Trends and Issues in Tropical Forest Management: Setting the Agenda for Malaysia

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Abstract:

There are limits to harvesting any natural resource if sustainable management is desired. This is very true in the case of Malaysian forests. If this premise is not accepted, we will see much of our forests becoming completely degraded. Conservative management has therefore, got to become part of the development of the forest resources. Sustainable forest management practices, holistic approaches which marry both development and conservation, are being increasingly sought after as the means to conserve tropical rain forests. Currently accepted sustainable practices require attention be paid to the legal and physical protection of the forests, sustainable production practices, good harvesting techniques, conservation of flora and fauna, tolerable impacts from development, and protection of forest dwellers rights and forest usage. Other studies are investigating into conservation issues like the size of a jungle reserve that will permit the maximum genetic flow and maintenance of species, the minimum set of species which are required to prevent ecosystem collapse, and the mobile links and keystone species that maintain the key ecological functions. There are also reviews looking into the appropriateness of the silvicultural systems now in use. All these studies are providing insights into how one can cut the forest, and yet keep it. But among them all, improvements in harvesting practices that have minimal damage to the forest environment would be the most critical. Improvements here would definitely ensure future productivity is not compromised, making other related issues such as nutrient budgets, biodiversity protection, and forest regeneration much simpler to manage.

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Introduction:

All flora and fauna, tropical or otherwise, have defense mechanisms to thrive on earth for a long time. We human beings everywhere, thanks to our inborn abilities, have outwitted their defenses and have wreaked havoc on earth. Of that we have destroyed, if the trend persists, may include the tropical rain forests. Today the whole world is beginning to express concern for their rapid destruction and degradation. This is mainly because of the amount of life found in the tropical rain forests. Although they cover only about 7% of the earth's land surface, yet these grand forests contain perhaps more than 50% of the terrestrial life. A case in point is that 10 hectares of a Borneo forest can contain more than 700 tree species, the same number found in the whole of North America. Likewise, some 30% (2,600 species) of the world's birds are estimated to be linked for at least some part of their life to tropical rain forests (Diamond 1985). Considering the rate at which tropical forests are removed, species would go extinct at rates unheralded in modern times. Several authorities predict that at the present rate of loss, easily 25% of the 10 million estimated species on earth would disappear before the year 2015 (e.g. Raven 1988); this would mean a loss of at least 50 species a day.

The concern for the disappearance of the forests and its constituent species is not merely based on a moral justification. Firstly the forest ecosystems and the species provide direct economic and social benefits. A simple list would include timber, non-timber products, and medicinal plants:

Wood products – This is the best known single product from the forests. The forest sector in the developing countries contributes about $100 billion annually in economic products, which comes to about 3% of the GDP of the Third World countries (FAO 1990). The timber and the wood industry employ a large number of people, and contribute much to the governments' revenues. For example, the forest sectors in Malaysia earn about RM 12 billion annually, and employ about 250,000 people.

Non-timber forest products – Numerous products such as poles, fuelwood, charcoal, rattan, bamboo, latex, palm oil, cocoa, vanilla, fruits, nuts, spices, gum, resins, and ornamental plants are collected from the forests. The forest dwellers and those in the margins depend considerably on these products for building material, food, and also for marketing some of it for cash. In one study, it was found that of the 275 tree species in one hectare in a Peruvian forest, 72 yielded products with direct economic value (Peters et al. 1987). The tropical forests are also a source of protein for the rural people, in the form of game and fish. In this way, although the relative value of the products may be low compared to timber, the minor products however contribute significantly to the survival of the poorer people in many of these countries. In Peninsular Malaysia, the non-wood forest products include rattan, bamboo, damar, jelutong latex, nipah thatch, and others. The annual value ranged from RM 2.5 million to RM 3.8 million annually (Table 1). It would also be appropriate to point out that newer sources of income from the rainforests are coming in the form of ecotourism. This aesthetic appreciation of nature is

slowly gaining interest, and may well earn more tourist dollars in the future for many tropical countries. This benefit is accrued from a non-destructive activity, and rural populations benefit directly from the tourism.

Table 1. Production of non-timber forest products in Peninsular Malaysia (1992-1996)

Products	1992	1993	1994	1995	1996
Poles	1,297,527	1,619,921	1,950,611	2,654,182	3,176.151
Firewood	113,589	176,465	105.633	67,558	41,660
Charcoal	856,677	599,316	514,606	504,069	431,967
Rattan	161,354	133,364	101,142	125,106	132,308
Bamboo	113,575	129,655	121,181	81,861	53,083
Damar	2,847	4,100	-	8,413	42,489
Jelutong latex	3,327	76,670	7,320	-	-
Nipah	3,541	5,544	27,012	4,106	8,937
Total	2,552,437	2,745,035	2,827,505	3,445,295	3,886,595

Medicinal plants – Tropical forests contain a disproportionately large number of plants which are regularly collected for their medicinal value by the local people. They are important as alternative sources of medicine for a lot of people who have little access to modern hospitals and clinics. These medicinal plants are now being marketed in semi-processed form, and significant domestic markets have arisen in many countries like Indonesia and Malaysia. In Malaysia, there are more than 2,000 species of plants that have been reported to have therapeutic or medicinal properties. Malaysia also currently imports about RM230 million of medicinal plants annually, and exports RM54 million. But of greater significance would be the occasional drug that one of the plants may yield. Some notable finds offer a very strong reason to conserve these majestic forests. Well-known medicines from tropical plants include anticancer drugs from the rosy periwinkle (*Catharantheus roseus*), steroids from Mexican yams (*Dioscorea composita*), and antihypertensive drugs from serpent-wood (*Rauwolfia serpentina*) (Reid & Miller 1989).

