WILL THE MANAGEMENT SYSTEMS FOR HILL DIPTEROCARP FORESTS, STAND UP?

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APPANAH, S. & WEINLAND, G. 1990. Will the management systems for hill dipterocarp forests, stand up? The hill dipterocarp forests of Peninsular Malaysia are managed under the Selective Management System (SMS), a variant of the Selective Fellings practised in Indonesia and the Philippines. Much controversy prevails over the capacity of the SMS to manage the dipterocarp forests. In this paper we review the silvicultural content of the SMS, recognising that a management system is as good as its silviculture.

The silvicultural core of the SMS is the retention of advanced relicts, which grow into the next crop and in addition provide much of the seedling regeneration. There are many limitations as a result: in dipterocarp forests the middle sizes of trees are not well represented; and they may not all be superior, and respond rapidly to logging; logging is not sensitive to variations in the stands; logging damage is usually heavier than projected; future regeneration may not be evenly distributed, or adequate; and the selective removal of dipterocarps may mar the sustainability of yield following the second cutting.

Several measures can be taken to improve the silvicultural content of the SMS. They include stratifying forest into productive and protection units, improving felling and hauling techniques, leaving seed trees, replanting denuded areas, and tending the young regeneration still surviving.

Key words: Malaysia - dipterocarp forests - management - selective fellings - residuals - increment - damage - regeneration

Introduction

That people have a right to exploit their natural resources for purposes of development and a higher quality of life is axiomatic. A case to cite will be North America where timber from natural forests fueled much of its early development. Many countries in southeast Asia are currently exploiting their timber-rich dipterocarp forests for the same purposes. Moreover, all these countries clearly desire to exploit their natural forests on a sustainable basis, in a way that "provides regular yield of forest produce without destroying or radically altering the composition and structure of their natural forest as a whole" (Wyatt-Smith 1987). The sustainability, however, is becoming very disputable.

Sustainability of forest resources, of course depends on sound management, which is dependent on good silvicultural practices well implemented. So the heart of the matter for scientific enquiry is the silviculture of dipterocarp forests, the theme of this paper. This may perhaps be best illustrated by the situation in Peninsular Malaysia.

In Peninsular Malaysia, the dipterocarp forests form the largest forest formation, covering about 5.62 million hectares, and the freshwater swamp and mangrove swamp forests only about 0.57 million hectares. In the Permanent Forest Estate, the major portion of the dipterocarp forests are from the hills and inaccesible areas (Table 1). These dipterocarp forests are managed under the so-called Selective Management System (SMS).

Table 1. Areas of natural woody vegetation in Peninsular Malaysia (MPI 1989)

I) Distribution and extent of major forest types in Peninsular Malaysia (million *ha*):

Dipterocarp	5.62
Swamp	0.46
Mangrove	0.11
Total Forested Land	6.19
Total land area	13.16

II) Forest resources in Peninsular Malaysia (million *ha*):

a)	Virgin	0.98
b)	Logged	1.87
	Productive Forest (a+b)	2.85
c)	Protective	1.90
	Permanent forest estate (a+b+c)	4.75
d)	National parks & wildlife	0.59
e)	Stateland forests	0.94

The SMS consists of the harvesting of trees of above a certain cutting limit, and leaving behind adequate residuals which are expected to form the next cut in about 25 to 30 *y*. The minimum economic cut is presently at 30 to 40 m^3 ha^{-1} of currently commercial and usable species. According to Thang (1987), the SMS "involves the selection management (felling) regimes based on inventory data, instead of arbitrary prescription, which is equitable to both logger and forest owner as well as to ensure ecological balance and environmental stability and quality."

Opposing views are held on the suitability of SMS and selective fellings for managing dipterocarp forests. Some, example Cheah (1978), Thang (1987) and FAO (1989) view the SMS most suitable for hill dipterocarp forests. Surprisingly, as early as 1954 selective felling on a short felling cycle under high lead logging was appraised and deemed unfit for managing dipterocarp forests, especially hill forests (Walton 1954). Others like Fox (1967), Wyatt-Smith (1963, 1987, 1988) and Chin (1989) concurred with Walton (*ibid*). Nonetheless, the SMS and selective fellings are the principle management systems for dipterocarp forests throughout southeast Asia. Albeit, some lowland dipterocarp forests are still being managed under the Malayan Uniform System (MUS).

It is therefore necessary that the SMS is reexamined for whatever its proponents represent it to be against that of its critics. This can only be done by examining the theoretical basis on which the SMS and its original system are based on, and their history and practice in the region. To achieve this, it is necessary to view the SMS against the theoretical framework of silvicultural systems for tropical high forests.

Silvicultural systems for high forests

High forests are crops and stands of trees generally of seedling origin, that normally develop a high closed canopy. This is referred to natural, essentially seedling, forest of long rotation against artificial, coppice forest of shorter rotation.

