans for the efficient prior harvesting of all areas scheduled for land clearance must be strictly enforced, and

ii) forested land which is not destined for conversion to agriculture will be designated as permanent forest and will be managed as a renewable resource in a manner designed to maximize commercial returns compatible with the maintenance of environmental value.

PENINSULAR MALAYSIA

Early Development

The first recorded forest management of importance in Peninsular Malaysia is generally known as the "gutta percha" era (1900 - 1910) (Barnard, 1954). The price of gutta percha, a latex of Palaquium gutta, then fetched a price of up to $500/pikul (60 kg) (Wyatt-Smith, 1963). Trees of P. gutta were destructively felled for their latex. Logging was highly selective and confined to the naturally durable heavy hardwoods, mainly Balanocarpus heimii (Chengal). It was estimated then that the virgin Malayan rainforest carried about 260 $m.^3$/ha of stemwood and at the start of the century only about 7 $m.^3$/ha were being extracted (Wyaatt-Smith, 1959). After this operation the forest was considered "worked out". Silvicultural operations were confined to the establishment of P. gutta and para rubber (Hevea brasiliensis) plantations with enrichment planting of Balanocarpus heimii, only fo fail through the lack of subsequent tendings.

For the period 1910 - 1922 a series of silvicultural treatments known as Departmental Improvement Fellings was implemented mainly to favour mostly the development of P. gutta and poles of immature trees (not young regeneration) of the more valuable timber species. During this period, exploitation of timber and fuel was carried out exclusively on Stateland forests. The treatment involved the removal of all species whose crowns were interfering with any valuable timber species and cutting of all bettam (Engeissona triste) and creepers (except rattans) within a fixed distance (Wyatt-Smith, 1963). It was observed that natural regeneration was very good for all species except Palaquium species and it was suggested that, instead of planting, it would be better to "assist the existing natural regeneration by giving them more light and space". These observations formed the basis of early forest improvement work which involved the freeing of young trees of economic value.

About 1922, a change occurred in the exploitation of the forests as Forest Reserves were opened for logging, mainly for firewood in response to an increased demand while the mining boom had also created a strong demand for poles. These developments were considered in relation to the early Departmental Improvement Felling operations which were aimed solely at improving the existing stock and as the response of immature trees to these treatments were poor, doubt was expressed about the value of such treatments. Moreover, in the face of the rising demand for timber, it was felt that it would be unwise to girdle trees which had a use as poles or fuel.

A review of silvicultural practices in 1926 (Wyatt-Smith, 1963) revealed that the value of earlier Departmental Improvement Fellings had been lost as they had not been repeated. However, profuse young regeneration of the more valuable species had resulted and the improvement fellings had, in effect, been regeneration fellings (For. Dept. W. Mal, 1972). As a result, three classes of operations were distinguished as follows:

i) Departmental Improvement Fellings (Operations).

ii) Commercial Regeneration Fellings (Operations).

iii) Departmental Regeneration Fellings (Operations) or Regeneration Improvement Fellings (R.I.F.).

The Departmental Improvement Fellings which had the intention of removing the inferior species in several stages to promote the development of species having actual or potential value before the felling of these species were permitted had virtually ceased by 1932 (Hodgson, 1932). The second and third methods had a great deal of similarity with the classical shelterwood systems where the original forest canopy was gradually removed over a period of 8 - 10 years, during which regeneration was expected to be established and was given repeated regeneration tendings (Blandford, 1929).

Commercial Regeneration Fellings which was also known as "Seedling Fellings" were formulated in 1927 with a 5 years regeneration period and several clearings. This operation involved the gradual removal in several stages, of the inferior species before the felling of the useful species under commercial operations when there was a market for firewood and poles and at a profit to the Forestry Department. The sequence of operations is as in Table 22 below:

Table 22

*Sequence of Operations for Commercial Regeneration Fellings

Year	Code	Operation
n - 1	P	Felling of unmarked class 2 poles under 20 cm dbh.
n	S1	First seeding felling of marked class 2 trees.
n + 2 or + 3	C1	First cleaning if necessary.
n + 4	S2	Second seeding felling of marked class 2 trees.
n + 5	C2	Second cleaning.
n + 6	F	Final felling of marked class 1 trees provided successful regeneration verified in C2.
n + 7	C	Clearing after final felling if necessary.

*Based on Baur (1964)

Hodgson (1932) prescribed a slightly different schedule to this. Pole felling (P) included the felling of poles up to 30 cm dbh, the second cleaning being caried out in year n + 6 or n + 7, final felling in year n + 7, and the cleaning after final felling being carried out some time after F if found necessary. The pole felling was to remove those small stems which were liable to be severely damaged if retained. In the first seeding felling the aim was to produce evenly distributed gaps of about 7.5 m diameter in the canopy and under-storey canopy opening was to be avoided. The long regeneration period of 6 or 7 years gave time for regeneration to be established, and if it was still absent at this stage the final felling was to be delayed. However, when final felling did occur, all trees above 50cm dbh were to be removed. Eugeissona was to be removed, if dense, before any treatment was given. It was expected that after treatment a felling cycle of 40 years, with intermediate thinnings, could apply.

The Departmental Regeneration Fellings also known as Regeneration Improvement Fellings (R.I.F.) were rather similar to Commercial Regeneration Fellings and were confined to areas where there was no demand for inland firewood. Canopy opening became bolder, or even drastic, with two or more complete undergrowth cuttings. The general schedule of operations was similar to those for Commercial Regeneration Fellings, but the inferior species were removed by girdling if over 15 cm dbh. Since the canopy was opened more gradually by the slow death of girdled trees, the first girdling operation was more severe than the broadly equivalent first seedling fellings, and where commercial trees were plentiful all inferior species might be removed during the first girdling operation.

The girdling was accompanied by the first cleaning (GCI), and the treatments were repeated 3 or 4 years later (GC2) when girdling was commonly confined to those stems that had survived the first girdling. Another cleaning might be given one or two years later, and the final felling was carried out to 2 to 4 years after GC2. The sequence of operations for Departmental Regeneration Improvement Fellings is shown in Table 23 below:

Table 23
*Sequence of Operation
for Departmental Regeneration Improvement Fellings (R.I.F.)

Year	Code	Operation
n	GC1	First girdling of inferior species and cleaning.
n + 3 or + 4	GC2	Second girdling and cleaning.
about n + 5	C3	Cleaning in necessary.
about n + 7	F	Final Fellings of marked trees.

*Based on Baur (1964)

Hence, Regeneration Improvement Fellings involved girdling rather than felling. Girdling helps to reduce damage to the residual stand, deprives climbers of the convenient ladder of a fallen but still strong crown, and slows down the increase of light, thereby giving trees more chance of competing with the more rapidly responding light demanding climbers. This operation was profitable as long as there was a high demand for fuelwood, but with the ever increasing competition from coal, oil and electricity, greater numbers of unwanted trees had to be removed by deep girdling. The loss of revenue, coupled with costly girdling operations resulted in the evolution of a cheaper and more efficient technique in tree killing operations by the use of an aqueous solution of sodium arsenite poured into a shallow frill-girdle round the tree. The Departmental Regeneration Fellings became known as Regeneration Improvement Fellings (R.I.F.), and strictly speaking this name should only be applied to the departmental operations. However, it now appears standard practice to refer to either type of regeneration inducement as R.I.F., in view of the great similarity between them. Moreover, from about 1935 onwards, as the demand for firewood decreased in the face of competition from alternative sources of fuel, and as the market for mining poles became more limited, departmental operations became increasingly widely applied.

During the period 1935 - 1941, while the demand for inland firewood was declining sharply, the development of medium powered sawmills and the shortage of supplies from accessible stateland forests had led to an increasing demand for timber from the Forest Reserves and less selective timber exploitation and to the evolutions of 'sawmill silviculture' (Barnard, 1954). As research results began to become available during this period, it was also realised that successful regeneration could be established with fewer cleanings. There were suggestions for cleaning of the regeneration to be carried out after exploitation was completed, in contrast to the pre-treatment in vogue, combined with poison-girdling of the remaining large trees would ordinarily suffice. There was also a general introduction of cheap poison-girdling by the application of sodium arsenite at 50 to 100 gm per litre of water to the frill (Mead, 1940).

Another development during the mid-thirties appears to have followed a suggestion of Edwards (1931) that some form of sampling should be employed, as a guide to cleaning treatments and to the desirability of carrying out final felling. About 1935, linear sampling using milliacre plots of 2 m x 2 m was introduced and was later widely used as a means of determining the extent and nature of desirable regeneration.

During the Japanese Occupation (1942 - 1945) great destruction took place on accessible forested lands which were converted for food growing. This included the destruction of about 14,200 ha under regeneration fellings and 5,300 ha, or nearly half of the fully regenerated forest available. Uncontrolled timber exploitation on stateland forests and in Forest Reserves occurred and no silvicultural operations were carried out.

The Malayan Uniform System (M.U.S.)

After the Pacific War, Regeneration Improvement Felling (R.I.F.) was discontinued after a couple of years because of the increased demand for raw materials from the increasing number of sawmills and the use of heavy machinery in harvesting. Moreover, it was observed that many of the untended clear-fellings made during the Japanese Occupation and suspected storm forests contained adequate advanced seedlings regeneration which were present on the ground at the time felling had survived undamaged and had even grown rapidly to form the dominant crop without any assistance while the slower growing 'economic species' had formed the sub-dominant crop. In fact, meranti seedlings already on the ground responded immediately to a sudden drastic canopy opening. These factors led to the formulation of the Malayan Uniform System (MUS) in 1948 which is basically a system for converting the virgin tropical lowland rainforest (a rich, complex multi-species and multi-aged forest) to a more or less even-aged forest containing a greater proportion of the commercial species, achieved by a clearfelling release of selected natural regeneration of varying age, aided by systematic poisoning of unwanted species (Wyatt-Smith, 1963).

Hence, MUS consists of removing the mature crop in one single felling of all trees down to 45 cm. diameter at breast height for all species and releasing the selected natural regeneration of varying ages which are mainly the light demanding medium and light harwood species. This felling operation is followed by a poison girdling operation of defective relics and non-commercial species down to a minimum dbh of 15 cm. - 5 cm. Approximately 5 to 7 years after felling a linear strip sampling is carried out to verify the presence of sufficient regeneration on the ground and subsequently to determine suitable silvicultural treatments.

The success of the system depends upon five important factors which are as follows:

i) There must be an adequately well-distributed stocking of seedlings of economic species at the time of felling. This information is obtained from a milliacre (2 x 2 m) linear sampling of the area. If stocking is inadequate the stand is to be left behind until after a seed year to be followed by another sampling.

ii) Complete removal of the canopy through poison-girdling of all remaining big sized trees and other species considered as non-commercial down to 5 cm. dbh.

iii) No tending until the regrowth has passed the ephemeral climber stage and is relatively clear below.

iv) Maintenance of adequate new canopy to prevent the redevelopment of climbers.

v) Linear samplings have to be carried out at regular intervals to assess the regeneration status of the seedlings.

The normal sequence of operations under the MUS as originally prescribed is as shown in Table 24.

Table 24

*Sequence of Operations for Malayan Uniform System (As Originally Prescribed)

Year	Operation
n - 1 1/2	Linear sampling (2m. x 2 m.) of regeneration, and enumeration of merchantable trees.
n to n + 1	Exploitation, followed by poison-girdling down to 5 cm. dbh.
n + 3 to n + 5	Linear sampling (5 m. x 5 m.) of new crop, followed by cleaning, climber cutting and poison-girdling as required.
n + 10	Linear sampling (10 m. x 10 m.) of new crop, followed by treatment as required or passed as regenerated.
n + 20, n + 40 etc.	Sampling and thinning as required.

*Based on Baur (1964)

Modified Malaysian Uniform System

This M.U.S. has been successfully applied to the lowland dipterocarp forest but has been found to be unsuccessful in the hill dipterocarp forest. The reasons for that include the comparatively more difficult terrain, uneven stocking, lack of natural regeneration on the forest floor before logging, uncertainty of seedling regeneration after logging because of irregular seeding from potential mother trees, sometimes at intervals of several years (Whitmore, 1975), heavy seedling mortality due to felling damage on steep slopes and poor viability of the seed of *Shorea curtisii* which is the main commercial species (Burgess, 1968, 1971).

Other factors, including the danger of erosion on steep slopes and the incidence of bertam (Eugeissona triste) and other secondary growth, do not favour a drastic opening of the canopy. Moreover, the poison-girdling of species down to a minimum of 5 cm dbh was considered to be too drastic even for forest in which Light Red Merantis predominate and for various reasons it is not always possible in practice to delay harvesting until there is adequate regeneration present on the ground. Often the mandatory pre-felling sampling could not be carried out and regeneration could only be done after the harvesting operation. This and other deviations led to the MUS being modified in various ways, mostly of a relatively minor nature initially, in the light of experience over the first decade (Baur, 1964). The general pattern of the sequence of operations in 1964 is shown in Table 25.

Table 25
*Sequence of Operations
for Malayan Uniform System (General Pattern, 1964)

Year	Operation
n - 3 to n - 7	Canopy opening at time of good seedfall, in areas where regeneration and seed bearers are scarce.
n - 3 to n - 5	Treatment of areas heavily infested with bamboo.
n - 3	Treatment of areas with dense Eugeissona.
n - 2	Climber cutting in areas of heavy vine infestation.
n to n - 1 1/2	Milliacre sampling and enumeration of utilizable stems.
n	Exploitation of all merchantable stems (normally to 45 cm dbh). Poison girdling all unwanted stems down to 15 cm dbh in Kapur and Seraya types and in heavily opened patches (except for dense shade-casters), and down to 5 cm dbh. in shaded patches in other types. Retention of any potentially valuable stems below 48 cm dbh (larger where minimum felling limit is larger).
n + 2	Commence tending in areas designated as heavy hardwoods sites.
n + 3 to n + 5	5 meter square sampling (not in swampy rain forest). Such treatment as indicated by diagnostic sampling, e.g. climber cutting, eradication of weed tree spp. etc.
n + 8 to n + 10	10 meter square sampling. Such treatment as indicated by diagnostic sampling.

*Based on Baur (1964)

Burgess (1970) has also emphasized that silvicultural systems for forests in so complex an environment as the hills of Malaysia can do no more than lay down the general guidelines. Any system must be executed with care and intelligence by officers who really understand the principles upon which it is based. The sequence of operations of the silvicultural systems for steep lowland forests, hill dipterocarp forests and upper hill dipterocarp forests as suggested by Burgess (1970) is shown in Table 26.

Table 26

*Suggested Silvicultural Systems for Steep Lowland Forests, Hill Dipterocarp Forests and Upper Dipterocarp Forests

n - 1	a)	Poison bamboo.
n	a)	Two meter square sampling (intensive) immediately before exploitation.
	b)	Exploitation to 1.2 m girth.
	c)	Girdle unwanted trees to 30 cm girth, retaining relic Dipterocarp trees.
n + 5 (and after next seed yr.)	a)	Regeneration assessment - 10 meter square sampling (all sizes).
	b)	If regeneration adequate, girdle Dipterocarp relics.
	c)	If regeneration is inadequate, enrich and tend.
n - 1	a)	Poison bertam.
n	a)	Visual assessment of regeneration or LSM (intensive) immediately before exploitation
	b)	Exploitation to 1.5 m girth, retain proportion of stand if necessary.
n + 2	a)	Girdle unwanted or defective trees to 1 m girth
n + 7	a)	Regeneration sample - 10 m square sampling (all sizes).
	b)	Regeneration adequate, girdle to 30 cm girth.
	c)	If regeneration is inadequate, enrich and girdle, tend.

Precipitous forests - no exploitation or treatment (slopes 45°).

Marginal or non-commercial forests: a) Enumerate stand and regeneration (LSM extensive); b) Regeneration fair and good log market - exploit to 1.2 m girth and enrich; c) Regeneration inadequate and poor stand - replace by planting.

*Based on Burgess (1970).

The sequence of operations of the 'modified' MUS that is still being used is shown in Table 27 below:

Table 27
'Modified Malayan Uniform System (MUS)'

Year	Operation
n - 1/2 to n - 1	Enumeration data of trees greater than 35 cm dbh as required for premium determination only (10% sampling intentity). Tree marking may be carried out for checking completeness of felling only. No marking of residual trees for retention.
n	Felling of all commercial and utilisable species of 45 cm dbh and above.
n + 1/4 to n + 1/2	Post-felling sampling to determine fines on trees unfelled, royalty on short logs and tops, damage to residuals.
n + 2 to n + 5	Linear Regeneration Sampling to determine appropriate silvicultural treatments.
n + 20	Linear Sampling of regenerated forest to determine status of the forest.

Artificial regeneration started in the mid-1960's, gained momentum in the late 1960's and early 1970's but waned in the mid-1980's. During this period, the Taungya system as a means of artificial regeneration was introduced to re-forest patches of Forest Reseves in Peninsular Malaysia, especially around the fringes, which were found to be devastated as a result of continuous illegal cultivation. Some ofthese areas had reverted to 'belukar' (secondary forest) while others were under sheet lalang (*Imperata cylindrica*). Under this system, the illegal farmers were given permits to cultivate the land provided that they would in turn plant tree seedlings provided by the Forestry Department. Generally, this system could be divided into two categories which were namely, Taungya with pine (predominately *Pinus caribaea*) and Taungya with hardwood species (mainly *Dryobalanops aromatica*, *Shorea leprosula*, *S. ovalis*, *S. curtisii* and *Swietenia macrophylla*).

The agricultural cash crops used were mainly banana and tapioca (black-twig variety). However, this system was discontinued because of the lack of response from the cultivators due to insecurity of land tenure, the accelerated development of large-scale agricultural schemes that were being under-taken by the Government thus relieving land pressure for agricultural land and the high costs of supervision incurred by the Forestry Department.

Technically, artificial regeneration with indigenous species is feasible as indicated by preliminary results of Shorea parvifolia established at Tapah Hills (Tang and Chew, 1980). The current annual mortality rate recorded was 10% in the first three years after planting and subsequently dropped to 5% in the following three years. The mean annual height increment was between 1.2 - 1.5 m while the mean annual diameter increment was between 1.3 - 1.5 cm. However, artificial regeneration on a large scale may not be a practical proposition since accessibility is poor and establishment and maintenance costs high.

The Selective Management System (SMS)

In recent years, virtually all easily accessible lowland and hill forests had been logged and about two-thirds (the more accessible parts) of the hill forests had been selectively exploited. As the remaining virgin forests are found on steeper slopes in the remote parts of the country, mainly in the central/eastern region, there has been growing support for a selective felling system to be applied in Peninsular Malaysia. Apart from the silvicultural and environmental difficulties encountered in trying to apply the MUS in the hill forest, the monocyclic approach may not be financially and economically attractive enough to encourage large investment in the forestry sector. The long rotation and the single cycle of the MUS would require a larger forest base in order to practise sustained yield forestry. Since land is limited, the way to achieve this is either to shorten the rotation or increase the number of cuts per rotation.

Consequently, the Selective Management System (SMS) was evolved as it seemed to offer the following advantages:

i) the flexibility to manage the highly variable forest conditions and the changes in the socio-economic environment,

ii) it is rationally based on the inherent characteristics of the forest and the prevailing socio-economic conditions, and

iii) it will allow for the optimization of forest management goals which are namely:
   a) an economic cut,
   b) the sustainability of the forest, and
   c) the minimum cost for forest development.

Thus, SMS is designed to optimize the management objectives of economic and efficient harvesting, sustainability of the forest and minimum forest development cost, under prevailing conditions. It requires the choice of management (fellings) regimes based on inventory data, instead of an arbitrary prescription, which will be equitable to both logger and forest owner as well as to ensure ecological balance and environmental quality.

In order to determine the appropriate minimum cutting limits (ideally of at least 45 cm dbh for the Non-Dipterocarp and 50 cm dbh for the Dipterocarp species) under this system of management, a pre-felling inventory is carried out to provide reliable estimates of the population parameters being measured which are as follows:

i) all tree species 5 cm dbh and above and tree species having a dbh of less than 5 cm but having a minimum height of 15cm and above by -

   a) dbh class,
   b) species, and
   c) volume/stems per ha.

ii) Incidence of weed species and climbers, and

iii) Physiography by -

   a) slope,
   b) elevation,
   c) soil types, and
   d) river systems.

Based on the above information and other relevant information about the markets and other socio-economic considerations, a felling regime will be formulated that will optimize the stated goals. Colour-coded stock maps which enable the subdivision of compartments in areas of different types of tree stock by predominant species groups and/or size (dbh) classes are also prepared.

Under this system of forest management, growth rates and the required stand determine the length of the cutting cycle. Disappointing growth rates would mean that the cutting cycle will have to be prolonged and a lower allowable annual coupe adopted while higher growth rates would lead to a shorter cutting cycle and higher allowable annual coupe.

Based on a series of about one hundred continuous inventory sample plots of 0.4 ha. each and another hundred experimental cutting and/or silvicultural treatment plots, usually of a size of 4 ha, each containing a systematic permanent observation sample, that were established in logged-over hill forest, the following annual growth and mortality rates of trees over 30 cm dbh (tree boles only) were observed (UNDP/FAO, 1978).

i)	Diameter Growth in cm/year:		
	a)	All marketable species	0.80
	b)	Dark/Light and Red Merantis	1.05
	c)	Medium-Heavy marketable species	0.75
	d)	Light Non-Meranti marketable species	0.80
and	e)	Non-marketable species	0.75
ii)	Gross volume growth in m3/ha/year:		
	a)	All marketable species	2.20
and	b)	all species	2.75
iii)	Gross volume growth percent:		
	a)	All marketable species	2.1%
and	b)	All species	1.9%
iv)	Annual Mortality percent: (of numbers of marketable species)		0.9%
v)	Annual in-growth percent: (of marketable species growing - inover 30 cm dbh limit)		0.6%

Preliminary studies have assessed felling damage to remaining intermediate sized trees of 30 cm dbh and above to be about 30%, and wastage due to breakage and bucking in the range of 6.5% to 8% of the gross timber volume (Griffin and Caprata, 1977). More effective use of directional felling would reduce the effects of logging on the residual crop. The relationship between percentage of felling damages to intermediate sized trees in relation to diameter classes is as shown in Table 28 below:

Table 28

Percent Damage according to Diameter Class

Diameter Class	Percent Damage
+ 60 cm	20
45 - 60 cm	30
30 - 45 cm	40
15 - 30 cm	50

The minimum numbers of trees required for the various dbh classes, are based on the overall stock results of the National Forest Inventory of 1973 for unexploited/undisturbed forests, as these are considered to represent the average stocking capacity of the natural forests. These stock data were increased by 30% - 50% for trees over 2 cm dbh to account for probable higher than natural mortality, wind-throw and growth stagnation of a portion of the trees remaining in logged-over forests, as shown in Figure 7.