Another critical service from forests is the environmental protection it provides both locally and globally. Because the tropics have high precipitation, the forests and trees protect watersheds and retard soil loss and erosion. By the same token, these forests are also very important sources of fresh water for agriculture, domestic needs and drinking. Another significant role for tropical forests is their contribution as global carbon sinks, for they sequester carbon at much faster rates than forests in other zones. Deforestation which, mainly occurs in the tropics, is believed to release about 1 billion tons of carbon at present. This could contribute extensively to global warming. These important services are not equated in financial terms and so are often relegated to an unimportant category. However, several agencies are seeking solutions to global warming by planting tropical trees under the carbon bond scheme. This has given the services rendered by tropical forests more value in financial terms.

The forests represent large land banks for conversion to other forms of uses, especially for agriculture development. At present about one-fifth of the world's tropical forests have been converted compared to one-third of the world's temperate forests. In Malaysia, large areas of forests were opened up for cash crop plantations in the 1970s. These cash crop plantations practically fueled the early development of the country.

Causes for deforestation and degradation:

The benefits mentioned above of the tropical rain forests are what we can crudely recognise. With more research, it will not come as a surprise that the 100 million or more years of evolution have certainly more hidden secrets waiting to be unravelled, and their implications for human survival may be greater than currently realised. But if we desire to conserve these forests, we should take a deep look at what are the causes behind forest conversion and degradation. Solutions to conservation of these forests can only be found if the root causes for destruction are known and corrected. The causes, briefly stated include agricultural expansion, fires, conversion to cattle ranches, commercial logging, infrastructure and commercial development, and mining. Of them all, perhaps the agricultural expansion is the most devastating. This alone contributes annually to about 60% of the loss, mainly from shifting agriculture activity. Besides that, there is the loss due to developing cash crop plantations such as rubber, oil palm and cocoa. Most of the accessible forest lands, the lowland areas have been alienated as a consequence. Increasingly the natural forests are limited to less fertile, inaccessible, and mountainous parts in many countries. The conversion of a lot of natural forests into timber plantations is beginning, especially for producing pulp. These plantations are poor in biodiversity, and therefore represent highly altered vegetation zones.

Fires too have had devastating effects on natural forests in the last two decades. Fires are usually used to burn debris in shifting farming. Nowadays, the same methods are used for opening lands for plantations. The fires escape to logged forests particularly during El Nino dry periods. As a result, a new phenomenon is being regularly witnessed – fires in tropical rain forests. In the last two decades, the Borneo island has witnessed huge fires, and smog from these fires affected the whole of Southeast Asia. In the 1983 fire, 1 million ha of tropical rain forests were burned down in Borneo alone (Leighton 1984). Commercial logging is a cause for concern as well . Although logging itself does need not necessarily result in loss of forest, unfortunately destructive harvesting methods are being employed, and this permanently destroys or degrades the tropical forests. Furthermore, once the forests are opened up for logging, they become accessible for shifting agriculture and other forms of destruction. Annually about 5 million ha of tropical forests are logged (FAO 1999). Both in Africa and Asia, about 20% of the productive forests have been logged whereas in Latin America, the least affected by logging, about 10% has been logged.

Solutions to deforestation:

As often the case with societal issues, the solutions to problems lie outside the cause. This is very true with in the case of deforestation as well – the solutions to forest loss lie outside the direct causative agent. Locking up the tropical rain forest from human intervention will never become a solution (Bawa & Seidler 1998, CIFOR 1999). Likewise, boycotting timber from tropical forests will not halt forest loss either. The converse is more likely with boycotts. If timber has no value, there will be tremendous pressure to convert these forests to agriculture and other economic uses. The underlying causes for deforestation are several, but primarily include population growth and rural poverty, bad economics and public policies, and market failures. Lacking alternative life pursuits, the large populations in the tropics continuously seek out arable land for agriculture. Deforestation in the tropics is mainly due to conversion for agriculture. In addition, public policies promote such agricultural expansion, which leads to extensive deforestation (Repetto 1988). Next, forest goods are under-priced, making alternative uses of the land more lucrative. All in all, the short-term exploitation of forests is favoured in many situations, making sustainable forest management difficult.

