ALTERNATIVES REDUCED IMPACT LOGGING TECHNIQUES IN PENINSULAR MALAYSIA

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ABSTRACT

Forest harvesting and all related infrastructure development in both Permanent Reserve Forest (PRF) and non-PRF forested land must be properly coordinated and regulated in accordance with the prescribed forest management and harvesting plans, so as to maintain a favourable level of log production while minimising damage to regeneration. The current forest harvesting technique used to log hill production forests has raised a considerable concern by many sectors as logging activities are normally associated with the reduction in the integrity of forest environment. Serious soil loss and degradation are important to be kept at minimal in logged-over forests to enhance better residual growth to form future crops in order to attain sustainable timber supply from a unit of forest. The research and observations of logging impacts undertaken by Forest Research Institute Malaysia (FRIM) and Japan International Research Centre for Agriculture Sciences (JIRCAS) have resulted in the introduction of two alternative reduced impact logging techniques known as Ecologically Friendly Logging System (ECOLOG) and Mobile Tower Yarder (MTY). The new methods has been tested and proven to be less damaging to the forest and environment compared to the current ground skidding system using bulldozer. This paper introduces the techniques and discusses some preliminary results of the trials.

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FOREST MANAGEMENT BACKGROUND

Proper planning, appropriate forest management practices and regulation are imperative and should be the essential components of long-term sustainable forest management. Recognising this, forestry planning and development in Malaysia is spearheaded through a series of five-year national development programmes under the various five-yearly Malaysia Plans. As in the case of Peninsular Malaysia, the Forestry Department Headquarters formulates forest policies and strategies for the development and management of the forest resources while the various State Forestry Departments are responsible for implementing these policies and strategies.

As defined in the National Forestry Act, 1984 (Amended 1993), the State Forestry Departments are responsible for all matters related to forest administration, planning, management and development. Under Section 4 of the same Act, the State Director of Forestry is required to prepare and implement forest management plan, reforestation plan and programmes relating to amenity forests. In this context, all the states in Peninsular Malaysia have already prepared their respective 10-year Forest Management Plans. In addition, sustainable forest management is impossible without having first the existence of a management system.

In this regard, systematic forest management and development has been initiated in Peninsular Malaysia a century ago when the first Forest Officer was appointed in 1901. Since then, forest management practices in Peninsular Malaysia are being developed and constantly revised to meet changing forest conditions such as from lowland to hill forest, fluctuating market and supply and demand situations, as well as advancement made in industrial, logging and harvesting technologies. This is clearly reflected in the development of various forest management systems used categorised from the Departmental Improvement Felling (DIF) in the 1920's, to Malayan Uniform System (MUS) in the late 1940's and to the Selective Management System (SMS) in the 1980's. All these are, but a reflection of Malaysia's sincere and continuous quest to manage its forest resources on a sustainable basis.

Currently, most of the production forest of the PRFs in Peninsular Malaysia are managed under the SMS which entails the selection of optimum management (felling) regimes based on pre-felling forest inventory and the retention of at least 32 sound commercial trees per hectare for diameter class 30-45 cm. The System is designed to achieve sustainability of the forest with minimum forest development costs and to optimise the management objectives of economic and efficient harvesting under prevailing conditions. The cutting cycle under the System is approximately 25-35 years after the first logging with an expected net economic outturn of 40-50 m^3/ha enriched with dipterocarp species for the next cut.

REDUCED IMPACT LOGGING (RIL) IN PENINSULAR MALAYSIA

In Peninsular Malaysia, even though RIL is still under trials especially in Terengganu (Borhan & Guglhor, 1998; Mohd Shawahid *et al*. 2001; Shamsudin *et al*. 2000), in actual fact looking at the activities before logging, RIL is being practiced but not done seriously due to lack of

supervision and knowledge. According to Appanah *et al*. (2000), in Peninsular Malaysia basically RIL involves logging guidelines for implementing good management practices, which include specifications for pre-harvest planning, vine cutting, felling, skidding, and post-harvest site closure. Pre-harvest planning entails preparation of 100% stock map of harvestable timber, including streams, road buffer zones and sensitive areas. Roads and skid trails are located on ridges to avoid steep grades, facilitate uphill skidding, and minimize skidding distances. The positions of roads and skid trails are preplanned, so that only the least minimum is required for extracting timber. Directional felling of trees was employed to minimize damage to residuals. Further, the bulldozer skidding was limited to slopes of less than 35° only, blading of skid trails was restricted, and the practice of blading off of surface soil and sidecutting were controlled. As the result of all these strict guidelines, it is expected that the damage to the forest will considerably reduced