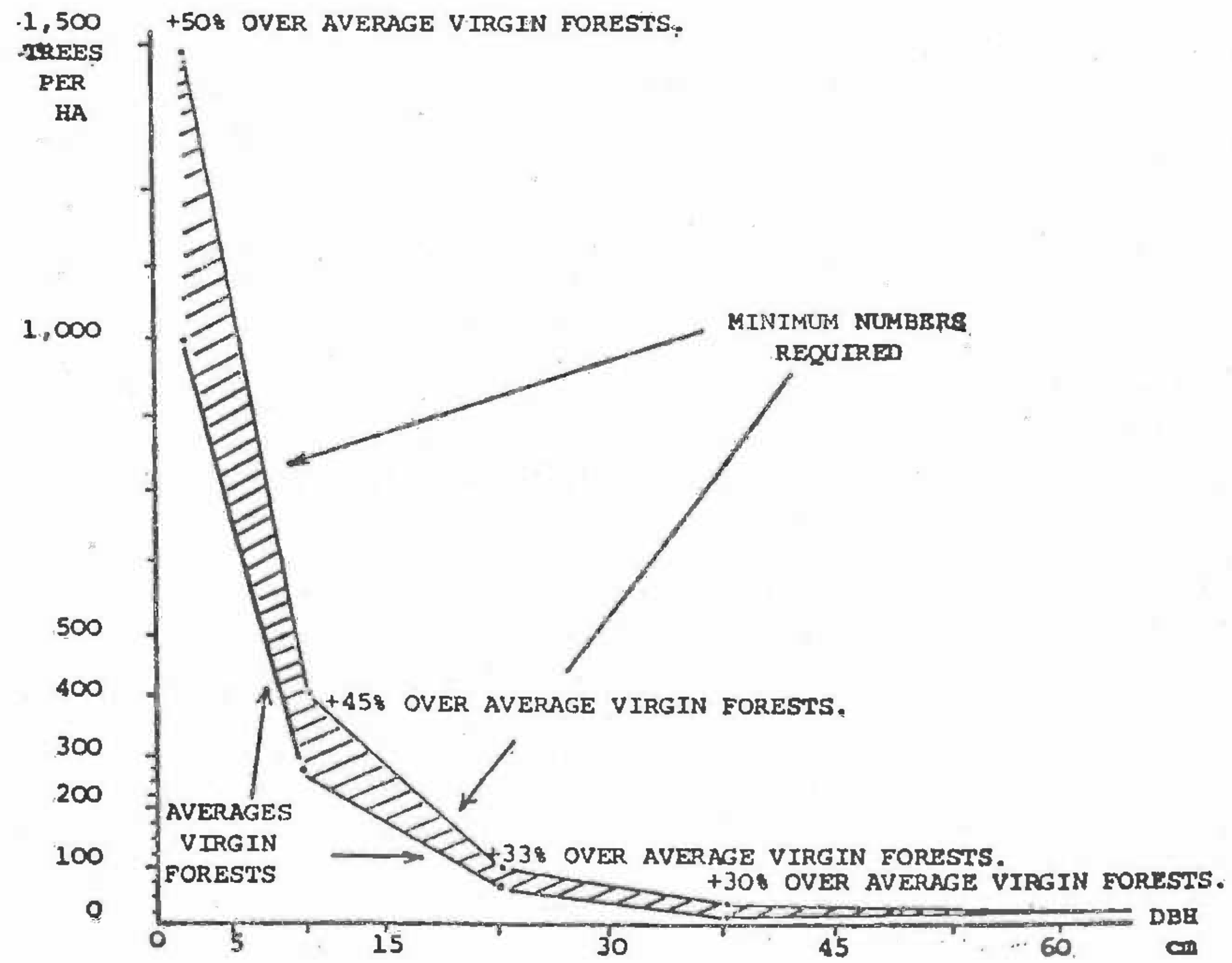
In determining the adequacy of residual stocking for the next cutting cycle, the number of residual stems in the higher dbh class is deemed to have an equivalent value to the proportion of stems required by the standards of the next lower dbh class. This concept can be illustrated more clearly in Table 29 below: (Forestry Department, 1977)

Table 29

Minimum Residual Stocking

Class	Size	Number of Trees per ha.			Tree Equivalence to 1 tree in class 30-45cm dbh
		No./ha before logging	No./ha after logging	Proportion of Rules Numbers	
Exploitable	+45 cm dbh	25	18	2	2
Ingrowth	30-45 cm dbh	25	33	3	1
Small trees	15-30 cm	99	75		(1/3) (trees below 30cm dbh are not considered for next cut)

FIGURE 7 FREQUENCY DISTRIBUTION OF TREES BY DIAMETER CLASSES



In practice when the next cut is expected in 25-30 years after the first logging, the cutting limits for the dipterocarp and non-dipterocarp species should not be less than 50 cm dbh and 45 cm dbh respectively; while the minimum residual stocking (medium sized trees 30-45 cm) should not be less than 32 sound marketable trees of good form from diameter class 30-45 cm or its equivalence.

For example, a stand after logging with 8 trees of 45 cm dbh and 17 trees of dbh class 30-45 cm, (in total 25 trees of +30 cm dbh), would not satisfy the rules for class +45 cm, neither for 30-45 cm, nor even the total +30 cm. However, the 8 trees of +45 cm dbh are equivalent to 16 trees of the 30-45 cm dbh class and the total equivalence becomes 16 + 17 = 33 trees, which satisfies the minimum number required for the 30-45 cm dbh class. It should be noted that when applying this technique, the age of the whole stand has to be accordingly lowered and used in calculations to estimate the expected yield and time of harvest.

Moreover, in order to enhance the next cut with a greater proportion of dipterocarp species than the non-dipterocarp species, the difference in cutting limits prescribed between the two groups of species should be 5 cm for any one cutting block or compartment.

Although the economics of logging in Peninsular Malaysia are not well understood because of the lack of definitive economic studies of the various logging systems, it is calculated that the minimum economic cut based on current log prices, estimated cost of logging and government charges should be in the range of 35 m3 to 40 m3 per ha. of currently commercial and utilisable species. Net volume is derived from gross volume minus 40% for trees having dbh less than 60 cm and minus 30% for trees having dbh greater than 60 cm.

The forest planning and operational studies carried out so far in Peninsular Malaysia have thus clearly indicated the feasibiltiy or continuous and economically viable hill forest production in terms of economic log-outturn volumes with periodic cuts every 35-40 years, using locally appropriate cutting limits and leaving adequate number of medium sized trees of marketable species for natural in growth to commercial sizes. It has been shown that, with average diameter growth rates of trees over 30 cm dbh of 0.8 - 1.0 cm per year in diameter and 2.0-2.5 m3/ha. per year in commercial gross volume, about three-quarters of the hill forests is capable of producing every 30 years about 40-45 net m3/ha. which is about the current average outturn level of virgin hill forest. However, it is imperative to limit exploitation damage of the residual stands to not more than 30% of intermediate sized trees.

There are two opportunities presently favouring the implementation of the Selective Management System in Peninsular Malaysia. Firstly, in the hill forests for which this is the appropriate management system, a concentration of operations on a large scale using mechanized equipment, is required, providing higher levels of employment and job diversification. Since these operations will, by being concentrated, become increasingly sophisticated the prospects of thereby transfering technical and organizational skills to local, largely rural residents, would be enhanced. Secondly, the large land development schemes expected to continue for another decade are releasing large amounts of wood material which are increasingly being utilized. The extensive tree-crop plantations of rubber and oil palm for which annual replanting schemes will steadily increase in future years, will also provide a source of woody fibre materials with potentials for industrial processing in coming decades of declining raw material and energy supplies.

The sequence of operations under the Selective Management System is as in Table 30 below:

Table 30
Selective Management System (SMS)

Year	Operation
n-1 to n-2	Pre-felling forest inventory using systematic-line-plots and determination of cutting regimes (limits).
n to n-1	Climber cutting to reduce damage during logging. Tree marking incorporating directional felling. No marking of residual trees for retention.
n	Felling of all trees as prescribed.
n+2 to n+5	Post-felling inventory using systematic-line-plots to determine residual stocking and appropriate silvicultural treatments.

SABAH

The rain forests of Sabah are very similar to those in Peninsular Malaysia, but are characterized by a smaller number of non-dipterocarps and by the presence of generally larger trees. Trees with diameter ranging from 116 cm - 155 cm are common and trees between 194 cm - 242 cm are not extreme rarities and are usually sound. The growth is generally superior and trees can exceed 73 m in total height while, particularly on the rich volcanic soils, the length of clear bole above buttresses and below the first branch is regularly over 30 m and frequently exceeding 36 m (Walton, 1955). The most common commercial species is Parashorea malaanon which, over large areas, makes up 80% of all the timber trees and in parts up to 98% (Baur, 1964). With the similarity of the rainforests and a very often senior personnel with Malayan experience, it was natural that the early forest management systems practised in Sabah would also be very similar to those in Peninsular Malaysia.

A Delayed Start

The history of forest exploitation and management in Sabah before the inception of the Forest Department in 1915 is obscure. During the period 1915 - 1951 the main policy of the Forest Department focused on exploitation rather than conservation and sustained yield management. Hence, the main functions of the Department were forest revenue collection and "to a more or less extent an agent of the timber concessionaire" in forest reconnaisance and marketing. In 1920 the first major timber concession was granted to the British Borneo Timber Company which had complete monopoly of forest exploitation over all inland forests up till the year 1952 with the Forest Department having no control over how and where forests were worked. The company, or any one authorised by it, could work anywhere, take or leave any tree or species of timber and cease work or move on to another convenient area at will. As there was no systematic working plan for the inland forests, logging was mostly selective depending on terrain and species utilised. This resulted not only in the creaming of the most accessible fringes of level country along streams and rivers but also provided experience in only the simplest and most primitive forms of extraction with minimal or no forest management inputs at all.

Nevertheless, the Forest Department conducted early research on silvicultural techniques and in 1934 had undertaken regeneration treatments of the dipterocarp forests in the form of Regeneration Improvement Fellings (R.I.F.) which were similar to those in Peninsula Malaysia but on a limited scale. The objective was to ensure adequate regeneration of commercial speices on the forest floor, prior to logging (Fox, 1968; Martyn and Udarbe, 1976).

In 1936, the Taungya system was introduced in Sabah as a means of checking the indiscriminate destruction of the forest lands by shifting cultivation which was considered to be a major management problem. The illegal occupants were given permits to till the land provided that they would in turn plant tree seedlings provided by the Forest Department. The scheme apparently was not successful.

In 1949, another method of improvement fellings was introduced which was known as the Selection Improvement Fellings. The aim of these operations was to assist pole-size trees of 10 cm dbh and above which were found on areas that had been logged 15 to 25 years before to develop into the next crop. This method involved the poison-girdling of non-commercial trees shading or competing with the commercial species, and included the cutting of climbers (Martyn and Udarbe, 1976).

For many years, effective forest planning and management in the State were hampered by the existence of the concession agreement mentioned earlier and the absence of an approved forest policy. In 1948, a State Forest Policy was finally approved by the Government in accordance with the recommendation of the Fifth Empire Forestry Conference, 1947. The policy recognised the importance of establishing the forest industry and the management of the forests on a sustained-yield basis and also the necessity of practising scientific forestry in maintaining and improving edaphic and climatic conditions. This policy, except for minor changes, was similar to the Forest Department policy which for a number of years had guided its officers in the management of the forests in Sabah.

As a direct result of this policy, negotiations were started to terminate the timber concession of the British Borneo Timber Company. In 1952, the Company's monopoly over the State forest ceased and they were granted instead a limited concession area of about 260,000 ha. In this agreement, the Government exercised control over forest operations whereby the whole area was to be expoited during the period of 21 years with an annual coupe of 12,380 ha. In theory, this agreement prescribed the final felling cycle of 20 years. During the same year, four other timber concessions were issued with a modified licence agreement of 21 years which stipulated an annual coupe of one percent of the concession areas which were to be managed under 80 years rotation. There was an allowance of 20 percent for unproductive forests. The minimum felling diameter limit was 60 cm. and the licensees were obliged to fell all trees over 80 cm. dbh. Yield regulation was carried out by area-control.

The Modified Malayan Uniform System

In 1956, the 'modified' Malayan Uniform System for forest regeneration treatment was introduced. This modification is aimed at achieving a more or less even-aged dipterocarp forest with an increase in both quality and volume over that of the original stand within a specified period of time, usually between 80-100 years (Chai, 1981).

The success of this system depends upon five important principles, which are as follows:-

(i) The presence of a sufficient number of seedlings on the forest floor prior to exploitation.

(ii) The ability of these seedlings to remain alive in unexploited forest for a period long enough to bridge the interval between seed years.

(iii) A sufficient number of these seedlings must remain on the ground after logging.

(iv) The ability of regeneration to respond to increased light through the opening up of the forest canopy.

(v) The crop trees forming the next regeneration will principally come from these seedlings. Advance growth is additional but its presence is not essential.

Basically the system prescribed the poison-girdling, immediately after felling, of all defective trees of commercial species and all non-commercial species down to 15 cm. diameter. In addition, in pockets of undisturbed forest in logged over areas containing regeneration, all non-comercial trees were girdled down to 5 cm. diameter. Sound commercial trees of over 60 cm. diameter left unexploited were also girdled. The cutting and poisoning of all woody climbers over 2.5 cm diameter was prescribed at a later date. This system of management became the standard regeneration technique of all dipterocarp forest in the Forest Reserves of Sabah during its early introduction, as evidence showed that there was nearly always adequate seedling present on the forest floor, especially if the forest was virgin before logging (Nicholson, 1958, 1965; Burgess, 1961; Cousens, 1965; Meijer, 1970: Wong, 1973).

Following further experimentation and studies the 'modified' MUS was further refined and a full description of this refined system has been discussed by Nicholson (1965). Its main features are as follows:-

i) Sodium arsenite at the rate of 2 lbs. per gallon of water is used as the poison, applied in a complete, level frill girdle

ii) Girdle:

a) All trees of commercial species, except belian, which are damaged, hollow, or otherwise defective, down to a lower limit of 15 cm. diameter, and where they are not needed as seed trees. Contrary to former instructions do not girdle all trees over 60 cm. dbh regardless of their quality. "Defective" includes logging damage above 2.5 m from ground (above stump height), bad bends, low forks, exudations (indicating borer attack), and severe crown damage.

b) All trees of non-commercial species over 15 cm. diameter.

c) All non-commercial trees over 5 cm. diameter in dense islands of unlogged forests where there is regeneration of commercial species.

iii) All woody climbers over 2.5 cm diameter are to be cut and the lower end dampened with sodium arsenite. Rotan should be cut but not poisoned.

iv) Belian is only to be girdled when the stem is so defective as to be useless.

v) No tree is to be girdled when it is closer than its own height to a main extraction route that will be in use six months after girdling.

vi) Girdling will continue right up to the banks of streams except where a falling tree will be a danger to navigation or where it is possible that human water supplies will become contaminated.

vii) No fruit tree (not including Kawang) will be girdled.

viii) Girdling is to cease at the edge of unlogged forest, except for the small islands within a logging area mention in ii(c) above.

ix) Guide lines for girdling control will be cut 20 m. apart and normally a milliacre (2 m x 2 m) sampling will be made along each.

x) All trees for retention must be marked with paint by the officer in charge of the gang.

xi) Commercial trees consist of all Dipterocarpaceae, all Leguminosae (expect _Koompassia excelsa_), _Eusideroxylon zwageri_, _Heritiera simplicifolia_ (and similar species), _Scorodocarpus borneenis_, _Azadirachta_ sp, _Durio_ spp. _Dyera_ spp, and _Octomeles sumatrana_ when there is nothing else.

In 1971 the 'modified and refined' MUS was subjected to further modification and refinement to become a minimum girth limit system (Stratified Uniform System, M.U.S.(modified)), but retained the principles of MUS following recommendations by Dawkins (1968).(Chai and Udarbe, 1977, Munang, 1978). These modifications and refinements centered mainly on the importance of advance growth for the next crop and the reduction of logging damage to them. As such, it is often still referred to as the Modified Malayan Uniform System.

The sequence of operations of the various silvicultural operations is shown in Table 31 below:-

Table 31

Sequence of Operations of the Modified Malayan Uniform System, Sabah

Year	Operation
n - 2 to n - 1	Allocation of coupe. First silvicultural treatment - protective tree marking and climber cutting.
n	Felling operation.
n + 0-1 month	Clearance inspection.
n + 0-2 month	Assessment of regeneration through Linear Sampling Milliacre (LSM) (2 m x 2 m plots).
n + 3-6 month	Second silvicultural treatment - First poison girdling of unwanted and defective trees, climber cutting if necesssary.
n + 10 to n + 15	Assessment of regeneration through Linear Sampling Half-Chain Survey (LS1/2) (10 m x 10 m plots). Third silvicultural treatment - Liberation treatment where necessary.

*Based on Fox and Hepburn (1972) and Chai and Udarbe (1977)

In brief, annual felling coupes are usually selected two years in advance with the first silvicultural treatment being carried out in selected coupes before logging commences. All climbers of whatever size will be cut once right through, as Fox (1968a) had shown that prefelling climber cutting can reduce logging damage by 20%. Along the strip and within each quadrat of forest 100 m by 100 m, twenty five trees of preferred or desired commercial species will be marked as protected trees. These trees will normally be between 0.6 m to 1.8 m girth, marked clearly with paint on three sides and recorded. This procedure of protective tree marking and climber cutting is fully documented in Sabah Forest Record No. 8 (Anon, 1972)which was summarised by Liew (1973) as follows:-

"The annual coupe is to be treated systematically using a grid of narrow rentises based on the company coupe boundary rentis, ridge tops, rivers or other features. The grid should consist of narrow rentises spaced at 5 chains apart at right angles to the base line. Within each strip of forest of five chains width and five chains length twenty five trees of preferred or desirable commercial species will be searched for. These should be in groups of three to four trees up to half a chain apart and individual groups up to two chains apart. The size of trees will normally be between two and six feet girth. Each will be marked on three sides with bright yellow or red paint. All climbers of whatever size will be cut once. Once trees have been marked for retention, they become prohibited species under licence Agreement (Schedule V) and may not be felled (Clause 16 (2)). However, variations are provided to suit the conditions of the forest. For example, (a) one-foot girth commercial trees are to be included if there are insufficient trees of two to six feet girth, (b) increase the list of species from preferred and desirable commercial species if insufficient of these are available, (c) the use of the special list of species if a new forest type is encountered, (d) if insufficient trees are available of the one to six feet girth classes of the species list, then, depending on the number of trees of one to six feet girth marked, mark one to three trees per acre over six feet girth as seed-bearers, starting with the preferred list. The last variation can only be applied provided that L.S.M. has been done and the stocking is found to be less than 200 stocked plots per acre".

The objectives of the second silvicultural treatment which is carried out immediately after the regeneration sampling (LSM) are as follows:-

i) to ensure that commercial seedlings where present have sufficient light for maximum development (but are not fully exposed), and to favour the development of advance growth;

ii) to remove unwanted species and defective stems which compete with the regeneration;

iii) where seedlings are deficient, to retain suficient stems of commercial species to ensure eventual maximum stocking of regeneration; and

iv) to eliminate any climbers which still remain after the first silvicultural treatment.

Thus, the purpose of the second silvicultural treatment is to promote vigorous growth of the natural regeneration present after logging, by removing competition, and creating a suitable environment for growth through the elimination of unwanted species and climbers. The bases of this treatment are the presence of regeneration and the intensity of logging. After such treatment, it is expected that an area should have a rich stand of commercial pole-sized trees 5 to 10 years hence and which would be able to maintain maximum growth when silviculturally treated.

Thus, after the LSM sampling, the third silvicultural teatment, which may be in the form of further poison-gridling and climber cutting, removal of seed-bearers and relics and tending could be carried out.

The areas treated under the modified Malayan Uniform System in the Permanent Forest Estates (Forest Reserves) expanded rapidly, aafter 1971, reaching a total of 140,975 ha. in 1983. However, with the huge expansion of areas being opened up for logging in the late sixties till the early eighties, it was impossible for silvicultural treatments to keep pace and a large backlog of untreated forest accumulated. In early 1977 all treament was stopped, after intensive investigation and studies conducted by Chai and Udarbe (1977) which cast doubt on the usefulness of such treatments. They noted that, owing to the high intensity of logging, silvicutural treatments when carried out were effectively done on only one-third of the logged-over area, with the other two-thirds having been released by logging itself.

Moreover, several concurrent developments encouraged changes in the silvicultural system. Firstly, the increased intensity of logging practices led to more damage to soils from heavy equipment. Secondly, the steadily increasing average volume of removals affected soils and regeneration. Lastly, very vigorous invasion of 'balukar' had been observed after heavy logging and treatment. As a result, poisoning or any other silvicultural treatment immediately after heavy logging in Sabah is no longer considered appropriate. Subsequently and currently the sequence of silvicultural treatments is as follows (Anon,1984):-

i) n - 2 to n - 1 ; Allocation of felling coupe followed by the first silvicultural treatment which involves climber cutting. This operation has not been carried out extensively.

ii) n : Felling operation.

iii) n + 3 to n + 5 : Linear Regeneration Sampling (LRS-I) followed by the second silvicultural treatment which involves mainly climber cutting. This is an effective treatment which usually results in the creation of forest gaps inducing growth of commercial species. Frill-girdling of non-commercial trees or weed species has not been undertaken because this operation was considered to be harmful to the ecosystem and economically unsound. The weed species may be a valuable resource for future utilization locally. Silvicultural treatment, particularly frill-gridling, was not carried out immediatley after logging because logging itself is a silvicultural treatment opening up sufficient gaps for inducing growth of seedlings and saplings and sapings. Under intensive forest management, enrichment planting would be carried out when necessary.

iv) n + 10 to n + 15: Further linear regeneration sampling (LSM) would be carried out to assess the forest conditions. This sampling is followed by the third silvicultural treatment which normally involved further climber cutting.

SARAWAK

There are three main forest types in Sarawak, namely, Mangrove, Swamp and Dipterocarp Hill Forests. Mangrove forests grow in the estuaries of the main rivers, mainly to the south of the Batang Rajang (the biggest river in Sarawak). They contain over 40 tree species and areas of Nipah palms. Historically, these forests provided raw materials for the tannin industry but now production is geared towards firewood, charcoal, poles and wood-chips.

Mixed Swamp forest is dominated by a few main commercial species, namely, Ramin and a Group of Swamp Merantis such as Shorea uliginosa, S. teysmanniana, S.platycarpa and S.scabrida. Ramin has been the main species exported in the processed form. The Swamp Forest sub-type, Alan Forest, is dominated by tall, often hollow trees of Alan (Shorea albida) which can occur in virtually pure stands. Padang Paya and Padang Alan Forest are observed on poorer sites.

The Dipterocarp forests have the greatest potential for development. They show remarkable homogeneity at the timber group level where dipterocarps account for 65-80% of the net industrial stemwood volume. A fourth type - Kerangas Forest is generally non-commercial, containing small trees of poor form and small size. The main species are Casuarina, Agathis alba, Dacrydium, Tristania and infrequently Shorea albida.

The recognised value and growing commercial and industrial significance of timber in Sarawak led in 1920 to the creation of a Forest Department. Before World War II, the timber industry in Sarawak relied mainly on the extensive areas of Lowland peat swamp forests. By about mid-sixties, the effects of depletion of these swamp forests became evident and logging was forced into hill forests. The first hill forest reserve however was not licensed for logging until 1969. Until then the bulk of the production had come off stateland forest areas where logging was basically clear felling for agricultural development purposes.

Lacking the experience in hill forest logging, Sarawak has tended to model its management systems along the lines of those in the lowland dipterocarp forest of Peninsular Malaysia (Lee. 1982). Experience with similar forest in Penisular Malaysia indicates that cut-over forests are mostly dominated by a few relic trees that are of inferior species or seriously defective. Mortality of the exposed relic trees is high and most damaged trees will not recover. Relic trees left in dense clumps grow slowly while seedlings or saplings of desirable species even if they have survived in the openings cannot be expected to reach maturity for 70 to 80 years (F.A.O., 1981 a).

Evaluation of Silvicultural Systems

From 1974 to 1980, three UNDP/FAO projects assisted the Forest Department to establish interim guidelines for silviculture and management in Mixed Dipterocarp Forest (M.D.F.). The primary solution to future timber supplies lies in the immature trees of the cut-over forests. Recent local studies indicate that 1) before logging there are commonly enough immature trees of quaility species for a future crop; 2) an adequate number for a second crop can be spared damage if logging is done with care; and 3) such trees respond sufficiently to liberation to present in 30 years a prospective second cut about equal in volume and similar in quality to the first cut.

