

Figure 1: State of the art of the research

Silvicultural system on the natural forest concession (management unit) in Indonesia can be classified into two kinds, i.e. Indonesia Selective Cutting and Planting, and Indonesia Selective Cutting and Line Enrichment Planting [8]. The second system is trusted has the better prospect to increase natural forest productivity. This system has two forest management areas, namely clear line (or line gap) and

conservation line (or line stand). The first is enrichment planting area, conducted to cultivate the native commercial trees, as *Shorea* spp., in an intensively manner to get the optimum growth and yield, and the second formed a part of conservation area. Many crops of Dipterocarp on the tropical forest are formed seed bank on the closed forest floor [9]. They need the light to grow well at the site [7,9,10,11]. The logical framework of this research as showed at Fig.2

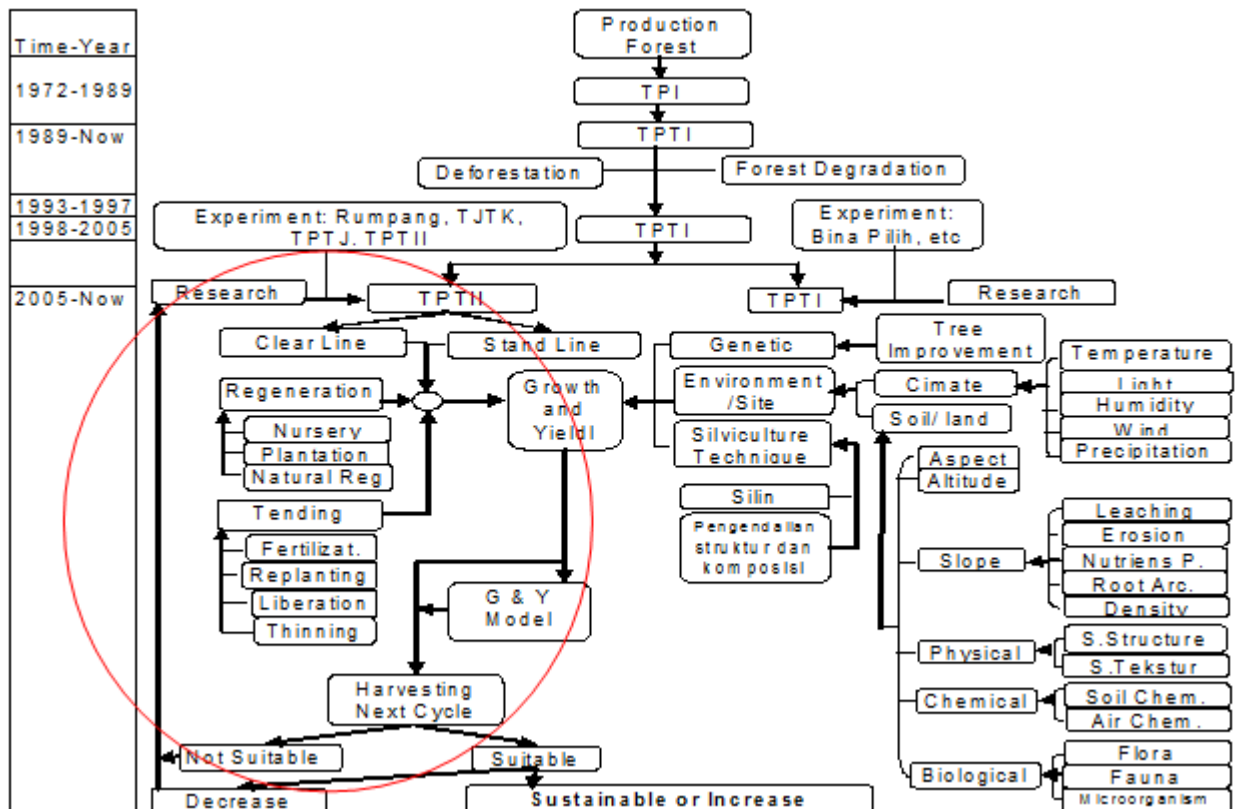


Figure 2: Logical framework of the research

3. Method

This research was conducted at Permanent Sample Plot on PT.Gunung Meranti Forest Concession, Central Kalimantan, latitude 0° 46' S, longitude 114°59' , made at 2004. Object of research was diameter at breast height of meranti (*Shorea leprosula*) at 10 years old. Three tree removal treatments of Indonesia Selective Cutting and Line Enrichment Planting silvicultural system was replicated (four) plots with combinations of ecological site type and slope. The treatments involved increasing levels of tree removal to open area, i.e: 3 m gap size (G1), 5 m gap size (G2), and 10 m gap size. All modelled gaps were assumed to lengthwise direction to 1000 m, characterized on slope with level 0-15% (S1) and 5-25% (S2). Distance of plants in the line gap was 3 m. Every plot was composed by 15 trees that determined by random, so each treatment