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Stand development after two modes of selective logging and pre-felling climber cutting in a dipterocarp rainforest in Sabah, Malaysia

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Abstract

Selective logging in dipterocarp rainforests is mostly done in a relatively unplanned manner that causes great damage to, and depletes, the residual stands. Better planning of logging and silvicultural activities – using (for instance) planned skid-trails, directional felling and climber cutting – is expected to reduce the damage and create healthier residual stands for timber production. In the study reported here a logging system involving the use of planned systematically aligned skid-trails combined with directional felling (SL) was tested, and compared with the conventional unplanned logging (CL) practiced in the area. Further, both logging systems were combined with and without pre-logging climber cutting. The post-logging development of the stands was followed for 8 years (1993–2001). Stand development following the two logging modes were found, statistically, to be relatively similar. Both logging modes lead to a net basal area growth, during the period of around 5.0 m^2 ha^{-1}, when considering all tree species combined. These findings implicate that SL may not be enough for improving the residual stand. The method is, at the same time, not leading to a reduced tree growth compared with CL and may have other gains. After 8 years and irrespective of logging modes the standing basal area differed statistically from a virgin forest only within the segment of trees having a diameter range of 60–89 cm dbh. Climber cutting significantly and positively affected total net basal area growth, resulting in net basal area growth during the 8-year period monitored of 6.4 m^2 ha^{-1} (compared to 3.3 m^2 ha^{-1} in plots where they were not cut), implicating that climber cutting could be an effective tool for increased forest growth.

Keywords: Dipterocarp; Directional felling; Pre-marked skid-trails; RIL; Stand growth

1. Introduction

The ongoing conventional selective logging in natural forests in Sabah, Malaysia usually causes relatively severe damage to the surrounding stand, proportions of damaged stems up to 50% of the original stand are normal (Pinard et al., 2000). Since the residual stand is relied upon to create the next harvestable crop, concerns about that high damage levels will impair future timber productivity were raised by Chai and Udarbe (1977). They also considered alternative logging techniques to reduce damage. Since then multi-component concepts, often called RIL (reduced impact logging) systems, have been developed for ameliorating this damage (cf. Pinard et al., 1995; Sist, 2000; Forshed et al., 2006). Common features of these damage-reducing systems include directional felling, pre-felling climber cutting and use of pre-aligned skid-trails.

Directional felling means felling a tree in a predetermined lay so that the log can be secured and the surrounding stand with potential crop trees can be saved. The feasibility of directional felling has been proven in several experiments (cf. Pinard et al., 1995; Cedergren et al., 2002).

Climbers are known to tie the forest canopy together, so when a tree is felled neighbouring trees may also be pulled down (Richards, 1996). Several studies have tested the potential usefulness of cutting climbers to avoid damage, some of which have found it be an effective strategy (Appanah and Putz, 1984), while others have found it to be ineffective (Parren and Bongers, 2001; Forshed et al., 2006).

Skid-trails are major causes of logging damage and associated mortality (Sist et al., 1998). RIL skid-trail networks are often based on stockmaps and topography (cf. Pinard et al., 1995; Sist, 2000). Aligning skid-trails in such a way can reduce

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damage, but it is time consuming and costly (Pinard et al., 2000). Another way of aligning skid-trails is to have them systematically aligned parallel to each other at a fixed distance, following natural borders, such as rivers and ravines (Cedergren et al., 1996). An advantage with such a method is that stocking maps can be excluded and therefore relatively cheap and easy to implement by logging contractors in routine practice.

RIL techniques have proven to be generally effective, to some degree at least, for reducing initial damage to stands. For example, is it shown that proportions of trees in the original stand that are killed or injured could be reduced to around 30% (Bertault and Sist, 1997; Pinard et al., 2000). Even if initial damage can be reduced by RIL it is important to follow-up how the forests respond to such silvicultural treatments. Will the reduced impact also give a long-term effect that actually improve the forests from a growth and yield point of view?

The objective of the study presented here was to compare the growth of the residual stand after logging with systematically aligned skid-trails (supervised logging) and conventional logging. The study compares stand development and tree basal area growth from 1993 to 2001; the 8 years following logging. Furthermore, the two modes of logging were combined with and without pre-felling climber cutting to evaluate the effects of cutting climbers on subsequent stand development and growth. Finally, the logged areas were compared with un-logged areas (control, virgin forest).

