Forestry has an important role to play in nature tourism (Laarman & Durst, 1987) which requires efficient management of the natural resources and an understanding of the role of trees in the ecosystem. Many forested areas are suitable for ecotourism. Facilities available within the national parks are generally adequate for this purpose. If managed on a commercial basis, they are able to cater for both domestic and international tourists (Yap, 1992). The potential of ecotourism in Malaysia is enormous. It can serve a dual purpose of enhancing public awareness and appreciation of aesthetic conservation efforts as well as the ability to tap an economic return from the forested areas without excessive damage to the natural beauty and resources.

5.0 DEVELOPMENT OF FOREST MANAGEMENT

The forests in Peninsular Malaysia have been systematically managed since the beginning of this century when the first Forest Officer was appointed in 1901. Over the years, ecologically and environmentally sound forest conservation and management practices have been developed to ensure forest renewal and sustainable yield of timber and other products. The earlier silvicultural management systems were primarily concerned with improving the existing timber crop for future exploitation. Very few timber species were harvested, then, and trees were felled selectively according to the requirements of good forest management, such as the removal of the overmature trees, and those which might compete with favoured species (Thang, 1986).

Market demands, however, increased tremendously after 1960s and coupled with aggressive land development projects and nation-building after independence, over-exploitation was rampant. This led to a crisis situation whereby it was forecasted in 1980 that by year 2000, Malaysia would become a net importer of timber as opposed to enjoying the status of a top exporter, then. If this happens, the balance of trade would certainly be affected and, subsequently, the wood-based and related industries would either be forced to scale-down or close down altogether. This could lead to retrenchment of workers and higher prices of timber products. The social, economic and political implications of the consequences should never be underestimated. In fact, rumour was rife that the timber trade was destined to be a sunset industry and timber merchants were busy diversifying into other trades. Positive measures, however, including intense research activities and reduction of the allowable annual coupe, were undertaken to face and prevent the impending timber crisis from happening in the country.

The great concern regarding forest management in Malaysia, can best be understood by tracing the past developments of previous silvicultural and management practices. The history of forestry practices can be conveniently divided into three major eras, namely: the Pre-World War Era (Before 1940); the Pre-Independence Era (1940 – 1957) and the Post-Independence Era (After 1957). These periods were marked with very distinct and interesting political, technological as well as economic developments which, to a large extent, have affected the management of the Dipterocarp forests in the country.

5.1 The Pre-World War (Before 1940)

The first Forest Department in the then 'Malaya' (now Peninsular Malaysia) was formed in 1883 under the Control of the Singapore Botanic Gardens to cover the Straits Settlements which included Malacca, Penang and the Dindings (now part of Perak). From 1895, this duty was transferred to the Land Office together with those of the forests in the then 'Federated Malay States' until 1901 when the Malayan Forest Service was established to serve all the 11 states in the Peninsular.

The early forest operations in the country placed special emphasis on the natural reproduction and stand improvement of lowland forests rich in *Palaquium gutta* trees and other valuable hardwood timbers such as Merbau *(Intsia palembanica)* and Chengal *(Neobalanocarpus heimii)*. The *P. gutta* tree was felled for its latex (getah taban) which fetched high prices during those days and became a major export-earner of the Federated Malay States until the early 1920s. Other species of the same *Palaquium* genus were also utilised for their latex such as *P. maingayi* for its 'getah sundex' and *P. obovatum* for its 'getah putih'. The exploitation of naturally durable heavy hardwood in the State land forests was, however, essentially on a small-scale basis due to lack of mechanisation and the very restricted demand. Plantations of *P. gutta* and rubber *(Hevea brasiliensis)* were also tried besides enrichment planting of Chengal.