was composed by 60 trees. Furthermore, the six of these treatments were named as treatment 1 (=G1S1), 2 (=G2S1), 3 (=G3S1), 4 (=G1S2), 5 (=G2S2), and 6 (=G3S2). The new pioneer species on line gap was recorded. Data analysis was done by analysis of varians and least significans different (LSD) used SPSS 19.0. Layout of the research is showed at Fig.3.

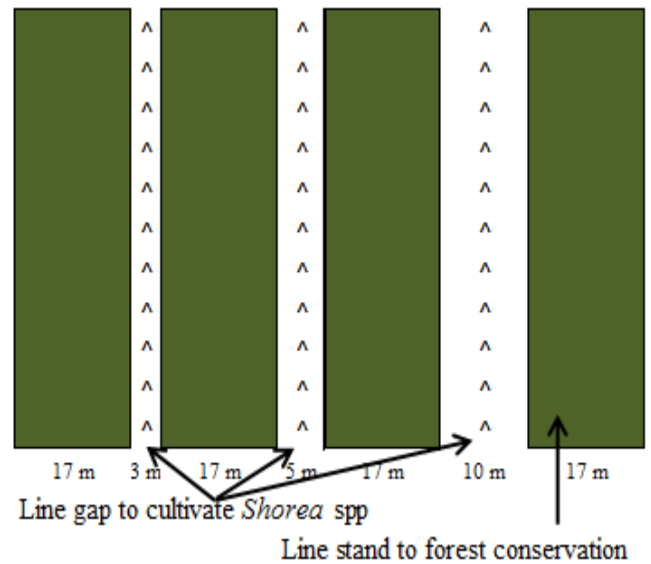


Figure 3: Layout of research

4. Result and Discussion

Gap density at the 3 m (G1), 5 m (G2), and 10 m (G3) of gap sizes are covered 15%, 22%, and 37% from all areas, and based on measurement of light, light intensity at the site namely 83.2, 83.1, and 77.5 densiometer scale(ds) respectively after 10 years. The diameter at breast height (dbh) description of *Shorea leprosula* at the line gap at the 10 years old as showed at the Table 1.

Table 1: Dbh description of *Shorea leprosula* at the line gap after 10 years

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1,00	58	19,6448	2,45258	,32204	19,0000	20,2897	14,60	26,30
2,00	59	20,3017	2,90247	,37787	19,5453	21,0581	14,10	25,90
3,00	36	16,3611	2,63680	,43947	15,4689	17,2533	10,30	21,60
4,00	57	19,6281	2,38146	,31543	18,9962	20,2600	14,80	25,20
5,00	58	20,1500	2,69159	,35342	19,4423	20,8577	15,30	26,50
6,00	30	15,6000	2,90125	,52969	14,5167	16,6833	9,60	20,60
Total	298	19,0661	3,10800	,18004	18,7118	19,4204	9,60	26,50

At the Table 1 showed that diameter growth of the *Shorea leprosula* at the 5 m gap size at the 0-15% of slope (G2S1) and 15-25% of slope (G2S2) were highest, i.e. 20.3 cm and 20.15 cm respectively, and then the treatments of G1S1, G1S2, and G3S1 (Table 1). Base on the analysis of varians (Table 2), value of sig. namely 0.000 that smaller than significans level of 0.05, its mean that there is one or more of the treatments which significantly different (intertreatments).