Nature Conservation and Development:

Having glanced at the causes for deforestation and degradation, some possible solutions exist. The idea of locking away the tropical forests in preserves for the future is certainly not tenable. But to do away entirely with the forest is also a prescription for ultimate disaster. The solutions would therefore, have to be holistic in nature, which meet the people's needs without jeopardizing the needs of the future generations. Conservation with development is beginning to be accepted as the best route at present (ITTO 1993). Contrary to peoples perception, conservation with economic growth is complementary, and brings about greater benefits. Merging conservation and economic development goals and concepts would perhaps be mankind's goal in the next century, one that will underwrite his survival itself. Such a goal would require development of the environment – with appropriate environment-friendly technologies, improved planning and balancing of land-uses, designing and implementing more effective institutional mechanisms, and policies directed towards attaining sustainable development.

Sustainable development has become the mantra in present day discussions concerning management of natural resources. With regards to conservation matters, the activities required to achieve such a goal are three-tiered, and require attention at the local, national and global levels (Botkin & Talbot 1992). Firstly management of forests should involve local people, and benefits of forestry should accrue to them. Unless poverty eradication is engendered in the forestry development scheme, the long term security of the forests cannot be assured. The people's rights to forest access, forest ownerships, customary rights, and forest dweller's needs have to be looked into in the conservational development of a forest.

At the national level, appropriate land-use, forest and agricultural policies should be drawn up. Conversion of forests should be based on land capability studies and economic and environmentally sound decisions. Forest policies should ensure the forests are valued correctly, and the goods and services are suitably priced to prevent short-term profits, and rent captures should be maximised. Development of wood-industries which are labour-intensive should be encouraged, providing alternative economic opportunities.

Finally comes the global scenario. To ask the poorest people of the world to stop exploiting their forests on account of the fact that the global warming is taking place, and therefore we need to retain the most efficient carbon sink, tropical forests, is probably a morally heavy request. For every 1 billion tons of carbon released into the atmosphere as a result of deforestation, another 1.5 billion tons are added as a result of fossil fuel burning mainly by the developed countries. Therefore, the cost of mitigating environmental damage should not rest entirely on tropical countries. Likewise conservation of biodiversity has universal value. If tropical rain forests are regarded as "global environmental goods", then their conservation costs should be borne by the world community as well. The global community has therefore to pay for the opportunity costs lost, including planting of trees as carbon sinks. So far the global community has not developed appropriate strategies for conserving tropical forests other then with threats of timber boycotts.

Nature Conservation and Development Possible:

Efforts to improve forest management in Malaysia have been stepped up in recent years. This has been mainly fueled by the need to attain sustainable forest management in line with the ITTO Year 2000 Objective. There is also pressure to obtain forest certification so as to make it possible to market the timbers in the lucrative European markets. While the Malaysian initiatives to conserve forests while harnessing its values would provide useful insights to other countries, there is also a pressing need to further improve on the management and silvicultural systems being employed here.

Status of Forests:

The timber tree family Dipterocarpaceae dominates the Malaysian forests, making them exceptionally rich in timber. In the past, most of the timber-rich lowland dipterocarp forests were converted to cash crops plantations of rubber, oil-palm and cocoa. Today, the timber forests are confined to the hills below 1000 m. In the case of Peninsular Malaysia, about 44 % of the land area is still under forest (Table 2). Some 4.6 million ha are dedicated to forestry pursuits, out of which some 1.8 million ha are further protected, leaving only about 2.8 million ha for production forestry. As the situation stands, already the large majority of the production forest has been logged at least once, leaving some 0.7 million ha remaining in a virgin state. The swamp and mangrove forests do not amount to more than 5.5% of the Permanent Forest Estate, which leaves the Dry Inland Forests, which is mostly the Dipterocarp Forests, as the most important for timber production. For purposes of management, the production forests are here divided into several categories of forest stands which require different management prescriptions, as shown below:

a) Virgin Stands
b) Logged-over Stands
    - MUS Logging
    - SMS Logging
    - Degraded

The SMS has been developed for virgin stands (Thang 1987). Nominally the system should operate for logged stands as well, and some of the stands are beginning to be logged a second time. These are mainly the areas that were logged in the 1950s under the MUS system or highly selectively logged (Wyatt-Smith 1963). In a few years time, the forests managed under the SMS would also be coming for the second cut. Generally, the Forest Department's Officers are convinced these stands can be managed using the SMS. Considering the huge variation of the stands, will that be possible? This is now an important issue that requires further investigation.

Table 2. Status of Forests in Peninsular Malaysia

Status	**Hectarage**
Forested area	5,820,547
Non-Forested area	7,341,551
Forested area:	
- Permanent Reserved Forest	4,684,094
- Stateland	521,526
- Wildlife Reserve	614,925
Permanent Reserved Forest:	
- Dry Inland Forest	4,425,767
- Peatswamp/Swamp Forest	169,591
- Mangrove Forest	88,736
Permanent Forest Estate	
- Protected Forest	1,800,000
- Production Forest:	
- Logged	2,096,000
- Virgin	704,000

Silvicultural Systems in Use:

The dipterocarp forests in P. Malaysia are managed under the Selective Management System (SMS) and the Modified-Malayan Uniform System (M-MUS). The SMS is a form of selective felling with diameter limits (Appanah & Weinland 1993). It ensures an economic cut, whereby trees of non-dipterocarps of 45 cm dbh and above, and dipterocarps usually above 50 cm dbh are removed, provided a minimum number of 32 medium-sized residuals (30 – 45 cm dbh) are left behind for the second cut estimated about 30 years later. In the event the number of residuals to be left behind cannot be

found in the stand, then the Modified-MUS is applied. In this case, all commercial trees above 45 or 50 cm dbh are logged, and the next rotation will be around 50 years.

