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# Effect of reduced impact logging to species composition and forest structure in tropical rain forest, North Borneo

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**Abstract**

Forest structure and species composition is the use of sustainable forest management, such as logging methods and underplanting. Diversity of species in tropical forest is very large and complex, its existence influence each other and interact with a genetic characters and the ecosystem. Measuring the impact of logging techniques of reduced impact logging (RIL) and conventional logging (CL) performed on the logging block of the current year. Plots consisted of CL and RIL block that the size of plot 15 ha, respectivly. Before logging in the conventional logging (CL), red meranti (*Shorea* spp.) were the dominant species at the tree stage (IVI=15.66-32.83 %) and after logging red meranti (*Shorea* spp) were dominant species (IVI=19.51-38.58%). Before logging in the reduced impact logging (RIL), red meranti (*Shorea* spp.) were the dominant species at the tree stage (IVI=26.84-30.87 %) and after logging red meranti (*Shorea* spp) were dominant species (IVI=18.27-19.71%).Species diversity index (H') before logging is greater than after logging. This indicates that logging activities contribute to changes in species diversity. Species composition responded differently caused by logging technique.

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## Introduction

Natural tropical forest management, especially logging is not done in a professional manner. It is because in the application of silviculture, logging systems do not integrate with silviculture system. Besides technical planning and operation of logging that is still not used in logging in natural tropical forests, Indonesia (Elias, 1998). In another hand, the improvement of forest management through the improvement of conventional logging to reduced impact lgging (RIL) indicated significantly effect reducing forest damage (Putz *et al.,* 2008) and RIL technique as a forest management practices increase forest productivity (Peńa-Claros *et al.,* 2008).

Logging, if uncontrolled can cause high damage on the residual stand and ground that affect to the structure and composition of stands and forest regeneration. Minimize damage from logging is a prerequisite for achieving sustainable forest management (SFM) because it reduces damage to soil and stands can guarantee the regeneration and growth of commercial stands (Sist *et al.,* 1998; Matangaran and Kobayashi, 1999).

Improvement of forest management through the implementation of sustainable forest management in line with climate change mitigation efforts, including: (a) Improvement of forest management and logging policies and technology to increase the capacity of the forests to carbon sequestration and storage (b), Investments that can minimize deforestation, maintain or improve stand growth, minimize disturbance to soil and residual stand in the logging of forest products, and ensures a quick and satisfactory regeneration, and (c) Adopting programs of forest protection that is socially acceptable or joint management.

Logging and silvicultural measures in natural forests, which until now carried out by the Utilization License of Timber Forest Products (IUPHHK) resulted in damage to remaining trees, openness areas, soil compaction, changes in the composition and structure of forest vegetation.

The objective of the research was to analysis the effect of logging on species composition and forests structure in the natural tropical forest.

## Materials and methods

This research was conducted in the tropical rain forest, Malinau, North Kalimantan. Measuring the impact of logging techniques RIL and CL performed on the cutting block of the current year. Plots consisted of conventional logging (CL) techniques and reduced impact logging technique. Size of measuring plots was 15 ha in which made three (3) permanent plots. Size of the permanent plot was 100 m × 100 m (1 ha). Permanent plots are systematically placed on both the research plots.Each permanent plot is divided into 25 sub-plot with a size of 20 m × 20 m. Parameters measured to observe the effect of logging RIL to changes in the forests structure and species composition of tropical rain forests.

Potential stands, the forest structure and species composition of the stand when the study was obtained through the analysis of vegetation on CL plots and RIL plots. Vegetation analysis carried out by nested sampling method and in each permanent sample plots (PSP) made the plot-plots were in the plot created sub-sub plots.

Data retrieval analysis of the vegetation in the field is as follows:1. The level of the tree is a woody plant with a limit of ≥ 20 cm diameter (diameter measurements made at a height of 1.3 m from the ground). Parameters measured include diameter, height, name the type and number of species; 2. The level of the pole stage is a woody plant with a limit of 10-19 cm diameter. Parameters measured include diameter, height, name the type and number of species; 3. The level of sapling stage is the woody plant that has a height> 1.5 m in diameter <10 cm. In this research, saplings stage measured vegetation is that has a diameter of 5 to 9.9 cm. Parameters measured include the type name, the number of individuals, diameter and height. Seedlings stage were level with the number of leaves of more than 2 leaves with a height of up to 150 cm. Parameters measured include the number of individuals and species name.