For the tropics, the silvicultural systems for high forests can be divided into two regeneration categories, namely concentrated and diffuse (Figure 1). The 'concentrated' of which there are three sub-categories refers to situations where fellings and regeneration for the time being are concentrated in part of the forest area only, and resulting in a relatively uniform crop. For example, in the first category trees are removed and the specific area is regenerated artificially (planting). In the seed-tree cutting method, mature timber from an area is removed in one cut, except for a small number of seed-bearers left singly or in small groups. As a result, future regeneration is essentially concentrated around seed-bearers. Thirdly there are the shelter-wood systems. These are even-aged silvicultural systems in which, in order to provide a source of seed and/or protection, shelterwood cuttings are done; the first is ordinarily the seed cutting and the last is the final cutting. In areas where adequate seedling regeneration is already present, the old crop above a designated minimum felling girth may be removed in a single cut; in Malaysia this is termed the Malayan Uniform System, a system which was in general successful in lowland dipterocarp forests. This uniform system relies on opening the canopy fairly evenly throughout the regeneration areas that are well stocked with seedlings.

The 'diffuse' regeneration category refers to systems where felling and regeneration are distributed continuously over the whole area with a view to creating and maintaining an irregular crop with adequate regeneration of all age classes. Herein lies the selection system. This is the uneven-aged system in which trees are removed individually, here and there, from a large area each year (annual coupes), with regeneration mainly natural and crop ideally all-aged. In the group selection system, trees are removed in small groups at a time. The Polycyclic Selection Logging in North Queensland (Baur 1964) and the Celos System of Suriname (de Graaf 1986) are group selection systems.

Within the selection systems, any exploitation cutting to remove certain species above a certain size, and of high value, and where silvicultural requirements and/or sustained yields are largely ignored or found impossible to fulfill, is called selective cutting or felling (Ford-Robertson 1971). Nevertheless, Smith (1986) opines that the true role of selective cutting has always remained vague. Selective cutting has been used for situations where silviculturally these operations were truly thinning, improvement cutting, and salvage cutting. Finally Smith (1986) claims that "many selective cuttings, especially those conducted under extensive practice, remove such a high proportion of the merchantable volume that they destroy rather than accentuate any unevenness that may have existed in the age distribution of the stand. This development has also resulted from the deterioration of residual stands left after cutting. Treatments of this kind tend to create even-aged stands and should be regarded as crude variants of the shelterwood method. Finally, there are some selective cuttings that create or maintain the inherent characteristics of the uneven-aged stand, and may be correctly referred to as selection cuttings."

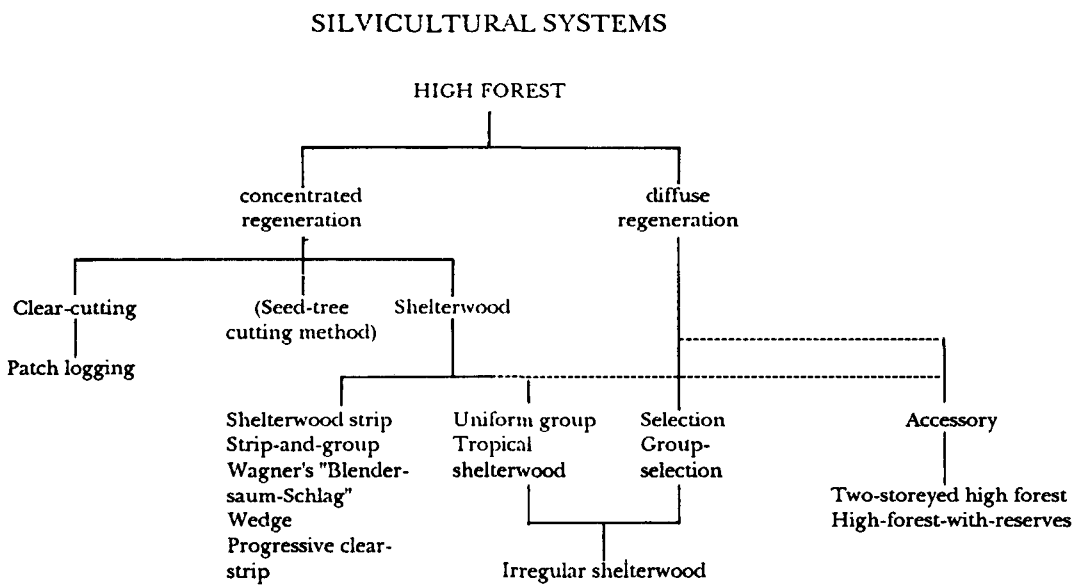

Figure 1. Chart of silvicultural systems for high forests based on natural regeneration (Ford-Robertson 1971)

The selective cutting was extensively used to manage American forests from 1930 to 1950. Thereafter it fell out of favour there because of poor results, and an increase in willingness to invest money in forest regeneration. That is the ignominious role of selective cutting or felling in silvicultural theory (Smith 1986).

Introduction of selective cutting (felling) in southeast Asia

Philippine Selective Logging System (Modified Selection)

While the selective cuttings fell into disfavour in the United States after the 1950s, about that time such cuttings with modifications were adopted for dipterocarp forests in the Philippines (FAO 1989). This was termed the Philippine Selective Logging System (PSLS). This system, described as the modified selection (see Virtucio & Torres 1978) is based on exploiting virgin forests in such a way that the residual stand - including natural regeneration and residual trees - can sustain production at roughly the level of initial use at rotations of 30 to 40 *y* and with suitable tending. Accordingly, during the first silvicultural operation only 30% of the trees with dbhs (diameter at breast height) between 15 and 65 *cm* and 60% of the trees of 65 *cm* and over may be felled. In Mindanao area, such logging yielded an average of 100 to 120 m^3 of logs per *ha*. Such high yield forests have rapidly dwindled. Currently, the consensus is that for PSLS to be successful, an effective monitoring system should be set up and logging damage should be drastically reduced. For the present 70 to 90 m^3 ha^{-1} sustained yield are based on a cutting cycle of 35 to 40 *y*. Lamprecht (1989) is of the view that the yields should be corrected downwards or the cutting cycles be correspondingly extended.