In order to obtain necessary information about the forest, a series of permanent sample plot was established in different parts of Sarawak (F.A.O., 1982). Three silvicultural treatment were evaluated, namely, (1) Overstorey Removal, (2) The Malayan Uniform System (MUS); and (3) Liberation Thinning.

The "Overstorey Removal" is a simple type of silvicultural treatment in which the overmature trees not commercially acceptable and left standing at the time of the harvest are removed.

The "Malayan Uniform System (MUS)" in its classic form, aims to produce the next harvest entirely from the seedlings and saplings which survive the effect of the logging. Other surviving trees, if not economical, are regarded as an impediment to the growth of saplings and seedlings, and are therefore removed. The treatment especially if applied to the MDF of Sarawak,may cause a drastic change in the forest environment, which may persist for several years, and during that time the site may become dominated by light-demanding pioneer species, resulting in a considerable change in the species composition.

Realising the potentially destructive effect of the classical Malayan Uniform System on advance growth of desirable species, a Modified Malayan Uniform System has been designed, which seeks to preserve the best of the advance growth of the desirable species. By this modification, a harvest from the advance growth may be obtained even before the maturity of the seedlings, resulting in a polycyclic form of management. The Sarawak Forest Department has applied the Modified Malayan Uniform System for many years, as a routine treatment after logging in the Mixed Swamp Forest.

"Liberation Thinning" is based on the identification of as many as possible desirable species, and the selection and liberation of the best of them from competition, as well as the removal of the overstorey trees. It is hoped that this treatment will permit the best of the desirable trees to grow at their maximum rate, yielding the next harvest in as short a time as possible. It does not seek to eliminate any particular species or species group, and the only trees which are removed, are those which restrain the growth of a selected tree. Trees of undesirable species, which appear not to compete with a reserved tree are therefore left untouched.

To provide the required data, an elaborate set of measurements was taken throughout several hundred hectares of forest. More than 117,000 individual trees were measured and most of them annually for several years. The studies demonstrated that:-

1) the residual stand contains a useful number of trees of desirable species which, with silvicultural treatment, are capable of producing a harvest on a short felling cycle.

2) as long as selective harvests remain of moderate intensity and damage to the residual stand is within acceptable limits, the MDF can be expected to maintain naturally the regeneration of sufficient stems of desirable species to warrant silvicultural treatment and management of the natural forest and that neither enrichment nor replacement planting will be needed.

3) from a simulated time span of about 20 years, most trees except large ones with very poor crowns, can be expected to react positively to release.

Overstorey Removal, by eliminating the large crowns from the upper canopy and improving illumination to the forest as a whole, may not provide sufficient release to all trees of desirable species or form. Furthermore, Overstorey Removal does not necessarily release the best trees. Yields will therefore be less and the felling cycles longer than can be attained if a slightly heavier treatment, favouring individually selected trees, is applied for a moderate increase in investment.

The positive effects of releasing individual trees is evident in Liberation Thinning and more so in the Modified Malayan Uniform System. Both systems provide overhead illumination which results in considerable increased mean diameter growth. Under the Modified Malayan Uniform System, however, a greater number of trees are eliminated, resulting in a stand containing a lower number trees of commercial value. Many of these eliminated trees are of good log grade, which if left standing, could be of good marketable value in future.

Liberation Thinning

Under Liberation Thinning, those trees if not competing with reserved trees, will be left, thus protecting species diversity and giving more freedom of choice to respond to changes in the market in the future. Because only individually selected trees are liberated from competition, Liberation Thinning maintains a high forest canopy. Its ecological effects are thus not as traumatic. Shade remains as a silvicultural tool, by which the species composition of the natural regeneration can be influenced by discouraging the establishment and growth of vines and light-demanding pioneer species. The sequence of operations is as shown in Table 32:-

Table 32
Sequence of Operations in Liberation Thinning

Year	Operation
F 1 + 0	Selective harvesting to a limit of 60 cm dbh.
F 1 + 1	Liberation thinning of residual forest. seclecting final crops trees in the diameter range 10 - 59 cm dbh.
F 1 + 30	Second selective harvest.
F 2 + 1	Liberation thinning of residual forest. (Trees which were seedlings in open spaces created by the first harvest will be liberated at this time).

Liberation Thinning it was therefore concluded would be the most appropriate type of silvicultural treatment for MDF (FAO, 1981b). Under present conditions, although it is premature to appraise the method in all its aspects, Liberation Thinning has demonstrated results which are sufficiently promising to suggest that it be applied as a routine treatment in Sarawak Mixed Dipterocarp Forest.

The sequence of field procedures for Liberation Thinning in Sarawak is described below (Hutchinson, 1979 a):-

a) Overstorey Removal

Poison-girdle all 'listed' trees 60 cms dbhob and larger, except those standing within 30 metres of the edge of a landing or other large area of bare soil. Poison-girdle all other trees 50 cms dbhob and larger, regardless of where they stand.

b) Identification of "Reserved" Trees

In the residual stand, identify all suitable 'listed' trees, in the specified diameter range (usually 10-59 cms dbhob). These will be the "reserved", or "potential final-crop" trees.

"Reserved" trees must not stand closer than two metres from one another. Whenever two possible "reserved" trees are found standing closer than two metres, the inferior tree is to be poison-girdled.

c) Removal of Current Competition

Poison-girdle all trees (except other reserved trees) which are found to overtop a reserved tree.

Poison-girdle all trees (except other reserved trees) which actively compete with a reserved trees.

d) Removal of Future Competition

All trees (except other reserved trees) which are considered likely to offer future competition for any reserved tree are poison-girdled. A Distance Table is used for this, (refer to Table 33). The Distance Table is based upon the relationship between the diameter of a reserved tree, and the diameter of each of the trees standing around it. The Distance rests upon the premise that growth in a uniform stand in which all trees are 11 cm dbh will decrease after the total basal area per hectare exceeds 14 square metres. The limit is assumed to increase linearly to 28 square metres at 61 cms dbh. Unless stands are uniform, the Distance Table leads to basal areas lower than the limit, because trees within the 'distance' from a reserved trees are removed automatically in spite of any compensating gaps which may exist in the canopy. Even though it may be modified in years to come, the Distance Table in its present form anticipates future competition and also serves as a means of making the task of thinning less liable to error and omission by providing supervisors with objective checks upon the treatment of trees around each "reserved" tree.

When considering prescriptions for silvicultural treatment, it is helpful to recognise that, immediately after logging, the forest consists of two major elements which are dissimilar. There are, (a) the residual forest, containing surviving trees, advance growth, and seedlings, and, (b) open spaces created by logging. These will develop to carry regeneration of desirable species beneath a canopy of even-aged, light-demanding pioneer species. Before prescribing silvicultural treatment, it is necessary to consider separately each of these two elements.

Stand table projections for recently-exploited forest, indicate the number of years after logging required to produce a second harvest. Projection of the stand table 10-59 cms dbhob gives the following results:

Silvicultural treatment	Projection period	Mean Total Number of Trees per hectare Produced for the Second Harvest, (Desirable Species, 60+ cms dbhob)
Control. (No Treatment)	55 years	4 trees
Liberation Thinning, 15 + cm dbhob	10 year	10 trees

Guideline enumeration of MDF heavily logged 23 and 27 years previously, indicates that stems of desirable species 10-59 cms dbhob comprise 30 percent of the mean total number of stems per hectare - a higher proportion than in unlogged forest. Deteriorating crown form suggests these stems have endured a period of considerable competition, relieved at this time by the death of some light-demanding pioneer species. That is, liberation thinning at F+30 would occur before natural competition begins to reduce significantly the stocking of desirable species.

The information above suggests that a suitable regime for silvicultural treatment in Sarawak MDF could be as follows:-

1. Liberate selected potential final-crop trees in the residual forest not later than two years after logging, while access for men and supplies remains clear, and while it is possible to see clearly injuries inflicted by logging. Trees "reserved" at this time will form the nucleus of the second harvest to be made 30 years after the first,

2. At F+30, when the forest residual from the first logging is ready to yield the second harvest, the areas which were open spaces created by the first logging, will be stocked with approximately 200 stems per hectare of desirable species in the diameter range 10-59 cms dbhob. The second harvest will leave most of these as residuals. They may then be released by liberation thinning immediately following the second harvest.

Table 33
The Distance Table

(Table of Minimum Distance permitted from a Reserved Tree to any Neighbouring Tree which is NOT Reserved Tree)

(Meters)

Reserved Tree Diameter (9cm)	Neighbouring Tree (Not a Reserved Tree) - Diameter bhob (cms)											
	10-12	13-17	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-59	60+
10-12	2.5	3.0	3.5	4.0	4.0	4.5	5.0	5.5	6.0	6.0	6.5	Poison-girdle all tree 60+ cms dbhob, except Listed Species standing on landings or within 30 metres of the edge of landings.
13-17	3.0	3.5	4.0	4.0	4.5	5.0	5.5	6.0	6.0	6.5	7.0	
18-22	3.5	4.0	4.0	4.5	5.0	5.5	6.0	6.0	6.5	7.0	7.5	
23-27	4.0	4.0	4.5	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	
28-32	4.0	4.5	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	
33-37	4.5	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	
38-42	5.0	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	8.5	
43-47	5.5	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	8.5	9.0	
48-52	6.0	6.0	6.5	7.0	7.5	7.5	8.0	8.5	8.5	9.0	9.5	
53-57	6.0	6.5	7.0	7.5	7.5	8.0	8.5	8.5	9.0	9.5	9.5	
58-59	6.5	7.0	7.5	7.5	8.0	8.5	8.5	9.0	9.5	9.5	10.0	

Poison-girdle all trees 50+ cms dbhob NOT "Listed"

Notes: a) In the forest, distance obtained from this table should be measured in the horizontal plane.

b) Do not apply this table to trees smaller than 10 cms diameter dbhob.

c) Do not apply this table to other reserved trees.

Source: Hutchinson, 1979 b.

Shifting Cultivation and the Co-operative Forestry Concept

The extent of agricultural encroachment into the hill forest land of Sarawak is formidable and it is a most important topic which can overwhelm plans for future yields of the hill forest. It has been reported that some 42,000 families are practising shifting cultivation. This leads to a rough assessment that each year the area of new forest used for shifting cultivation amounts to 34,000 hectares.

A Workshop on Shifting Cultivation held in December 1978 with the cooperation of six government departments and the State Planning Unit, examined the dimension and gravity of the problem. It recommended an interdepartmental programme of immediate action covering a comprehensive set of directives aimed at offering the farmers opportunities of shifting towards stabilized agriculture for a better future. The contribution of forestry can be manifold in the areas of agro-forestry and cooperative forestry.

Efforts of the research programme may give major attention to some qualities of trees which can directly benefit the farmer. Three important aspects can be cited in which the Forest Department has already scheduled research efforts, and which deserve expansion:

a) The soil improvement aspect.
The soil improvement qualities of certain tree species of the Leguminosae are known. The Ipil-ipil (Leucaena leucocephala) is an example. If successful this could serve in the reforestation programme of areas where shifting cultivation exhausted the soil. If the soil fertility can be regenerated the production of wood may be an additional benefit.

b) The production of alternative products.
The production of stems and leaves for fodder, or fruits and nuts for food or folder may be a valuable complement for the farmer especially if the tree, as with the Leguminosae, were a soil improver, be it with the leaves as compost or with the root-nodules as a nitrogen-fixer.

c) The soil stabilisation properties.
Trees as a means of action against soil erosion, or for areas with steep slopes, for fixing the soil and terraces cannot be overlooked.

The major objective of these efforts would be to assist the farmer rather than ultimately to produce wood.

For generations these farmers have lived from the forests. Now a series of industrial complexes are scheduled to be built and will generate sizeable benefits. It is natural that these farmers should expect to participate in some of these benefits. Under the cooperative forestry concept, several aspects can be considered from the institutional, the commercial and other points of view. These could include:-

a) Shareholding

The chiefs, or some of them, representing the people, could be made cooperative or pseudo-active, business partners with a participation in the revenue related to total roundwood production, or similar systems.

b) Employment

They could be offered, in preferential entry to the labour force of the industrial complexes, or be in a certain labour input relationship with the company that would provide some returns. This would help alleviate their struggle for physical survival.

c) Assistance

For some of the concessions particularly threatened by the shifting cultivators, agreements, might be sought so as to allocate in cooperation with the authorities of the respective government departments some (cut-over) lands in the vicinity of the concession areas. There, the concessionaires would assist them in their efforts to shift over to a settled food and cash crop oriented agriculture.

The assistance of the companies could range from physical assistance such as terracing, housing construction, to financial support in offering fertilizer, improved tools and seeds. The state would contribute with agricultural extension, schools, dispensaries, subsidies etc.

RESEARCH AND DEVELOPMENT

Malaysia is faced not only with a new dimension in developing silvicultural and management techniques fully adapted to environmental conditions, but also the dilemma of ensuring that these techniques guarantee a sustained and uninterrupted flow of timber for the highly capitalised, sophisticated multiple-product industries. Any optimism about the potential of the hill forests was based on the premise that a wider range of species and tree sizes would be commercially harvested and that a system to ensure an adequate proportion of the good quality growing stock would be retained for latter cutting. The forestry sector in Malaysia is thus beset with many problems. However, these problems can be traced back to three root problems which can be identified as follow:-

i) Rapid rate of resource depletion
ii) High rate of resource wastage
iii) Slow rate of resource replacement.

Steps have been taken to reduce the socio-economic impacts of the impending shortage of high quality timber, with the following measures:-

i) Establishment of Permanent Forest Estate
ii) Reduction of the present rate of logging
iii) Establishment of forest plantations with quick-growing species to augment the timber supply during the deficit years
iv) Intensification of research activities on forest management and development.

Under the present situation, research activities in Malaysia have to be geared towards developing and formulating necessary research strategies and identifying priority projects in accordance with current problems affecting the forests. The Forest Research Institute, Kepong has identified three main areas of research, namely, to undertake and support an intensive research programme in forest development aimed at achieving maximum yield; maximum direct and indirect benefits from harvesting and utilisation and, above all, maximum financial return on investment in forest development activities.

Some of the major research projects which has been identified in relation to its current problems, research activities undertaken and achievements or benefits anticipated are outlined below (FRI, 1984)-

a) Natural Forest Management

Current Problems

i) Inadequate stocking and distribution of natural regeneration and residual stand of the main economic species particularly in the hill forests.

ii) Inadequate knowledge of the response after logging of residual trees to damage as well as to post-logging stand conditions.

iii) Changing "marketability" status of timber tree species with time, causing problems on choice of species to be treated.

iv) Increasing expectation levels of the yield of future forests with increased cultural inputs.

v) Inaccessibility of hill forest for treatment and management purposes after logging due to the inherent hilly and rugged terrain.

vi) Inadequate knowledge of the silvics of commercial species and high cost of artificially regenerating logged over forest.

Research Activities

i) Studies on variation of cutting limits in relation to original and residual stand composition and structure, especially in the implementation of the Selective Management System.

ii) Studies on logging wastage and damage to residual stand.

iii) Determination of growth and yield of residual stands especially after treatment (including logging).

iv) Determination of relevant post-felling silvicultural treatments.

v) Development of natural regeneration e.g. recruitment, survival, development etc., following logging.

vi) Development of techniques of artificial regeneration of poor areas e.g.planting, spacing, planting techniques, selection of species, treatments, etc.

vii) Time and cost-studies of various management and silvicultural operations.

Benefits Anticipated

The ecology and dynamics of the Hill Forest are much more complex than those of the Lowland Forests and much less understood, although Hill Forest research started as far back as 1947. More studies it is hoped will lead to a better understanding of the processes involved. Studies of the response of regeneration and residual stands to logging damage and post-felling conditions, should then enable the most cost effective systems to be developed for establishing the future forests and increasing their productivity.

b) Wood-Waste Utilisation

Current Problems

i) Wood residues generated from logging activities and primary wood processing industries are estimated to be 6.1 and 3.1 million m3 per annum respectively. Milling residues which includes sawdust, offcuts, edgings, slabs and trimming, etc. have no economical outlet except as boiler fuel. Wastes from agricultural/resettlement schemes are also considerable in amount.

ii) The depletion of good quality timber in large and long sizes necessitates the search for innovative ways of producing useful products from short lengths.

iii) The crux of the problem is to convert these currently wasted residues into saleable and value-added products economically.

Research Activities

i) To determine the physical, chemical and fibre morphological properties of available materials.

ii) To assess the suitability of available materials for the manufacture of pulp and paper, and wood-based panel products.

iii) To convert woodwaste into gaseous, liquid and solid fuels economically and to design efficient stoves.

iv) To design and fabricate mobile sawmills for the efficient conversion of small diameter logs into timber.

v) To develop techniques for utilising timbers of short length in long span and large members through glue lamination processes.

Benfit Anticipated

i) Development of appropriate technologies for conversion of these available cellulosic materials into various useful and marketable products, would maximise the economic and social return from the natural resources. At the same time it would facilitate the establishment of a wider range of forest products industries.

Rattan Research

Current Problems

i) Shortage in the supply of commercial rattans to supply the industry with the raw material.

ii) Lack of plantations of commercial rattans to supplement the supply.

iii) No standard processing and preservation techniques for rattan sticks and no standardised grading rules the processed rattans.

Research Activities

i) Tissue culture for producing large-scale superior seedlings.

ii) Establishment of seed orchards and trial plots.

iii) Collection and storage of seeds.

iv) Nursery techniques to raise seedlings.

v) Silvicultural treatments in plantations for faster growth.

vi) Standardisation of processing techniques and development of preservation techniques against insect and fungi.

vii) Development of standard grading rules for classifying processed canes.

viii) Charaterization of properties of lesser-known rattan species so that they could also be utilized.

Achievements and Benefits Anticipated

i) Development of technical capability in establishing largescale plantations and their proper management.

ii) Development of uniform method for processing and protecting canes.

iii) Establishment of a grading system for processed canes.

iv) Preparation of manual on silviculture and processing of rattans.

v) Promotion of rattan planting by small-holders.

d) Watershed Management

Current Problems

i) Forested watersheds play a vital role in perpetuating consistent water resources of good quality for domestic, agricultural, industrial and recreational uses. Most of these watersheds are situated in uphill areas (slopes > 30%). Presently mechanical logging operations are encroaching into these sensitive areas. The activities can lead to increased surface runoff resulting in accelerated soil erosion and sediment transport. The end-result is lower water quality and reduced stream capacities with increased tendency to flooding. Increased surface runoff also results in lower river yields because these are derived mainly from subsurface systems.

ii) The present dearth of quantitative information on hydrologic behaviour of disturbed forested catchments, inhibits the development of guidelines to minimise the consequences of timber harvesting.

Research Activities

i) In 1978 two experimental basin studies were initiated by the Forest Research Institute with New Zealand assistance under the New Zealand Bilateral Aid Programme. Sites of study are Jengka in Tekam, F.R., Pahang and Berembun F.R., Negeri Sembilan. The studies yield climatological and hydrological data in forested catchments before and after logging operations. Based on these, guidelines will be developed for reducing disturbance during logging operations.

ii) At both sites, stream weirs and equipment for measuring numerous hydrological and climatological parameters have been installed.

iii) Based on research data so far, preliminary guidelines to logging in hill forests have been prepared.

Achievements and Benefits Anticipated

As a result of information and experience gained from this study, better logging practices and preventive measures in logging road construction can be implemented. They in turn will lead to reduced soil erosion and surface runoff, reduced deterioration of water quality, reduced adverse effects on water yield and control over flooding or drying up of rivers.

e) Forest and Tree Crop Plantation

Although plantation activities are not strictly speaking a component of natural management systems for tropical mixed forests, they are in Malaysia closely integrated with or related to the implementation of those systems. The compensatory forest plantation programme is aimed at filling the gap in supplies of industrial wood expected in Peninsular Malaysia within the next decade or so. Agro-forestry programmes in conjunction with compensatory plantations are moving from experimental to operational stages with some crop-forest combinations e.g. cocoa and Pinus, Araucaia, and Gmelina. A considerable research programme covering species trials, agro-forestry combinations and practices, and silvicultural regimes, is therefore included in the national research effort.

With approximately 9.7 million m3 of rubberwood potentially available each year, the contribution to the wood supply from this resource is something that must be integrated with national and state planning and forest management. Oil palm stems could also become a significant resource in the national context. Research to widen the range of possibilities for rubberwood and to facilitate oil palm stem utilisation is therfore an important component of the forest products research programme.

FUTURE PROSPECTS

Tropical forest ecosystems are both complex and fragile, with the various processes within the climate-soil-vegetation complex held in a delicate dynamic balance. It is on this delicate balance that the productivity of tropical forests depends. Tropical forests will recover when subjected to disturbances within their limits of tolerance; disturbances beyond such limits can disrupt long-term productivity and related benefits.

Tropical rain forest management seems to be entering a new phase with the trend along the conservation line in which methods are being developed to reduce injurious effects on the natural ecosystems aimed at achieving a more judicious use of the forests as well as increasing productivity. In principle, the prospects in tropical rain forest management should be good in view of the favourable physical environment for the crops. Those prospects can be enhanced by positive and innovative policies and strategies and integrated programmes for land use. Plantation forestry has gained recognition but that does not mean substituting plantations for existing natural forests. In the Malaysian context, at least, they are not really competitive but complementary. Plantations may serve to produce long fibred pulpwood or general utility timbers products while natural forests produce high quality veneer and sawlogs.

The future trend in forest management in Malaysia is therefore the emphasis on forest conservation and the conservative approach towards forest harvesting. Various strategies are designed to have the following effects:-

1) conserve the dwindling forest resources
2) ensure sustention of the resource base
3) minimize re-investment
4) preserve environmental quality
5) reduce excessive damage
6) reduce excessive wastage
7) induce optimal utilisation.

The future prospect and development for forest managemnet in Malaysia can be considered in 3 phases, (Mok, 1977);-

Phase I: Conservation, Research and Development, with emphasis on (i) very conservative harvesting of the potential Permanent Forest Estate through the selective management system and strict yield regulation, and (ii) forest management and operations research studies to obtain data for the development and formulation of optimal forest management regimes and guidelines for their implementation.

Phase II: Training, Extension and Planning, with emphasis on (i) retraining of staff and the dissemination of information and guidelines for the formulation of sound forest management practices and (ii) preparation and implementation of forest management plans consistent with the concepts of sustained yield and the generation of maximum social and economic benefits.

Phase III: Consolidation, Refinement and Sophistication, with emphasis on (i) defining clear-cut objectives for the Permanent Forest Estate based on the concept of optimal use, (ii) improving the efficiency and effectiveness of forest management through the introduction of industrial and business techniques, and (iii) increasing the productivity and productive capacity of the Permanent Forest Estate through purposive, positive and dynamic investment programmes.

The present forest management systems as practiced in Peninsular Malaysia, Sabah and Sarawak are not without problems and unanswered questions. Growth and mortality data, realistic estimates of timber extraction cost and silvicultural costs are needed on regional basis. New techniques of managing the forest resource under these systems should be studied. To those ends the following fields need further investigation and continuing refinement:-

1) the economics of logging under the various systems.

2) the economic and marketing strategies for under utilised or lesser known species,

3) determination of regional minimum stocking standards,

4) continuing evaluation of studies concerned with growth, defect, wastage and logging damage,

5) compilation of regional volume tables,

6) the application of photogrammetric techniques,

7) development of complementary silvicultural systems before and after logging and an appraisal system or diagnostic technique to guide when and where, silvicultural treatment should be applied and how to evaluate the results of the treatment,

8) standardisation of data collection and processing of all forest for compilation purposes.

