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A Comparative Study of Carbon Stock Changes from Different Logging Techniques in Ulu Jelai Forest Reserve, Kuala Lipis, Pahang

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Abstract

Conventional logging practices are often highly destructive to forest ecosystems. Heavy machinery can compact the soil and destroy vegetation. Previous research by others have demonstrated that environmental damage can be minimized through the use of site-sensitive harvesting techniques. Forest harvesting in the inland forest in Malaysia is generally carried out by a combination of crawler tractor and winch lorry, which we defined as the current logging technique. Under the current logging technique, crawler tractors are used to skid logs from felling sites to skid trails and winch lorries continue the transportation to the roadside landings. In the early nineties, a Low Impact Logging (LIL) practice using an improved logging system was carried out in some forest areas in Peninsular Malaysia. The technology, called logfisher was mainly deployed to retrieve logs from rocky and deep, narrow ravine which was deemed uneconomical, difficult and dangerous for the crawler tractor to operate. In certain logging areas in Pahang, a combination of crawler tractor and logfisher is being used which we defined in this study as LIL. The study focuses on quantifying the carbon stock changes from the different logging techniques in Lipis, Pahang. Based on preliminary results, the LIL technique showed less carbon loss if the carbon stocks before and after logging were compared. This study indicates that different logging techniques results in different impact on the total residual forest carbon stocks. The introduction of LIL systems and practices have indeed reduced the logging damage and improved stand conditions. Improvement to the current practice, enhance the productivity of the residual stand and reduce forest degradation in terms of carbon stocks as well as other ecological co-benefits.

1. Introduction

Conventional logging practices are often highly destructive to forest ecosystems. Heavy machinery can compact the soil and destroy vegetation. Previous research by others has demonstrated that environmental damage can be minimized through the use of site-sensitive harvesting techniques. Reduced Impact Logging (RIL) system consists of technologies and practices to minimize environmental impacts associated with harvesting operations. The introduction of RIL systems and practices have reduced the logging damage and improved stand conditions [1,2,3,4,5]. RIL practices had indicated that RIL techniques were developed to mitigate deleterious environmental impacts of tree felling, extraction and hauling [6].

Forest harvesting in the inland forest in Malaysia is generally carried out by a combination of crawler tractor and winch lorry, which we defined in this study as the current logging technique. Under the current logging technique, crawler tractors are used to skid logs from felling sites to skid trails and winch lorries continue the transportation to the roadside landings. Gan et al. (2006) has mentioned about the various functions of the crawler tractor in the current conventional logging operations (Table 1) [7].

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In certain logging areas in Pahang, a combination of crawler tractor and logfisher (Figure 1) are being used which we defined in this study as a Low Impact Logging (LIL) technique. Logfisher was mainly deployed to retrieve logs from rocky and deep, narrow ravine which was deemed uneconomical, difficult and dangerous for the crawler tractor to operate. The logfisher is able to undertake long distance yarding up to 200 m. On the other hand, crawler tractors only carry out short distance yarding usually not exceeding 20 m. As such the use of logfisher system is expected to reduce the intensity skid trail construction and subsequently also reduce the amount of damage. The functions of the crawler tractor and logfisher in the RIL practice are tabulated in Table 2.

The damage caused by logging will affect the forest carbon stock and the changes of carbon stock might be occurred after logging. Consequently, the objectives of this study are to assess the forest carbon stocks before and after logging using different logging techniques. This study is important in the scope of Reduce Deforestation and Forest Degradation (REDD) plus as carbon stock is one of the essential elements that considered to define forest degradation.