A critical look at the silvicultural system, the SMS in particular, shows numerous difficulties, as follows:

a) Residual Damage – Most of the production forest is confined to the hills, where the terrain is rough and the slopes are steeper. Logging is mainly done using tractor-skidder system. *San-Tai-Wong* lorries are used to haul the timber along main roads out of the forest. The resulting damage from the heavy machinery to the residuals and the younger regeneration is indeed very heavy (e.g. Canonizado 1978). Harvesting one tree can result in damage to 8-10 residuals (> 10 cm dbh) in the path of the falling tree and the tractor. Trees get damaged – uprooting, broken stems, lopped crowns, gashes along the stem, torn roots, or broken branches are common. Outside of those trees that are clearly knocked down, the others may seem fine in the beginning. But subsequent observations indicate that they slowly succumb to the damage, and such mortality prevails for as long as 15 years (Figures 1 & 2). Ultimately, the expected crop may be severely deficient. The younger regeneration, due to harvesting disturbance, may become ever more patchy, making future crops deficient in terms of both quantity and quality.

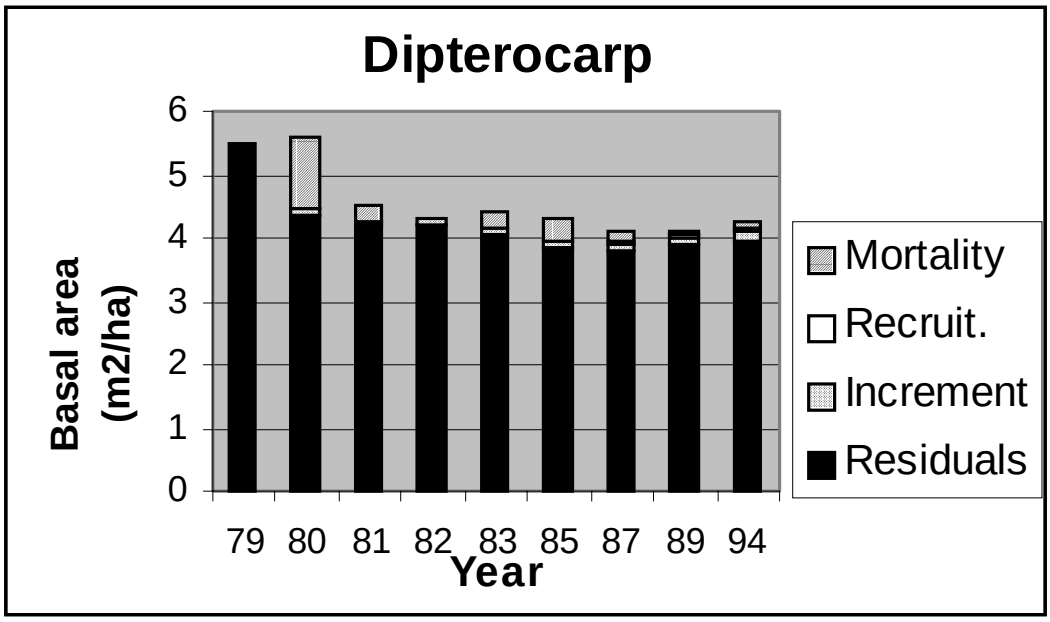

Figure 1: Total basal area of residuals, mortality, and recruitment for dipterocarps.

b) Soil Damage – As a result of using heavy ground skidder-tractor machinery, both aerial damage and soil damage are extensive. Some reports have indicated aerial

damage to be as much as 80%. These result from construction of extensive and unplanned main roads, secondary roads and skidder tracks. Besides, the tractors also churn out a large area around a felled tree. Unplanned, numerous and unnecessarily large log dumps further add to the aerial damage. Besides aerial damage, the soils also become severely compacted as a result of frequent heavy vehicle movements. These compacted sites do not support normal plant growth for 2-3 decades. They usually become colonised by *Selaginella* ferns which further prevent seedling growth in the area for an extensive period, in excess of two decades.