The quantitative analysis such as density, frequency, and abundance of tree species is calculated. In additon, indices of similarity and dissimilarity were calculated. To determine the importance of species in the forests structure is used the importance value index (IVI). Species diversity and dominance were evaluated by using the Shannon's diversity index.

## Results and discussion

*Species composition and forest structure of stands before and after logging*

The composition of stands in this study was defined as the diversity of the forest stand. Diversity of species in wet tropical forest is very large and complex, its existence influence each other and interact with a genetic trait and the ecosystem.

**Table 1.** Number of species found in research plots.

| Plots | No Plot | Tree | | Poles | | Saplings | | Seedlings | |
|---|---|---|---|---|---|---|---|---|---|
| | | Speciesha$^{-1}$ | | | | | | | |
| | | Before logging | After logging | Before logging | After logging | Before logging | After logging | Before logging | After logging |
| CL | I | 35 | 24 | 21 | 14 | 27 | 20 | 28 | 25 |
| | II | 33 | 29 | 26 | 18 | 29 | 24 | 30 | 28 |
| | III | 32 | 27 | 24 | 17 | 28 | 22 | 25 | 23 |
| RIL | I | 33 | 28 | 25 | 18 | 25 | 22 | 23 | 21 |
| | II | 27 | 25 | 23 | 18 | 25 | 21 | 27 | 26 |
| | III | 32 | 30 | 26 | 24 | 24 | 24 | 27 | 27 |

The types of trees and poles, saplings, seedlings before and after logging the timber and change the position of a kind in every plot can be seen in Table 1.

This study showed that the number of species is found in each plots before logging and after logging was almost the same. Conventional logging (CL) and reduced impact logging plots, the species most commonly is found in seedlings stage based on Importance Value Index (IVI) was *Eugenia* spp., red meranti (*Shorea* spp.), Medang (*Litsea* spp) and yellow meranti (*Shorea ovalis*). At saplings stage the species most commonly found on both logging plots, banitan (*Polyalthia* sp.), Medang (*Litsea* spp.), red meranti (*Shorea* spp.) and *Eugenia* spp. At poles stage, the species that most commonly found on both logging plots was red meranti (*Shorea* spp.), *Eugenia* spp., yellow meranti (*Shorea* ovalis) and medang (*Litsea* spp.). Similarly to tree stage that the species most commonly found among other red meranti (*Shorea* spp), yellow meranti (*Shorea ovalis*) and medang (*Litsea* spp.).

Importance Value Index (IVI) is an appropriate indicator to see how changing the number of species in the plots before logging and after logging.

Decreasing of individual in one species or the loss of the number of species in logging causes shifting of IVI species. This shift pushed and amend the IVI value a species uniformly, for example in Plot I, a conventional logging plotsI, red meranti (*Shorea* spp) at tree stage, the value of IVI was 32.84%, after cutting the value of IVI increased to 26.42 % and after skidding rose to 35.58 %.

This research indicated that changing of IVI value cause changes in ratings IVI on each species. There are times when there is the kind that ranks below other types, it is change cause by logging. For example, on a plot I in a conventional logging to the tree stage, before cutting yellow meranti (*Shorea ovalis*) is second rank with an IVI value was 24.64%, after logging occupied by *Eugenia* sp (IVI= 20.71%) and after skidding yellow meranti (*Shorea ovalis*) is second with an IVI = 31.05%. This is due to the shifting position are the number of individuals in a species that is reduced or some kind of species is a loss.