Table 1: The functions of crawler tractor in the current conventional logging system [7,8]

Processes	**Sites**			
	Skid Trail	**Log Landing**	**Feeder Road**	**Main Road**
Clearing, leveling and cutting of earth	Crawler Tractor	Crawler Tractor	Crawler Tractor	Crawler Tractor
Clearing, cutting and blading of earth	Crawler Tractor	None	None	None
Winching logs from the forest	Crawler Tractor	None	None	None
Skidding to log landing	Crawler Tractor	None	Crawler Tractor	None

Figure 1: Application of logfisher in Low Impact Logging Technique

2. Materials and Methods

A sampling plot measuring (50 m x 50 m) was established in logging compartments situated at Ulu Jelai Forest Reserve, Kuala Lipis, Pahang (Figure 2). The number of plots is based on 2% of the total area of the logging compartment and the plots are randomly located in the compartment. There are two different types of logging compartments selected which are current logging technique using crawler tractor and low impact logging (LIL) technique using a logfisher combining crawler tractor. The tree diameter at breast height (DBH) was measured to calculate biomass. The aboveground biomass was estimated using an allometric equation developed by Chave et al. (2005) [9], $(AGB)_{est}=\rho x\exp(-1.499+2.148\ln(D)+0.207(\ln(D))^2-0.0281(\ln(D))^3)$ while belowground biomass was estimated using Niiyama et al. (2010) [10], $Y=0.023(X^{2.59})$. The data collection was conducted before logging started and after logging completed at the same plot.

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Table 2: The functions of crawler tractor and logfisher in RIL logging system [7,8]

Processes	Sites		
	Log Landing	**Feeder Road**	**Main Road**
Clearing, levelling and cutting of earth	Crawler Tractor	Crawler Tractor	Crawler Tractor
Clearing, cutting and blading of earth	None	None	None
Winching logs from the forest	None	None	None
Skidding to log landing	None	Crawler Tractor	None
Construction of bridges and culverts	None	Log fisher	Log fisher
Stacking of logs along feeder road and log landing	Log fisher	Log fisher	None

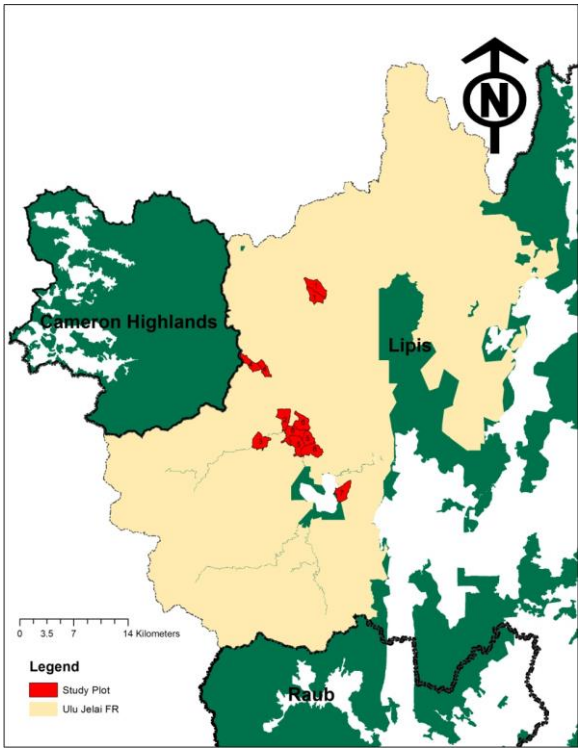

Figure 2: Location of the study.

3. Result and Discussion

The total biomass of each study plot is tabulated in Table 4. The total biomass after logging slightly decreased compared to before logging. The decrease is due to the felling of trees and the damage to the residual tree during logging activities. The carbon stock depends on total biomass value and the decrease of total biomass will affect the amount of carbon stocks after logging. The percentage of carbon loss for logging using current techniques was found to be higher than logging using low impact techniques.

As shown in Figure 3, boxplot graph was used to compare the difference of carbon stock before and after logging. For current logging technique, both medians before and after logging did not overlap and this showed that there was significant differences in the carbon stock before & after logging. Figure 4 showed that there was no significant difference before & after logging using low impact technique because both medians were overlapped. This indicated that logging using log fisher combined with crawler tractor or LIL resulted in lower impact in terms of the amount of carbon stock after logging.

The total volume of affected trees that caused the carbon loss is shown in Table 5. Results showed that the damaged trees from LIL logging technique was lower than current logging technique. Furthermore, the total standing of residual stands in LIL study plots was also higher than current logging technique study plots (Table 6). This proved that logging using LIL technique is better for the environment which helped to improve stand conditions and provide less damage to other trees.