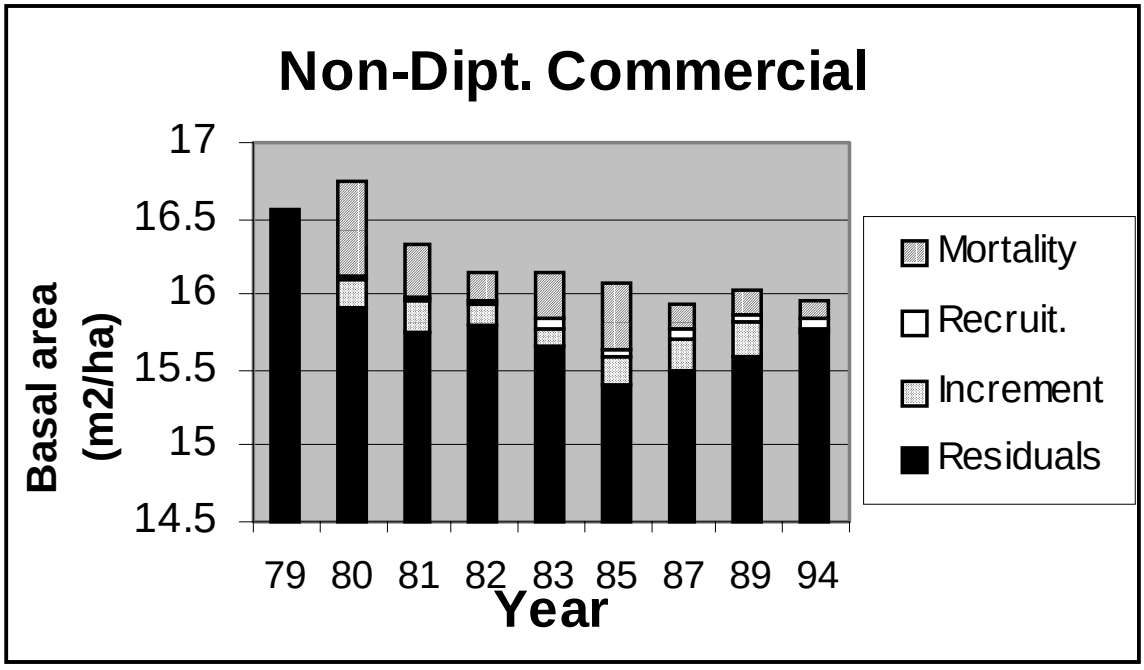

Figure 2: Total basal area of residuals, mortality, and recruitment for commercial non-dipterocarps.

c) Species Compositions – Certain features in the SMS were introduced to maintain the original species composition of the forest so that subsequent crops will retain their quality. The cutting regime is lower by at least 5 cm for non-dipterocarps so that more dipterocarps would be left in the residual stand. This should result in future crops that favour dipterocarps. Unfortunately, during logging, the dipterocarps, because of the their clumped nature, appear to receive more damage, and subsequently they suffer a higher mortality. The resulting crop is more skewed towards non-dipterocarps many of which are not so valuable in commercial terms (Figure 3). This shift in residual composition would impoverish the forests of high quality timbers after a couple of cutting cycles, and will affect the timber productivity of these forests.

d) Growth Rates – The cutting cycles under the SMS have been estimated at around 30 years (Thang 1987). This was on the basis of findings from forest plots located in the foothills, and along the west coastal states of Peninsular Malaysia. The growth findings were also limited to the results of the first few years (ca. 3 years). The

growth in terms of diameter was set at about 1 – 1.5 cm, and the economic volume was in the region of about 1.5 – 2.5 m3. Since then, longer monitoring periods and plots in the hills of the east coast region indicate markedly reduced growth figures. The new findings clearly indicate that the initial boost in growth, seen in the first 3 years, declines rapidly thereafter. On average, commercially valuable trees put on diameter growth of about 0.5 cm only (Figure 4). A further worrying factor is the mortality. In some plots, positive growth is only shown after 15 years following logging. In addition, the dipterocarps which generally grow twice as fast as the commercial non-dipterocarp species, are declining in numbers as a result of mortality, and their contribution to volume increment in the plots is less. So, overall the growth of these forests is much less than originally anticipated.