**Table 2.** Similarity index between before and after logging in reduced impact logging (RIL) and conventional logging (CL) plot.

| Stage of forest stand | CL | | RIL | | Average of IS (%) | |
|---|---|---|---|---|---|---|
| | IS (%) | Plot | IS (%) | Plot | CL | RIL |
| Before logging | | | | | | |
| Seedlings | | | | | K = 57.754<br>B = 79.303 | K = 54.531<br>B = 75.991 |
| *K | 50.909 | II vs III | 52.000 | I vs III | | |
| **B | 67.925 | I vs III | 84.000 | I vs II | | |
| Saplings | | | | | | |
| K | 43.636 | I vs III | 53.061 | II vs III | | |
| B | 87.719 | II vs III | 85.714 | I vs III | | |
| Poles | | | | | | |
| K | 60.000 | II vs III | 53.061 | II vs III | | |
| B | 72.340 | I vs II | 62.745 | I vs III | | |
| Trees | | | | | | |
| K | 76.471 | I vs II | 60.000 | I vs II | | |
| B | 89.231 | II vs III | 71,186 | II vs III | | |
| After felling | | | | | | |
| Seedlings | | | | | K = 52.871<br>B = 71.453 | K = 53.045<br>B = 75.847 |
| K | 47.273 | II vs III | 48.000 | I vs III | | |
| B | 50.000 | I vs III | 84.000 | I vs II | | |
| Saplings | | | | | | |
| K | 39.216 | I vs III | 51.064 | II vs III | | |
| B | 92.308 | II vs III | 83.333 | I vs III | | |
| Poles | | | | | | |
| K | 53.333 | I vs III | 51.064 | II vs III | | |
| B | 56.410 | II vs III | 69.388 | I vs III | | |
| Trees | | | | | | |
| K | 67.742 | I vs III | 50.794 | I vs III | | |
| B | 87.097 | II vs III | 66.667 | II vs III | | |
| After skidding | | | | | | |
| Seedlings | | | | | K = 50.125<br>B = 68.373 | K = 51.321<br>B = 71.103 |
| K | 47.059 | II vs III | 45.833 | I vs III | | |
| B | 62.500 | I vs III | 76.596 | I vs II | | |
| Saplings | | | | | | |
| K | 61.905 | I vs III | 48.889 | I vs II | | |
| B | 69.565 | II vs III | 78.261 | I vs III | | |
| Poles | | | | | | |
| K | 38.710 | I vs III | 52.381 | II vs III | | |
| B | 62.857 | II vs III | 57.143 | I vs III | | |
| Trees | | | | | | |
| K | 52.830 | I vs II | 58.182 | II vs III | | |
| B | 78.571 | II vs III | 72.414 | I vs III | | |

*K = the smallest of IS valuel, **B = the largest of IS value.

Changing of species composition cause by logging on Indonesian selective cutting and planting system was inconspicuous decrease because intensity of logging was 5 trees/ha. In contrast to Indonesian line cutting and planting was very intensive logging that causes a reduction in number of species. This research indicated that species composition based on commercial Dipterocarps, noncommercial dipterocarp and noncommercial, before logging and after logging has changed. However, due to logging causes a reduction in the number of trees as a result of damage to the residual stand. Fig. 1 and 2 showed changes in the species structure and forests composition of stands before and after conventional logging and reduced impact logging.

*Species diversity*

To determine the value of species diversity can be determined by counting the species diversity index (H'). The higher the value H' will describe the higher levels of diversity. Species diversity index (H ') describes the large number of individual types and number of species. Changes in the IVI lead to changes in the value of H' that it's generally change was decreased. This is due to reduced populations of certain species and even the loss of a species, which cause certain species dominate.