Although the forest is relatively resilient ecosystem, its regenerative capacity will be greatly affected if disturbances incurred are beyond its withstanding limits. When this happens, the overall sustainability of the forest will be jeopardised. Thus, stringent measures must be taken so that the detrimental effects on the environment arising from forest production are kept minimum. In this regard, forest harvesting and all related infrastructure development in both PRF and non-PRF forested land must be properly coordinated and regulated in accordance with the prescribed forest management and harvesting plans, so as to maintain a favourable level of log production while minimising damage to regeneration. Towards this end, the Forestry Department has adopted regulations and guidelines for the harvesting of such forest lands. These include "Standard Road Specifications" and "Forest Harvesting Guidelines". These guidelines are all incorporated as part of the conditions or requirements in the logging licenses which must be adhered to during forest harvesting operations.

CURRENT HARVESTING TECHNIQUE

A combination of crawler tractor and winch lorry is the logging method currently employed in Peninsular Malaysia. Under this harvesting system the crawler tractor skids the logs from the felling sites to the skid trails where the winch lorry continues the transportation to the roadside landings. Generally, the skidder does not pick up its load from the felling site because of adverse soil and terrain conditions. Nevertheless, crawler tractors are primarily designed for constructing roads but not skidding logs. Since the machine is engaged to do more earth works than the actual skidding of logs, it is common to expect greater damage to soil and residual stands especially when the machine is allowed to move freely in the forest. It has been estimated that in areas where removal of approximately 30-50m^3 ha^{-1} of timber by the conventional logging method resulted in 10-25 % of the total area compacted by skid trails, roads and log landing sites (Winkler, 1997). This subject has been examined and discussed by many authors. Poore *et al*. (1989) discussed about the quality of the forest management in the tropics, which need to be improved. Excessive damage to the residual forest and reduction of forest value for the future timber production due to uncontrolled logging was thoroughly examined by Ewel and Conde (1980). Silviculturist and ecologist such as Wyatt-Smith (1987), Appanah and Weinland (1991) in their paper agreed that the traditional ground-based logging practices are damaging unsustainable.

Hence, conscientious efforts are directed toward research and development to formulate more environmentally friendly harvesting practices, such as the use of reduced impact logging (RIL) forest harvesting technologies so as to minimize the negative impacts on the environment. To date, Peninsular Malaysia has undertaken a number of collaborative projects to explore the feasibility of these technologies. In view of that, FRIM and JIRCAS has undertaken research and observations of logging impacts which resulted in the introduction of two alternative reduced impact logging techniques known as ECOLOG and MTY. The new method has been tested and proven to be less damaging to the forest and environment compared to the current ground skidding system using bulldozer.

OBJECTIVE

Objective of this paper is to introduce two alternative reduced impact logging techniques in Peninsular Malaysia known as ECOLOG and MTY.

ECOLOG

FRIM embarked on developing an ecologically friendly timber harvesting method in 1998. Part of the process was the identification of causes of environmental damage as a result of timber harvesting. Among the more obvious causes are excessive road building and construction of log yards. The massive network of unplanned skid trails to pull the logs from the stumps to the feeder roads was identified as the most damaging in timber harvesting. Research on an alternative harvesting technique dispensing the use of skid trails was initiated in a forest concession area in Terengganu. Field trials on using a winch to hoist logs uphill as an alternative to construction of skid trials were undertaken. A logging cone was later introduced to minimize damage to the forest floor and residual stand. Refinements were made to improve efficiency and later incorporated into the new harvesting system. ECOLOG was thus developed.