Indonesian Selective Cutting System

In 1972, a simplified variation of the PSLS was introduced into Indonesia for selective logging of lowland dipterocarp forests there (Soedjarwo 1975). In the Indonesian Selective Cutting System (ISCS), the regulation follows the cutting regime shown in Table 2.

Compared to the PSLS, the ISCS is a much simpler system. In the latter everything above a certain diameter limit (Table 2) may be harvested. It is therefore cheaper amd easier to monitor. The forests in East Kalimantan are poorer than those of the Philippines, and so only 10 to 15 stems per *ha* (≈100 m^3 ha^{-1}) are extracted.

Table 2. Indonesian selective cutting system regulations (FDI 1972)

Cutting limit (*cm* dbh)	Cutting cycle (*y*)	Number of residuals retained	Diameter range of residuals (*cm* dbh)
50*	35	25	>35
40	45	25	>35
30	55	40	>20

*The cutting limit is based on the economic yield/volume at time of felling. In the event, the economic yield is not met, cutting limits could be lowered to 40 or 30 *cm* dbh. Having chosen the cutting limits for the site, the cutting cycles, number of residuals, and diameter range of residuals are determined as shown along the line.

Selective Management System (SMS) of Peninsular Malaysia

History of selective fellings in Peninsular Malaysia

The selection system and its derivative, selection felling, were already tried out in Peninsular Malaysia from about 1926 (Arnot & Landon 1937). Selective felling, in the context then applied, was the judicial removal of a portion of the commercial species in the overwood previous to any silvicultural treatment requiring financial outlay.

These fellings have been termed 'selection fellings', 'preliminary timber fellings' and others (Arnot & Landon 1937). They were "essentially revenue-producing operations executed before any treatment of the forest, though the resultant canopy opening was silviculturally beneficial. They were normally sited in areas where advance growth of desirable species were already established, or else, in stands where exploitable forms were sufficiently heavy to make a selective felling fiancially attractive without unduly depleting the forest of seed bearers" (Arnot & Landon 1937). In the selection felling the opening of the canopy accelerated the growth of seedlings and poles already established, while in preliminary timber felling, it tended to create a condition suitable for the more rapid development of seedlings that might subsequently be produced by the remaining parent trees. In this case, of course, there was always some advance growth present, but where this was deficient, the success of the operation depended on the timely incidence of a seed year. The reason for a selective, and not final, felling under the first set of conditions was dictated by the fact that advance growth is seldom, if ever, sufficient to constitute complete regeneration.

Wyatt-Smith (1963) reviewed the selection system (including selective cuttings) and doubted if it would be financially viable or practicable for the following reasons:

- (i) The management of selection forest requires a greater degree of expert supervision than uniform forest;
- (ii) Frequent removal of small quantities of timber from large areas is expensive since extraction routes in the tropics need frequent maintenance;
- (iii) In tropical rain forests, current growth rates of individual trees cannot be estimated without regular measurement, so the removal of slower growing trees and retaining the fast ones cannot be done;
- (iv) The crowns in the tropical forests are large, and they cause extensive damage to the regeneration (Wyatt-Smith & Foenander 1962); and
- (v) Tending operations like opening of the crown to allow the more valuable stems and regeneration to grow need to be repeated over the whole area repeatedly, because the canopies close up rapidly.

The lowland dipterocarp forests of Peninsular Malaysia were managed under the Malayan Uniform System from the 1950s (Wyatt-Smith 1963). In the 1970s the situation changed dramatically for forestry when these lowland dipterocarp forests were mainly alienated for other land uses. As a result, forestry was shifted to the hill dipterocarp forests and lowland dipterocarp forests in hillier terrain and less accessible parts of the country. The dipterocarp forests in the hillier regions are more poorly stocked compared to those of the lowlands excepting for seraya (*Shorea curtisii*) formations on ridge tops. The regeneration in the hills is poorer and scattered. Under these circumstances and with rough terrain, the MUS was considered unviable for financial and silvicultural reasons (Mok 1977).

Consequently, the Selective Management System was evolved and introduced in 1978 for the remaining dipterocarp forests in Peninsular Malaysia. Whitmore (1979) interprets Mok's (1977) concept of the SMS as a system that chooses one of three procedures for managing the forests, based on prefelling inventory data:

(i) the areas richest in adolescent trees of commercial species are assigned to be managed on a polycyclic system with one intermediate felling;

(ii) the areas without such trees are to be managed by the Malayan Uniform System; and

(iii) the areas in which natural regeneration of desired species is inadequate or absent are to be enriched by planting or replaced by plantations.

But this, however, is not clearly apparent in the report of Mok (1977), and the term 'selective' was an unfortunate choice (Whitmore 1979), for it bears a silvicultural meaning different from that intended here.