During the years 1910 to 1915, a series of stand improvement felling and silvicultural treatments were designed and carried out on a trial-and-error basis with the objective of favouring the growth of *P.gutta* poles and other more valuable timber tree species. Some of these treatments were found to be successful leading to the recommendation that natural regeneration should be preferred to planting. After 1915, few departmental works were done owing to shortage of staff during the First World War and the economic slump of the 1920s. By 1926, the various tending and felling operations were conveniently divided into three distinct classes for different objectives:

(i) Departmental Improvement Felling
The operation here is to assist the most preferred trees of certain ages by removing inferior species.

(ii) Departmental Regeneration Felling
The intention here is to assist new natural regeneration of the most preferred tree species by removing the inferior species before the felling.

(iii) Normal (Commercial) Regeneration Felling
The operation is for similar purposes as (i) and (ii) but contracted out to other agencies at a profit.

The Departmental Improvement Felling went out of favour by 1932 (Hodgson, 1932). While 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 eight to ten years. The 'Seedlings Felling' system was formulated in 1927 and required a five-year regeneration period with several clearings. This operation involved the gradual removal, in several stages, of the inferior species before the felling of the useful species was permitted.

These commercial operations supplied a market for firewood and for added revenue to the Forestry Department. The sequence of operations is outlined in Table 5.

Table 5: Sequence of Operations for Commercial Regeneration Felling

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

Regeneration Felling 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 in revenue, coupled with costly girdling operations, resulted in the evolution of a cheaper and more efficient in tree-killing operations by the use of an aqueous solution of sodium arsenate poured into a shallow frill-girdle round the tree. The Departmental Regeneration Felling, then, became known as Regeneration Improvement Felling (RIF), and correctly this should only be applied to the departmental operations (Table 6). However, it appeared to be a standard practice to refer to either type of regeneration inducement as RIF, in view of the considerable 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, there was a severe decline in the demand for firewood due to the introduction of other fuels. However, the development of medium-powered sawmills and the shortage of supplies from accessible State Land forests had led to an increasing demand for timber from the Forest Reserves and less selective timber exploitation and to the evolution 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 that cleaning of the regeneration carried out after exploitation was completed, in contrast to the pre-treatment involved, combined with poison-

Table 6: Sequence of Operations for Departmental Regeneration Improvement Felling (RIF)

Year	Operation	
n	GC1	First girdling of inferior species and cleaning
n + 3 or + 4	GC2	Second girdling and cleaning
about n + 5	C3	Cleaning, if necessary
about n + 7	F	Final felling of marked trees

girdling of the remaining large trees would ordinarily suffice. There was also a general introduction of cheap poison-girdling by the application of sodium arsenate at 0.25 – 0.5 kg per litre of water to the frill (Mead, 1940).

In 1938, a scheme was devised on an all-Malayan basis, of setting aside a total of about 404,860 ha. of reserved forests for the purpose of intensive management for the future timber requirements of the country with the assumption that each hectare, if areas rich in primary hardwoods were chosen, would produce an average of 0.70m^3/ha of primary hardwoods and 2.8m^3/ha of other timbers annually. One third of this area was supposed to be managed for Heavy Hardwoods and the other two-thirds for Medium and Light Hardwoods. The ambitious plan, however, did not materialise for various reasons, particularly in relation to the Japanese occupation during the Second World War in the early 1940s.

5.2 The Pre-Independence Era (1940 – 1957)

During the period of the Japanese occupation of Malaya from 1942 to 1945, there was considerable destruction of accessible forested lands due to the conversion into agricultural land for food growing. About 14,200 ha. under regeneration felling and 5,300 ha. or nearly half of the fully regenerated forest, then, were destroyed. Uncontrolled timber exploitation on State Land forests and in Forest Reserves occurred and no silvicultural operations were carried out.