Jabil (1983), proposed relevant measures that would need to be taken in the future development of forest managment in South East Asia and the Pacific to ensure successful implementation of forest management and development activities in achieving sustained yield. They include:-

a) a rational and far-sighted socio-economic development policy and strategy;

b) a sound, clearly defined and integrated land-use policy and master plan;
c) a pragmatic and dynamic forestry policy and strategy;
d) an adequate and effective forest estate;
e) a strong and positive forestry legislation;
f) a comprehensive perspective forestry plan;
g) an efficient and dedicated forestry organisation;
h) an objective forestry research and development programme;
i) a systematic forestry manpower development programme; and
j) a continuing forestry education and extension programme.

CONCLUSION

In spite of considerable experience gained in the management of tropical forest through the years, serious gaps in information on the resources and their characteristics, particularly of hill forest and lesser-known species, are obvious. Information is also lacking in the use of approriate technology, particularly in respect of cost-effectiveness and the impact on the forest environmnent.

It is envisaged that in the near future there will be a change in the basis of the regeneration and management systems used from being primarily biologically justified to being also financially justified. Research and development activities must clearly be stepped up to provide the information needed for this change.

Natural regeneration has always been the basis for the sustained yield management of tropical high forests in the region. The silvicultural systems which have been developed for these forests have relied upon either advanced growth or seedling regeneration. It is essential that the validity of the assumptions underlying these systems are continually reviewed in relation to the condition of the forests which are currently being managed. Should the basic assumptions be found to be no longer applicable, alternative silvicultural systems will have to be considered. It has been noted that retention of advance growth has become the basis of regeneration in forest management in Malaysia. However, the following conditions must be fulfilled (Tang, 1980):-

a) the residual stand after logging must contain an adequate stocking of undamaged advanced growth of good form and vigour of the 'regeneration' species.

b) the undamaged advance growth must be able to respond vigorously to the 'release 'provided by the logging operations.

The selection of regeneration systems cannot be based on biological or silvicultural considerations only. It must be made in relation to the respective national land-use and timber production strategies. A large part of the remaining "productive" forest resources of the region will lie on steep or generally inaccessible land. The more accessible and suitable parts of this area should be identified for intensive natural forest management practices, aimed at producing maximum yields of timber of high quality and value on a sustained yield basis. It is envisaged that artificial regeneration will play a prominent role in such forest. The remaining forest should be managed under an essentially extensive management system, although varying degrees of management intensity may still be used. It is envisaged that natural regeneration will play the dominant role here.

The feasibility of managing tropical high forests on a sustained yield basis has become increasingly questioned in recent years. Many tropical countries have turned away from natural forests management to plantation forests management and tropical forestry itself is increasingly become a matter of establishing and managing plantations in the tropics rather than of managing tropical forests as natural forests (Leslie 1977). The main cause of this trend is economic. However, the establishment of the Compensatory Plantations in Malaysia is not to convert a greater part of our natural forests to open plantation of fast-growing species. Compensatory forest plantations are aimed to overcome the anitcipated domestic timber shortages. The natural forests have very important traditional, social, conservational, and scientific roles to play which cannot be provided adequately be plantation forests.

Finally, in the opinion of Leslie (1979), the more the professional foresters know about the technical requirements for sustained yield the better their chances of successsfully implementing such policies. Unfortunately, "standing of that level is hard to come by in tropical forestry; our knowledge of the stand dynamics of tropical forests, even after a century or more of so called management is still too rudimentary, too inconclusive and too ambiguous for it to be otherwise".

CHAPTER V

THE MANAGEMENT OF MIXED TROPICAL HARDWOOD FOREST IN THE PHILIPPINES

AN HISTORICAL OVERVIEW

The management of the Philippine forests is believed to date back to earlier than the 15th century. At the time the archipelago was not yet a country in the sense of a unified government but a series of territories occupied by different tribes. It is believed that individual governments of these tribes, which usually consisted of a duly recognized "datu" or chieftain advised by a council of elders, set norms for the extraction of forest products and the use of the forest within the tribe's sphere of ownership. The tribe's forests were communally owned, and the chieftain prescribed what to do and what not to do regarding these forests. In general the forests were associated with the tribal gods, and activities relating to the forests were such that the gods of or in the forests were not to be angered, if only to assure bountiful agricultural harvests, abundant wild game for food and a beneficial relationship with the forces of nature.

Spanish Colonial Era

The colonizing influence of the Spaniards eventually changed the state of the tribal man-forest relationship. Over about 400 years the Philippine forests were transferred into a source of vital trade commodities to support the undertakings of the government in Spain and the Spanish civil government in the Philippines. Timber, resins, wildlife, etc. were freely shipped to Spain and Mexico through the galleon trade route.

During the four-century period of Spanish colonization, forest products were likewise traded by the tribes to occasional Chinese, Japanese and Dutch traders.

The first official act to administer the forests by the Spanish colonial government was made only in 1863 with the creation of the "Inspection General de Montes", an administrative body which was intended to intervene in all matters pertaining to cutting and extracting of timber, resins, etc.; to open up virgin lands; to give concessions over mountain lands, and transact business related to lands and forests. As part of its functions the office was required to gather data on the forests of the state and those owned by corporation, town, churches and universities. Eventually, this office expanded its activities to the conduct of reconnaissance of the country's forest lands, the determination of the suitablity of native timber species for civil and naval works, the prevention of trespass and encroachment into the forests, and the prevention of illegal timber cutting. Rules and regulations on cutting of trees and the classification, delimitation and demarcation of forest lands were promulgated. While all timber cutting was supposed to be for puposes of the colonial government, the free use of timber by the people was allowed under gratuitous licences. Kaingin-making (the primitive agriculture system of slash-and-burn) in forest lands was officially prohibited, and the cutting of trees for commercial purposes in the island provinces of Cebu and Bohol was considered a crime, in reaction, presumably, to the denudation of the forests in these major maritime outposts. (Today these islands no longer have significant tracts of natural forests).

American Regime

The science of forestry as known in the Philippines traces its roots mainly to the influence of American forestry. Forest land administration, timber managment systems, management concepts, and procedures, are all influenced by the American system.

One of the first major acts of the United States Military Government in the Philippines, when the US took over from Spain, was the organization of a Forestry Bureau in 1900 ostensibly to harness the forest resources for military logistics. This bureau was later renamed Bureau of Forestry. The passage of the Forest Act in 1904 signalled the development of forestry as a science in the Philippnes. This Act enacted, among others, a forest policy which was to form the basis of forest resource management in the Philippines.

The period from 1900 to 1942 saw the institutionalization of forestry practices that were to determine the present state of Philippine forestry. Extensive forest mapping and delineation were undertaken; the Philippine flora and fauna were identified and catalogued, which classifications are still the basis of floral and faunal characterization in the country. It was during this period when mechanized timber extraction and processing was introduced: the steam-driven "donkey" engines, rail-and truck-transport systems, and sawmills became part of the forest management environment. These were all patterned after North America forestry practice. The first entrepreneurs in timber operations were mostly Americans with a few carried over from the Spanish era. To this day Philippine logging and wood processing terminologies, procedures and standards still retain the strong influences of the period.

The Bureau of Forestry was extensively involved in the classification of the public domain, the grant and regulation of operations of forestry licenses, measurement of forest products, the development of a national system of forest management, forest protection, and the conservation of wildlife and some hardwood species, and the initiation of forest parks management. Jurisdiction and management of pasture and grazing lands were later placed under the Bureau.

Forestry practice was expanded to include education and training of technically-capable Filipinos to handle the growing activities of the forest service. In 1910, a school of forestry under the Bureau of Forestry was established. This later became the Forestry School under the University of the Philippines in 1916 which was to become the forerunner of various forestry colleges and schools throughout the country.

Japanese War Occupation

During the war years of 1942 to 1945 all forestry activities were placed under the Japanese military government. The Bureau of Forestry was changed to the Bureau of Forestry and Fisheries under the Ministry of Agriculture and Commerce. Forest districts and stations within or near the territories controlled by the occupation forces were allowed to continue operating, although in general the forestry administrative organisation was non-existent because of the absence of a nationally accepted civil government.

In this period, forest based industries virtually came to a standstill except for a few logging and processing operations undertaken or supervised by the occupying military forces. In the confusion and destruction during these war years invaluable documents, records, research and specimens relating to the Philippine forest resources were lost or destroyed.

Two enactments related to forestry were promulgated by the Japanese military government during this period. In 1943, an Act prohibited the cutting of trees within public or private lands where a spring existed which could be used for irrigation or water supply purposes. In 1944, an Act was enacted limiting the maximum areas to be devoted to pasture and reforestation or tree plantations to 2,000 hectares. The areas to be devoted to fishponds, salt works, nipa, palm and other swamp species, as well as for rights-of-ways, was limited to 200 hectares.

1945 - 1953

The postwar years created conditions which were to have long-lasting effects on the Philippine forest management scene. Immediately after resuming its functions as a civil government, the Philippine Commonwealth, even then under the umbrella of the US government, declared that all forestry activities, terms, conditions or stipulations involving public lands, forest and mineral concessions existing in 1942 were recognized and would continue as such. The Bureau of Forestry was reconstituted and expanded by creating more divisions and field offices. In 1953, the Parks and Wildlife Commission was created, and all functions pertaining to Parks and Wildlife Management previously under the Bureau of Forestry were transferred to this Commission.

A significant development during this period was the emergence of the forest-based industries. The war had caused great damage to the country's economy; the industries were at a standstill. The reconstruction boom urgently needed capital and raw materials. It was this need that caused the opening up of extensive forest lands to logging and thus the emergence of the forest industries as a major contributor to the economy. Cut and yield regulations were minimal, if ever imposed. The export of logs was unrestricted, and anybody who had the capability to go into the forests and bring out logs could get concessions for the asking. The only forest management control imposed at the time was the "diameter limit" on trees to be cut; a diameter of 50cms. was set as the minimum cutting diameter. At the time, however, the natural forest growth was dominated by the trees way beyond this minimum limit.

This generated a substantial portion of the capital needs of the other sectors of the economy. Ironically, it was this liberalism during the reconstruction years that was to be felt by forest managers twenty years after.

1953 - 1972

In the 1950's the selective logging system was developed in the Philippines. This is a modification of the selection cutting adopted by some European and North American countries. The system was the culmination of research conducted in the southern island province of Basilan. From field observations of post-logging spatial and size distributions and the analysis of periodic annual growth increment measurements, it was possible to obtain estimates of size and volume distribution in the future, i.e., at the end of the first cutting cycle.

In the desire to reconcile the volume and size distribution of the unmanaged natural forest and the managed forest at the beginning and end of the first cutting cycle, respectively, rules, regulations and procedures were prescribed. This set of rules, regulations, and procedures became what is now known as the Philippine Selective Logging System (see Silvicultural System for a description of the system.)

In essence the system prescribes details for pre-logging inventory, road location guidelines, felling, yarding and skidding procedures, post-logging inventory, and silvicultural treatment of the residual or logged-over areas.

Cognizant of the need to have more detailed information on the forest resources particularly the country's timber resources, the first comprehensive forest resources inventory was conducted in 1961 to 1967. This inventory consisted of photopoint sampling on aerial photographs coupled with ground plot sampling. (See National Forest Resources Inventory). This national inventory provided much-needed data on the actual extent and location of the forest resources of the country. Area estimates of various vegetative cover types were derived and volume estimates of the old growth forests in various geographical regions were made.

Efforts were directed to the determination of prediction equations and tables for volume estimation of standing trees. A set of such prediction equations and tables was derived for each of the major geographical zones.

In 1967 a Presidential Directive required the consolidation of small logging concessions into working units of at least 20,000 hectares in size. Contiguous but independent small concessions were merged into working units, and the nature of management of these areas changed from predominantly singly-owned operations to corporate management. This action gave impetus to the efforts of government to rationalize the management of the timber resources, and paved the way to greater government control of logging operations. A more significant effect of this consolidation move was the elimination of the small "cut-fast-and-get-out" logging operators, and the replacement of these with corporate or semi-corporate organizations which had the capability for long-term planning and the capital requirements for long-range management of the timber lands under license to them.

1973 - 1984

The period of the 1970's and 1980's was characterized by a noticeable shift in the direction of natural resources policy. In the forestry sector such policy redirection was very apparent. Where the previous decades were characterized by the general attitude that the forest resources were inexhaustible and could naturally replenish whatever volume was extracted, it was now realized that the rate at which the timber resources were being extracted at that time could in fact lead to a total loss of such resources before the end of the 20th century. In the 1970's pressure for a re-study of natural resource management perspectives built up. This re-evaluation was prompted by many factors: growing concern for the environment, the friction in the international energy scene, and worldwide recession. In the Philippines there grew the impression that past beneficiaries of the forest resources were only a privileged minority, contrary to the constitutional pronouncement that these resources are owned by the State and that these would be enjoyed by all the people and by future generations. Four policies on the forest resources were enunciated:

a) The multiple uses of forest lands shall be oriented to the development and progress requirements of the country, the advancement of science and technology and the public welfare;

b) Forest land classification and survey shall be systematized and hastened;

c) The establishment of wood processing plants shall be encouraged and rationalized; and

d) The protection, development and rehabilitation of forest lands shall be emphasized so as to ensure their continuity in productive condition.

Forest management emphasis was shifted from timber harvesting and utilization to the protection, development and rehabilitation of the forest lands. While timber management remained the major field of concern, the management of the soil and water resources, range resources, wildlife, and recreation resources were given greater attention.

Within the framework of multiple-use forest management, the mixed hardwood forests of the Philippines were managed intensively. The selective logging system remained as the silvicultural system for these forests, but modifications in the field procedures and harvesting requirements were introduced to satisfy the multiple-use requirements.

During this period four factors affected timber resources management in the Philippines. These were:

a) The imposition of severe restrictions on the export of raw logs, which was intended to encourage the development of the domestic wood processing industry;

b) The withdrawal of large tracts of forest lands from commmercial exploitation and placing these lands under reserve category, either as buffer stocks for future timber production requirements, or as watersheds to support various hydro-power facilities and irrigation infrastructures;

c) The acceleration of the development of industrial tree plantations, agro-forest plantations and tree farms, which are intended to produce timber to augment the expected shortfalls in production from natural hardwood forests; and

d) Imposition of strict performance standards for timber licensees; the periodic assessment of forest development performance of these licensees by the government, and the imposition of appropriate penalties and administrative sanctions - ranging from fines to suspension of operations or cancellation of license - for unsatisfactory performance. The concern of timber resources management was broadened from purely silvicultural and economic considerations to the broader concerns of environmental stabilization, future resources requirements, socio-economic welfare and national development. This is the framework within which the mixed tropical hardwood forests of the Philippines are now being managed.

THE PHILIPPINE SELECTIVE LOGGING MANAGEMENT SYSTEM

Development of the System

Logging in the Philippines at the very start was done in the most primitive way. Felling, bucking and squaring of logs were done by axe and hauling was done by manpower and carabao. The logs were usually squared in the forest and hauled to the nearest river or beach for transportation to market. This system was inefficient and only the smaller diameter of high quality trees were taken as these are light enough to be pulled by one or two carabaos. Thus, big, mature and overmature trees were left in the forest, eventually to die and rot.

During the Spanish colonization era a few sawmills were established in Manila and neighboring provinces, but these were unable to compete with lumber handsawn by the Chinese. The Americans, who came with logging and sawmilling expertise, immediately discerned that the timber stand presented a lucrative opportunity for the development of a lumber industry. However, the antiquated method of logging could not adequately supply the mills established by the Americans; eventually machinery and steam donkey logging were introduced.

As the system of logging developed, the sawmills were also improved. New band mills were built; several mills with improved operational designs and equipment powered by electricity were established. Only a few were left using the steam engine, while the bulk of the smaller mills were powered by diesel engine.

The employment of mechanical logging, skidding and highlead yarding and combinations of the over head (skyline) system with powerful logging engines posed a great threat to the natural forests. With powerful machines and careless loggers, logging became more of a clear-cutting system despite the imposition of a diameter limit.

The diameter limit, paired with a rough estimate of the yearly cut, was then used as a measure of token control over forest operations. The system, however, proved to be ineffective, hence the development of the selective logging system with the promulgation of Forestry Administrative Order No. 23 in 1954. The system basically required that 60% of the total number of healthy commercial residuals in the 20-70 centimeter diameter classes in a given set-up be retained as growing stock for future harvest. This residual stand requirement was later increased to 70% of the total number of commercial residuals in the 20-60 cm. diameter classes under Forestry Administative Order £74, Series of 1974. This is the stand requirement being used at present in determining the authorized cut.

Description of the Selective Logging System

Selective logging is the removal of mature, over-mature and defective trees in such a manner as to leave uninjured an adequate number and volume of healthy residual trees of the commercial species and other tree species to assure the future crop of timber, and to maintain adequate forest cover for the protection and conservation of soil and water.

The objective of selective logging is, in a strict sense, the conservation of the forest by cutting only enough trees and leaving an adequate growing stock of different size classes which will progressively grow into harvestable sizes at predetermined periods with yield approximately equal to the volume of the cumulative growth increment within a cutting cycle.

Selective logging as it is now being implemented involves three principal phases, i.e.: tree marking, residual inventory and timber stand improvement.

Tree marking is a means to ensure that the number of trees for future crops and seed trees shall be left and protected from logging damages. Logging operations are guided by marking trees that shall be cut and those that shall be left, and protected from logging damages, and directional felling marks are made so that felling of trees is done in such a manner as to cause the least injury to residual commercial trees. The objective of marking trees are: to acquaint loggers and licensees on the kind, condition and quality of trees needed for residual growing stock; to facilitate forecasting of future crop yields based on recorded marked trees; and, to have a basis for the imposition of regulatory fines and penalties on damage to the residual stand.

Residual inventory involves the physical examination and count of marked residuals left in a set-up after logging. It is in this phase of selective logging that the activities of the timber licensees are evaluated as to whether or not they have exercised care in avoiding damage to marked trees and to determine the condition, size, and number of healthy residials based on criteria set for the purpose. The healthy residuals will be the basis in predicting the volume to be harvested in the next cutting cycle (yield projection).

Timber stand improvement is the post-logging phase of the system. It seeks to improve the growth, quality and composition of the growing residual stock. It consists of those treatments applied before and after the major harvest and intermediate thinnings for the purpose of attaining maximum timber quality and quantity, composition, growth rate and condition. It has two main phases, namely refining and liberation. The former implies cutting of climbers and girdling of over mature non-commercial trees and other badly shaped or defective trees. Removal cutting is concentrated on the inferior elements of the stand. Liberation, on the other hand, involves eliminating competition from inferior trees which impede crown development of the potential crop trees.

The cutting intensity in selective logging is prescribed by an annual allowable cut formula. The annual allowable cut is determined to meet the sustained level of production. The formula (prescribed in FAO No. 74, Series of 1974) is as follows:

For areas with approved Timber Management Plan:

$$AAC = \frac{VoA + VrA}{2\ cc} f$$

For areas without approved Timber Management Plan:

$$AAC = \frac{VoAo}{2cc} f \quad 75\%$$

Where:

AAC = Annual Allowable cut

A = Total Operable Area

Vo = Allowed harvestable volume within the virgin forest, equivalent to 25% of the 60 cm. DBH, 55% of 70 n cm. DBH and 100% of 80% cm and larger DBH classes.

Vr= Harvestable volume from the residual forest, determined by yield prediction.

cc = Cutting cycle, i.e., 30, 35, 40, 45 years depending on the climatic regional location.

f = Recovery factor based on timber utilization efficiency of the particular licensee.

75% = Reduction factor to give allowance for mortality of residual trees due to breakages during logging.

Logging Systems Employed

The logging systems commonly used in the country are:

Truck Logging - Also known as the "Bataan System", involves the use of converted trucks equipped with a winch to pull out the logs, bring it to the landing point, land the log in the truck and transport it to the processing plant. The main block of the cable is fastened to a spar tree about 3 - 5 metres high depending on the yarding distance, usually not exceeding 100 metres because of the limited power of the truck. For the same reason the logs are usually bucked to 10 metres (2 log lengths). On reaching the loading point the logs are loaded by skilful manoeuvering of the truck and manipulation of the block and choker.

In view of the limited yarding distance, the system requires a dense network of roads, which if not properly constructed results in severe erosion. This necessity constitutes the main handicap of this system. Also, logs with diameter exceeding 120 cm. are usually left due to the limited winch power of the trucks. Damage to the residuals is however slight and hardly noticeable after a year. This system is mainly practiced by small concessionaires who are not in a position to invest in powerful logging equipment.

Tractor Logging - a system characterized by a mobile unit on traction chains or tyres equipped with winches with our without log arches, to bring the logs from the stump to the landing area. To avoid excessive damage to residuals and regeneration, tractor routes are laid out beforehand. The loading area in a tractor logging set-up is usually located downhill of the tractor routes, otherwise the tractor will be forced to follow a zigzag course uphill in bringing logs to the landing point, thereby requiring more power and increasing the damage to residuals.

If care is exercised, the use of tractor logging may cause low residual damage and a relatively small area of destruction.

High-lead Yarding - a cable system of logging which makes use of a stationary "donkey" engine yarder, which brings the logs from the stump to the log landing with cables combined with an assortment of blocks, a butt chain assembly, chokers and other accessories.

The yarding unit is usually stationed at the spar tree which may be a large straight boled tree, whose crown has been removed by high-climber before rigging to avoid branches falling on the equipment.

The yarding distance is usually limited to 250 - 300 metres to avoid excessive logging damage, thus the maximum area of 20 hectares for a high lead set-up. The larger the set-up, the larger the area of the log landing where vegetation is always totally destroyed. Also, in a large set-up, there is usually heavy damage along the cableways near the log landing. In practice, the log landing size is restricted to be no larger than a circle of 40 m. radius which in a 20 ha. set-up means 2.5% of the area. The cableways should take up no more than 4-5% of the area of the set-up.

In rough terrain where set-ups are not situated on a logging road, interior set-ups are connected by a skyline switch to the landing at the road side. In some cases, when the topography permits, high-lead logging combined with tractor skidding is practised. Gently sloping areas are logged by tractor while steeper ones are logged by high-lead.

Evaluation of the Selective Logging System

Selective logging if properly implemented is still regarded as the best silvicultural system applicable to the Philippine dipterocarp forest. Studies show that for the period 1974-1983, forest destruction occurred over an average of 21% of the area logged per year, leaving an adequately stocked logged over area of 79% (Table 1). These adequately stocked residual forests, if given the needed protection and appropriate post-logging silvicultural treatment would make possible another economic cut after a cutting cycle of 30, 35, 40 or 45 years.

The damage to residuals is related to the logging method employed. A study conducted by the RP-German Rain Forest Development Project in Mindanao showed that damage to residuals in high-lead yarding is higher than that where tractor skidding was used with 54.5% of the residuals of all species being saved whereas only 43.3% was saved with the use of high lead yarding (Table 2). Efforts to save dipterocarp residuals also proved to be more successful in the case of tractor-logging rather than in high lead yarding.

Table 34

Sustained Yield Management and Residual Forest Activity Data

Year	Area Logged (HA.)	Destruction (%)	Adequately Stocked Residual Forests (HA.)	Silviculturally Treated (HA.)
FY 1974-75	62,660	28	45,100	14,000
CY 1976	73,840	28	53,165	16,000
77	67,260	25	50,445	33,000
78	64,090	24	48,700	47,000
79	57,275	20	45,820	44,000
80	66,932	19	54,215	53,000
81	58,416	19	47,310	49,200
82	52,596	18	43,130	56,300
83	51,993	16	43,670	33,900

Source: Bureau of Forest Development

Table 35

Residual Stands After Tractor Skidding and Highlead Logging

	High-Lead Percent (%) of Residuals		Tractor Skidding Percent of Residuals	
	Undamaged	Damaged	Undamaged	Damaged
Number of Trees				
All species	43.3	56.7	54.5	45.5
Dipterocarp	44.5	55.5	64.8	35.2
Non-dipterocarp	41.9	58.1	46.7	53.8
Basal Area				
All species	43.2	56.8	63.1	36.9
Dipterocarp	43.9	66.1	71.2	28.8
Non-dipterocarp	41.5	58.5	52.3	47.7

Source: RP-German Rain Forest Development Project Report.

