Comparison of 10-years post logging dynamics under three different management in lowland dipterocarp forest in Central Kalimantan

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Abstract

In Indonesia, to establish the sustainable management in lowland dipterocarp forest, line planting of the commercial dipterocarp species is conducted in logged-over forests. However the sustainability has not been evaluated based on long-term monitoring data. The aim of this study was to evaluate the efficiency of line planting system from the comparison of 10-years post logging forest dynamics under different managements. Monitoring plots were established in three logged forest managed by the conventional selective logging (CL), the reduced impact logging method (RIL), and RIL with line planting (RIL+LP). In the RIL+LP site, 80 seedlings/ha of *Shorea johorensis* were planted along a 3-m wide planting strip opened in the logged forest. The post logging dynamics was monitored with trees more than 10 cm DBH. For 10 years, pioneer invasion was significant in the CL site, however it was suppressed in the RIL and RIL+LP site. RIL method functioned well for mitigating logging impact. However, the regeneration of dipterocarps was not significant both in the CL and RIL site. In the RIL+LP site, intensive management enhanced the natural recruitment of dipterocarp seedlings. The cumulative recruitment of dipterocarps (dbh > 10 cm) for 10 years was about 76 trees/ha. In addition, *S. johorensis* planted in RIL+LP site grew to an average DBH of 15.7 cm and the survival rate was 78.2% after 10 years. From the comparison of post logging forest dynamics, we conclude that line planting system was expected to sustain and enhance the regeneration of dipterocarps in logged forests.

Key Word: Enrichment planting, Dipterocarpaceae, Shorea, RIL

Introduction

In Southeast Asia, the primary lowland dipterocarp forest is decreasingly in alarmingly rate because of logging aiming dominant dipterocarps. Generally, after conventional selective logging, low-commercial value pioneers invade to the disturbed logged forest and dominate in the stand. Such a low commercial value forest is likely to be converted to other land use. It is a main cause of forest loss in the area. Then, the sustainable forest management, which enables repeatable harvesting of dipterocarps is required to maintain the forest area. To achieve the sustainable management, in Indonesia, reduced impact logging (RIL) method and line planting system have been practiced in these years. A RIL is used to suppress the pioneer invasion and promote better regeneration of dipterocarps by mitigating logging impact. Line planting is conducted to promote the regeneration of dipterocarps. Useful *Shorea* seedlings are planted in strip cutting lines opened after selective logging from North to South. However, about the RIL and line planting system, the efficiency for the dipterocarp regeneration has not evaluated based on long term monitoring of forest dynamics. In this study, we evaluated the sustainability of RIL and line planting system from the comparison of 10-years post-logging dynamics under different management.

Methodology

The study was conducted in active logging concession in Central Kalimantan, Indonesia. To compare the post logging dynamics, three 1-ha (100x100 $m^{2)}$ monitoring plots were set in the logged over forest sites by three different managements, conventional logging (CL), RIL and RIL with line planting (RIL+LP). In the RIL+LP site, *Shorea johorensis*, one of main commercial dipterocarp species were planted after selective logging. The seedlings were planted in 3-m wide strip cutting line opened from North to South in 25-m intervals. In each line, seedlings were planted in 5-m spacing. Planting density was 80 trees/ha. In addition, annual weeding of understory was conducted in the RIL+LP site.

The monitoring was conducted seven times, logging year, 1, 2, 4, 6, 8 and 10 years after logging. The dynamics was monitored with trees more than 10 cm DBH. Tree growth was monitored by DBH increment. Recruitment was recorded with the number of trees newly reached to 10 cm DBH between given two serial monitoring. Trees were separated three species group, dipterocarp, pioneer and other. The growth and survival of planted trees in the RIL+LP site were also monitored for 10 years

Results and Discussion

Stand condition change for 10 years

For 10 years, the stand stock (tree density and basal area) increased in all three sites (Table 1). The difference among the three management was found in species composition change over 10 years. In the CL site, conventional selective logging induced abundant pionner increase. Whreas, in the RIL site, pioneer invasion was suppressed significantly. However about the dipterocarp regeneration, there was no significant diffrence btween CL site and RIL site. The dipterocarps did not increased significantly both in the CL and RIL site. In the RIL+LP site, the number of dipterocarps almost doubled over 10 years, and many of them was commecially important *Shorea* species.