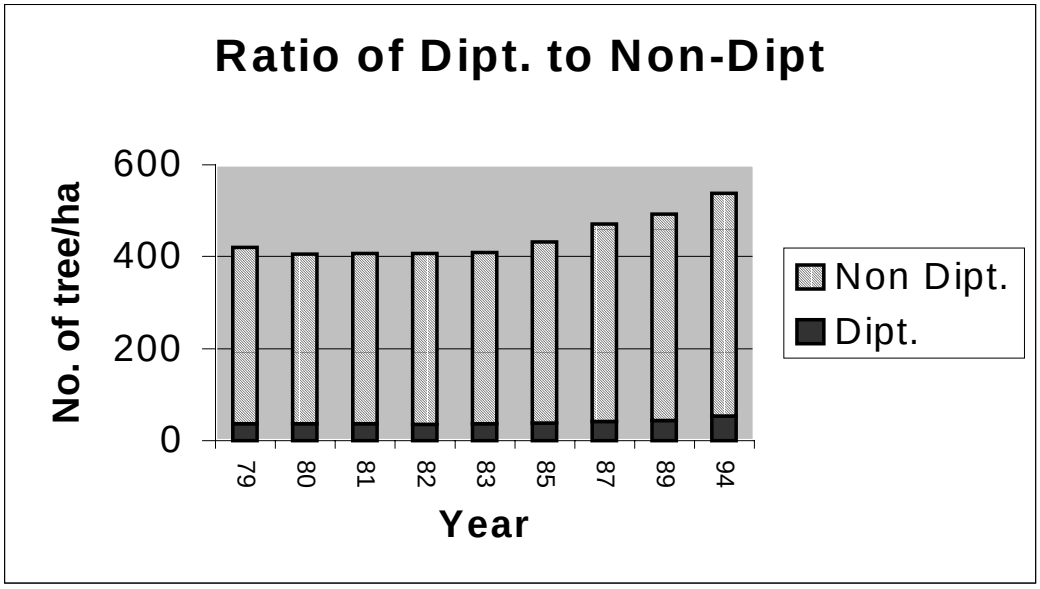

Figure 3. Population ratio between dipterocarps and non-dipterocarps

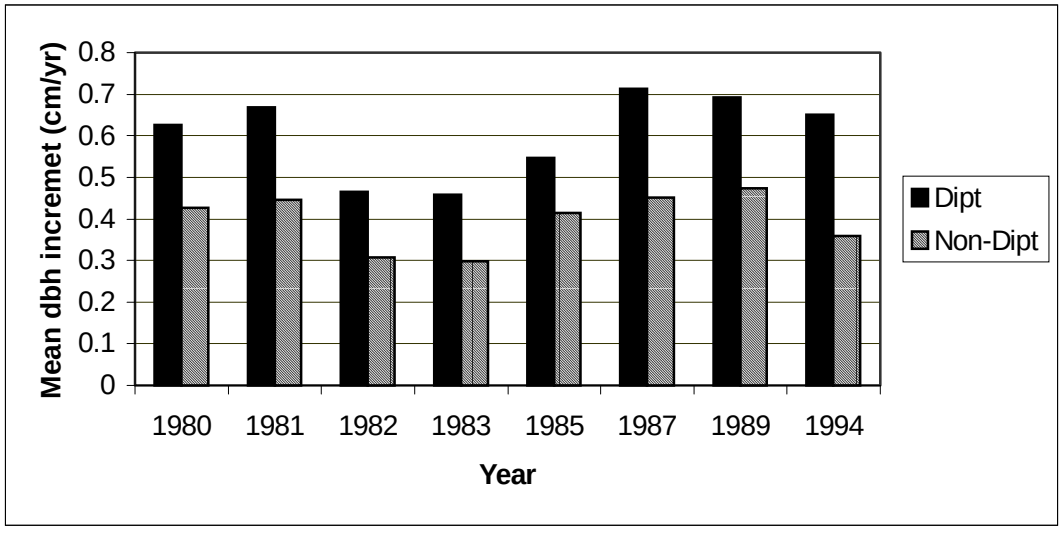

Figure 4: Mean diameter increment for dipterocarps and non-dipterocarps

e) Environmental Damage – The damage to the soil and other plant and animal species has not been fully evaluated. But studies on soil erosion, water quality, and nutrient dynamics suggest there are serious problems with the rate of recovery of the forest soils. Controlled selective logging experiments have indicated a 2-fold increase in the export of Ca and Mg and 3-fold for K (Zulkifli et al. 1998). The losses from timber extraction under SMS for Ca, Mg and K were 115, 13 and 44 kg/ha, respectively (Nykvist 1994). The recovery rates, as a result of atmospheric and weathering inputs, were 35-90 years for Mg, 20-35 years for Ca, and 10-50 years for K (Figure 5). Therefore, in terms of nutrient budgets, a 55 year cutting cycle is more appropriate for selective felling of dipterocarp forests with the removal of about 40 m3/ha. Normal logging is far more damaging to the soils and the vegetation than that under the controlled conditions for the study. Therefore, nutrient recovery rates would be usually much longer than those estimated for experimental basins.

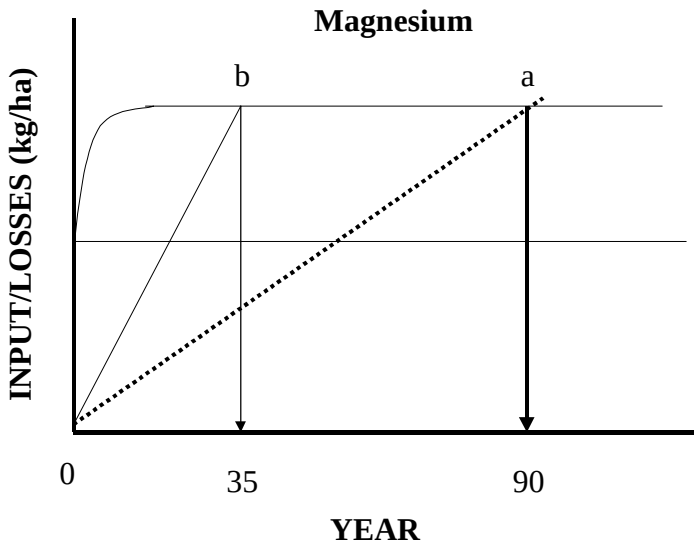

Figure 5: Losses of Mg in biomass and enhance leaching time (year) by a-rainfall and b-rainfall & weathering inputs to replenish the losses

f) Biodiversity Losses – No research exists to precisely quantify how much of biodiversity is lost as a result of selective fellings. But one can reasonably conclude that since logging is concentrated on the bigger trees, mainly dipterocarps, but also the other groups, all the rarer dipterocarps and non-dipterocarps would be lost in the first cut. The rarity of a lot of these species is often due to poor regeneration, and they may not be well represented in the seedling population as well. Some of the threatened dipterocarps include *Shorea blumutensis, S. maxima, S. kuantenensis, Hopea polyalthioides, Dipterocarpus obtusifolius* and *D. sarawakensis.* These species would be lost forever if they are not protected from logging.