Table 2: Analyse of varians for the six treatment

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	819,469	5	163,894	23,351	,000
Within Groups	2049,459	292	7,019		
Total	2868,928	297			

According to the LSD test (Table 3), between the treatments of 1 (G1S1), 2 (G2S1), 4 (G2S1), 5 (G2S2) were not significantly different group to group, but they are significantly different with the treatment of 3 (G3S1) and

6 (G3S2). Meanwhile, the treatment 3 (G3S1) is significantly different with the treatment of 6 (G3S2). Thereby, based on the growth rate, the best treatments (one after the others) are G2S1 namely 20.3 cm of dbh, G2S2 namely 20.15 cm of dbh, G1S1 namely 19.64 cm of dbh, and G1S2 namely 19.63 cm of dbh, they are at the conditions of gap size: 5 m with slope: 0-15%, gap size: 5 m with slope: 15-25%, gap size: 3 m with slope: 0-15%, and gap size 3 m with slope: 15-25% respectively. The unfavorable treatments are treatment of 3 (G3S1) and treatment of 6 (G3S2), however based on the growth rate, the treatment of 3 (G3S1) namely 16.36 cm of dbh is significantly different or better than the treatment 6 (G3S2) namely 15.6 cm of dbh.

Table 3: LSD test for the six treatment

Dependent Variable: VAR00007		Multiple Comparisons					
LSD		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval		
(I) VAR00008	(J) VAR00008				Lower Bound	Upper Bound	
1.00	2.00	-.65687	.48987	.181	-1.6210	.3073	
	3.00	3.28372*	.56212	.000	2.1774	4.3900	
	4.00	.01676	.49411	.973	-.9557	.9892	
	5.00	-.50517	.49196	.305	-1.4734	.4631	
	6.00	4.04483*	.59579	.000	2.8722	5.2174	
2.00	1.00	.65687	.48987	.181	-.3073	1.6210	
	3.00	3.94058*	.56029	.000	2.8379	5.0433	
	4.00	.67362	.49203	.172	-.2948	1.6420	
	5.00	.15169	.48987	.757	-.8124	1.1158	
	6.00	4.70169*	.59407	.000	3.5325	5.8709	
3.00	1.00	-3.28372*	.56212	.000	-4.3900	-2.1774	
	2.00	-3.94058*	.56029	.000	-5.0433	-2.8379	
	4.00	-3.26696*	.56400	.000	-4.3770	-2.1569	
	5.00	-3.78889*	.56212	.000	-4.8952	-2.6826	
	6.00	.76111	.65492	.246	-.5279	2.0501	
4.00	1.00	-.01676	.49411	.973	-.9892	.9557	
	2.00	-.67362	.49203	.172	-1.6420	.2948	
	3.00	3.26696*	.56400	.000	2.1569	4.3770	
	5.00	-.52193	.49411	.292	-1.4944	.4505	
	6.00	4.02807*	.59757	.000	2.8520	5.2042	
5.00	1.00	.50517	.49196	.305	-.4631	1.4734	
	2.00	-.15169	.48987	.757	-1.1158	.8124	
	3.00	3.78889*	.56212	.000	2.6826	4.8952	
	4.00	.52193	.49411	.292	-.4505	1.4944	
	6.00	4.55000*	.59579	.000	3.3774	5.7226	
6.00	1.00	-4.04483*	.59579	.000	-5.2174	-2.8722	
	2.00	-4.70169*	.59407	.000	-5.8709	-3.5325	
	3.00	-.76111	.65492	.246	-2.0501	.5279	
	4.00	-4.02807*	.59757	.000	-5.2042	-2.8520	
	5.00	-4.55000*	.59579	.000	-5.7226	-3.3774	

*. The mean difference is significant at the .05 level.