Table 36

Felling and Yarding Damage by High-Lead and Tractor Skidding Under Gentle and Rough Topographical Conditions

Logging Method	DAMAGE Residual Dipterocarps Trees (%)	Residual Dipterocarps Basal Area (%)	Residual Non-Dipterocarp Trees (%)	Residual Non-Dipterocarp Basal Area (%)
Tractor skidding, flatter terrain				
Felling damage	13.1	11.5	53.3	47.7
Yarding damage	22.1	17.4	-	-
High-lead flatter terrain				
Felling damage	16.7	17.6	58.0	58.5
Yarding damage	38.7	38.5		
High-lead, rough terrain				
Felling damage	14.1	14.6	62.3	58.9
Yarding damage	52.0	50.9		

Source: RP German Rain Forest Development Project Report.

Timber Stand Improvement (TSI): The RP German TSI Project

The RP-German Timber Stand Improvement (TSI) Project, a project under a bilateral agreement between the Republic of the Philippines and the Federal Republic of Germany is primarily aimed at determining the growth rates in logged-over areas and applicable treatments to improve the quality and quantity of the residual forest. It started with its experimental phase in August 1975 under the RP-German Rain Forest Development Project in four major timber license areas in Eastern Mindanao. Results of these experiments are embodied in BFD Circular No. 32, Series of 1981 known as Guidelines for the implementation of TSI in logged-over dipterocarp forest within timber license areas.

Under the project, a shift from the traditional timber stand improvements applied to the existing dipterocarp forest to a well planned TSI treatment following the guidelines set forth in the aforementioned circular was made possible.

The TSI treatment as prescribed by the project is basically a potential tree crop concept wherein the best of the most promising trees of valuable species are selected as potential crop tree (PCT's).

Trees to be classified as PCT, should have the following features:

- belong to the preferred species which, in the Philippines, are the Dipterocarps like Red lauan (*Shorea negrosensis*), White lauan (*Shorea contorta*), Tanguili (*Shorea polysperma*), Bagtikan (*Shorea plicata*), Almon (*Shorea almon*), etc.

- be in the diameter range of 5-20 cm. DBH and occuring at an interval of not less than 6 metres.

- have well developed crowns.

- have cylindrical, straight and healthy boles.

- be stable and in a vigorous condition.

No fixed number of potential crop tree per hectare is prescribed as the number thereof depends on the silvicultural needs of the area. However, as a rule of thumb, it is suggested, until research proves otherwise, that for the first liberation thinning 10-15 years after selective logging, 160 PCT's per ha. be retained. An area is considered to be adequately stocked for TSI operations if there are at least 40 PCT's per hectare.

The first TSI treatment is conducted when the second growth has reached a stage that permits movement on the forest floor after the blanket of vines has been lifted from the ground by the growth of young trees; this is usually reached 10-15 years after logging. At least two TSI treatments between cutting cycles are recommended as follows:

Years in Cutting Cycle	Operation
0	Logging of virgin forest (first major harvest)
10 - 15	First TSI treatment
20 - 25	Second TSI treatment
25 - 45	Second Major Harvest (cutting cycle)

Residual and Continuous Inventory Assessments

In the final analysis the success of the selective logging systems depends on the survival without excessive damage of the planned residual stand after logging and its subsequent growth. The system therefore includes two sets of inventory procedures to provide this information and at the same time monitor the performance of the licencee and the progress of the forest.

The Residual Inventory

The objectives of residual inventory are:

- to determine the extent and causes of damage done to the residuals, so that corrective measures could be instituted.

- to gather information on the appraisal of residual growing stock for yield prediction, mortality and silvicultural treatments.

- to quantify the number and volume of damaged residuals for the determination of the penalties that shall be imposed to the licensee.

The timber management personnel of the BFD, who have jurisdiction over the concession area, conduct the residual inventory. The inventory is done by set-up and all residuals that were marked before the logging operations are accounted for. The criteria in describing the condition of the residual trees after logging are as follows:

Healthy Residual - must be sound, thrifty, with straight cylindrical bole and uninjured or slightly injured, to wit:

- Not more than 1/6 of the crown is severed or damaged.
- Any injury on the trunk reaching the wood (beneath the cambium) should not be more than 5 cm wide and 50 cm long along a straight line parallel to the longitudinal axis of the trunk.
- Not more that 1/2 of the circumference at any place on the trunk is girdled and deeply indented by wire rope.
- Not more than 1/3 of the number of buttresses is badly battered.
- Not more than 1/6 of the root system is removed or disturbed.

Sub-standard Residual - the magnitude of the injury is:

- More than 1/6 but not more than 1/2 of the crown is severed or badly damaged.
- Any injury on the trunk reaching the wood, over 5cm wide to 1/3 of the circumference and not more than 2 metres long along a straight line parallel to the longitudinal axis of the trunk.
- More than 1/2 but not more than 2/3 of the circumference of the trunk is girdled or seriously indented by wire rope.
- Over 1/3 but not more than 1/2 of the number of buttresses are battered.
- Over 1/6 but not more than 1/4 of the root system is removed or disturbed.

Damaged Residual - the injury is so much beyond sub-standard that it is likely that the tree will not survive or if it does that the bole will no longer be usable.

Continuous Forest Inventory (CFI)

This is a method for predicting growth and mortality rates of trees based on the results of repetitive measurements of the same trees found within permanent sample plots established in the residual forest.

Initially, the total number of sample plots for a particular concession is calculated from a desired degree of accuracy and a pre-determined coefficient of variation. The CFI plots are located and established on the ground based from easily recognizable starting points i.e. curve of river, junction of roads, permanent bridges, culverts, etc. The direction and horizontal distance from the starting point to the centre of the plot are noted on the field sheet. The plot centre is marked with a strong pole where the corresponding plot number is indicated. Likewise, the centre is "witnessed" by two known trees whose distances, directions and DBH/DAB are measured and printed with two yellow or white horizontal bands facing the plot centre.

The trees within the CFI plots are categorized into four size classes. These are:

1. Reproduction - all trees below 5 cm in diameter and at least 1.3 m (30 cm for Pine) in height. The reproduction is enumerated in four subplots with a radius of one meter and established 5 m from the plot centre along the cardinal directions.

2. Saplings - trees whose DBH is between 5 and 14.9 cm.

3. Pole Timber - trees whose DBH/DAB ranges from 15 to 34.9 cm.

4. Sawtimber - all trees with DBH/DAB of 35 cm or larger.

The data and information that shall be determined or measured from trees classified as sapling, pole timber and sawtimber are: species, stump class (except sapling), crown class, tree quality, DBH/DAB and merchantable height (except sapling).

Stump Class - indicates the point where the mercantable height of the tree starts and the portion where the tree shall be cut which is called stump height. Generally, there are three stump classes:

1. Normal Stump - when the tree has no basal flanges or is without butt swell. The stump height under this category is 0.5 m for all species (except pine which is 0.2 m) above the ground as measured on the uphill side of the tree.

2. Buttressed - if the tree is naturally swell-butted or with high basal flanges. The stump height for buttressed trees is at the termination of the pronounced swell.

3. Forked - if the tree does not have at least 3 m log below the base of the fork. The stump height will be at the crotch and each prong shall be considered a separate tree.

Crown class - the tree crowns are categorized as follows:

Dominant - Trees with crown extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand and with well-developed crowns but somewhat crowded on the sides.

Co-domimant - Trees with rown forming the general level of the crown cover and receiving full light from above, but little from the sides.

Intermediate - Trees with crown either below or extending into the crown cover formed by co-dominant and dominant trees, receiving little direct light from above, but none from the sides.

Overtopped - Trees with crowns entirely below the general level of the crown cover receiving no direct light either from above or from the sides.

Tree Quality - There are two broad classes of tree quality based on the present or potential merchantability of trees for sawlogs. A tree 35 cm DBH or larger is considered "sound" if it meets the merchantability requirements for sawlogs; and a smaller tree is "sound" if it is expected to attain a diameter of 35 cm. or more and meet the merchantability requirements for sawtimber at that time. Trees not qualifying as sound trees are classed as cull trees.

A tree 35 cm DBH or larger must meet the following requirements to be considered sound:

a) it must contain at least one merchantable sawlog 5 metres or longer, or contain two or more sawlogs 3 or 4 metres in length, except that one 3 meter log will qualify dangula, molave tindalo, tambulian, or narra.

b) The sawlog portion (from stump to upper limit of merchantability) must be at least 50 percent sound. In other words, it must be possible to saw out at least 1/2 the volume of lumber that could be sawed if the section were smooth, straight, and sound.

c) Each log making up the sawlog portion must meet the following requirements to be considered merchantable:

1) Minimum length - it must be at least 3 metres in length.

2) Maximum size of limbs and knots - the sum of the diametres of the limbs and knots in any 1/4 metre section of the log cannot exceed 1/2 the diameter of the log at that point.

3) Maximum cull volume - volume loss from sweep, crook, decay and other defects cannot exceed 50 percent of the gross log volume. It must be possible to produce at least 1/2 as much lumber 3 metres or longer as could be produced if the log were smooth, straight and sound.

Six classes of tree quality are provided for sound trees and one for cull trees. The first 4 classes were designed to identify the healthy, vigorous trees of medium to high quality that might be managed for future crops of sawlogs or veneer logs. A tree is considered sawtimber when it reaches 35 cm DBH. Nevertheless, in classifying the quality of small trees, the future diameter of 55 cm should be used in projecting estimates of merchantable length, clearness of stem, cull volume, etc. providing that the tree can be expected to reach that size by maturity.

Class 1 - High Quality Future Crop Trees

Sound dominant or co-dominant trees less than 75 cm DBH (45 cm for pine) having now or potentially at least 10 metres of clear sawlog containing no more than 10% cull. To be classed as clear, a sawlog must have three of its four 90 degree quadrants (faces) free of limbs, knots or deep wounds one cm or more in diameter. The foliage must be dark green or normal color for the species, the crown must be normal to large in size with no more than 25% of the crown destroyed, and it must not be spike-topped or contain upper limbs that are dead. No surface wound can be as large as 15 cm by 15 cm or as wide as 1/2 the stem diameter; no girdling wound can cover as much as 1/2 the circumference of the stem, and the centre of the main stem must not be rotten or hollow. The tree must be firmly rooted and the root system must not be more than slightly damaged.

Class 2 - Medium Quality Future Crop Trees

Requirements for this class are the same as for Class 1 trees, except that length of clear sawlog is 5 metres but less than 10 metres and the trees must be less than 55 cm DBH (45 cm for pine).

Class 3 - High Quality Potential Crop Trees

Sound intermediate for overtopped trees less than 55 cm DBH (45 cm for pine) having now or potentially at least 10 metres of clear sawlog containing no more than 10% cull. The foliage must be normal in color for the species, the crown must be normal to large in size with no more than 25% of the crown destroyed, and it must not be spike-topped or contain upper limbs that are dead. No surface wound can be as large as 15 cm or as wide as 1/2 the circumference of the stem, and the centre of the stem must not be rotten or hollow. The tree must be firmly rooted and the root system must not be more than slightly damaged.

Class 4 - Medium Quality Potential Crop Trees

Requirements for this class are the same as for Class 3 trees, except that length of clear sawlog is 5 metres but less than 10 metres.

Class 5 - Merchantable Mature Trees

Sound trees 55 cm DBH (45 cm for pine) or larger that do not qualify as Class 1 trees.

Class 6 - Doubtful Residuals

Sound trees less than 55 cm DBH (45 cm for pine) that do not qualify as Class 1, Class 2, Class 3 or Class 4 trees.

Class 7 - Cull Trees

Live trees that do not qualify as sound trees, Classes 1 through 6.

Measurements of Diameter and Heights

The DBH/DAB and merchantable height of each tree, including visible defects shall be measured and recorded. The DBH is measured 1.3 m from the uphill side of the tree, while DAB is 0.3 m from the swell or highest flange. The merchantable height is reckoned from the stump height up to the first main branch. However if there is clear length of 3 m or more beyond the 1st main branch the merchantability limit is up to the second main branch or top end diameter of 30 cm (20 cm for Pine).

Frequency of Measurement

Each tree measured and tagged in a CFI plot shall be measured yearly for the first five years and once every five years thereafter up to the 15th year. During the next re-measurement, all trees that will reach 5 cm DBH in each plot shall be tagged and measured and shall be classified as ingrowth trees and recorded separately. Likewise, all tagged trees that have died shall be noted.

INFORMATION SYSTEMS FOR MANAGEMENT

a) Forest Types

Very little is known regarding the assessment and inventory of the forest resources during the Spanish period (1521-1898). However, some publications and reports reveal that forest species identification and nomenclature were undertaken by Spanish botanists during their exploration and reconnaissance trips in several areas of the country.

During the American regime (1899-1941) the work begun by the Spaniards was continued by pioneer American and Filipino foresters. Information on forest types and important timber species was collected, including volume estimates. From the studies of these early botanists and foresters a classification of the forest types of the Philippines was eventually established.

The indigenous vegetation consists of about 1500 genera of flowering and seed-bearing plants, representing more than 8,000 species of which about 3800 are trees. Most of the tree species are found in all the major islands, except Pinus kesiya (Benguet Pine) and Pinus merkusii (Mindoro Pine), which are only found in the provinces of Benguet, Ifugao, Kalinga-Apayao, Mt. Province and in patches of Abra, Mindoro Occidental, Nieva Ecija, Nueva Vizcaya and Zambales.

Generally, the forest vegetation is classified into six broad types:

1. Mangrove
2. Beach
3. Molave
4. Dipterocarp
5. Pine
6. Mossy

Mangrove Forest Type - found in tidal flats at the mouth of streams and in the shores of sheltered bays. The most important species are: Bruguieera gymnorthizza (Busaing), Bruguierra parviflora (Langarai), Ceriops tagal (Tangal), Rhizophora apiculata (Bakawan lalaki) and Rhizophora mucronata (Bakawan babae). To date, large areas of this forest have been converted to fishponds and other uses.

Beach Type - found in dry and sandy beaches; the principal species are: Barringtonia asiatica (Botong), Calophyllum inophyllum (Bitaog), Casaurina equisetifolia (Agoho) and Terminalia caatappa (Talisai). Presently, the beach forest is almost gone, but the principal species are still found singly or in small patches on some sea shores.

Molave Type - this type frequently occurs in areas with a distinct dry season and limestone soils at low to medium elevation. The wood of the tree species under this type are noted for durability and beauty, and hence are used mainly for furniture. The most important species are: Afzelia rhomboidea (Tindalo), Intsia bijuga (Ipil), Pterocarpus indicus (Narra), Serialbizia acle (Akle), Vitex parviflora (Molave) and Wallaceodendron celebicum (Banuyo). The remaining area of the molave forest is integrated with the Dipterocarp type considering that it occurs in small patches or singly in association with dipterocarps.

Dipterocarp Type - this forest type is heterogenous in composition. The species belonging to the family Dipterocarpaceae are the most important (known in the world market as "Philippine Mahogany") and predominates in terms of volume, comprising about 70-80% of the total timber stand. The principal species are: Dipterocarpus grandiflorus (Apitong), Dipterocarpus grandiflorus (Apitong), Dipterocarpus gracilis (Panau), Dipterocarpus warbugii (Hagakhak), Hopea philippinensis (Gisok-gisok), Shorea contorta (white lauan), Shorea gisok (Yakal), Shorea guiso (Guijo), Shorea negrosensis (Red lauan), Shorea almon (Almon), Shorea polysperma (Tanguile), Shorea squamata (Mayapis), etc.

Pine Type - found in the mountain regions of high altitude in Northern Philippines particularly in the province of Benguet, Ifugao, Kalinga-Apayao, Mt. Province and in small patches in Abra, Mindoro, Nueva Ecija, Nueva Vizcaya and Zambales. There are only two species under this type: Pinus kesiya (Benguet Pine) and Pinus merkusii (Mindoro Pine).

Mossy Forest Type - found on steep and high mountains, whose sides are cut in ridges by deep canyons, usually at elevation of 1,200 metres and above. This forest type has no commercial value, but it serves as protection forest. The trees are dwarfed, with clear bole of less than five metres in length, and the trunks, branches and leaves are covered by moss, liverworts and other epiphytes.

b) Land Classification Survey

This survey pertains to the classification of the public domain into two broad categories, eg. timberland and alienable or disposable land (A or D). The former category is for forestry purposes, while the latter is for agriculture and other non-forestry uses. The criterion for determining A or D is primarily based on the slope gradient, which is zero to eighteen percent (0-18%) slope, except those areas within 40 metres from the shoreline measured during high tide and 20 metres from both sides of rivers or streams having a width of 5 metres or more. Another basis for A and D classification is that the volume of timber content of the area which should not be more than 40 cubic metres per hectare.

The areas classified as A or D and timberlands are indicated on maps with scale of 1:20,000. The technical desriptions of each classification are also incorporated on the map. In addition, a certification is prepared for the approval of the Director of Forest Development and Minister of Natural Resources. Once approved, the boundary between the A or D and timberland becomes permanent.

c) Forest Surveys and Resource Inventories

Forest inventory is the series of processes whereby relevant data and information about the forests (forest types, stand size, extent, condition and location) are gathered, analysed, compiled and presented for policy formulation and the preparation of forest management plans and programmes.

The first official volume estimates of important timber species were made in 1910 by Forester H.N. Whitford, who stated in his report that the forests of the Philippines contained about 200 billion board feet (approximately 470 million m^3). Compilation of results from the reconnaissance and valuation surveys conducted by foresters in the district offices in the various provinces before the outbreak of the 2nd world war revealed that the volume of standing timber was 464 billion board feet (approximately 1.1 billion m^3).

After the war, when peace and order were re-established in the Philippines,forestry activities expanded tremendously due to the reconstruction and rehabilitation of areas ravaged by the war. As a corollary, various surveys and inventories were conducted within the forest lands. These have by now developed into a suite of surveys and inventories to provide information pertaining to forest management at all levels and phases. Although they are all inter-related and sequential three sets can be, for convenience recognized. They are:

a) Surveys and inventories related to harvesting
b) Inventories related to future
c) National forest inventories

Pre-Investment Survey

This survey is done to determine the profitability of utilizing the resources within a specific forestland area. It involves the identification of the area wherein a permit or lease may be issued, including the kind and volume of resources that may be allowed for utilization.

Delimitation and Inventory of Forest Concessions

The portions of the forest lands that are licensed to qualified private individuals or corporations for purposes of harvesting the mature and over-mature timber stand in accordance with prescribed laws, rules and regulations are delimited and inventoried prior to the conduct of logging operations. The boundaries of the licensed area or concession are established on the ground. The technical descriptions from this survey are indicated on the concession map and approved by the Director of Forest Development and Minister of Natural Resources.

A forest inventory is also conducted within the concession area, the intensity of which is at least five percent (5%) of the forested area. The width of the strip is 20 metres, while the length is determined by the extent of the forest. The number of strips, distance between strips and sampling intensity are computed as follows:

1. Area to be cruised = Total forest area x % estimate

2. No. of strips = $\dfrac{\text{Area to be cruised}}{\dfrac{\text{length x width of strip}}{10{,}000}}$

or

$$= \frac{\text{Area to be cruised}}{\text{Area of one strip}}$$

3. Distance between strips = $\dfrac{\text{width of strip}}{\text{\% estimate}}$

4. Sampling intensity = $\dfrac{\text{Area cruised}}{\text{Total forest area}} \times 100$

In a systematic strip cruising, the timber cruisers start from a baseline and run a straight strip on a compass line across the forest tract up to the boundary of the concession. While running the line, they identify the tree species, measure diameters at breast height (DBH) or diameter above buttress (DAB) and corresponding merchantable height. They also note the external defects, if any of the sawlog portion, including its dimension, for purposes of computing the net sawlog volume. The cruisers also note the extent of the forest type and forest stand size along the strip. These procedures are done until all the computed number of strips are established.

The statistical method of sampling is another system of inventory being adopted in the assessment of the forest resources. The coefficient of variation is determined by establishing about 30 preliminary sample plots within each timber concession. The number of circular samples is computed based on the coefficient of variation and allowable sampling error which is pegged at 5%. The computed number of sample plots is distributed within the forest area by calculating the area represented by one plot i.e. divide the area of the forest by the total number of plots and convert the quotient in square metres, to enable the calculation of horizontal distance between plot centres. This is done by multiplying the area represented by one plot by 10,000 and extracting the square root of the product which is the distance between plots. The distance between plots is reduced by one percent (1%) in order that all sample plots shall fall within the boundary of the concession. A grid pattern with the same scale as the concession map is prepared based from the calculated distance between plots and then transferred to the topographic map wherein the boundary of the concession is indicated.

The sample plots are established using the natural features indicated on the topo map and identified on the ground as guide. All the trees within the circular plot, whose radius is 17.84 metres or an area of 0.1 ha, are identified and measured - their respective DBH/DAB and merchantable heights, including the external defects, are recorded.

The forest inventory report contains the following:

- Area of the commercial and non-commercial forest. The locations of these factors are indicated on the vegetative cover map;

- Timber species, their distribution by size classes and corresponding number of trees and volume per hectare. These are shown on a stand and stock table;

- Description of the forest as to topography, soil type, climate, distance to human communities, etc.

- Other relevant information.

Logging Set-Up Survey and Inventory

A logging set-up is the smallest subdivision in a forest concession. This is often referred to as "yarding set-up" or "setting". The boundary and extent of the set-up must be known from the operations map and surveyed on the ground. The factors to be considered in the delimitation of the set-up are the location of the spar tree, log landing, accessibility from logging road network, topography and the yarding distance of the yarding unit, which is limited to a maximum of 240 to 270 metres for highlead yarding and 75 to 90 metres for truck or tractor skidding.

The intensity of inventory within a set-up is at least 20%, to determine the number and volume of the preferred timber species to be cut as well as the residuals to be left for the next cutting cycle. The trees that shall be cut or left are marked and numbered accordingly. The markings on the former indicate the direction of fall while on the latter they show the tree number and the set-up number for the purpose of assessing its condition after logging of the set-up.

Management Inventories

These are of two types, as follows:

a) Residual inventory which is the physical examination and counting of the marked and numbered residuals left in a set-up after logging
b) Continuous forest inventory for predicting growth and mortality rates of trees in the residual forest.

They are therefore integral parts of the implementation of selective logging management in the Tropical Mixed Forest. Accordingly they have been described in the later discussion of that system.

Other Forest Lands

Forested lands that may be allowed for clear-cutting such as A or D, private lands, civil reservations, resettlement areas including those under the jurisdiction of other government agencies are to be inventoried at one hundred percent (100%). The inventory is to be conducted separately for each lot covered by title/certificate or other documents of ownership. However, the trees within 20 m from both sides of streams/rivers at least 5 m wide; 40 m from the shorelines and 60 m from both sides of public highways; within parks, plazas and school grounds shall be excluded from the tally of trees to be cut.

Other areas that shall be subjected to 100% inventory are areas used by timber concessionaires as roadways, cableways and log landings.

c) National Forest Inventories

First National Forest Resources Inventory ((NFI-I)

NFI-I was undertaken from 1961 to 1967. A double sampling design, consisting of photo-point sampling on aerial photographs and ground plot sampling was used. The procedures of this inventory are as follows:

The aerial photographs of the country with an average scale of 1:50,000 taken by the U.S. Air Force from 1947 to 1953 were obtained. Sometime, from 1962 to 1966, the Bureau of Forestry, requested the Philippine Air Force to take strip photography at 15 km between trips with an averge scale of 1:12,000. The later photography was delineated on the former. Both sets of photographs were interpreted for land use, forest type and forest stand sizes.