After the Second World War, the RIF was discontinued because of the increased demand for raw materials with increasing number of sawmills and the use of heavy machinery in harvesting. Moreover, it was observed that many of the untended clear-felling made during the Japanese Occupation, and that of the suspected 'storm forests', contained adequate advanced seedlings regeneration which were present on the ground at the time of felling. These seedlings had survived undamaged and had grown rapidly to form the dominant crop without any assistance while the slower growing 'economic species' had formed the sub-dominant crop. Seedlings already on the ground were also observed to respond immediately to a sudden drastic canopy opening. This led to the formulation of the Malayan Uniform System (MUS) in 1948. It is basically a system for converting the complex lowland

dipterocarp forest to more or less even-aged stands containing more commercial species (Wyatt-Smith, 1963).

The mature crop is harvested in one single felling of all trees above 45 cm. dbh for all species. This allows the natural regeneration of varying ages which are mainly the light-demanding medium and hardwood species. The felling operation is followed by a poison-girdling operation of defective relics and non-commercial species down to a minimum of 5 cm dbh. A linear strip sampling is carried out at least five years later to verify the presence of sufficient regeneration and to determine suitable silvicultural treatments.

The success of the MUS system depends on the presence of adequately well-distributed stocking of seedlings of economic species at the time of felling; complete removal of the original canopy through poison-girdling of all remaining large trees and other species considered as non-commercial down to 5 cm dbh.; no tending of re-growth is necessary; maintenance of good new canopy to prevent the redevelopment of climbers; and linear samplings carried out at regular intervals to assess the regeneration status of the seedlings. The normal sequence of operations under the MUS is shown in Table 7.

The end of the 1940s and early 1950s saw a great increase in world demand for timber. The introduction of preservatives and timber treatment technology coupled with research intensification of the mixed unclassified timber resulted in a large surplus of unacceptable timber in the market. The demand for inland firewood during the period was, on the other

Table 7: Sequence of Operation under the Malayan Uniform System

Year	Operation
n - 1½	Linear sampling (2 m 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.

hand, reduced virtually to nil. Towards the end of the 1950s, plans were drawn up which showed the future requirement in Peninsular Malaysia of an overall productive forest estate of 3.24 million ha.

5.3 The Post-Independence era (After 1957)

With the achievement of independence in 1957, there was a great revival in silvicultural interest and activity. The "Manual of Malayan Silviculture for Inland Forests" (Malayan Forest Record No. 23), which subsequently became the most important source book of Malaysian silviculture and management until today, was published in 1963.

The early 1960s also saw a tremendous drive in rural development resulting in a great pressure on the accessible Lowland Forest Reserves, most of which were then under regeneration. Concerns were expressed as some State Governments began exploiting State Land forests for conversion to other non-forestry activities. The operation of the National Land-Use Policy based on the Land Capability Classification (LCC) which was adopted in 1964, had pushed forestry to the hill forests and those on the non-agricultural soils in the lowlands. Unfortunately attempts to apply the MUS to the hill forests met with failures due to the inherently different character of these forests as compared to the lowland dipterocarps. The terrain was more difficult, the stocking was uneven, and the natural regeneration on the forest floor was insufficient before logging. Seedling regeneration after logging is also uncertain because of irregular seeding from potential mother trees, sometimes at intervals of several years (Whitmore, 1975) and heavy seedling mortality due to felling damage on steep slopes and the poor viability of *Shorea curtisii*, the main commercial species in the hills (Burgress, 1968, 1971). Other factors, including the danger of erosion on steep slopes and the incidence of *Eugeissona triste* (Bertam) 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 in the hill forests and it is not always possible in practice to delay harvesting until there is adequate regeneration present on the ground. Under the MUS pre-Felling (Pre-F) sampling is mandatory but this is often not practicable in the hills until after the harvesting operation. Thus, in the hill forests the MUS has to be modified in various ways, in the light of experience over the first decade of implementation (Baur, 1964). The general pattern of the sequence of operations of the modified MUS is shown in Table 8. This modified version is still being used today in some States.