Today the above concept has been trimmed down to more or less represent selective fellings practiced in the Philippines and Indonesia. The SMS, as practiced in Peninsular Malaysia, represents only a modified and simplified form of PSLS. It would have been more precise to have called it a selective cutting system, as in Indonesia. Tang (1987) too points out how the SMS has been misconstrued to be a selective logging system, and has thus created further confusion.

Basically, Mok (1977) specifies diameter limits as the cutting system. He clearly expresses that the forests should be managed by selective fellings. He further states that the new management system for Malaysia should "emphasise judicious management and perpetuation of the existing forest resource rather than its regeneration". This obviously is a departure from the MUS where young regeneration is a prerequisite (Tang 1987). This trend to dismiss natural regeneration as an important deciding factor before logging can be carried out, was already set in motion in 1966; Ismail Ali (1966) considered inadequacy of seedling "stocking before felling should not be allowed to hinder the progress of exploitation." This decision marked a major shift in forestry in Peninsular Malaysia, and a logical consequence of it may have been the uncritical introduction of selective felling in Peninsular Malaysia. The problem, however, was already foreseen under the MUS and in such cases silvicultural treatment pre-felling was recommended (Part III, Chapter 5F; Wyatt-Smith 1963).

In the SMS all commercial species above 45 *cm* dbh for non-dipterocarps and 50 *cm* for dipterocarps are felled. The residual stocking to be left behind is as follows:

Class	dbh (*cm*)	Minimum no. of trees ha^{-1}	Trees equivalent
Exploitable	> 45	25	2
Ingrowth	30-45	32	1
Small trees	15-30	96	1/3

(Source: Thang 1987)

'Trees equivalent' in the above table in practice means that a residual >45 *cm* is equal to two trees in the 30 to 45 *cm* dbh-class, and a residual in the 15 to 30 *cm* class is equal to one-third tree in the 30 to 45 *cm* class. The 32 residual trees are calculated on these equivalence classes. The cutting cycles are fixed at 25 to 30 *y* (Thang 1987). The sequence of operations are as in Table 3.

Table 3. Sequence of operations in the Selective Management System (Thang 1987)

Year	Operation
n-2 to n-1	Pre-felling forest inventory using systematic-line-plots and determination of cutting regimes
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 are prescribed.
n+2 to n+5	Post-felling inventory using systematic-line-plots to determine residual stocking and appropriate silvicultural treatments.

What are the silvicultural elements in selective cuttings?

Basically, selective cuttings (including selective loggings and SMS) boil down to determining cutting limits for harvesting and retaining advanced residuals (30-45 *cm* dbh) for the next harvest and a short cutting cycle (*cf.* MUS). Additionally, climber cutting to reduce logging damage, and line planting of areas inadequately stocked of young regeneration are prescribed, variably. Reports regularly indicate only a small portion of the logged forests are treated silviculturally (Forest Department, P. Malaysia Annual Reports 1980-1988).

Silviculturally viewed, the SMS has several shortcomings. First, there is a dearth of details on the silvicultural operations for line planting and tending in the SMS guidelines. Such detailed prescriptions are absolutely essential for line planting to succeed. Second there is the disregard for tending methods to enhance natural regeneration, usually much cheaper means when available. In this respect, a more favourable system would be the PSLS, which requires the retention of a small number of seed trees. This would increase the natural regeneration uniformly throughout the working compartment. But can 30 to 45 m^3 ha^{-1} be obtained from the Malaysian forests, while still retaining the seed bearers and the advanced residuals? This needs to be examined. In the ISCS and SMS, any retention of seed trees of exploitable size and of good form and crown development is not by design; those left are usually hollow or with poor stem form. Third, although aspects such as tree marking for directional fellings to reduce logging damage to residuals and young regeneration are stipulated, serious attention on their practicality and performance in rough terrain is not given.

As a consequence, selective cuttings only have a specious resemblance to a silvicultural system, and sustainability is not inherent. Under situations where the natural regeneration happens to be rich, for example, in the dipterocarp-rich forests of Mindanao, selective logging might work without much effort. Other situations where selective logging may succeed include logging following heavy dipterocarp seed years.

In dipterocarp forests, sustainability of timber yields depends on the regeneration of dipterocarps rather than the non-dipterocarp timber species. The reasons are two fold: dipterocarps regenerate much more copiously, and many species grow faster than other emergent timber groups. In the Philippines they have been shown to grow nearly twice faster than non-dipterocarps (Table 4); in Peninsular Malaysia, the data suggest such a conclusion too, nearly (Tang & Wan Razali 1981, M. Borhan unpublished report). However, Tang (1987) contends that it is possible to rely on advanced growth to produce a new timber crop of largely non-dipterocarp species in 50 to 60 *y*, although no data are forthcoming to sustain this view. Additionally, dipterocarps form relatively uniform timber groups which can be easily marketed. Selective loggings selectively remove the majority of valuable dipterocarps, and their regeneration is not specifically catered for. As such, the forests may gradually become poorer in dipterocarps, reducing the chances for sustainability.