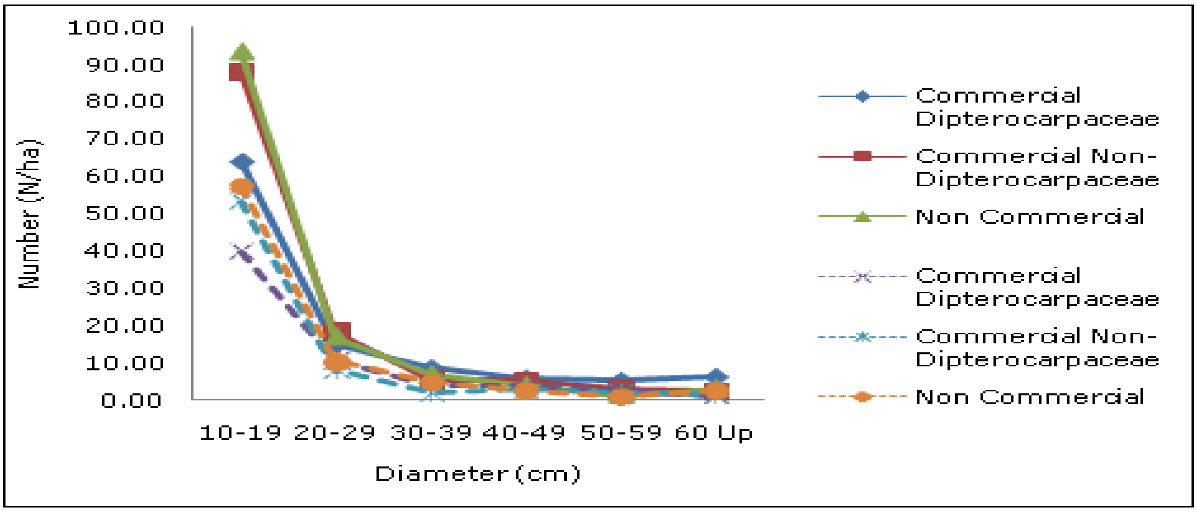


**Fig. 1.** Forest structure and species composition at CL plots.

The results showed that there is a change (reduction) species diversity. For example in the conventional logging plot for poles stage, the species diversity index (H') before logging was2.862, after logging was 2.622 and species diversity index in the RIL plot, before logging was 2.861 and after logging was 2.787 (Fig. 3).

This study showed that species diversity index (H') before logging is greater than after logging.

This indicates that logging activities contribute to changes in species diversity. The result of the calculation of species diversity index (H') which is based on IVI found that species diversity before and after logging have different. The decline in the diversity index value showed that primary forests (forests unlogged) has a great diversity of species. This is due at the time of felling and skidding occurs reduction in the species and abundance of certain species of changes.

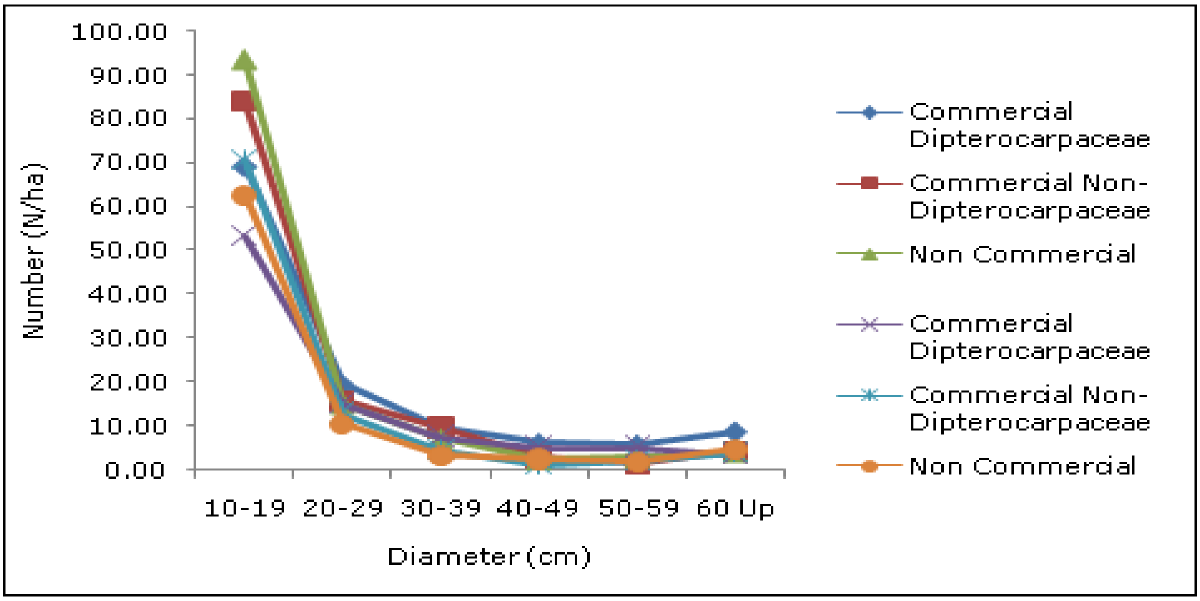


**Fig. 2.** Forest structure and species composition at RIL plots.

In this study, the index of diversity at all stages (Seedlings, saplings, poles and trees) was 2.481 to 3.344. Some of the factors that affect the diversity of species that make up the number of species in the area, soil conditions, altitude, the environmental conditions in particular the climate is very suitable for the growth and reproduction in any season. Diversity among members of a group consisting of two components, namely the species richness and relative abundance. Species diversity contained in RIL plots was larger thanCL plots.