The different species composition chage was caused by difference in the recrutiment dynamics in each site (Table 2). In the CL site, there was significant pioneer recruitment in the 2-4 years monitoring period. The pioneers apparently responded to the logging disturbance by conventional method. For 10 years after logging, the cumulative recruitment of pionners was 62±18.4 trees/ha. Whereas, in the RIL site, the pioneer invasion was suppressed significantly. In 1-ha plots, only 7.7±3.1 pionner seedlings recruited for 10 years. RIL method functioned well for mitigating the logging impact. However, there was no difference in the dipterocarp recrutiment between the CL and RIL site. RIL was not efficient for the dipterocarp regeneration. Whereas in the RIL+LP site, intensive management enhanced the dipterocarp recruitment significantly.However the number of recruitment ranged widely.

Table 1 Stand condition change for 10 year in each site (Mean ± S.D)

Site	Species group	Mean tree density (/ha)		Mean basal area (m^2/ha)	
		Logging year	10 years after	Logging year	10 years after
CL	Dipterocarp	59.7 ± 39.4	65 ± 34.9	7.1 ± 3.1	6.9 ± 3.4
	Pioneer	2.7 ± 2.3	41.7 ± 8.7	0	1.2 ± 0.4
	Other	267.3 ± 54.6	309.7 ± 28	17.9 ± 5.5	18.5 ± 2.6
	Total	316.3 ± 62.2	405 ± 56.5	23.2 ± 4.8	25.1 ± 2.9
RIL	Dipterocarp	57.3 ± 24	72.7 ± 38.6	6.5 ± 2.5	7 ± 3.2
	Pioneer	21.3 ± 15.9	16.3 ± 9.3	0.3 ± 0.3	0.8 ± 0.6
	Other	219.3 ± 27.4	266 ± 32.9	11.2 ± 2.6	14.9 ± 2.5
	Total	298.3 ± 16.8	355 ± 53	18 ± 0.1	22.7 ± 0.3
RIL+LP	Dipterocarp	70 ± 21.5	132.7 ± 37.4	7 ± 3.3	9.5 ± 3.1
	Pioneer	11.7 ± 12.4	10.3 ± 9.3	0.2 ± 0.2	0.6 ± 0.5
	Other	176.3 ± 14.2	217.7 ± 14.7	8.8 ± 0.2	11.9 ± 1.4
	Total	258 ± 1	360.7 ± 36.5	16 ± 3	22 ± 2.4

Table 2 Recrutiment dynamics of each species group in each site (Mean ± S.D.).