The concept of ECOLOG is based on the building of logging road on the ridge. Log removal is carried out via a very long wire rope (800 m in length) assisted by a logging cone affixed at the front of the log to facilitate the winching process and to protect the forest floor and residual trees. No heavy machinery is allowed to move freely in the logging area. Using this harvesting system road construction and log landings occupy approximately 2% of the logging area compared with about 15 to 40% of the current logging methods.

Plate 1: A fibreglass cone fixed in front of log to assist hauling process

With the omission of skid trails, impacts on the forest environment, canopy cover, forest floor and residual trees are minimal. Surface erosion can be reduced to a very low level and the downstream waterways remain clear after logging. This alternative logging method keeps the forest ecosystem intact after logging. An experiment at an operational scale is being planned to determine the cost-effectiveness of ECOLOG and its impacts on biological diversity, changes in microclimate, forest floor disturbances, surface erosion, water quality, and residual stand.

MTY

This project is a collaborative project between FRIM, JIRCAS, Oikawa Motor Company (Japan) and Kumpulan Pengurusan Kayu Kayan Terengganu (KPKKT).

Cable yarding has an advantage over ground skidding systems in that there is no need to bring in heavy machinery into the forest. A cable system is being developed that suitable for selective cutting operations.

The system has features for quick installation, operation and dismantling. It uses a 20 mm diameter wire rope for the skyline, which is quite small for tropical natural forests. To provide sufficient safety for heavy logs, the skyline is swung loosely with a maximum mid-span deflection of 0. 1. The skyline tension and sag can be controlled according to log weight.

For light logs less than 2 ton in weight, with the sag of 0.04, it was observed that the cable system could totally lift up the logs all the way in the span. With a 0.08 sag setting, heavy logs up to 5 ton could be totally lifted at the middle of the skyline over the buffer zone. On the slope, it could be extracted by dragging with one side lifted up. The mobile tower yarder has 3 double capstan wheel drums with interlock mechanisms, and 2 normal drums, all of which are powered by integrated electric- hydraulic systems. The target specification of the system is 6,000 kgf carrying load, 200 - 500 m working range, and 50 m or more lateral working range.

Plate 2: Mobile Tower Yarder

The trials in a 30-ha research plot in Compartment 51, Jengai Forest Reserve, Terengganu. Eight cable corridors and tail spar trees were chosen according to cable installation conditions, maximum accessibility to cutting trees, and minimising of road construction. The span of skylines, lateral extraction distances, and the covered areas for each skyline installation were 190 - 420 m, 40 - 90 m, 2.6 - 4.5 ha respectively. Work to further improve the machine, techniques, ground preparation work and operational procedures for efficient and low impact harvesting is continuing.

RESULTS AND DISCUSSION ON THE PILOT STUDY

The result and discussion below was discussed by W.A. Wan Mohd Shukri *et al.* (2000) and H Azman *et al.* (2000) on ECOLOG and MTY respectively.

ECOLOG

Damage to Residual Stand

The extent of damage to residual trees (>10cm) by ECOLOG and the conventional bulldozer skidding method is discuss below.

A total of 69.3% of the residuals in ECOLOG area was survived compared to only 47.3% in conventional area. The differences of 22.0% of survived and killed residuals between the two logging methods clearly shows that ECOLOG give better environment to residuals stand compared to conventional logging. Limiting the movement of bulldozer into logging area by limiting construction of skid trails will reduced mortality and at the same time increase survival of residuals.

Survived individuals were further classified into undamaged and damaged. Among the survived residuals, 89.6% was totally undamaged in ECOLOG area compared to only 70.0% in conventional area. More residuals were left healthy in ECOLOG area. This can be seen that only 10.4% residuals were damaged compared to 30.0% in conventional area.

Damaged individuals then further classified into light and heavy damage depending on the degrees of damage suffered by the bark, root and crown. For both light and heavy damage class, conventional method shows higher number of damage compared to ECOLOG method. For all damage suffered by the bark, root and crown, most of the damage (63.6%) falls under light damage compared to 52.4% for ECOLOG and conventional method respectively. Conventional method shows higher percentage under heavy damage (47.5%) compared to ECOLOG method only 36.3%. These figures shows that by using ECOLOG method, damaged of the residuals more confined under light damaged while less damaged occurred under heavy damage. Heavy damage class which can be considered as 'high risk' class also occurred in the conventional logging area. Damages may lead to death of the residuals.