Table 4. Periodic annual diameter increment (*cm*) of dipterocarps (D) and non-dipterocarps (ND) in untreated control plots in Timber Stand Improvement study sites, Philippines (Manila 1989)

Diameter class	Taggat		Acoje		Sudecor		PTDC	
	D	ND	D	ND	D	ND	D	ND
10	0.15	0.10	0.16	0.18	0.20	0.10	0.14	0.10
20	0.32	0.14	0.20	0.20	0.52	0.30	0.42	0.22
30	0.40	0.17	0.24	0.22	0.72	0.56	0.49	0.56
40	0.56	0.20	0.32	0.32	0.80	0.69	0.56	0.68
50	0.40	0.18	0.26	0.40	0.92	0.82	0.66	0.55
60	0.39	0.16	0.24	0.33	0.86	0.62	0.49	0.42
70	0.38	0.14	0.22	0.24	0.80	0.51	0.32	0.36
80	0.36	0.12	0.20	0.20	0.65	0.42	0.28	0.30
90	-	-	-	-	0.58	0.49	-	-
100	-	-	-	-	0.50	0.38	-	-
Mean	0.37	0.15	0.23	0.26	0.66	0.49	0.42	0.40

Note: Geographical location of sites are as follows: i) Taggat Industries, Cagayan, north Luzon; ii) Acoje Mining Company, Zambales, central Luzon; iii) Sudecor (Surigao Development Corporation), Carmen, northeast Mindanao; iv) PTDC (Great Pacific Timber and Development Corporation), Zamboanga, southwest Mindanao

The tenet that following selective cutting, the forests will regenerate naturally, without much inputs, and therefore need no large investments, has not been validated. This lack of linkage between logging operations and silvicultural considerations is potentially destructive to the forest: much is left to chance than to design. It must be emphasised that if regeneration is left to chance and not incorporated as an element of the silvicultural practice, sustainability may cease sooner or later. Good natural regeneration on a widespread basis is unattainable without much silvicultural inputs.

In addition to the above, many other assumptions are made in the SMS (see Thang 1987). These are:

(i) Although seedling stocking may be considerably reduced or absent following logging, the stocking is replenished easily by seed trees. Hence, seedlings and saplings become established despite logging;

(ii) The advance growth is adequate and evenly distributed over the area. They will form the next cut;

(iii) Following logging, the growth rates of the residuals are between 0.8 and 1.0 *cm* y^1. Thus enough trees will achieve the required size at next cut in 25 to 30 *y*. The growth in *cm* y^1 is: (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; and (e) non-marketable species, 0.75;

(iv) Residual trees which are left behind are considered to be sufficiently vigorous, that is with large crowns, dense foliage *et cetera*;

(v) Logging damage is only about 30% or below for intermediate size trees;

(vi) Damage to the residuals is principally a result of logging damage; and

(vii) Residuals left behind are genetically of the same quality as those harvested.

Can each of the above assumptions be validated?

We hardly know anything about the reproduction of dipterocarps in logged forests namely, the minimum size and/or age before reproduction can begin, the quantity and quality of seeds produced, establishment and growth of seedlings *et cetera*. While residuals of the larger class, example >25 *cm* can seed, individuals below 25 *cm* dbh very rarely do so (Appanah & Mohd. Rasol 1990). The situation is even more unyielding where options are available for leaving behind residuals >30 *cm* dbh, based on the equivalence class. Such small trees may take another decade or more to become reproductive, and two or three decades more before they are seeding heavily enough to regenerate the forests. While in virgin forests the seedling populations are replenished at irregular intervals (Fox 1972), this may not always be the case in logged forests (Liew & Wong 1973). It is also known that seedling populations in some forests may completely disappear before the next fruiting (Wyatt-Smith 1963, Whitmore 1979). Logging forests when the dipterocarp seedling populations are low or absent will drive the forests towards non-dipterocarp constitution, and accompanying that will be loss of sustainability of timber yield.

The advance growth, even if adequate and all survive to the next cut, will not necessarily be evenly distributed. Dipterocarps mostly occur in clusters, and logging under SMS may increase the clumping instead, considering the amount of natural regeneration destroyed, and cutting in unregenerated areas.

That the residuals (dipterocarps and non-dipterocarps) grow on average at 0.8 to 1 $cm\,y^{1}$ (Thang 1987, 1988), is a prejudgement. The results were based on a UNDP/FAO Project (1978) (Table 5a), which Wyatt-Smith (1988) has argued to be of dubious value. The data were derived from a few isolated and non-representative increment studies. They were then swelled up with increment data from inventory plots in the west coast states. There is much variation in the growth rates of forests throughout the peninsula, and differ especially between the east and west coast states, due to differences in climate and forest composition. In general, the growth rates are poorer in the former states. Hence, using growth data from a few sites, from the west coast, and extrapolating them for the whole country can be highly erroneous (Wyatt-Smith 1988). Moreover data collected from sample plots where logging is controlled and felling damage is limited, is not reflective of the real situation. At present, the major slice of the permanent forest estate actively managed under the SMS is in the eastern states. Without the anticipated growth rates, many of the residuals are unlikely to grow into merchantable size in the 25 to 30 *y* SMS cutting cycle (Tang 1987).