The estimates of the area of the land use classes were determined by examining and classifying points on every other photograph, both for the 1950 and 1963 airphotos with the use of photo templates. The proportion of points on the 1963 photos within each class was used to calculate the updated areas.

Ground samples were systematically selected from the forest photo points and distributed in each forest stand classes based on a certain level of precision. These field plots were located and established on the ground with the use of the 1963 airphotos. Each ground sample was composed of five variable plots wherein observation and measurements of the different parameters were made, such as: tree species, DBH/DAB, merchantable length, tree quality, forest type, stand size and condition, site quality etc. Any changes that have occurred within the sample since the date of photography were also recorded. The volume estimates by stand size were arrived at by mulitplying the calculated average volume per hectare by the estimated area of the stand size.

Forest drain was calculated from the results of the timber utilization studies conducted within pre-selected small, medium and large timber operations as well as from reported timber production and other forces of forest depletion.

The growth and mortality rates were determined from the results of the continuous forest inventory.

The inventory data were computed, evaluated and compiled wherein summary tables on land use, forest areas and timber volume estimates were prepared. The location of the forest areas could not be determined since no maps were produced.

Forest Inventory by Aerial Photo Interpretation

Another inventory on the extent and location of the forest was undertaken by BFD from 1967 to 1972, with the application of photo-interpretation. Aerial photographs of the country having an average scale of 1:15,000 flown during the period were obtained and interpreted. The interpretation was used as basis in the preparation of forest resource condition maps (FRCM). The photo interpretation codes as indicated on the FRCM and its description are as follows:

Code	Description
A. Forested Lands	
22	Mangrove Reproduction
23	Young Growth Mangrove
25	Old Growth Mangrove
12	Reproduction Brush
13 L	Residual Dipterocarp Low Volume
13 H	Residual Dipterocarp High Volume
15 L	Old Growth Dipterocarp Low Volume
15 M	Old Growth Dipterocarp Medium Volume
15 L	Old Growth Dipterocarp High Volume
10	Mossy Forest
30	Unproductive Forest
PL	Pine Forest Low Volume
PH	Pine Forest High Volume
P	Forest Plantation
b) Non-Forested Lands	
O	Open/grasslands
C	Cultivated lands
M	Marshlands
Ps	Pasture or Rangeland
U	Urban, built-up areas

About 15.1 million ha out of the total 17.4 million ha forestlands were mapped.

Forest Inventory by Landsat Imagery Analysis

In 1978, the Natural Resources Management Centre (NRMC), Ministry of Natural Resources conducted an inventory of the forestlands through the analysis of LANDSAT Imageries. The forest classification system was based on the spatial and spectral characteristics of the forests, and on the interpreter's knowledge of the various forest types. The categories developed with the use of G.E. Image 100 system are:

1. Forested Land - Partial Canopy Closure

   Forest composed primarily of dipterocarps, stocked with tree reproduction or brush. Some agricultural high crops such as coconuts and bananas were mixed in especially when located in proximity to forestland.

2. Forested Land - Obscured by Clouds

   This category was created because of the cloud conditions in many of the Landsat scenes. It encompasses areas believed to be forested, but obscured by clouds and cloud shadows. The boundaries of such areas were defined as polygons in the bulk processors. They were based on information from Landsat Imagery for other dates, and from various ground sources.

3. Forested Land - Mangrove

   Forest stands found in swampy tidal areas (mouths of rivers and streams), and along the shores of sheltered bays. Composed predominantly of mangrove (Bakauan) and associated species.

4. Forested Land - Mossy or Mid Mountain

   Forest stands found in high and very rough mountainous regions of the country. Characterized by low growth and small commercial value.

5. Non-Forest Land - Wetlands, Marsh and Small Water Bodies

This non-forest category was included in addition to the forest classification because of its potential value in the development of the natural resources base in the Philippines. The category includes wet areas characterized by partial cover of grass, weeds and brush. It also includes small water areas, shallow portions of large rivers and the majority of commercial fishpond areas. Some cultivated lands are flooded and planted to rice and also categorized as wetlands.

Present Forest Inventory and Resource Assessment

With the forests becoming more and more devoted to a multiplicity of uses i.e. water, timber, wildlife, recreation, grazing, protection, etc., priorities will need to be set with the participation of all sectors of society. It is therefore imperative that reliable and accurate data and information about the forests are collected, analyzed and interpreted for the preparation of short, medium and long range forest management plans and programs.

Sub-classification Survey of Forestlands

The previous system of land classification, based primarily on slope gradient and timber content has therefore been modified to include not only the above criteria, but also other factors to satisfy requirements for socio-economic development and at the same time promoting the equitable and optimum utilization of the forest resources. Such factors as physical, biological and ecological aspects are measured quantitatively and qualitatively. The results therefrom are the basis in determining the best use of a particular area of the forestlands.

Forest Inventory and Resource Assessment within Timber Licensed Area/Concession

The procedures in the inventory of concession areas are similar to those been previously discussed in this paper. Deviations occur only when recent aerial photographs (not more than 5 years from date of photography) over the area are available. In such case, the stratified random sampling proportional to the size of the stratum is applied. This inventory technique is expeditious and relatively more accurate than the systematic line plot and strip methods.

The pre-logging and residual inventory within a set-up are also undertaken as described earlier in this paper.

Second National Forest Resources Inventory (NFI-II)

NFI-II was planned in 1978 since the data obtained from NFI-I during the period from 1961 to 1967 were deemed outdated, a a result of the tremendous changes in the forests due to population pressures and improvement of accessibility in these areas.

The objective of NFI is the collection, analysis and evaluation of forest resources information by region and province relative to the area, as a volume and dynamics and its interpretation for policy formulation and basis for conservation and progressive forest management.

To attain the above objective, a multi-stage sampling design was adopted for NFI-II; (1) Analysis of LANDSAT Imagery, (2) Aerial Photo-Interpretation,and (3) Field Sampling.

Multi date LANDSAT Images are to be analyzed and land use maps at scale 1:250,000 produced. The data and information on the changes and extent of the forest resources can be obtained rapidly by this method and at lower cost compared with other sources of information.

Aerial photography is another source of information about the forest resources. Recent aerial photographs of North-eastern Mindanao and Luzon at an average scale of 1:25,000 and 1:60,000 respectively are interpreted to provide a basis in the preparation of forest resources condition maps (FRCM) at scale 1:50,000. The FRCM contains information on the forest type, forest stand size, stand density and site quality, particularly those prepared from the 1:25,000 airphotos, but for the 1:60,000 photographs only forest type and forest stand size are indicated.

Field sampling is indispensable in gathering reliable data on the timber species and volume estimates based from the measurement of corresponding DBH/DAB and merchantable length. To arrive at a certain desired degree of accuracy, an optimum number of field samples need to be established within forestlands by province and region.

The field sampling design in North-eastern Mindanao is based on a camp centre with four sampling units whose aggregate area is two hectares. The distance between camp centres is eight kilometres and pre-located within forestlands. A camp centre, showing the sampling units (SU),recording unit (RU) within SU and subplots with RU is illustrated.

Sample trees are measured within the 3 subplots. Within the first subplot having a dimension of 5 m x 50 m, all trees with diameter from 19cm to 29cm are tallied; within the second sub-plot whose dimensions are 10m x 50m trees with DBH/DAB from 30cm to 59 cm are tallied and for the third sub-plot or whole RU,m with dimensions of 20 m x 50m all trees with DBH/DAB of 60cm and larger are tallied. Tree regeneration is tallied in RU 1 within a 10 m x 10 m subplot. Bamboo, erect palms and rattan are recorded in RU 1, 3 and 5 within a subplot of 10 m x 10 m.

The field sampling design for Luzon and other forestland areas of the country has been modified to make use of a stratified random sampling. The different strata are determined from photo-interpretation where an optimum number of sampling units will be located within each stratum. A sampling unit is composed of clusters based on horizontal point sampling (BITTERLICH-method) with wide-scale relascope.

The estimated total timber stand within the various forest types and stand sizes will be computed based on the average stand/ha obtained from field sampling and the area of a particular stratum determined from photo-interpretation. These data will be analysed with the use of mini-computer HP 9836 with provision for mass storage and retrieval system.

The Project will also produce land use maps at scale 1:250,000 from LANDSAT Imagery for macro planning and forest resources condition maps at scale 1:50,000 for an intensive forest management.

INSTITUTIONAL ASPECTS OF FOREST MANAGEMENT

Licensing System

All the forest resources of the country are owned by the state. The government agency entrusted to manage these vast resources is the Bureau of Forest Development under the Ministry of Natural Resources.

To regulate the cutting, gathering and transporting of timber and other forest products as well as the occupancy and use of forest lands, the Bureau of Forest Development issues licenses, leases and permits to qualified individuals. In the granting of privilege to cut or gather forest products, or occupy or use forest lands, the financial and technical capability of the applicants to manage, develop, utilize and protect the forest resources are taken into consideration.

Types of Licenses, Leases or Permits being Issued

There are at present several types of licenses, leases and permits being issued by the Bureau. For the occupancy and use of forest lands, the Bureau issues the following:

1. Pasture permit or lease for grazing purposes covering an area of not exceeding 100,000 hectares with a tenure of one year to 25 years.

2. Industrial Tree Plantation Lease Agreement for the planting of tree crops to supply the raw material requirements of wood processing plants.

3. Tree Farm Lease Agreement - a long term contract covering any small forest land or tract of land for purposes of planting tree crops.

4. Agro-Forestry Farm Lease Agreement similar to tree farm lease agreement except that the land is used to produce agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially, and applies management practices which are compatible with the cultural patterns of the local population.

5. Stewardship Agreement - a contract entered into by and between an individual forest occupant or forest community association or co-operative and the government allowing the farmer the right to occupation and possession over a designated forest area.

6. Prospecting Permits - a short term permit authorizing the grantee to enter and undertake mineral prospecting inside forest lands.

7. Special Use Permit - a short term permit for the occupancy and use of a portion of the forest land for purposes other than those stated in the foregoing leases and permits.

For the cutting/gathering of timber and other forest products, the following licenses, and permits are issued:

Long-Term licenses (10-25 years)

1. Timber License Agreement - a long term license for the extraction of timber in forest lands subject to prescribed duties and responsibilities for forest management imposed on the grantee;

2. Pulpwoood License Agreement - similar to timber license agreement except that it is for the cutting of pulpwood species only;

Medium and Short-term licenses/permits (less than one (1) year to 5 years)

1. Provisional Timber License - a short term license issued by the Minister of Natural Resources over areas previously under ordinary timber licenses where field evaluation is prevented by fortuitious circumstances or events such that cancellation of license or its conversion into a longer term license cannot be done in the interim;

2. Softwood Timber License - a license issued by the Minister of Natural Resources for the cutting of timber species inside forest lands, which are suitable and used solely for wooden shoes, matchsticks, carving and similar purposes;

3. Mangrove Timber License - license issued for the cutting and utilization of mangrove timber species;

4. Civil Reservation Timber License - license issued for the cutting and utilization of timber inside civil reservations;

5. Tree Recovery Permits - a short term privilege issued for the gathering, transporting and disposing of trees damaged by typhoons, floods and other natural calamaties, including those illegally cut, which otherwise may be laid to waste, as well as the cutting, gathering, transporting and disposing of naturally grown trees inside private lands;

6. Tree Plantation Cutting Permits - a permit issued for the cutting of trees planted inside private lands;

7. Minor Forest Products License - a license issued for the cutting, gathering and utiliation of any forest products otherthan timber inside forest lands; planted inside private lands;

8. Rattan Cutting Permit - a short term license issued for the cutting and utilization of rattan poles.

In line with the wood industry rationalization program of the government, the Bureau and the Ministry of Natural Resources have stopped the issuance of short-term licenses to cut natural grown timber inside forest lands covering less than 10,000 hectares. In lieu thereof, long-term licenses with tenures up to 25 years renewable for a similar period are being issued to those whose concession areas are at least 10,000 hectares with a remaining virgin forest stands of not less than 4,000 hectares. Those whose areas are less than the minimum requirement are being encouraged to merge with adjacent concessions. It is envisaged that by providing them security of tenure, holders thereof would be encouraged to undertake long range management and development programs designed to sustain the productivity of the forest.

Limitations Under the Constitution

Although the Bureau of Forest Development and the Ministry of Natural Resources have set the minimum area to be granted under a timber license to 10,000 hectares, the Philippine Constitution provides that the maximum area of forest lands that may be granted under a license lease or permits is only 100,000 hectares. However, a license, lease or permit covering more than the maximum limit may be granted upon approval by the National Assembly on the recommendation of the National Economic and Development Authority. The tenure of licenses, concession or lease that may be issued has also been limited for a period not exceeding twenty five years, renewable for not more than twenty-five years.

Duties and Responsibilities of Timber License Agreement (TLA) Holders

In order that holders of Timber License Agreements can continuously avail themselves of the privelege granted under their licenses, they have to comply with certain requirements embodied in the agreement, among which are the following:

1. Submission of a complete aerial photo coverage of the forest area within four years after execution of the agreement;

2. Submission within one year from the effectivity of the agreement of an Integrated Forest Management Plan covering all forestry activities within the concession for the duration of the agreement and a five-year medium term plan to be supplemented by an annual operations plan.

3. Take full responsibility for the protection of the concession area;

4. To reforest all open areas within the concession. Timber licensees are given two options, that is to either undertake a seven year reforestation program or apply for Industrial Tree Plantation Lease Agreement over suitable portions of the licensed area;

5. Utilize or remove all woodwaste generated from logging within three months after primary logging operations have stopped in a given set-up;

6. Maintain a forestry department to be headed by a registered forester on a full time basis to take charge of forestry activities in the concession.

7. Sell or offer for sale within four years from the execution of the agreement at least 10% of the subscribed capital stock to its employees or the general public.

Although security of tenure is guaranteed under existing forestry laws and regulations, the license agreement is subject to review at least once in every two (2) years to ascertain compliance with the terms and conditions of the agreement. For breaches of any forest laws, rules and regulations, committed by the licensee, the Director of Forest Development or the Minister of Natural Resources may cancel or suspend the TLA or the logging operations. Once a license is cancelled, the area is declared as vacant and may be granted to other qualified applicants.

Forest Taxation

Taxes imposed on timber and non-timber products cut or gathered from the forest as well as in the use and occupancy of forest lands represent the share of the state as owner thereof. In the Philippines, taxes and fees being imposed on forest products and in the use of forest lands are either fixed through legislative or administrative issuances.

Forest Charges and Fees

Until 1982, forest charges levied on timber and non-timber products covering from forest lands were based on the rates fixed by Commonwealth Act No. 466 promulgated in 1939. For timber, the rates varied from P0.60 per cubic meter for timber belonging to the fourth group to P1.25, P2.00 and P3.50 for the 3rd, 2nd and 1st group. For other forest products, the rate was fixed at 10% of the assessed market value. All forest charges collected accrue to the general government fund.

Additional charges and fees were later imposed on timber for specific purpose under the following issuances:

		Rate
1.	Republic Act 115 (Reforestation Fund)	P0.50 cu.m.
2.	Republic Act 3523 (Forestry Information Fund)	0.10/cu.m.
3.	Republic Act 5526 (FORPRIDECOM Fund)	0.25/cu.m.
4.	License Application Fee	P1.00/hectare
5.	License Fee	5% of the average forest charges based on the annual allowable cut.

Recognizing the need to increase revenue derived from the forest resources, the Interim National Assmbly, in 1980, decided to restructure the antiquated rates to make them more realistic and attuned to the present economic situation through the passage of Cabinet Bill No. 38. This was later approved by the President to become Batas Pambansa Bilang 83 entitled "An Act amending certain Sections of the National Internal Revenue Code of 1977, as amended, governing the taxation of Forest Products and for other purposes."

The main features of the new forest tax measure are the following:

a) The various fees and charges such as the regular forest charges, reforestation fund, forestry information fund, FORPRIDECOM Fund, Special Deposits under FAO 64 were abolished and consolidated into one rate of tax and increased as follows:

On timber in the first and second groups	-	P30.00/cu.m.
On timber in the third and fourth groups	-	15.00/cu.m.
On timber used as fuelwood other than mangrove species	-	2.00/cu.m.

b) Charges on gums, resins and other forest products remained at ten per centum of the actual market value.

c) Charges on illegally cut or gathered forest products were increased by three hundred per centum, and for those discharged without permit by any means of transportation the charges were increased by fifty per centum.

d) Forest products cut/gathered from forest lands under a gratuitous license are not subject to tax.

e) Trees and products removed from public lands under a tree farm lease are likewise tax exempt:

f) The charges of forest products are to be paid to the revenue officer in the municipality where the concession area is located before the same are removed from the cutting area. However, prepayment of forest charges may be waived by the government if the concessionaire has filed a bond in the form and amount as determined by the Bureau of Internal Revenue; provided, the concessionaire must pay the charges within twenty days after the end of each quarter. In case the taxes are not paid within the prescribed period, a surcharge of twenty-five per centum is imposed and the unpaid charges and surcharges are subject likewise subject to interest at the rate of twenty per centum per annum.

Real Property Tax

In addition to the above charges and fees, holders of forestry licenses, leases or permits are required to pay real property taxes over the area covered by their license, lease or permmit. Presidential Decree No. 853, as amended by Presidential Decree No. 888, provides for the classification and valuation of timber and forest lands for purposes of real property tax declaration. As provided for under said decree, timber and forest lands are assessed at 40% of their market value as determined by the Provincial/City Assessor. However, the taxable area for a given year is based on the operational area within the concession as determined by the Bureau of Forest Development. The rate of levy for all provinces, municipalities and cities with the annual rate as follows:

- For the province, one-half of one percent of the assessed value of the taxable area of the property;

- For the municipality, one-half of one percent of the assessed value of the taxable area of the property; and

- For the city, one percent of the assessed value of the taxable area of the property.

Export Tax

In line with the government's program to encourage the exports of manufactured and semi-processed wood products, Executive Order No. 558 was issued by the President of the Republic of the Philippines, revising/modifying Executive Order No. 434 by imposing a 20% ad valorem tax on all logs including poles for exports. Semi-finished products such as lumber and veneer are also subject to 4% ad valorem tax in accordance with the provisions of Republic Act No. 1937, as amended.

FOREST MANAGEMENT AND SOCIO-ECONOMIC DEVELOPMENT

The Economic Contribution

The forests play a vital role in the industrial and economic development of the country. They are one of the major sources of foreign exchange earnings and revenues needed to sustain the various programs and projects of government designed to uplift to social and economic well-being of the people. They have provided employment to thousands of skilled and unskilled workers especially in the rural areas.

From 1968 to 1982, the forestry sector contributed some P3,559 million annually to the national economy representing 3.17% of the country's Gross National Product (GNP). During the same year, exports of major wood products like logs, lumber, veneer and plywood earned for the country an average of US $295.97 million per year. In 1983, log, lumber, veneer and plywood and other forest products exports contributed some US $447.03 million to the country's foreign exchange earnings.

In 1982, some 43,500 people with some 200,000 dependents were employed by various timber licensees in their logging operations. Saw milling, plywood and veneer manufacture had about 53,000 workers with some 246,000 dependents. Thousands of skilled and unskilled workers were also employed in other forest-based industries such as the rattan industry, furniture and fixture manufacture, builders woodworks, etc.

The operations of timber concessions have opened vast tracts of virgin lands and facilitated their development for industrial and agricultural purposes. The thousands of kilometres of road network built by logging companies connected the once inaccessible areas to population centres. In areas where these logging companies operate, new towns or villages were established.

Log Export Ban

The log export ban had its early beginning with the promulgation of Forestry Administrative Order No. 5 dated October 29, 1973, effecting a three-year schedule allowing 60, 30 and zero percent log export for the years 1974, 1975 and 1976, respectively.

The ban on log exportation is designed to pursue the program of the government to rationalize the development of the wood industry, draw in capital investment from abroad for wood processing ventures, accelerate the reforestation program in anticipation of the needs of our local processing plants, encourage the establishment of industrial tree plantations, process the logs withdrawn from export into finished products and finally to curb the alarming destruction and denudation of the forests by destructive logging.

Realizing the impact of the implementation of the program such as the difficulties of the local concessionaires in fulfilling previously committed exports, the policy was amended through Presidential Decree No. 428 issued in April 1974. Timber licencees were allowed to export a maximum of eighty percent (80%) of their total log production during the calendar year 1974 and 1975 but the zero percent export to start on January 1976 remained. This was predicated on the high prices for logs prevailing at that time. The wood industry, however, suffered a slump in the export prices of logs as well as cut back on the volume imported by the traditional markets as a result of a world wide recession. This, in effect, reduced the foreign exchange earnings of the country causing a problem in the country's balance of payments and also creating instability in the world industry.

To cushion the impact of the ban on log exportation and forestall any adverse effect it might have in the country's balance of payments, employment and the stability of the industry; PD 865 allowing temporarily limited and selective exportation of logs was promulgated. It allows, among others, the aggregate log export not exceeding 4 million cubic metres or roughly 25% of the total annual allowable cut. Timber licensees allowed to export are those with viable processing plants, with duly approved processing projects, or have acquired processing machineries and equipment, and where log exports are in line with government approved trade agreements.

Impact/Implication of the Log Ban

The Philippines has always been known in the international world trade market as a supplier of raw materials. Other developing countries have often been in the same category. This situation has continuously caused the failure of the local industry to benefit from "value-added" accruing to the industry as a result of manufacturing. Thus there are economic gains foregone in exporting logs, which include additional income and additional employment.

Before the imposition of the temporary and selective log ban, the growth of the local wood processing industry had been relegated to the background. The concentration on exports of raw materials stifled the opportunities for industrialization in forestry. However, with the imposition of the export ban, the establishment of new processing plants was intensified and the utilization of logging and milling wastes was further enhanced for the development of new wood product lines.

Annually until 1973, the majority of the country's log production was exported, leaving only a very minimal volume of the total annual cut for local processing. Better quality logs were exported while inferior ones were made available to domestic manufacturers resulting in the failure to diversify products and improve quality thereof. But with the development of the wood processing capacity of the wood industry, the country expects to reap the benefits in terms of self-sufficiency in processed wood requirements, improved quality of finished wood products, higher foreign exchange earnings and cheaper wood products for local consumption.

With the imposition of the log ban, there was a considerable decrease in the log exports from 5.4 million cubic metres, which is 52% of the total 10.2 million cubic metres log production in 1974 to 0.79 million or 15% of the total 4.4 million cubic metres log production in 1983. Simultaneously, there is a continuously increasing annual trend in exports of finished or sime-finished wood products. The increasing trend in the export of wood products is a clear indication that under normal market condition our manufactured exports are gaining acceptance in the world market. Table 36 shows the volume and value of logs and wood products exports for 1965 to 1983.

Also as a consequence thereof there was a tremendous gain in forest conservation as indicated in the reduction of the area logged annually and a marked increase in employment in the forestry secotr, in view of the diversification of log use and the utilisation of the traditional logging and milling waste.

Utilization of Lesser-Known and Lesser Used Species (L.K.S.)

Only about 8% or approximately 300 of the 3800 or so tree species in the Philippines find their way into the market. Moreover the bulk of the production and trade comes from the dipterocarp species which are usually utilized for construction purposes.

The increasing demand for wood based products has put tremendous pressure on the supply of traditionally used commercial species. The pressure is such that the potential of the lesser-known and lesser-used species has had to be recognized.