The specific questions addressed were the following. Are there differences in total and/or Dipterocarpaceae (dipterocarp) basal area development following Supervised logging and conventional logging? Are there differences in total and/or dipterocarp basal area development between areas where climber cutting has been practiced compared to areas where they have not been cut? Are there differences in total and/or dipterocarp standing basal area between the logged areas and the un-logged virgin forest areas?

2. Materials and methods

The study was carried out at the Gunung Rara Forest Reserve in Sabah, Malaysia (approximately 4°33′N, 117°02′E) (Fig. 1). The forest was a primary mixed dipterocarp forest, dominated by trees belonging to the Dipterocarpaceae family on Haplic Acrisol (Ultisol, USDA Soil taxonomy) soil (Cedergren, 1996). The terrain is hilly and the altitude at the site ranges from 300 to 610 m a.s.l. The climate in the region is wet tropical, with monthly rainfall exceeding 100 mm, and long-term mean annual rainfall ranging from 2000 to 4000 mm (Whitmore, 1998). The experimental area is a part of the Yayasan Sabah Forest Concession. The allocated experimental site is around 3000 ha.

The experimental design was a randomised 2 × 2 factorial complete block design, where the effects of two modes of selective harvesting, conventional logging (CL) and supervised logging (SL), and cutting climbers (CC) versus not cutting climbers (NCC), were evaluated during an 8-year period (1993–2001). The study area comprised four blocks and 20 treatment plots defined here as gross plots, each covering 5.76 ha (240 m × 240 m), except one measuring 200 m × 240 m. In the centre of each gross plot a net plot of 1 ha (100 m × 100 m) was established. The blocking factor was based on average ground inclination within net plots, with a variation in mean slope from 22° (block 1) to 6° (block 4). Each logging treatment was randomly assigned within blocks. In addition, on one randomly assigned plot per block and logging method, CC or NCC was carried out. Finally, four plots, one per block, of virgin forest were assigned as control plots.

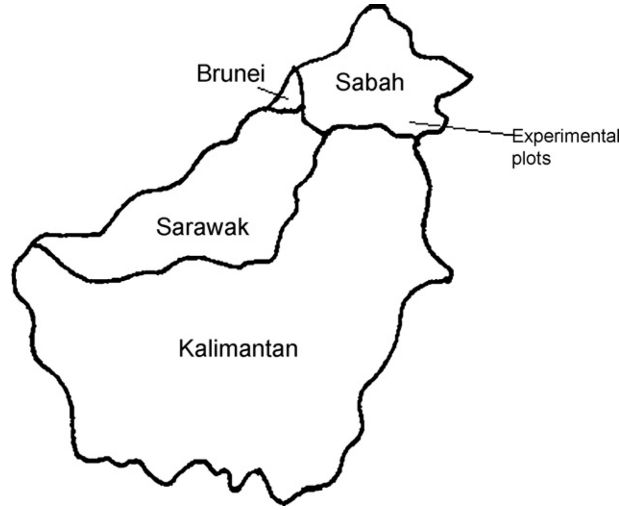

Fig. 1. Map of Borneo, showing state boundaries in Borneo and the location of the experimental plots.

Plot establishment, including climber cutting, was conducted from March 1992 to June 1992 at the same time as the ordinary commercial logging took place in the area. The first measurements in the plots were carried out at the same time. Harvesting commenced in June 1993 and was completed in August 1993. Further measurements in the plots were then taken in October–November every second year after harvesting in 1993, 1995, 1997, 1999 and 2001. Year 1993, when the forest was in its initial post-logging state, is defined as year 0, and thus the years 1992, 1995, 1997, 1999 and 2001 are defined as years −1, year 2, year 4, year 6, and year 8, respectively. The mean logging intensities for the two logging modes were 13.0 stems per ha (of which 12.4 were dipterocarps) for CL and 9.4 (6.7 dipterocarps) stems per ha for SL, while the mean intensities for areas in which climbers were cut (CC) and not cut (NCC) were 13.0 (11.7 dipterocarps) and 9.4 (7.4 dipterocarps) stems per ha, respectively (Forshed et al., 2006).

The net plots were each divided into 100 sub-plots (10 m × 10 m), which were marked out on the ground for easy reference. During the first measurements, before logging, all trees within each sub-plot with a diameter at breast height (dbh) of at least 10 cm were recorded and marked with an individual 5-cm aluminium number tag that was buried in the soil at the base of the tree. Recorded data for each tree were its number, distance (in dm) and bearing (obtained using a 360° compass) from the centre of the sub-plot, species, dbh at 1.3 m (measured with a diameter tape in mm, except in 1992 when it was measured in cm) if possible, otherwise 0.3 m above the