Table 5a. Summary of growth and yield figures for trees above 30 *cm* dbh in Peninsular Malaysia; the figures are averages for the region [UNDP/FAO 1978, as in Thang 1987; these were the figures that were questioned by Wyatt-Smith (1988)]

A)	Diameter growth ($cm\,y^{1}$):	
	All marketable species	0.80
	Dark/Light Red Meranti	1.05
	Medium-Heavy marketable species	0.75
	Light Non-Meranti marketable species	0.80
	Non-marketable species	0.75
B)	Gross volume growth ($m^{3}\,ha^{1}\,y^{1}$):	
	All marketable species	2.20
	All species	2.75
C)	Gross volume growth (%):	
	All marketable species	2.1%
	All species	1.9%
D)	Annual mortality % (of numbers of marketable species):	0.9%
E)	Annual ingrowth % (of marketable species growing-in over 30 *cm* dbh limit):	0.6%

While in the best sites, vigorous individuals can certainly grow at such rates (0.8 - 1.0 $cm\,y^{1}$), on the average, this is highly unlikely for dipterocarp forests in Malaysia. As early as 1981, the growth data, which included many plots in the hill dipterocarp forests in the east coast, were reviewed (Tang & Wan Razali 1981). The conclusion was that the growth rates indeed do not support short cutting cycles of the SMS. Subsequent studies (Wan Razali 1986, M. Borhan unpublished report) support this view too (see also Tables 5b & c). Yet the management took no cognizance of these reports.

Additionally, the mean growth rates are derived from large variations, 0.3 to 0.9 $cm\ y^{1}$ (Tang 1987). Dawkins (1958) estimates that tropical forest inventories often have standard errors of the means as high as $\pm$20% or more. From the management point of view the use of mean growth rates based on such large variations without reduction is imprudent. This leads to overcutting and rapid depletion of the forest. The correct step would have been to carry out a representative survey, and then to derive the Reliable Minimum Estimate, which is the overall mean reduced by the product of Standard Error and t-value (see Dawkins 1958). Moreover, under the SMS the crop will be poorer in dipterocarps and richer in non-dipterocarps, and this will result in poorer overall growth and yield.

Table 5b. Summary of growth rates from growth and yield plots of regenerated forests in Peninsular Malaysia 25 to 45 years after final felling (Wan Razali 1989)

Trees >10 *cm* dbh	Diameter increment ($cm\ y^{1}$ $tree^{-1}$)
i) Dipterocarps	0.52
ii) Non-dipterocarps	
LHW	0.31
MHW	0.30
HHW	0.23

Table 5c. Diameter increment ($cm\ y^{1}$) by diameter class of commercial timber species (dipterocarps and non-dipterocarps) in five logged over dipterocarp forests in southeast Asia

Diameter class	Malaysia		Philippines		
(*cm*)	D. Ehsan	G. Tebu	Mindanao	Visayas	Luzon
10-20		0.41	0.52	0.46	0.37
20-30	0.42	0.47	0.64	0.58	0.56
30-40	0.48	0.51	0.74	0.61*	0.59
40-50	0.58	0.61	0.81	0.59	0.63
50-60	0.71	0.83*	0.85	0.55	0.64*
60-70	0.66	0.60	0.87*	0.49	0.61
70-80	0.72*	0.77	0.86	0.43	0.55
80-90			0.83	0.37	0.51

(* = maximum growth rates; note that they are generally in the bigger diameter classes of >50 *cm*; Sources: G. Tebu - Thang & Yong 1989; D. Ehsan - Tang 1976; Philippines - Weidelt & Banaag 1982, based on data from Continuous Forest Inventory plots of 27 concessions)

In the SMS, the residuals selected are considered to be vigorous. In practice, there is no evidence that residual selection on basis of vigour exists. Many residuals left behind were poorly formed trees (S. Appanah & G. Weinland personal observations). Only residuals that possess distinct monopodial crown structures have the capacity to expand their crowns in response to the logging opening and grow in diameter rapidly.

In the SMS, logging damage to the residuals is estimated at about 30% for trees above 30 *cm* diameter. This is attributed to the study by Griffin and Caprata (1977) (Table 6). But Burgess (1971) estimates that the basal area destroyed amounts to 55% for the extraction of only 10% of the basal area of timber. Canonizado (1978) estimates that logging damage is about 69% for trees 15 to 30 *cm* diameter, and 64% for trees 30 to 50 *cm* diameter, based on a study in Jengka, Pahang. Other studies too report similar high logging damage except for Borhan *et al.* (1987) who report damage below 38% (Table 7). Another difficulty with most of these logging damage studies is that they are confined to examining damage to residuals following logging. The correct procedure should be one where all potential crop of residuals are marked before logging, and the loss incurred to them as a result of logging should be evaluated as well. Yet again, these studies do not consider post-logging mortality. Wyatt-Smith (1954) observed that following logging, damage increased progressively, and lasted for several years. We found heavy damage from windthrow on a seraya ridge top several years after logging (S. Appanah & G. Weinland unpublished). Again, many trees that are only partially affected during logging may appear well initially, but could die several years later. This will raise logging damage beyond the tolerance level of 30% estimate. The risk of fire as a result of the wastes left behind increases too. The large forest fires in Borneo in 1983 are such a result. Incidences of forest fires are increasing throughout southeast Asia at present.