A few lesser-known species are already identified as being suitable for manufacture or processing into various wood products. Some of these are Magabuyo (Celtis luzonicus) Balobo (Diplodiscus paniculatus) and Toog (Combtretodendrom quadrialatum).

At present the government, through the Forest Products Research and Development Institute (FPRDI) and the Forest Research Institute, is undertaking a series of research projects towards generating technology for the proper management of lesser-used and lesser-known species in both natural and plantation forests as well as the utilization and marketing aspects.

Industrial Tree Plantation

In line with the policy for the government provided in Presidential Decree 705 (as amended by Presidential Decree 1559) the establishment of Industrial Tree Plantations is being implemented nationwide. The policy is primarily aimed to accelerate the revegetation of the country's open, denuded brushlands and inadequately stocked areas in order to support the raw material requirements ofthe wood-based and related industries, energy generating facilities and at the same time improve and maintain a desirable environment.

Primary targets of the program are the open, denuded and inadequately stocked areas within existing concessions. Areas outside timber concession are also made available for industrial tree plantation development giving priority to communities, municipalities, cities and provinces in the form of communal tree farms.

Forest land areas available for development into an industrial tree plantation pursuant to Ministry Order No. 5, Series of 1981 are as follows:

a) Bare, open, denuded or grass-covered tracts of forest lands.

b) Brushlands.

c) Open tracts of forest lands interspersed with patches of forest.

d) Open, denuded, brushland and/or inadequately stocked areas within timber concessions.

e) Portions of areas covered by pasture leases or permits needing immediate reforestation.

f) Government reforestation projects or portion thereof found to be more suitable for industrial plantation in terms of benefits to the government and to the surrounding communities.

To attract investors to develop industrial tree plantations, a package of incentives is offered as follows:

a) Nominal land rental not exceeding one peso per hectare per year.

b) Payment of only 25% of the regular forest charges on products harvested from the ITP area.

c) Exemption from all forms of sales taxes, local, municipal, and real property taxes.

d) Tax credit equal to 100% of the amount expended for the establishment, development and operation of the ITP up to the time the production stage is reached.

e) Priority in the granting of long term low interest loans from any of the government financing institutions.

f) Allowance to export timber and wood products from the ITP without restriction in quantity or volume.

The implementation of the program was given impetus through the issuance of Executive Order No. 725 in 1981 requiring massive implementation of the ITP program naming the livelihood program as one of the implementing arms of the ITP establishment.

As of December 1983, a total of 64 ITP leases covering some 247,900 hectares was awarded, 23 of which are within timber concession areas. The largest area so far granted covers 54,300 hectares in the provinces of Surigao del Sur and Agusan del Sur.

The Rationalization Program for the Wood Industry

The wood industry has been recognized as one of the pillars of the country's economy. However, despite the local wood industry's comparative advantage in terms of raw materials sufficiency and low cost of labor over log-importing countries like Japan, South Korea and Taiwan, our wood products can hardly compete with these countries in the world market in terms of product price and quality. The non-competitiveness of our products have been attributed to several factors such as (a) production inefficiency (b) diseconomies of scale; (c) fragmented processing locations, and (d) inefficient shipping ports and bottoms.

To correct the situation, and in order to enable the local wood industry to meet the keen competition developing in the world's wood products market, and at the same time conserve the country's remaining forest resources, the government has launched the wood industry rationalization program.

Program Strategies

To attain the objectives of the program the following strategies have been laid out:

a) Establishment of integrated wood processing centres and phase-out of inefficient and uneconomic-sized mills;

b) Establishment of regional manpower training centres financed by the private sector to produce products that will meet the international standards.

c) Utilization of wood for the production of as many industrial wood products other than those traditionally manufactured products with emphasis on those using wood fibre, such as paper fibreboard, etc.

d) Utilization to the fullest extent of woodwaste for fuel in consideration of the energy crisis and other needs of other wood dependent industries;

e) Improvement of harvesting and processing efficiency by using new and appropriate technologies;

f) Encouragement of the utilization of the lesser-known species.

All circular sawmills regardless of capacity and bandmills with capacities below 10,000 board feet per day, except for a few operated by mining firms, and those operating in remote areas or servicing the raw material requirements of cottage industries, have already been phased-out. Likewise, sawmills which are perennially lacking in raw materials are not allowed to operate.

To encourage local processing of logs, those timber licensees without processing plants and wood processors without back-up concessions are required jointly to adopt any feasible tie-up scheme to be approved by the Minister of Natural Resources. Those who fail to comply with the said requirement by 31st March 1985, will not be allowed to operate.

To ensure local wood processors of adequate raw material supply, the government has implemented the limited and selective log export ban. The aim is to totally phase-out log exportation in favour of finished and semi-finished wood product exports once the economic situation permits.

To maximise the utilization of the timber resource, and at the same time minimize timber drain, timber licensees and wood processors are being encouraged to gather and utilize logging and milling wastes. As an incentive, a minimal forest charge of P2.00 per cubic metre is imposed on logging wastes gathered and utilized by timber concessionaires for fuel or as raw material for wood products manufacture.

Research on the properties and uses of the lesser-known and lesser-used species is being vigorously undertaken by both the government and the private sector. Initial findings indicate that many of these species are potential raw material for pulp and paper manufacture or substitutes for commercially known and premium species for construction purposes, furniture manufacture, and others.

Table 37

Volume and Value of Log Production and Log Wood Product Export

(Volume in '000M^3 and Value in '000 US $, FOB)

Year	Log Production	Logs		Lumber		Plywood		Veneer	
	Volume	Volume	Value	Volume	Value	Volume	Value	Volum	Value
FY 1965-70	49592	3695	906,271	-	-	-	-	-	-
70-71	10680	8443	223,617	-	-	-	-	-	-
71-72	8425	7018	172,253	-	-	-	-	-	-
72-73	10451	6949	201.985	179	73.791	692	54344	107	6180
73-74	10208	5434	240.343	275	148	353	47281	178	3065
74-75	11156	6840	283.164	458	195,572	249	32571	135	12310
CY 1976	8648	2331	135.222	493	68.144	261	43165	166	17882
1977	7873	2047	133.848	455	66,681	221	40,589	155	20071
1978	7169	2211	144.869	573	85.187	362	70.613	154	22278
1979	6578	1248	144,407	915	198,345	324	85,203	186	34590
1980	6352	715	91.997	742	181,210	322	103.843	62	15410
1981	5400	706	76.287	547	125.725	370	110.741	138	31336
1982	4514	752	78.477	591	123.695	242	67,435	98	20247
1983	4430	786	73.680	728	149.087	295	26.678	123	27820

Ref: CJ74

CHAPTER VI

EVALUATION OF THE ASIAN MANAGEMENT SYSTEMS

The country reviews show quite clearly that the tropical mixed forest can be managed in association with timber production as sustainable and near natural systems. Without doubt that is more easily and more often achieved in the lowland Dipterocarp types than in the hill or upland Dipterocarp types and in both groups of Dipterocarp types than in the evergreen types of India. But even the pessimistic assessments of the results of Selection management systems in India are expressions more of the failure to apply the systems than of defects in the systems themselves.

Just as clearly, getting to the point of having a successful management system in place is not easy either. Nor is it easy to maintain the necessary dynamic equilibrium between the interacting and often conflicting elements which have to be taken into account in the management system as a whole. The main message from the Asian experience is that it can be done; that conservation and management of the tropical mixed forests are not necessarily incompatible. On the contrary, it is much more likely that management is the only way to conservation.

That raises, however, two questions. They are:

a) Under what conditions is this result attainable, and

b) Why has that result been attained in Asia more than elsewhere?

The more detailed look that these questions warrant is the main topic of this and the next chapters.

THE CONDITIONS FOR THE MANAGEMENT OF THE TROPICAL MIXED FOREST

From the country reviews it can be deduced that five conditions at least, must apply for a natural management system involving timber production to succeed, in a tropical mixed forest. They are:

a) That after the harvesting of a timber crop, the land remains in forest use.

b) That the harvesting operations be carried out without impairing the ability of the forest to maintain or re-establish a "natural" structure and composition.

c) That the harvesting operations be carried out without damaging the environmental and social functions that the forests serve or without impairing their capacity to maintain those services in the future.

d) That the harvesting is carried out in such a way that adequate regeneration to replace eventually the harvested crop is induced or, if already on the ground, released without damage.

These conditions encompass all the elements of an integrated forest management system - social, economic, technical and political.

a) <u>The Land Use Condition</u>

Full social acceptance of the decision that the land to remain in forest after harvesting is necessary for the decision to be effective. This means that at both official and local community levels, the idea is fully accepted that forestry is a more beneficial form of use for that specific tract of land than any other use. Official recognition is not enough. Experience in both India and the Philippines shows that strongly and repeatedly. Local attitudes are ultimately the real arbiters.

In such circumstances the technical apparatus of land use planning has to take second place to the social pressures for land. It is not surprising, therefore, that the ultimate location of forestry is firmly based on land use planning in Malaysia only, where population pressures on land are the least intense. The planning itself is not without fault. Like most land use planning, it is automatically assumed that agriculture is the highest form of rural land use, an attitude which is consistent with land use planning theory of the 1960's. The result is that a permanent forest estate is constitutionally assured, but on the whole, in the higher and steeper terrain of the country only. Moreover, because of the less intense population pressure and the siphoning off of the demand for agricultural land into the planned settlement schemes, that assurance has a good chance of success in practice.

The situation in India illustrates the other extreme. Formal land use planning played a minor role. The pressure of population on the land was intense, even when management was first attempted and has been continually increasing ever since. The principles underlying forest land reservation in the forest policy of 1894 amounted, however, to a land capability classification giving precedence to agriculture and the rights of local communities except for two classes of forests. They were forests on hill slopes which were to be protected, "To preserve the climatic and physical conditions of the country and to protect the cultivated plains that lie below them" and secondly, "Forests which are the reservoirs of valuable timbers" which were to be managed commercially as a source of revenue for the state (Taylor, 1981; Kulkarni, 1983).

In practice, that policy proved hard to follow. In 1952, the recently independent government of India issued a National Forest Policy in which the extent of deforestation of mountain slopes and the upsetting of water supplies, soil erosion and declining soil fertility were closely linked. The precedence given to agriculture had, it was noted led to the conversion of "Even valuable forest lands for permanent cultivation", while the lightly restrictive interpretation of the rights of use and access accorded to local communities was regarded as detrimental to the national interest and the interests of future generations (Taylor, 1981).

One result of that has been to force forestry departments into a defensive attitude, reflected in legislation and administration. This custodial emphasis has apparently been insensitive to social needs and realities. Another is that in confining forestry departments to resistance to change, it may have retarded advances in land productivity (Romm, 1981). But certainly whatever the effects, the Indian experience confirms that land use planning, regardless of the level of sophistication, is no basis for forest management, if the social pressure to provide land for agriculture cannot be otherwise relieved.

The Philippines, in that respect, occupies a midway position. Intense population pressure on the forests for the land they occupy is much more recent than in India and nowhere near as high. It is, however, more intense than in Malaysia, and has been a strong force in deforestation since well before World War II. At the same time, land use planning is more formalised in concept and application than in India. The same high priority is given to forests as a land use for the conservation of soil and the regulation of stream flow for the protection of down-stream agriculture. In this respect, both India and the Philippines are in sharp contrast to Malaysia, where forestry is a residual use, rather than a priority use for these purposes.

But again, it is the implementation of land use planning rather than its intent that is crucial. Deforestation of land which the land use policy identifies as forest for environmental protection purposes has proceeded so far that reforestation rather than forest management is the need. Even where the catchment forests have survived, the failure of other measures in the economy to relieve the poverty and population induced pressure for land, still shows the social limits to official land use designations.

b) The Logging Operation Conditions

Given that the forested land does remain in forest thus making natural management a possibility, then the manner in which the timber crop to be harvested is removed becomes paramount. The second and third of the five conditions listed earlier, thus amount to saying that the logging operations are conducted in a way that meets the requirements for forest management rather than in the most convenient way for the loggers.

That, however, is really another form of the social element in a total system. The loggers are often regarded as interlopers. The view is, however, just as wrong-headed as the equally common view of local communities as threats. Both are elements which have to be taken into account in the development and implementation of management systems.

Logging is an essential phase in timber production management. Without loggers there would be no timber harvest so that their attitudes, explicit or otherwise, to how a forest management system would operate have to be incorporated in the system.

The question of achieving management control of the logging operation is, however, probably even more intractable than that of the local communities. More often than not, logging crews are made up of people who come from other communities, other tribes and sometimes other countries. With the advent of modern highly mechanized logging systems, crews tend to be full time workers in the industry, moving with the machines from setting to setting, with minimal reinforcement from local people. Their interest in the future of any one are of forest, of any one forest or of the local communities, is likely to be marginal and ephemeral. This poses a formidable obstacle to getting them to adopt less destructive methods, if they cannot see any benefit to themselves from doing so.

But if that cannot be done then it does not matter in the slightest, how good any other aspect of the management is, in principle or in application. Damage to or destruction of trees and advanced growth to be retained, reduced the quantity and quality of the next cut under Selection management; badly located and poorly constructed and maintained roads and skid trails lead to land slips, siltation, local flooding which greatly degrade the environmental protection efficiency of the forest.

The point is that none of that is necessary, either on physical or economic grounds. In fact, it has been repeatedly shown in other parts of the world that better planning and design of logging systems and tight implementation of those plans can raise productivity and reduce costs substantially, compared with the deceptively more convenient, traditional methods. The same has even been shown to apply in the more difficult conditions of tropical forests (Kerruish, 1983).

In none of the countries reviewed, has the control of the logging operation phase of harvesting been as effective as it could or ought to be. There are some local exceptions, but on the whole, it is one of the weakest links in the Asian management systems. In general, what needs to be done is fully realised, but how to bring about the implementation is the real problem. The problem is further compounded by the fact that prescriptions for the control of logging in the interests of management can never be static. Technological advances in logging equipment, changing economic and social conditions affecting logging costs, crews and management objectives plus improvements in silvical knowledge make setting and applying harvesting systems a tricky, dynamic affair.

The ability of the various forest services to keep pace with the growing and changing needs in logging supervision is variable, but generally it is inadequate. What is worse, is that while the need to develop that highly skilled and motivated calibre of staff is usually recognized, the means for putting it into place have been quite ineffective. Good staff qualified in that field then tend to find better employment opportunities and scope for their abilities with the industries. The institutional weaknesses that permit this most crucial point of failure to persist will have to be overcome if the potential for management is to be fully realised.

c) The Technical Conditions

In the historical development of the management of tropical mixed forest silvicultural problems have been dominant over most of the hundred years or so that management has been attempted in Asia. This could hardly be otherwise, since one of the two obvious requirements for a natural system of management is regeneration to ensure continuity of the ecosystem. If that cannot be achieved or assured in conjunction with timber harvesting, then one or the other has to give way. Historically, that has almost never been the harvesting.

The second obvious requirement is that the reduction of the growing stock in harvesting does not exceed the regenerative and growth capacity of the forest. That presupposes a fairly accurate knowledge of the growing stock and its distribution by species, size classes and location and of how they change under harvesting and treatment. Inventory and increment studies, therefore, figure prominently also in that history of tropical forest management.

As a result, much more is known about what could be called the "disturbance ecology" of tropical mixed forests in Asia, than about any other element that affects the development of a management system. Nobody would pretend that all that is needed is at hand. But in the Asian countries reviewed here, there is probably enough to provide that "minimum critical mass" of information for implementing a sustainable natural system of management (Jabil, 1983).

Even so, that level of knowledge is still deficient in many respects. For instance, "Growth and yield statistics on most of the evergreen species are not available. ... No information is available on the annual increment and how much can be removed without endangering the productivity of evergreen forests" (FAO, 1984). But compared with the void that exists in respect of the social elements especially, but also the broader economic and political elements, affecting an integrated management system, even such gross deficiencies on the technical side may be insignificant. Certainly, any claim that the silvicultural and yield regulatory elements in Asia at least are the limiting factors to the advancement of forest management would be hard to sustain.

Yet it seems that almost all of the forestry research in the region is directed towards silvicultural, inventory and utilization problems. There is nothing wrong with that in itself. Indeed, a great deal of research in that direction will be needed to lift sustainable productivity above the relatively modest levels currently attained and to extend management to other types in the tropical moist forest complex.

What is wrong with it, however, is that there are few signs of that effort being matched by a co-ordinated effort in the more decisive non-technical components of any forest management system. There is quite clearly, a considerable amount of work being done on those aspects in the region. Most of it is being done in universities, and other institutes outside the normal forestry sector. Again that is as it should be, but it is not being done as part of any co-ordinated, interdisciplinary effort. Nor is it linked, even moderately effectively, with the development of integrated forest management. On the contrary, much of it has the appearance of being motivated more by single interest objections to multiple use management inclusive of commercial timber production, than by scientific objectivity.

A more effective recipe could hardly be devised for stultifying progress on any side towards integrated management in the tropical mixed forests at any level of social interest.

INTEGRATED FOREST MANAGEMENT SYSTEMS

In a way, it could be argued from the reviews that no great progress has been made in building up management systems for tropical mixed forests as integrations of all the elements involved in, and affected by the ecosystem and its treatment. It is, after all, over one hundred years since the Indian Forest Policy set out the interests that forest management had to serve, and the priorities to be accorded to them. Those are still much the same and, apparently, they are being served no more satisfactorily now than they have ever been. It is clearly one thing to be able to state what a management system ought to do, but quite another thing to devise a management system that will do it. In other words, systems theory and systems analysis are still a long way from being able to guide systems management.

It is, however, unjustified and pointless to criticise the failure in forest management to develop integrated, total management systems for tropical forests. It has not yet been done in any other field of comparable complexity. The concept is good and even useful in providing a short of check-list for management planning but operationally it, goes no further than that.

One thing that is evident from the country reviews is the widespread awareness of the need to take all facets of the social-biological system into account in formulating a management system. That is a first step and a very major one, when it is recalled how little appreciated it was in the region no more than 20 years ago. But it is only a first step. By comparison, moving from awareness to an operational total management system is an enormous stride, and one that has not yet been made anywhere, other than conceptually. Management systems in the countries reviewed are still, at heart, directed towards commercial timber production with social and non-wood issues accounted for as constraints on timber production, rather than as objectives in themselves, and as integral parts of the system.

Nevertheless, within that limited view, some progress is being made in the better integration of those parts of the management system that can be seen as bearing directly on timber production management. A few examples from the country reviews will serve to make the point.

For instance, inventory and resource assessment generally, go further, sometimes much further, than enumeration of commercial trees for exploitation planning. Other products of commercial value are recorded and some attention is given to the products of interest to local communities. Topographical and other physical features that could bear on watershed, and wildlife values are noted as features in those terms rather than as obstacles to logging or roading. Stand assessments are linked to silvicultural and yield regulation considerations by better recording and measurement of trees and stands on which subsequent cuts will depend. Then by paying more quantitative attention to currently non-merchantable species, they not only anticipate technological change which could widen the merchantable range, but provide a basis on which such industrialisation can be planned and managed. Post-harvest inventory has also a broader and more prominent role in monitoring the performance of management systems.

Trends in research parallel those in resource inventory. Projects aimed at providing the information needed to integrate non-wood products and species in management systems are now prominent and important features of most forestry research programmes. Forest hydrology studies are increasing in number and quality. Emphasis in them is being directed towards developing management systems which can incorporate the highpowered, mechanised logging operations dictated by the steep and rugged topography associated with most of the future resource.

AN APPRAISAL OF ASIAN FOREST MANAGEMENT

All of that reads as though all is well with the status of forest management systems in the tropical mixed forests in Asia. That, however, is only partly true. The Malayan Uniform System did work well and did adapt to changing circumstances in the lowland Dipterocarps, and would work in any of those or similar types which happen to survive the onslaught of conversion to agriculture. The Selection systems can work in the upland Dipterocarp and Evergreen types, if applied properly. Moreover, within their limits, they are certainly much more integrated systems that they were in the past.

As far as the modern management systems go they do then represent an advance on what happened in the past. The trouble is that they do not go far enough in three respects at least. One is that they apply as yet to a restricted range only of the types in the tropical mixed forests complex. In Malaysia and the Philippines admittedly, those types account for the great bulk of their tropical mixed forests. In India, however, a substantial part of the tropical mixed forest resource is in the moist deciduous types for which natural management is, for the most part, not considered. Outside the countries reviewed, only Indonesia, and to some extent Indo-China have Dipterocarp forest, to which the experience in Malaysia and the Philippines could apply directly. In the rest of the region the tropical moist forest types bear little resemblance to the Dipterocarp types, although they may have some affinity with the evergreen types. It has yet to be demonstrated that natural management can also succeed in them.

The second aspect in which these management systems fall well short of the optimum is that integration has not ventured far beyond the timber production aspects. Efforts to incorporate, for instance, local communities and refugees from poverty as intrinsic elements in the management systems are more notable for their rarity than for their success. Attention is given to them but it tends to be as specialised markets to be satisfied, or special interests to be mollified or suppressed. Nor, as mentioned earlier, have effective links been established for bringing other sources of information and knowledge relating to these matters, into the formulation and implementation processes of the management systems.

The third weakness is that the management systems are not applied as thoroughly or as universally as they need to be for success. This has not been made sufficiently clear in the country reviews, although some emphasis is given to its importance in the evergreen types of India. Nevertheless, it is evident in the field, that implementation is not always as strict as necessary for success.

Lax supervision and lack of support for enforcement measures which are the usual explanations for such failures are certainly prevalent, but those failures have much deeper origins. They arise, in fact, from the failure of the management systems to integrate adequately the political components affecting system performance.

As a result, utilisation of the forest resource for industrial purposes has proceeded in a way that bears no relationship at all to the capacity of the residual forest to support it. It makes little difference whether the utilisation is caught in the stranglehold of log exports, or was based from the start on processing for domestic and/or export markets, or has belatedly replaced log exports by processed products. The end result is the development of powerful vested interest groups who can exert political and other pressures to have measures aimed at better forest management relaxed, postponed or aborted. Moreover, plausible national interest arguments based on foreign exchange, employment and strategic considerations can always be found to support and prolong temporary departures from acknowledged long term policy.

These are realities of any social system. Forest management systems that ignore them cannot but fail. It is pointless to argue that a particular management system would work if it were not for the political and institutional obstacles to its implementation.

At first sight it might appear that there is no effective way of incorporating that aspect of the political element into a system of natural forest management. After all, overcutting, or cutting (or damage) in the wrong size classes, or logging which destroys regeneration and advanced growth or the capacity of the forest to regenerate must reduce any sustainable yield based on their non-occurrence. That, however, still leaves several possible ways of adapting management to meet the situation. They include:

a) To base the management system on the eventual and possibly sharp decline in output implied by the policy.

b) To develop the management system in terms of the yield being maintained by substitution of less preferred species, smaller size classes and lower quality trees as the resources at current standards are depleted.

c) To develop the management system in terms of maintaining the yield by substituting wood from compensatory plantations.

There are historical precedents for each of these possibilities, and indeed, in the country reviews, that of compensatory plantations is quite strongly pursued. That option, however, is itself an expression of a partial failure in the natural management system, overstrained by industrial development.

WHAT REMAINS TO BE DONE

The obvious improvements that need to be made are those arising from the deficiencies which have just been outlined. However, the better integration of the forest-oriented elements of the system with the less immediate but crucial society determined elements, is particularly difficult in the absence, of any well functioning basis for implementing a fully integrated management system for such complicated social-biological physical complexes. More appropriate is the approach described by Poore (1962) as "Successive Approximation", and which is more or less the way that the management systems have been evolving. There is a need, however, to speed up the pace at which adjustements for the next approximation are introduced and a need for a more venturesome approach as to what those approximations cover.