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Table 4: Total biomass and carbon stock of each study plot.

Plot No.	Logging Technique	Total Biomass (t/ha)		Carbon Stock (tC/ha)		Carbon loss (%)
		Before	After	Before	After	
1	LIL	103.81	102.38	51.91	51.19	1.39
2	LIL	269.68	250.69	134.84	125.35	7.04
3	LIL	179.93	165.56	89.97	82.78	7.99
4	LIL	140.55	125.57	70.28	62.79	10.66
5	Current	124.35	95.48	62.18	47.74	23.22
6	Current	166.43	127.81	83.21	63.91	23.19
7	Current	206.41	163.55	103.20	81.77	20.77
8	Current	193.65	149.81	96.82	74.91	22.63

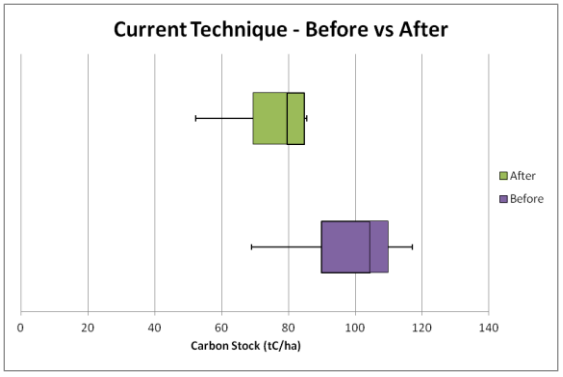

Figure 3: The difference between before & after logging using current technique.

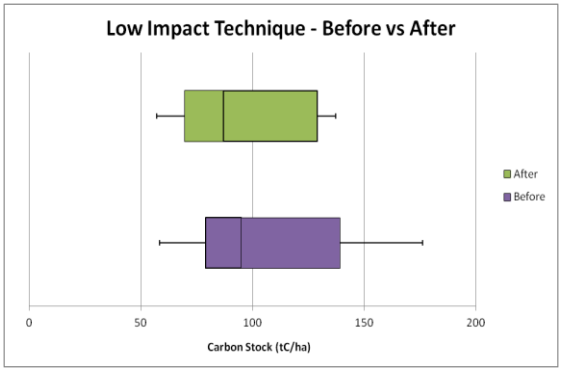

Figure 4: The difference between before & after logging using low impact technique.

Table 5: Total volume of affected trees and species group

Plot No.	Total area (ha)	Technique	Volume (m3/ha)		Total volume (m3/ha)
			D	ND	
1	3.0	LIL	4.04	6.96	11.00
2	2.0	LIL	0.00	16.05	16.05
3	1.5	LIL	10.00	8.17	18.16
4	2.0	LIL	3.14	14.28	17.42
5	2.0	Current	0.00	30.38	30.38
6	2.8	Current	19.80	17.24	37.05
7	1.8	Current	27.82	12.15	39.97
8	2.0	Current	28.25	14.55	42.80

*D is dipterocarp; ND is non dipterocarp

Table 6: Total standing of residual stands in study plots.

Plot No.	Total area (ha)	Technique	Total no. of trees	Tree/ha
1	3.0	LIL	125	42
2	2.0	LIL	148	74
3	1.5	LIL	79	53
4	2.0	LIL	102	51
5	2.0	Current	62	32
6	2.8	Current	129	46
7	1.8	Current	106	59
8	2.0	Current	97	49

4. Conclusions

This study indicates that different logging techniques resulted in different impacts on the total forest carbon stock within the residual stand after logging. The introduction of LIL systems and practices have indeed reduced the logging damage and improved stand conditions. Thus improvement to the current practice can enhance the productivity of the residual stand and reduce forest degradation in terms of carbon stocks as well as other ecological co-benefits. However, there are cost implications in using the LIL system compared to the current practice. If the incentives provided for reducing emissions are attractive enough, there is great potential that logging operators will employ the LIL system which in the long run will be both economically and ecologically beneficial.

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