*Similarity index*

One of the elements to determine the type of forest is to do a comparison of each two of the stand or the community at a different plot. How to get the best value comparison using similarity coefficient of community. Similarity index (IS) indicates the degree of similarity in forests composition of the two sample were compared. Number of research plots as much as two plots (each 3 plots) to a location adjacent to determine the degree of similarity between plots calculated communities community similarity index (IS). Valueof IS is a range 0 to 100%.

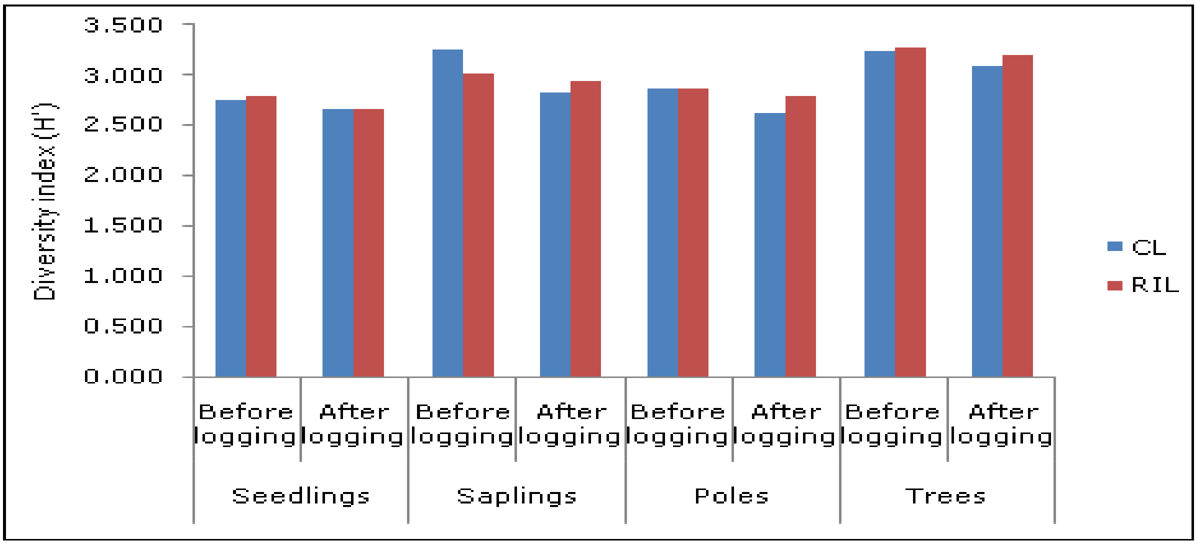


**Fig. 3.** Species diversity index before and after logging.

Comparing the similarities of forest composition before and after logging is intended to determine the extent of the changes that occurred in the plots being compared. This research resulted that the smallest IS value was in conventional logging after skidding amounted to 38.710%. It means that several different species in the plots as a result of a reduction in some of the same species on the plots being compared. Average value of IS at all stage stand before conventional logging and RIL amounted to 50.125% - 79.303% and 51.321 - 75.991%, respectively.

This means that more than half the number of species present in each plot is almost found. Species compostition varies with stand age, forest layer and sire (Pena-Claros, 2003). The spesies composition of mature forest recoverd at different rates in the different forest layer.

Extensive logging had a profound effect on current forest composition and structure (Nowacki and Abrams, 1994). Tree species responded differently to major anthropogenic disturbance. The anthropogenically altered area had higher numbers of individuals of autochoric species than the numbers of anemochorous and zoochoric species (Lopes *et al.*, 2012). Andersson, *et al.* (2012) resulted that long-term effects from harvesting on beetle abundance, species richness and species composition was generally small in comparison to the influence of the characteristics of the surrounding forests.

**Conclusion**

Species diversity index (H') before logging is greater than after logging. This indicates that logging activities contribute to changes the species diversity. Species diversity index (H') which is based on IVI found that species diversity before and after logging have different. The smallest IS value was in conventional logging after skidding amounted to 38.710%. Species composition responded differently to logging technique.

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