This analysis show that 10 m of gap size is unfavorable for diameter growth of *Shorea leprosula*, meanwhile, the slope effect, i.e. 0-15% and 15-25%, is not influence for diameter growth of *Shorea leprosula* at the site. The research recommend to use 3 m to 5 m of gap size at the applying the Indonesia Selective Cutting and Line Enrichment Planting silvicultural system at all areas of tropical forest. This statement appropriate with Esteban that Dipterocarp plants can not grow well on the direct open site [8,12,13,14,15].

At the 10 m of gap size at the both of slope, the diameter growth was 16.36 cm and 15.6 cm and they have the smallest life percentage, namely just 60% and 50% only, but in this site, it be founded nine of pioneer species, i.e. *Macaranga hypoleuca*, *Ficus Virgata*, *Mallotus Paniculatus*, *Macaranga Gigantea*, *Glochidion colmanianum*, *Geunsia pentandra*, *Millettia sericea*, *Macaranga triloba*, and *Pternandra azurea*. Meanwhile, at the 5 m of gap size was founded two pioneer species, i.e. *Macaranga triloba* and *Millettia sericea* and at the 3 m of gap size was only founded one pioneer species, i.e. *Macaranga sp.* This phenomenon show that progressively close by canopy then progressively a low of pioneer species, because pioneer species needing full of light. They are included the intolerant species that have light demanding characteristic. The line gap treatments stimulate germination of pioneer species seed from dormancy what was caused by high light intensity. Many pioneer species were under pressure to dead at the closed canopy, although initially, at the first or second years, this species exist there [12,16,17,18].

At 10 m of gap size was unfavourable for diameter growth of meranti (*Shorea leprosula*) because meranti was semi-tolerant species that needing the tree port in the site. They

need indirectly light through intercanopy of other trees at the early days, and then, in the gradually manner, they need the full light to grow well at the site [7,19]. Although the line gap treatment had biodiversity added, but was not recommended by government because it is not intention of selective cutting and line enrichment planting silvicultural system [7,8].



Figure 4: Meranti (*Shorea leprosula*) at 3 m gap size after 5 years

At the guide line of Indonesia Selective Cutting and Line Enrichment Planting silvicultural system [8], gap size on this system was 3 m, meanwhile wide of line stand was 17 m. The cutting cycle of this system was 30 years. This research result accord with this regulation, that the 5 m of gap size resembles with the 3 m of gap size with using 17 m of wide of line stand, hence total of the trees in this case was 167 trees per ha.

With assumption that the trees were cut at cutting cycle next is 80% [1] and according to table of volume of *Shorea* spp at the Central Kalimantan region [20], so standing stock and final harvested of wood were:

$$V_{st/ha} = 80\% \times [10.000 / (3 \times 20)] \times 3.87 \text{ m}^3/\text{tree} = 515.99 \text{ m}^3/\text{ha}$$

$$V_{fh} = 515.99 \times EF = 330.23 \text{ m}^3/\text{ha}$$

where: st: standing stock, fh: final harvesting, EF: exploitation factors (:0.64)

During the time, harvested of logs from production natural forest in Indonesia is just 25 to 75 m³/ha only [1,4,5]. Foreseeable, applying the Indonesia Selective Cutting and Line Enrichment Planting could to improve the productivity of natural production forest in Indonesia, become 330.23 m³/ha, it is a big progress and can be answering of demand of domestic wood requirement and to export interest.

5. Conclusion

Shorea leprosula is suitable planted at the line gap of the Indonesia Selective Cutting and Line Enrichment Planting silvicultural system with 5 m or 3 m of gap size. At the 10 m of gap size, it is unfavourable for diameter growth of *Shorea leprosula*, although it be founded nine of pioneer species. Hence, applying this system at the natural production forest is better choice, and it be estimated able to improve growth and yield of *Shorea* spp.

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