Table 6. Percent damage according to diameter class (Griffin & Caprata 1977)

Diameter class (*cm*)	% damage
≥60	20
45-59.9	30
30-44.9	40
15-29.9	50

Table 7. Logging damage to residuals in dipterocarp forests of southeast Asia

Location	Felling type	Hauling type	Damage % of stems	Source
West Malaysia	Selective	Tractor	64-69	Canonizada 1978
"	"	Tractor/skidder	8 - 21	Borhan *et al.* 1987
"	"	High-lead	24-38	"
Philippines	"	High-lead	64-70	Uebelhoer 1989
"	"	Tractor	50-66	"
"	"	High-lead	57-58	Weidelt & Banaag 1982
"	"	Tractor	46-54	"
Indonesia	"	"	50	Tinal & Palenewen 1975
"	"	"	50	Abdulhadi *et al.* 1981
"	"	"	42	"
"	"	"	46	Abdulhadi *et al.* 1987
Sarawak	Modified MUS and Selective	"	48-72	Liew & Ong 1986
Sabah	"	"	68-75	Fox 1968

Finally, the SMS does not consider the genetic quality of the residuals left behind. This is important because many of the residuals left behind may actually be mature individuals that are small (slow growing), and those harvested the genetically superior ones. This dysgenic effect, of course will only be apparent after the second cut.

Central to the SMS are the residuals. Therefore, considerable attention should be paid to them, in terms of form, growth potential, damage, and adequacy of numbers. No evidence exists that the issues are rigorously pursued.

It must be admitted that selective fellings have no ecological basis. Some other theoretical disadvantages of selective fellings were clearly pointed out earlier by Walton (1954), Fox (1967) and Wyatt-Smith (1988). One is that selective logging is widely adopted in all areas whatever the stand, topography, logging method and quality of management. Another is the poor representation of the middle sizes of trees in the Malaysian dipterocarp forests; mainly large trees and small seedlings or saplings are present. In situations like this, selective cuttings result in very unsatisfactory residual stocking. The apparent success of the selective felling in the Philippines is attributed to the abundance of the intermediate classes in the dipterocarp-rich forests there (Walton 1954).

Above all these scientific considerations, if the logging practices in SMS do not adhere to a minimum of correct procedures such as directional felling, organized hauling systems, and forbidding premature relogging, it is highly unlikely that any system can achieve a degree of success. It is obvious that for a silvicultural system for managing dipterocarp forests, the SMS leaves too many things to chance and caprice.

Reconstructing SMS into a silvicultural system?

Smith (1986) enunciated that a rational silvicultural system for a particular stand should comprise the following objectives:

(i) Harmony with goals and characteristics of ownership,
(ii) Provision for regeneration,
(iii) Efficient use of growing space and site productivity,
(iv) Control of damaging agencies,
(v) Provision for sustained yield,
(vi) Optimum use of capital and growing stock, and
(vii) Concentration and efficient arrangement of operations.

The forest owners in Peninsular Malaysia, which are the states, desire development of the forestry sector, as well as retaining self-sufficiency in forest products. This would necessitate management on a sustained yield basis. The SMS may by design ensure a second cut of comparable volume to that of the first, but even then may contain a proportion of less desirable species (Wyatt-Smith 1987). But the third and subsequent cuts may not be as desired. Such a sequel would certainly jeopardise the industrial infrastructure developed.

In the SMS the regeneration is left to chance, silvicultural provisions for controlling logging damage are practically non-existent, and post-logging mortality is not compensated for. Consequently, the maximum stocking of the most productive species will not be achieved. Although the harvesting operations are concentrated and are efficient in operation, the SMS favours diffuse regeneration. This would raise the cost of operation during future operations.

Despite the numerous flaws in the SMS and selective fellings, nevertheless they are the accepted systems for managing dipterocarp forests throughout southeast Asia: the SMS provides a system for harvesting these forests with minimum investment.

Nevertheless, some silvicultural inputs can be incorporated into the SMS, by undertaking several management steps described below. Firstly, and of immediate concern, is the improvement in logging practices. The following need to be attended to immediately:

(i) directional felling;
(ii) reducing size of heavy machinery;
(iii) reducing logging damage through better felling and better and organised extraction procedures;
(iv) prohibit any reworking of the area till the next cut. This would ensure regeneration is not totally destroyed;
(v) consider leaving seed trees on an even distribution throughout the logging set-up. This consideration should be extended to leaving behind an even distribution of residuals as well;
(vi) vast areas that have been completely denuded from log landings, *et cetera* should be replanted immediately;
(vii) log landings should be located, and kept to a minimum, along road sides, as far as possible; and
(viii) detailed planning for road construction and skidding set-ups is required.

The above procedures will involve more planning and care during logging, but are simple and effective, and require no major silvicultural changes. These small improvements in logging techniques, which require only small financial outlays, would improve greatly the recoverability of the forest.

Today less than 20% of the permanent forest estate (PFE) in Peninsular Malaysia is still unlogged (Table 1). The rest have mostly been logged. By extrapolation, some of the forests should be undergoing the second logging soon after the year 2000. So the major issue henceforth would be the management of logged-over forests. With that in view, the regeneration status of logged forests should be ascertained, and for the second logging only set-ups with adequate regeneration should be released. The management should concentrate on management units, that are stratified into the most promising areas based on topography, accessibility and stocking.