Realising the urgent need for further research into the silvicultural and management of the mixed Dipterocarp forests, particularly at high altitudes, a project was initiated to study the ecology of the hill forest and to devise a silvicultural system for their natural regeneration after timber exploitation. The study concluded that forests of 45 degree slope and steeper are impossible to regenerate and should not be exploited. However, the lower hill-slope and valley-bottom forests where the timber stand is low can be harvested and regenerated by artificial means through enrichment planting (Burgess, 1970).

In 1972, the Bi-cyclic Felling System (BFS) was introduced in anticipation of replacing the Modified MUS. The BFS was based on a rotation of 50 years with a felling cycle of 25 years. However, due to several reasons particularly with regard to its lack of universal applicability in the highly variable forest conditions encountered in Malaysia, the BFS failed to gain sufficient footing. On the other hand, towards the middle of the seventies there was a shift towards a more 'conservational approach' to forest management and a stronger emphasis on multiple-use forestry, and everyone knew that a new development was about to happen again.

Table 8: Modified Malayan Uniform System

Year	Operation
n - ½ to n - 1	Enumeration data of trees greater than 35 cm dbh as required for premium determination only (10% sampling intensity). 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 + 5 to n + 5	Linear Regeneration Sampling (5 m x 5 m) to determine appropriate silviculture treatments. Generally, poison-girdling of all dbh and climber cutting. Retention of advanced-growth of potentially commercial stems.
n + 20	Linear sampling of regenerated forest to determine status of the forest.

Forest land clearance and conversion to agriculture gained momentum and peaked in 1976 during which year the rate of forest removal hit a figure in excess of 404,860 ha a year. Thus the need to conserve and 'defend' the forests and to arrest the speed of forest alienation was felt even more. The concern and interest in the predicament of the Dipterocarp forest swept through a cross-section of Malaysian society as well as the international community and this did, to some extent, influence the policy-makers' decisions. Appropriate measures were taken to reduce the rate of forest removal as well as environmental conservation.

Since 1952, forest administration and management were guided by the Interim Forestry Policy which was adopted as the National Forestry Policy only in 1978. However, due to the recent emphasis on environmental issues, particularly that relating to global warming, the National Forestry Policy was revised in 1992. Meanwhile, other policies and strategies have also been formulated specifically for forest management, development, silviculture, research and industries.

Technological innovations and sophistication in wood-processing, coupled with the changing pattern of wood utilisation, have resulted in the current management policies favouring timber harvesting regimes that are more flexible, consistent with steps to safeguard the environment, and at the same time take advantage to the demands of the timber market (Darus, 1983). The Selective Management System (SMS) was, therefore, formulated as a more cautious approach to managing the hill forests and to accommodate these changes. The concept and philosophy underlying this system are in accordance with the 'conservational approach' to hill Dipterocarp forest management.

Basically the SMS is 'the application of cutting regimes (minimum cutting limits) over a specified area of forest that will yield an economically viable amount of timber while retaining adequate advanced regeneration for future economic cutting cycle in the shortest possible time' (Griffin and Caprata, 1977). It was developed to meet the following requirements:

(i) to allow flexibility in managing the highly variable forest conditions and the changes in the socio-economic environment;

(ii) to enable decisions be made more rationally, based on the inherent characteristics of the forest and the prevailing socio-economic conditions;

(iii) to allow for the optimisation of forest management goals, namely, on economic cut, sustainability and minimum cost.

Thus, SMS is designed to optimise the management objectives of economic and efficient harvesting, sustainability of the forest and minimum forest development cost, under prevailing conditions. It requires the selection of management (felling) 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 maintain 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 that are being measured as follows:

(i) inventorise all tree species 5 cm dbh and above and tree species having a dbh of less than 5 cm dbh but having a minimum height of 15 cm and above, by dbh class, species, and volume/stems per ha;

(ii) note incidence of weed species and climbers;

(iii) note physiography by slope, elevation, soil types and 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 optimise the stated goals. Colour-coded stock maps which enable the sub-division 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 allowable annual coupe reduced, while higher growth rates would lead to a shorter cutting cycle and higher allowable annual coupe.