Site	Species group	Monitoring period (year)						Cumulative
		0-1	1-2	2-4	4-6	6-8	8-10	
CL	Dipterocarp	3 ± 2.6	1.7 ± 0.6	5.3 ± 3.5	2.7 ± 2.1	1.3 ± 0.6	2.7 ± 0.6	16.7 ± 6.1
	Pioneer	0	2.3 ± 2.5	33.3 ± 13.8	0.7 ± 0.6	25.7 ± 14.4	0	62 ± 18.4
	Other	10.7 ± 9.9	12 ± 5.6	38.7 ± 9.6	5.7 ± 3.5	15.3 ± 5.9	15.3 ± 7.6	97.7 ± 32
	All	13.7 ± 8.6	16 ± 4.4	77.3 ± 5.8	9 ± 1	42.3 ± 20.8	18 ± 7.8	176.3 ± 15.5
RIL	Dipterocarp	2.3 ± 2.1	1.7 ± 2.9	2.7 ± 2.1	4.3 ± 3.8	11 ± 9.2	3.7 ± 3.1	25.7 ± 21.5
	Pioneer	1.7 ± 2.1	2.3 ± 2.3	2.7 ± 2.1	0	0.3 ± 0.6	0.7 ± 1.2	7.7 ± 3.1
	Other	14.7 ± 8.1	8 ± 1.7	9 ± 5	10.3 ± 2.9	32.3 ± 8.1	6.3 ± 2.3	80.7 ± 17.1
	All	18.7 ± 8.3	12 ± 2.6	14.3 ± 9	14.7 ± 3.8	43.7 ± 16.3	10.7 ± 5	114 ± 38
RIL +LP	Dipterocarp	3.3 ± 0.6	4 ± 1.7	5.7 ± 2.3	16.7 ± 4.7	39.3 ± 26.9	12.3 ± 10.2	81.3 ± 38.2
	Pioneer	1.3 ± 0.6	0.7 ± 1.2	0.3 ± 0.6	0	0	0.3 ± 0.6	2.7 ± 2.1
	Other	16.3 ± 1.2	5 ± 1.7	9 ± 3.6	12.3 ± 6.1	28.3 ± 2.1	5.3 ± 3.1	76.3 ± 4.7
	All	21 ± 1	9.7 ± 4.6	15 ± 5.3	29 ± 6.1	67.7 ± 27.8	18 ± 7.2	160.3 ± 32.7

Survival and growth of planted Shorea johorensis

Planted *Shorea johorensis* recorded favorable results 10 years after planting. The average survival rate of *S. johorensis* among the three plots was 78.2± 6.7%. There was no statistical difference (p<0.05, one-way ANOVA). The rate was higher than previous planting tests using same *S.johorensis* (Ǻdjers et al. 1995, Matsune et al. 2006). The mortality was occuered over 10 year (Figure 1).

The average DBH in each RIL+LP plot were 15.7 ± 5.5, 14.8 ± 3.6, and 15.7 ± 4.6 cm, respectively. No statistical difference was found among the three plots. The survival rate and growth results were more stable compared to the natural recruitment.

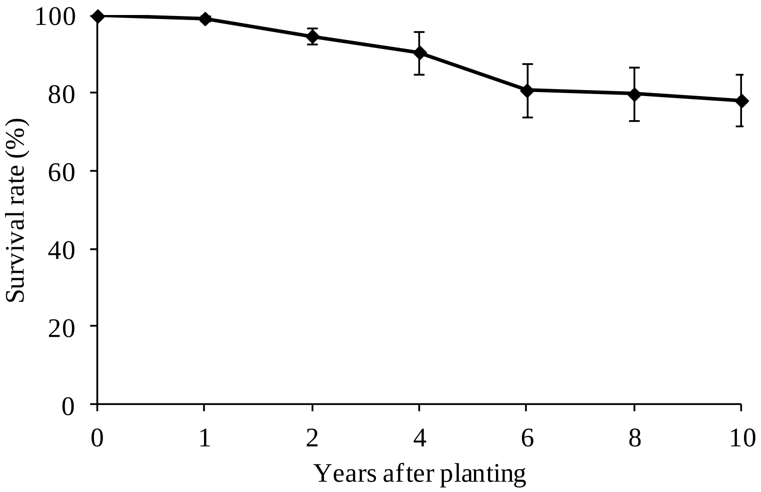

Figure 1 Average survival rate of planted *S. johornesis* in the RIL+LP site. The error bars expressed the standard deviation among the three plots.

The efficiency of line planting system for sustainable forest management
Prospects for the sustainable forest management

From the 10-years monitoring, the RIL was effective to mitigate the logging disturbance and suppress the pioneer invasion after logging. However, only RIL, the dipterocarp regeneration might be insufficient. The dipterocarps would deplete under repeatable logging. The dipterocarp regeneration could be promoted under intensive management, and planted trees in planting lines contributed to the regeneration of dipterocarps by the stable high survival rate and steady growth. Line planting was effective to sustain the dipterocarps in logged forest. Therefore, the management system composed by selective logging and line planting was expected to the sustainable forest management in the lowland ditperocarp forest.

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