But the narrow orientation of the management systems is not their only sub-optimal aspect as they now stand. Integration at the forest level is far from complete or even adequate, in at least two aspects. They are where:

a) Components of the systems are not functioning at anywhere near their potential, even within the limits of currently applied technology,

and

b) Performance of the systems might be improved by adaptation or adoption of more advanced technical or managerial technology.

a) Sub-Standard Functioning

The most glaring and dangerous weakness arising from substandard functioning in the management systems at present is in the management control of logging operations. It is also perhaps the one that is most readily amenable to improvement by the forestry sector itself, in that it is least dependent on outside acceptance or authorisation.

Being the easiest does not, however, mean that it is easy. The key is better supervision of better standards. For both of those stronger staffing and deployment are necessary and that is where the catch lies. Staff responsible for the supervision of harvesting need to be trained and experienced in the design, planning conduct and management of logging operations as a phase in forest management rather than simply as a stage in an industrial process. They also need to be located where they can put those qualifications to effective use, i.e. in the field.

To achieve those three attributes - training, experience and location, - remembering that none is much use without the others, some institutional and administrative changes will have to be effected. Training with that managerial orientation runs counter to modern trends in academic education. Experience with that managerial orientation is not readily acquired except by working in or with industry, while public service procedures and urban bias in development discriminate, against locating highly qualified personnel in field positions. But if those obstacles are not overcome, then any effort put into developing, let alone improving, forest management systems is wasted. No management system, irrespective of how well it might integrate social, economic and ecological forces will work, unless it is implemented on the ground by people who want it to work, and can make it work.

At the same time, management systems have to be well attuned to the ecological parameters if they are not to collapse eventually under the weight of deficiencies in those respects. Undoubtedly the most serious weakness in this planning, as distinct from the implementation phase of the management systems reviewed is the fragile, narrow and unreliable data base underlying their yield control provisions.

Ultimately the yield of wood, in any form, that the tropical moist forest can sustain depends on the growth rates of the trees that constitute and will constitute the parts of the forests which will provide the cut. What those growth rates are for the hundreds of species and how they vary with age or size, with canopy position and with different stand conditions and treatments are basic therefore to yield control. The limited information that has been accumulated to date is, on the whole, too fragmentary and often too conflicting, for it to provide even an approximate basis for yield control by volume. The systems for permanent sampling, perpetual and continuous inventory which are being established and extended in the region are a start. But to cover even an adequate selection of the range of possibilities presents a formidable task in terms of the physical installations and their maintenance, of logistics, of measurement and consistency, of data recording, storage, retrieval, processing, analysis and intepretation. So formidable in fact, that it could well turn out to be, if not strictly impossible, then not worth the effort.

It is, therefore, hardly surprising that yield control components of the management systems have not advanced much beyond the area control approximation, or even-flow distributions of gross volumes over time or approximations of the rate of progression through size classes of a few selected species. So far, overcutting in terms of currently preferred species and qualities has been almost universal. But when that cycle has run its course some drastic industrial, economic and social adjustments will be unavoidable. A much wider and deeper understanding of the growth patterns and stand dynamics than is now available or being developed with then be needed.

That knowledge will not have to be anything approaching a complete knowledge in breadth or depth. As for present management, a "minimum critical mass" will be enough, but a different set of knowledge will need to be added to that which supports the currently used systems. To get it by the time it is needed, the investigatory work ought to be well under way now. Since it is not adequate anyhow, a look at the second class of deficiencies in present management systems may give some guide to catching up.

b) Technological Applications to Management Performance

In some aspects forest management systems have incorporated advanced technology almost to the limits of its potential. One case in point is the extensive use of remote sensing in resource mapping, assessment and monitoring. That it has gone little beyond the use of standard aerial photography in Malaysia, as constrasted with the Philippines is striking. As Tang (1983) explains that reflects in part, an initial belief in the adequacy there of basic information as good as that which longer distance sensing seemed likely to provide. But now, he implies the resulting lack of expertise in and familiarity with the more recent technology is limiting the extent to which its greater potential can be utilised to improve resource information.

The three countries have also gone a long way in the application of electronic data handling technology to the recording, storage, retrieval of inventory and growth information. In fact, the periodical and continuous inventory systems that are being put in place both depend on, and are built around, the increasing versatility available from this field of technology.

The enthusiastic and fruitful applicatons on the information gathering and processing side have, however, out-run and over shadowed the adoption of similar technological possibilities for using such data in management planning. The Malaysian forestry planning model (FAO 1972, Alexandratos et al. 1975) was one of the first and, at the time, most innovative development of sector modelling for forestry in the world. Its successful use in resource assessment and co-ordinated rural land use planning has sparked some emulation, at that broad level (e.g. FAO 1978, Svanquist 1980). However, the logical step from the sector to the forest level has yet to be taken.

This is feasible since stand growth modelling is only a more comprehensive extension of stand projection methodology, which has been a standard tool of forest management for a very long time. Moreover, it is an extension made possible by that same computer technology which has been adopted so productively on the data processing side. However, after some tentative explorations for Dipterocarp forests (Canonizado 1978; Salleh 1978) interest in it seems to have lapsed.

Yet on the face of it, stand growth modelling combined with the increasing power of system dynamics theory and modelling to understand and predict the behaviour of complex systems would seem to offer exactly what is needed for tropical forest management. The reluctance to take up the offer is, however, understandable.

For one thing, the informational requirements for even a simple model of a tropical mixed forest must seem virtually unattainable. On top of that it is clear that the performance of any management system is greatly influenced, if not controlled by social and political elements, and these are largely unquantifiable. It is hard to resist, therefore, the conclusion that any such techniques are of mainly academic relevance (e.g. Fontaine, 1982).

Such a verdict may, however, be too harsh and premature. Bragg and Henry (1983) in reviewing the possibilities in relation to the management of the North Queensland tropical rainforests, are much more optimistic. It is a technological application that warrants renewed investigation.

The findings from management science relating to the functioning of organisational and institutional structures have had even less influence. Yet institutional re-structuring of a most drastic nature is almost an absolute pre-requisite for effective progress towards integrated management of the tropical mixed forest in Asia. Inter-disciplinary analysis and action are needed for the integration of non-forest elements into forest management, but the conventional departmental structures cannot accommodate them. Highly skilled, motivated and experienced professional staff for planning and supervision of logging operations are essential for effective timber production management, let alone the integration of wood and non-wood management. But conventional forestry education and training are not well-equipped or motivated to provide them. Nor once trained is the conventional public service system equipped to retain them. Tinkering with the present institutional structures will not cater for the changes needed to overcome deficiencies of these magnitudes.

Unfortunately, long established institutions can, as the study for India repeatedly shows, be remarkably resistant to fundamental changes. A restructuring that starts with the education system, runs through the departmental, civil service and treasury systems, and discards many of the conventions of all of them could hardly, therefore, be easy. But anything less is almost doomed to fail. The major upheavals that have been initiated recently in Australia for re-directing state forestry into a multi-disciplinary, multiple use, multiple interest orientation could repay careful study (Fitzgerald, 1985).

A third weakness in these management systems could be their insufficient or inappropriate incorporation of recent developments in social theory. For the most part, social issues such as traditional rights, uses and customs, shifting cultivation or localised markets are regarded as problems. Solutions to them tend to be sought in plantation programmes. There are some notable exceptions, especially with relatively small tribal groups, but, where substantial numbers of people have been or could be involved, the plantation solution seems to prevail. How long that can continue or whether it is really a good, far less an optimum solution are questions that do not seem to have arisen within the forestry system. There are signs, however, that they cannot be ignored or treated in such an over-simplified manner for much longer (eg. Vadya et al., 1980, Fernandes & Kulkarni, 1983). More fundamentally, however, the possibility that these social forces, rather than being problems, could be harnessed for more durable integrated management, hardly seems to have been considered. Yet, that is exactly what the Taungya system originally set out to do more than a hundred years ago. A return to that field orientation could well be exactly what is needed in tropical forest management.

CHAPTER VII

ON TROPICAL FOREST MANAGEMENT IN GENERAL

THE LIMITS TO EXTRAPOLATION

As a rule it is more dangerous than instructive to extrapolate findings beyond the context from which they were derived. The history of forestry offers plenty of examples of the truth of that axiom, especially with the transfer of European silvicultural and management practices. It could be equally hazardous to apply the experience from the tropical mixed forests of Asian too rigidly to the other tropical forest regions. The differences underlying the superficial similarity in appearance, between the tropical moist forests of Asia, Africa and Central and South America are quite marked, and obvious to all but the most casual observation.

Several quite notable features may make that point. For one thing, there is nothing resembling the Dipterocarp dominated forests of Malaysia and the Philippines in either the African or American regions. The Mora forests of Guyana certainly attain a high degree of uniformity, but it is a uniformity of the one species rather than the one family. Then while some genera are common to all three of the main regions, and even more of two, very few species are. Thirdly environmental combinations of soil and climate within the global range of the tropical mixed forest vary quite widely, and apparently produce in the African and American regions a greater sensitivity to disruption than is evident in South-East Asia. Fourthly, the long term pattern of the development of human activity and settlement in the tropical mixed forests of the three regions has been quite different, and even the exploitation of the forests in the modern area has continued to follow markedly different paths.

With such ecological and societal differences, it is most unlikely that the conditions governing sustainable management will be similar enough anywhere for the experience in Asia to have much direct application. But to go from there and assume that there is nothing to be learned from it would be equally dangerous. At the very least, the Asian experience shows that sustainable, integrated management of the tropical mixed forest is technically feasible. There are two further aspects in which the experience in Asia does give some very useful indications to the management of tropical mixed forests, generally. One of those refers to technical considerations, the other to organisational matters.

TECHNICAL AND SOCIAL INTERACTION

The three country studies emphasise, quite strongly, certain technical problems encountered in bringing the various types of the tropical mixed forests under sustainable management with a timber production orientation.

The review of management in India, illustrates, over a very wide range of tropical mixed forests types, the technical problems of adjusting rotations and silvicultural regimes to rapidly increasing demand for industrial timber and fuelwood. The Philippine review concentrates on the development of inventory systems, to provide the informational base necessary for calculating, planning and implementing a natural system of sustained yield management and its post-harvest monitoring. In Malaysia, the emphasis is largely on the silvicultural problems of adjusting management to the ecologically and topographically difficult hill forests as agriculture forced forestry out of the lowlands.

The emphasis in each case reflects a technical reaction in forest management to changing social environments. It has become fashionable to ridicule this as a typically insensitive technocratic response. But it is the only possible response. The techniques of forest management cannot be applied anywhere else but to the forest. That is the only way in which the development of a forest can be directed towards whatever objectives forest management should be trying to achieve. What it should be trying to achieve is however, a social choice, not a technical one. The technical content of the choice is confined to defining the limits within which it can be made. Often that choice has had to be made during the process of forest management because of the failure of those responsible for the making of social choices to do so firmly and unambiguously, with respect to forests. Leaving the choice of the objectives of forest management to the managers invites a technical bias and almost excludes the possibility of an in depth analysis of the social needs of the future.

The second lesson of general application which emerges from these case studies is therefore a twofold one. In the management of the tropical moist forest, objectives must be defined, but they must be defined from social requirements, within the limits of what is technically possible, not the other way round.

LAND USE PRINCIPLES

The primary social consideration bearing on the management of the tropical mixed forest concerns the ultimate use of the land occupied by the forests at present. Land use classifications tend to rate agricultural uses as higher forms of land use than forestry. The Malaysian land use policy illustrates this principle in force quite clearly. Yet there is no absolute or scientific basis for that hierarchical system. On the contrary, it can be demonstrated that forestry would be a much better form of land use even on prime quality agricultural land in certain circumstances. And certainly in mountainous terrain, forests provide much more effective catchment protection than most forms of agriculture, and better stream flow regimes than most engineering remedies to catchment mis-use can provide. The Indian and Philippine case studies bring out this aspect quite clearly.

In spite of the fairly obvious common sense of such precautions in land use, the forest, it seems, inevitably gives way to agriculture wherever food production is a dominating social or political necessity. Even the well known fact that massive and expensive reforestation will eventually be necessary to repair the widespread social and infrastructural damage from unbridled forest clearance, cannot stop the process. India and the Philippines add to the already ample historical demonstrations of this phenomenon. In such circumstances, land use planning without land reform would seem to be pointless.

Nor, does an unrelenting opposition to encroachment have much future. The solution lies mainly in a much broader social milieu than that affected by forestry, although forestry can be a part of the solution. The proper role of forest management in such circumstance has two functions. The first is to facilitate a more orderly transfer of land use so that the wood from the forest clearances is utilised rather than wasted. The second is to develop viable agro-forestry systems in situations where straight agricultural development will lead to soil and watershed degradation in situ and downstream. The Malaysian experience has some relevance to the first, and the Philippine work in agro-forestry settlement indicates some possibilities in the second.

Where population and poverty are not so crushing, the opportunity may exist for a reasoned approach to land use planning and its implementation. This was, and to some extent, still is the situation in Malaysia. There, land use planning, although predicated on the false assumption of the invariable superiority of agriculture, has left an identified and reasonably secure resource base for the management of the tropical mixed forest. In that respect, it offers, with appropriate adjustment to the system for ranking land uses, a pattern that could well be emulated in countries enjoying similar circumstances.

SILVICULTURE AND YIELD

In an overall assessment of the management of tropical forest management, Masson (1983) in addition to some very pertinent observations on the land use question, points to a number of serious weaknesses on the technical side. They provide an instructive basis for evaluating the general applicability of the Asian management systems at this level.

A forest management system must integrate three sub-systems - the forest, the society and the means by which the needs of the latter are linked to the potentials of the former. Each sub-system is, in turn, a complex system of dynamic inter-active elements and sub-systems. Forest management has traditionally been concerned more with the forest and technology sub-systems. On the whole, the needs of society have been taken as given or as little different from those of the immediate past. To a degree, the limited and sporadic success with attempts at management of the tropical mixed forest can be traced to that simplistic treatment of the social sub-system. However, even if that had not been so, knowledge of the functioning of the forest eco-system could easily become the limiting factor. The forest eco-system is far from simple, even in the extreme case of monoculture plantations. The amount of research effort still devoted to them is evidence enough of that. The tropical mixed forest eco-systems are so many orders of magnitude more complex, that the chances of bringing them under sustainable management could easily be dismissed as non-existent.

Fortunately, the Asian management systems show that sustainable management under timber production does not require anything approaching a full understanding of the relationships and dynamics of the eco-systems. But it does require more than the elementary or superficial knowledge that, for the most part, rules outside some of the Asian tropical mixed forests.

Of fundamental importance in that respect, is the need to distinguish between management that achieves sustainability by the release of regeneration and management that depends on inducing regeneration for continuity (e.g. Wyatt-Smith, 1959). The Malayan uniform system and its development is a text book example of the success of a shelterwood system based on the release of already established regeneration of the desired species. Some of the areas in which natural systems were technically successful in India seem also to be more of releasing than inducing systems. It also seems quite likely that the forms of selection system developing for the hill Dipterocarp forests are, in the main, regeneration release systems.

The disappointing results of the early attempts to transpose the Malayan uniform system to West Africa, where the canopy opening led more often to climber tangles than to established regeneration (Kio,1981), show the high degree of sensitivity to this distinction. A very substantial jump in the uncertainty, as well as the difficulty of management is clearly associated with systems depending on induced regeneration as compared with release. So much so, that it could well be that the Dipterocarps are a fortunate exception; perhaps one of the few types of the tropical mixed forest, in which, given the present state of ecological knowledge, natural management systems can be confidently advocated and put into effect.

The results discussed in the review of management in India show the difficulties quite markedly. There, unreliability of regeneration reinforced the trend towards plantations. Pessimism about the prospects for the management of the tropical mixed forest where regeneration is not readily assured, might therefore be justified. Fortunately, there are several indications to the contrary.

The tropical shelterwood system in West Africa, developed by adaption from the Malayan Uniform System did, according to Baur (1964), lead to more often than not, to the successful establishment of a satisfactory second crop. Moreover that crop had all this signs of being a more productive one than the forest it replaced. More recently Kio (1981) has argued that the tropical mixed forest in West Africa can be managed under natural systems depending, partly at least, on induced regeneration. Two things seem to be required. They are:-

a) Some quantitative information on the dynamics of response to treatment has been collected, analysed and applied.

b) The patience to wait until the regeneration processes have had time to work instead of rushing to hasty conclusions on the basis of early results.

The latter point links to the uneasiness expressed, especially in the Indian review, but still evident in Malaysia and the Philippines, regarding the low yield of the natural tropical mixed forest. The industrial problems and economic questioning that its low yield can lead to, can eventually overwhelm natural management. India provides an instructive example of this course to an advanced degree. Although overcutting is most serious in respect of plywood logs, and in certain regions of the country, the outlook is for the overall demand for industrial wood alone to exceed by several times the expected sustained yield capacity of the whole of the tropical mixed forests, by the end of the century. Such conditions, severely stress the functioning of proper management systems. Moreover, shortening of rotations and felling cycles will inevitably reduce the resource base and its productivity progressing in a vicious cycle to liquidation.

For other regions the message then is clear. Yield enhancement measures need to be investigated and initiated from the earliest stages of management. Increased utilisation of the lesser-known or lesser-used species could be part of the solution (Tisseverasinghe 1981; Freezaillah, 1984). But the possibility that greater use of those species could lead to heavier cutting and more concentrated logging, which may be ecologically inappropriate, could as Freezaillah (1984) also points out, make it counter productive. Tisseverasinghe (1981) on the other hand, is of the view that such more intensive utilisation is the key to management. Concentration on the lesser known species as the channel to improved yield may therefore be part of the answer without being the full answer. Efforts to increase increment on the presently used species are therefore indicated.

The prospects for achieving an increase in that direction are, from the Asian experience, hard to assess. The evidence is at the best, non-commital if not discouraging. Nicholson (1979,1985) is extremely sceptical of the chances of raising the increment of the Dipterocarp forests to more than 2-3 m^3/HA. The fact that after a century or more of management in India, the average increment for the natural forests is still only 0.5 m^3/HA., suggests that Nicholson's maximum may be an optimistic estimate. Even if it is not, it is certainly going to be very difficult to achieve. Palmer (1975), although not quite so despondent, hardly suggests major increases are in sight.

There are two points worth making with reference to that rather dismal assessment. The first is that the increments are measured in terms of industrial wood currently harvested, and that is a relatively small fraction of the wood actually grown. The second is that if the average increment in India could be raised to the lower end of the presumed maximum range, then the problem of over-cutting in industrial wood, would be virtually overcome.

The prospect is therefore much less dismal than a simple comparison of the postulated maximum with alternatives would suggest. Even then, the fact that plantations, when they succeed, show five to ten fold increases in increment over the fully-managed tropical mixed forest is a hard criterion to overcome. It is however, strictly relevant only where the quantity of wood production is the sole criterion, irrespective of quality, value or variety. The sort of situation, in other words, that might apply for socially oriented fuelwood management under conditions of acute distress. Otherwise the comparison must extend to a wider value orientation, including non-wood products. In those terms natural systems may be much more productive than plantations. (Fernandes, 1983).

The enhancement of increment by increasing the growth rate of individual trees and stands, depends ultimately on the results of long-term, detailed investigations of their responses to a wide range of treatments . As Fox's observations indicate, the variable and erratic nature of behaviour so far recorded, means that any programme of such studies will be complex, prolonged and expensive.(Fox 1970). In the short-run however, a substantial lift in recorded increments could be achieved by more intensive utilisation of the trees felled or damaged under the present rather selective regimes. It is rare for more than 25 to 30% of the volume standing in tropical mixed forest to be removed, and considerably less is actually utilised (Self & Trenaman, 1972, Catinot, 1974, Masson, 1983). A marked and immediate improvement in the economics of management could presumably be achieved, simply by a market diversification programme, combined with more effective supervision and control of logging.

This latter consideration is of the greatest significance. One of the serious threats that this view of the low productivity of the tropical moist forest poses to their management is that it cannot be justified in economic terms. Superficially, it is a hard charge to deny. Long rotations combined with low final mean annual increments require almost impossibly high average stumpage rates to break even, no matter how low the management costs and interest rates applied in the calculations. There are, of course, many things wrong with comparative evaluations of management systems for the mixed tropical forests, in terms of their out turn of industrial wood at current price gradients. (Leslie, 1977). So many, that it is almost inconceivable that policy could be predicated on them. But it is, and it is still urged that it should be (e.g. Spears 1979). More effective utilisation and more realistic pricing of the commercial wood produced would go some way towards correcting that bias. Neither call for much greater technical knowledge than is already available for tropical forests anywhere. They may however require institutional changes before they can be put into effect.

INSTITUTIONAL REFORM

Some of the technical findings of general relevance to the management of tropical mixed forests could be applied independently of the institutional and organisational framework. The relative lack of information relating to measures for the augmentation of increment, for example, cannot be attributed to institutional factors or failings in the countries reviewed. Many of the deficiencies in the Asian management systems are however institutional in origin. They would limit, just as much, if not frustrate, attempts at management in any tropical forest region should they exist or be allowed to develop.

One - land reform - has been mentioned earlier. Two forms in which institutional restructuring in that respect may be a pre-requisite to integrated forest management stand out. One is the land ownership pattern which forces subsistence farming into more widespread and more frequent forest clearing, despite the existence of substantial areas of already cleared land which could contribute much more to local food supplies. This is the institutional form of land use on which most land reform proposals have been predicated. Where it applies, rural land reform to relieve the pressure on forested land could well be the necessary condition before forest management is feasible.

The second form-communal land ownership-may involve institutional reform of a different nature. In this case it may not be so much the institutions itself that is in need of reform, as the attitudes to it of the super-imposed western style institutions of government. As a rule these have taken the view that communal land ownership is an obstacle to rational land use and development. Consequently the approach has been either to overthrow it, as happened in India and the Philippines, or to modify it, so that land use and management could proceed as the government organisations thought best, without the impedance of communal ownership.

That the difficulties experienced with the implementation of these approaches have become more overt in recent times (Fernandes & Kulkarni, 1983) suggests that the opposite approach might be more fruitful. Communal land ownership and the social systems associated with it, are very powerful means for exercising co-operative community action. To a large degree, all that prevents this social force being mobilised for more durable and effective conservation and management of the tropical mixed forest, is the institutionalised perception of it as a problem.

To change that perception to one in which communal systems are viewed as opportunities, does not, in itself call for any major organisational re-structuring. To act on the changed perception may. Wherever western legal and communal institutions have been super-imposed they tend to over-ride customary institutions in the event of conflict. In such circumstances the ability of a forestry administration to reverse the relationship of its own volition, is very limited. Even arrangements that ought to be matters of internal administration are constrained by society-wide institutional implications. For instance, it is widely recognized that effective integrated management calls for the most highly qualified, experienced and motivated personnel to be working in the forests. But that cannot be effected by a forestry administration on its own, within an overall institutional and social structure whose rating and rewards system is urban biased (Lipton, 1977).

The incorporation of inter-disciplinary informational sources and views into integrated management planning; the participation of affected and interested parties and social groups in the design and implementation of integrated management; the decentralisation of decision authority to accommodate local variations in ecological, economic and sociological determinants of management are further examples of the institutional flexibility that is necessary to meet the multiple objective, multiple interest nature of integrated forest management. None of them is readily accommodated within the standard forms of governmental organisation.

In this area, the Asian countries reviewed have some elements to offer of general applicability. The Malaysian National Forestry Council is of obvious relevance to federal states; The Philippines' approach to rural development problems could be transferable where agro-forestry formulations are being sought and the Indian Forestry Development Corporations could provide models for accelerated plantation programmes. But, by and large, the institutional structures have to be changed significantly if integrated forest management is to succeed in the region.

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