In terms of species composition lost, 88.9% dipterocarp species groups survived in ECOLOG logging site compared to only 80.0%, which survived in conventional logging area. Non-dipterocarp also gave the same pattern of survival where 89.7% survived in ECOLOG area compared to 68.3% in conventional logging area.

Comparing both logging methods, most of the residuals in ECOLOG area were confined in light damage class. However, in conventional area, damages occurred throughout all classes from light to heavy damage. This clearly shows that limiting the movement of bulldozer in the ECOLOG logging site and creating only small path of corridors can help in significantly reducing logging impact on residuals. The high density of skid trails in conventional logging area will lead to severe damage to the residuals. By inflecting such damage to the residuals, sustainable of the future crops becomes questionable.

Plate 3: A minimum clearing done along the corridor

Soil damage

Analysis of 10 samples taken along both corridors and skid trails, show that almost all ECOLOG samples gave better results compared to conventional in terms of soil compaction and soil moisture. On the average, bulk density of soils in ECOLOG area gave only 1.1 gm/cm^3 whereas in conventional 1.5 gm/cm^3. This clearly shows that the movement of heavy machines especially bulldozer in the logging site, have resulted in a higher compaction of soils in the conventional logging site.

With regards to soil moisture, an area logged using ECOLOG was 8% more moist compared to areas logged by conventional logging. This could be due to more canopy opening in the conventional area as a result of a large number of residuals removed along skid trails and road. Consequently, more direct sunlight reach the forest floor and promote a greater rate of evaporation of soil moisture.

Results on the damage to residual and soil after logging have already been reported by other studies in the region. Tinal & Palenewen (1978) and Rochadi *et al.* (1981) reported that poor logging practices often lead to high density of unplanned logging roads for extracting timber. Therefore it is not uncommon to find an intricate network of logging roads in logged-over hill forests, very often with residual and soil badly disturbed and compacted. In this method, smaller trees, irrespective of species are pushed down. Marn and Jonkers (1981) stressed on extensive damage done to residual stand by using crawler tractor in logging activities, particularly in skidding operations. The loggers are allowed to move this heavy machine freely in the forest in trying to skid logs out of logging area.

MTY

Corridor density and conditions

Based on the tree distribution map, a total of eight corridors were identified to be constructed in the plot with the shortest corridor measuring 190 m and the longest being 420 m (Figure 1). The total length of the corridors is 2594 m resulting in a density of 86.5 m ha^{-1}. The length of corridor 1 is 190 meters with an average width of 4 meters. The width of the corridor is slightly narrower than that of a skid trail which is generally 5m. Thirteen trees marked for harvesting were logged and yarded through corridor one.

If the corridor is considered to be equivalent to skid trails in a ground-based crawler tractor harvesting method, then the density of the corridor is significantly lower than the maximum allowable density of 300 m ha^{-1} as specified by FDPM (1999) for such logging method. However, the density is not much lower than that of a normal logging using the crawler tractor which has been shown to be around 80 m ha^{-1} in Bukit Berembun Forest Reserve (Zulkifli *et al.* 1991). The big difference, however, is in the conditions of ground surface along the cable corridor and skid trails. The ground surface along skid trails is generally stripped of the top surface soil and organic matter. Kamaruzaman (1994) in a study in Sungai Tekam Forest Reserve and Berkelah Forest Reserve, Pahang, showed that more than 40% of all logging blocks observed could be considered as "seriously" disturbed due to the movement of the crawler tractor.