With such a stratification, the various functions of the forest can be identified and incorporated. Our current practice is to delineate forests into production forests, protection forests, parks, reserves *et cetera.* This type of traditional demarcations should remain, but elements of them can also be incorporated within the production forest itself. This is because not all areas of production forests are uniformly productive, and harvesting areas unfit for timber production can be very destructive in the end. Therefore, areas unfit for timber production can be disengaged for protection and conservation functions. This could have been the intention when Burgess (1973) suggested that unproductive areas should be left alone. But Tang (1974) suggested that unproductive areas beyond the ridge tops can be artificially regenerated.

Natural forestry site potential	Protection value, protection need	Recreation and amenity value	Economic site value, accessibility	Natural regeneration of useful plant species	Preferred alternatives: Forest category	Preferred alternatives: Forestry option
+	+	+	+	+	F. R., N. P.	S. S., T. S. I.
				-	F. R., N. P.	A. N. R.
			-	+	F. R., P. F.	S. S.
				-	F. R., P. F., N. R.	N. O.
		-	+	+	F. R.	S. S., T. S. I.
				-	F. R.	A. N. R.
			-	+	P. F., N. R.	N. O.
				-	P. F., N. R.	N. O.
	-	+	+	+	F. R., A.	S. S., T. S. I.
				-	F. R., A.	A. N. R.
			-	+	P. F., N. P.	N. O.
				-	P. F.	N. O.
		-	+	+	A., F. R., P. F.	T. S. I.
				-	A., F. R., P. F.	A. N. R.
			-	+	P. F.	N. O.
				-	N. R.	N. O.
-	+	+	+	+	F. R., N. P., N. R.	S. S.
				-	F. R., P. F., N. R.	S. O. or N. O.
			-	+	N. R.	N. O.
				-	N. R.	N. O.
		-	+	+	F. R., P. F.	S.·S.
				-	P. F.	S. S.
			-	+	P. F., N. R.	N. O.
				-	N. R.	N. O.
	-	+	+	+	F. R.	S. S.
				-	P. F.	N. O.
			-	+	N. R.	N. O.
				-	N. R.	N. O.
		-	+	+	F. R., A.	S. S.
				-	F. R., A.	S. S.
			-	+	N. R., A.	N. O.
				-	N. R., A.	N. O.

+ advantageous, high, necessary, positive
– disadvantageous, low, not necessary, negative
F.R. Forest Reserve (production forest), permanent forests; preferably production function
P.F. Protection forest (preferably); limited production function
N.P. National parks; recreation; landscape and biotope conservation
N.R. Nature reserves with absolute protection of all animal and plant species and their biotopes; protection of gene pool
A. outside forestry alternative conversion into agricultural land
S.S. Silvicultural systems; low intensity silviculture; natural regeneration without silvicultural interventions
T.S.I. Timber stand improvement system; high intensity silviculture; conversion into stands of high productivity
A.N.R. assisted natural regeneration; S.S. and accessory planting of presently preferred species
N.O. 'No operations': no utilisation of the forests; reserve function
C.P. Conversion into compensatory plantations

Figure 2. Decision-Matrix: Alternatives for the management of tropical forests on sustained yield principle (modified from Bruenig 1989)

Bruenig (1989) provides some guidelines for developing such stratification units as an alternative to logging (Figure 2). The results of such stratification will be a mosaic of interconnected areas of different forest functions. This stratification will permit concentration of forest operations and investments to highly productive areas, and the rest can be left to natural succession, with low inputs. In this context, areas which enjoy good young regeneration can also be managed under the Malayan Uniform System.

Earlier, we concluded that the major defect in the SMS is the lack of consideration for regeneration of the forest. This is the component in SMS that needs to be advanced, and is possible. Practices like directional felling, careful hauling and minimising log landings, if done with a view to reducing damage to regeneration, are then components of silvicultural practices. Tending operations on regeneration should be examined. Further to the conservation and tending of regeneration, planting of species of medium rotation length and of high commercial value, example *Swietenia, Khaya, Flindersia et cetera* need to be developed. It must be pointed out that in this realm, numerous possibilities exist, and only need to be tested out in the field.

All said and done, if we consider that a sound silvicultural system is an absolute essential component of a management system, and is a method of carrying out the fellings that remove the mature crop with a view to regeneration, then the SMS as practised does not have adequate silvicultural components in it to be a satisfactory management system for dipterocarp forests. Nevertheless we also believe that many options particularly with regard to lowering logging damage and ensuring the natural regeneration of the forest still exist. In addition, artificial planting should be stepped up. Only with the uninterrupted reproduction of the forest, will sustainability of yield be assured. The task would be easier if management concentrates on highly productive parts, and other areas are left for protection and conservation purposes.

Finally, we should bear in mind that the hill dipterocarp forests are very variable in structure, stocking, regeneration, and growth rates. In trying to manage such forests under only one system, the SMS, we are limiting our options for the silviculture of the stands, considering the SMS only revolves around cutting cycles, cutting limits, growth rates and stocking adequacies of residuals. As a result the silviculture for the hill forests did not develop adequately, and the maximum silvicultural options available have not been used. A more desirable and flexible approach would incorporate pre-felling treatments, tending of young regeneration, clear felling, *et cetera.* This would entail planning the necessary operations for each compartment/stand separately according to its needs. A variety of systems should be applied.

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