Improvements in Harvesting and Silviculture Needed:

a) Harvesting Technology – If at all the single most important change that can yield in the greatest improvement in forest management, it would be none other than the harvesting technique. Several improved techniques are already available. First there is the popularly known Reduced Impact Logging Technique (RIL). This is not a new system – it is merely a good implementation of the tractor-skidder system. First, directional felling is employed so residuals are saved from damage. Next, skid trails are predetermined based on the distribution of trees and terrain. This allows for the construction of the minimum number of skid trails. The operation of the tractor is further controlled. Blading is avoided so soil loss is minimised in constructing skid trails. Logging over slopes of above 40 degrees are not allowed either. The tractors are not allowed to free range in the field, but only to use the skid trails in the minimum to haul out the trees. The trees are further bucked so whole logs are not hauled, which again reduces damage to residuals. Finally, only a minimum amount of feeder roads and main roads are constructed. The next system is based on long haulage ground cable system. The third system is the skyline cable system. The mobile system is tested in P. Malaysia and the stationary one in Sabah. All these improvements result in reduced damage to the residuals and soils considerably (Figure 6; see also Marsh et al. 1996). While these improved systems are more expensive, large concessionaires could easily employ them for harvesting. Considering the huge savings on damage to the stand and environment, management should make these techniques mandatory for harvesting trees in the tropics. Although productivity may decline somewhat, this is a small price to pay for the savings in terms of residuals and environment. Direct financial calculations without costing environmental and future crop losses result in poor management judgements.

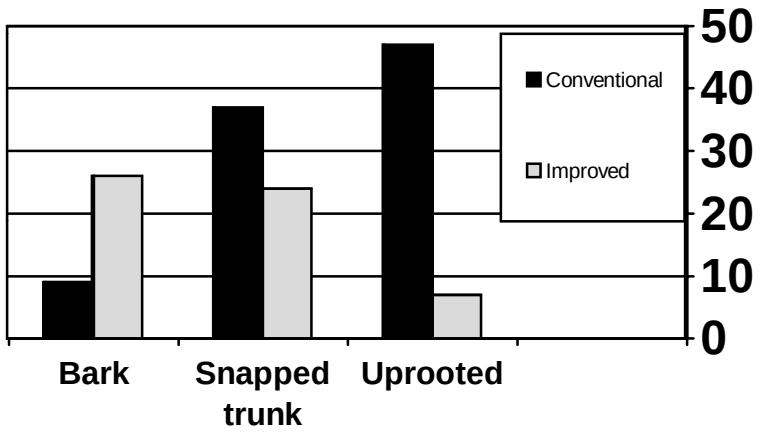

Figure 6: Comparison between long haulage cable system and conventional logging system on residual damage

b) Silviculture – The silvicultural basis for the SMS remains arguably flawed. At present it merely is an economic cutting tool. This has to be amended or modified in order to make the system workable. Some of the improvements would include the following:

- Cutting cycles – Both the growth rates and nutrient recoveries indicate a much longer cutting cycle than 30 years. But if damage to residuals is controlled, and mortality kept low, most of the residuals would become trees of 45-60 cm dbh even at increments of only 0.5 cm/annum. Then the only further consideration would be nutrient budgets, which require further investigations. Going a step further, it would be necessary to adopt local growth figures since there is considerable variation over the whole country, resulting from differences in soil fertility, rainfall and differences in species groups. The west coast has more of the light red meranti which grow faster, while the forests in the east coast have more of the balau species which generally grow more slowly.

- Minimum diameter cutting limits – Under the SMS, the minimum cutting diameter limits are 45 cm for non-dipterocarps and 50 cm for dipterocarps. This should be revised according to the following formulae. Groups of commercial trees with different timber properties and growth rates have certain maximum diameter limits to which they grow. Therefore, trees which are small should have correspondingly lower cutting limits compared to big trees. This would keep the natural structure of the forest, and retain more of the bigger trees which will allow better regeneration. The bigger trees within the species usually produce more seedlings than the smaller individuals. This would also, theoretically, retain a wider spectrum of the gene pool of the species.

- Treatments – Several silvicultural treatments which were developed under the Malayan Uniform System were adopted in the SMS as well. These post-felling treatments include cutting of climbers, girdling, and enrichment planting. The exercise is undertaken about 5 years after felling. The condition of the stand following logging under SMS is very heterogeneous and the regeneration is patchy. If the young regeneration is not treated in these patches, they would be rapidly covered by climbers and pioneers and the regeneration would slowly disappear. The practice of treating them 5 years after felling was developed for the lowland forests where seedling populations are high, and more evenly distributed. In the hills it is not the case, and so early release would ensure the few are able to succeed. Furthermore, working 1 year after logging is still quite easy, and the stands are still accessible. Another new development is the introduction of pre-felling climber cutting to reduce felling damage. This practice has not been given much emphasis yet, although the stand would benefit considerably.