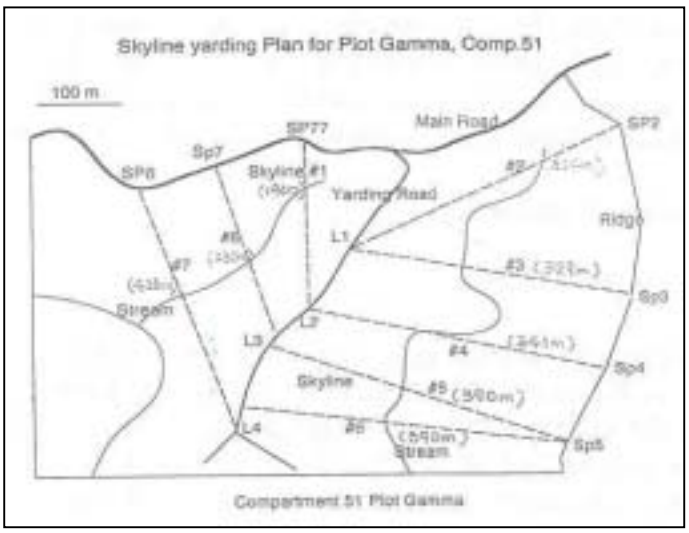

Figure 1. Identified cable ways for timber hauling based on tree map

On the other hand, observations made on the conditions of corridor 1 after the felling and hauling exercise showed that much of the ground surface along the corridor was still covered with organic matter and woody materials and even low vegetation remained intact (Plate 3). This is due to the fact that in most cases, timbers were lifted off the ground during hauling. Only in certain cases when the timbers were too big that one end was dragged along the ground.

The determination of appropriate skyline corridors based on tree stocking ensures that the corridors are optimally used. Even though trees have to be cut and cleaned along the skyline corridor, the forest floor remains intact. The soil was not exposed and most organic matter was not disturbed.

Hauling damage

As the felling in corridor 1 was considered as a trial for workers to familiarize with the machine, no study was carried out to quantify the damage to the residual stand as a result of yarding. However, from visual observations made during the whole exercise, the most damage incurred during the clearing of a 4 m wide corridor for rigging up the system. In constructing the corridor, all vegetation deemed to hinder the cables and hauling of logs was cut. However, some of the medium to big-sized trees can be utilized. Ludwig (1994), using a cable crane system in the Philippines showed that serious damages to the remaining stand due to yarding were 2.9% ha^{-1} and 4.0% ha^{-1} of the population for trees ≥ 35cm and those ≥ 15cm < 34.9 cm dbh respectively. Observations made during hauling at corridor 1 indicated injuries on trees which were supposed to be removed for the cable way in the first place but were instead let to remain.

Plate 3. General condition of corridor 1 during hauling

When the skyline corridors are correctly constructed, damage to residuals as a result of hauling is minimized if not totally eliminated. This is because all the timbers from the quadrate are dragged along the same skyline path. There is no heavy machinery moving unnecessarily over the forest floor.

Soil compaction and bulk density

Results on the analysis for bulk density of the soil samples from the various sites are summarized. The bulk density of the undisturbed site is consistent with that reported by Kamaruzaman (1991) for undisturbed soils at the Tekam Forest Reserve, Pahang, Malaysia which was 0.97 g cm^{-3}. However, the creation of the corridor and the subsequent hauling of

the logs along it had increased the bulk density by almost 70% along the corridor. Nevertheless, it is still lower than that of the skid trails which averaged 1.51 g cm^{-3}. Baharuddin *et al*. (1996) reported an increase of 32% in the bulk density of skid trails in relation to undisturbed sites in a study conducted at the Tekam Forest Reserve, Pahang, Malaysia.

The results indicated that a certain degree of compaction did occur along the corridor and this may be adduced to repeated dragging of heavier logs. This could be further reduced if all logs hauled out were lifted off the ground. The higher bulk density on the skid trails, which denotes a higher degree of soil compaction was a result of the many passes that the crawler tractor made over it. However, the skid trails were more compacted when compared to the soil along the corridor.

CONCLUSION

Results from the observations made during trial processes indicated that overall, ECOLOG and MTY have proven to have less impact to the forest environment especially to residuals and soil. Stocking of desirable timber species can be maintained whilst allowing hill forest to be logged. It is hoped that these techniques will become the system for harvesting Malaysia's dipterocarp forests in the near future. By practising this kind of reduced impact logging system, the concept and principle of 'Sustainable Forest Management' is attainable.

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