A series of one hundred continuous inventory plots, each of 0.4 ha were established in logged-over hill forest. The following growth data was observed (Wan Razali *et al*, 1988; UNDP/FAO, 1978).

(i)	Diameter growth in cm/year:		
	(a)	all marketable species	0.80
	(b)	dark/light red Meranti	1.05
	(c)	medium-heavy marketable species	0.75
	(d)	light non-Meranti marketable species	0.80
	(e)	non-marketable species	0.75
(ii)	Gross volume growth in m^3/ha/year:		
	(a)	all marketable species	2.20
	(b)	all species	2.75
(iii)	Gross volume growth per cent:		
	(a)	all marketable species	2.1%
	(b)	all species	1.9%
(iv)	Annual mortality per cent: (of marketable species)		0.9%
(v)	Annual ingrowth per cent: (of marketable species growing for trees over 30 cm dbh limit)		0.6%

The economics of logging in Peninsular Malaysia is still not well understood because of the lack of definite economic studies under the various logging systems. However, based on current log prices, the estimated cost of logging and government charges, the minimum economic cut should be in the range of 35 m^3 to 40 m^3 per ha of currently commercial and utilisable species. Net volume is derived from its gross volume minus 40% for trees having dbh less than 60 cm, and minus 30% for trees having dbh greater than 60 cm.

Forest planning and operational studies carried out so far in Malaysia have clearly indicated the feasibility of continuous and economically-viable hill forest production in terms of economic log-out-turn volumes. Periodic cuts are every 25 – 40 years using locally-appropriated cutting limits and leaving adequate number of medium-sized trees of marketable species for natural ingrowth into commercial sizes. It has been shown that, with an average growth rates of trees of over 30 cm dbh of 0.8 – 1.0 cm per year in diameter and 2.0 – 2.5 m^3/ha. per year in commercial gross volume, about three-quarters of the hill forest is capable of producing every 30 years about 40 – 45 net m^3/ha which is about the current average out-turn level of virgin forest (Thang, 1987). However, it is imperative to curtail 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 (SMS) in Malaysia. First, this type of management requires concentration of operations on a large-scale using mechanised equipment, and provides higher employment and job diversification. These operations will become increasingly sophisticated and would enhance the prospect of transferring technical and organisational skills to local communities. Secondly, the large land development schemes which is expected to continue in the 1990s release large amounts of utilisable wood material readily available to the

Table 9: Selective Management System (SMS)

Year	Operation
n - 2 to n - 1	Pre-felling forest inventory using systematic-line-plots and determination of cutting regimes (limits)
n - 1 to n	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.

industry. The extensive tree-crop plantations of rubber and oil palm annual replanting schemes also provide excellent source of wood (fibre) materials with the potential for industrial processing to compensate for the expected decline of wood materials from the PFE under the SMS. The sequence of operations under the SMS is shown in Table 9 (Thang, 1987).

6.0 REVIEW ON APPROACHES TO SUSTAINABLE FOREST MANAGEMENT

The management of tropical rainforests, including those in Malaysia has of late been the focus of world attention, especially in the developed countries. The major concern is the alarming rate of tropical forest deforestation worldwide, which was reported to be as high as 16.8 million ha annually for the period 1981 – 1990. It is now realised that forests are important, amongst others, for carbon dioxide fixation preservation of biological diversity and the maintenance of an equable climate. Concern has also been raised that the tropical forests will be completely depleted in the near future and hence, there has been an unfortunate tendency to discourage the use of tropical timber in Europe and North America.

6.1 Policy and Strategies

In the endeavour to ensure sustained development of the forestry sector in Malaysia and as a supplement to the National Forestry Policy, the following explicit management and conservation policy and objectives have been formulated and adopted for implementation, especially in Peninsular Malaysia:

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