- Enrichment Planting – Under the SMS, in places where regeneration is poor or completely destroyed, enrichment planting is recommended. However,

despite the earnest efforts, many failures have occurred with enrichment plantings. The major causes include: insufficient crown openings which stagnate seedling growth; species completely unsuited for such plantings; planting in compacted sites; and high costs. New innovative methods have been developed which can bring about better success. These include: planting large seedlings/saplings which will reduce frequent tendings; planting in very open and degraded sites with lots of light; planting in big holes which will remove compaction, and protect the seedlings during dry episodes. Suitable species for planting have already been well identified (Appanah & Weinland 1993).

c) Waste Wood – At present the industry is crying for timber, yet large quantities of wood are left in the forest following logging. The industry takes only the best form of trees, and preferably the high quality species. This is mainly because of the inflexible taxation system which is mainly by volume, and does not give reductions for trees of poor form, hollow logs, and split stems, all of which fetch poor prices in the market. Neither are the larger branches and much of the stump wood extracted. Studies have shown that all in about 40% of the extractable volume is left behind (Table 3). It is more costly to collect and transport these material, but the collection and taxation systems again are inflexible and hinder such extractions. The additional wood would help much in relieving the shortage faced by the industry currently. The furniture industry can utilise small and short stems quite effectively.

Table 3: Results of a waste wood case study in Selangor

Timber commercial class	Waste Volume (m^3)	Total Volume (m^3)
A	15.93	46.29
B	45.93	148.69
C	24.0	53.53
Total	86.06	248.51

Forest Stand Management:

The management of the forests will have to take into consideration the heterogeneous condition of the stand. Systems that are appropriate for the condition of the stands will have to be developed. Some suggestions for initiating management systems that are tailored to the different forest conditions are made below. They can be used as initial starting points, but need to be further developed.

a) Virgin Stands – With the improved harvesting technology, it is possible to safely manage the virgin stands. Nevertheless, some modifications are needed here too. One case would be the timber-rich seraya (*Shorea curtisii*) and kapur (*Dryobalanops aromatica*) forests. They have somewhat different regeneration patterns and stand structures. With minimum diameter cutting rules, seraya stands which are dominated by big trees, would be completely bereft following a logging. With selective felling,

many of the smaller trees would get knocked down as well. The diameter limit rules should be revised to reduce the cutting intensely in a narrow area, and instead should be spread out more evenly over the whole area. Directional felling should be employed to protect the smaller residuals.

b) Second Growth Stands – Many of the formerly logged areas are beginning to come under a second felling. Those that were felled on a highly selective basis but were not treated subsequently can be managed with the improvements suggested for the SMS.

c) Degraded Stands – These are forest areas where the existing stand is either very poor in timber or is stocked with poor quality trees. In such situations, the remaining trees should be harvested for chips, interior of plywood and other suitable uses. The felling should be done along rows, if possible. The wide trenches created in the forest can then be planted with high quality timber species like those suited for the furniture industry, such as nyatoh (*Palaquium* spp.), ramin (*Gonystylus* spp.), jelutong (*Dyera costulata*), and dark red meranti (*Shorea platyclados*, *S. acuminata*, *Shorea curtisii* etc.). These would mature after 30 years, and would provide enough timber for the high-value added furniture industry which is currently dependent on a few species, particularly rubber wood.

Conserving biological diversity:

Measures are being taken to increase the number of virgin jungle reserves (VJRs) in every forest reserve. These VJRs, of about 80 ha or more in area, are located in logging areas, usually where unique, rare or valuable groups of species are found. Currently research is in progress to determine the minimum size of the reserves in order to conserve the maximum genetic diversity of all the important plant species as well. Besides this, sites with rare species are being located which will be set aside as biological reserves.

Next, studies are in progress to find out what are the important species, example keystone species, which are critical to the maintenance of the ecological linkages between animals and plants. One often cited example is the link between fruit bats which pollinate trees like *Parkia* and *Durio*. Destruction of the pollinators would have further implications on the fruit plantations as well. With information on the minimum set of species, it would be possible to incorporate protection measures to them during a logging operation. This would ensure the forest ecosystem is not drastically damaged in terms of plant-animal interactions, and pollination and dispersal patterns are maintained. The ecosystem would be protected as a whole, despite the logging and removal of a specific group of trees.

Conclusions:

Tropical rain forests, the Malaysian forests in particular, are too valuable to be destroyed. Their benefits in the long term far outweigh any short-term profits that may come from

cashing them in. But the issue of locking up these majestic forests into inviolate preserves is not a tenable solution. Sustainable forest management practices hold the future for these forests. The scientific basis for such practices are not new for most Malaysian foresters. Many of the systems for good management are already available in Malaysia. Paramount among them would be good harvesting practices. This alone holds the biggest chance for achieving sustainable management. Additional research into silvicultural systems, productivity, nutrient budgets, and rehabilitation practices are needed. But the fundamental information is already existing to start implementing sustainable forest management in Malaysia.

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