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STRUCTURE, DIAMETER INCREMENT, AND CUTTING CYCLE OF RESIDUAL STAND IN LOGGED-OVER FOREST IN EAST KALIMANTAN

(*Struktur, Riap Diameter, dan Siklus Tebangan dari Tegakan Tinggal di Hutan Bekas Tebangan di Kalimantan Timur*)

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ABSTRACT

This study aims to determine the structure, diameter increment, and cutting cycle estimation of residual stand for commercial species at log over forest managed with a selective cutting and line planting system (TPTJ) at PT Balikpapan Wana Lestari East Kalimantan, Indonesia. The residual stand parameter (tree amount, diameter, and increment) measurement was conducted at the log over area for 1 year, 2 years, and 3 years at the inter-planting line in TPTJ block from 3 PUP (Permanent measuring plot) which each with a size of 100 m x 100 m (1 ha). The result presents residual stand structure at the inter-planting line based on diameter class in the 'J' upside-down form indicates the larger diameter class, the smaller tree amount. The average diameter increment of the residual stand at the inter-planting line for commercial species is 1.04 cm/yr, and non-commercial is 0.65 cm/yr. The estimated cutting cycle is 19 years for commercial species with a cutting diameter limit of 40 cm up. The potential of stands in the inter-planting line can be expected to produce logging at the end of the cycle, besides the stand in the planted line, including superior species and having significant increments.

Keywords: cutting diameter limit, diameter increment, nucleus tree, stand structure

ABSTRAK

Penelitian ini bertujuan untuk mempelajari struktur tegakan, riap diameter dan pendugaan daur tegakan tinggal jenis komersil di hutan bekas tebangan yang dikelola dengan sistem Tebang Pilih Tanam Jalur (TPTJ) di areal konsesi PT Balikpapan Wana Lestari di Penajam Paser Utara, Provinsi Kalimantan Timur. Pengukuran parameter tegakan tinggal (jumlah pohon, diameter dan riapya) dilakukan pada areal bekas tebangan 1 tahun sampai dengan 3 tahun pada jalur antara (terletak diantara dua jalur tanam) di blok TPTJ dari 3 PUP (Petak Ukur Permanen) yang masing-masing berukuran 100 m x 100 m (1 ha). Berdasarkan hasil penelitian diketahui struktur tegakan tinggal di jalur antara berdasarkan kelas diameter adalah berbentuk J-terbalik, artinya semakin besar kelas diameter maka jumlah pohon semakin sedikit dan sebaliknya. Rataan riap diameter tegakan tinggal pada jalur antara untuk jenis komersil sebesar 1,04 cm/th, non komersil sebesar 0,65 cm/th, dan pendugaan daur tebang sebesar 19 tahun untuk jenis komersil dengan limit diameter tebang 40 cm up. Potensi tegakan di jalur antara masih bisa diharapkan produksi tebangannya pada akhir daur, disamping tegakan pada jalur tanam yang merupakan jenis unggulan dan mempunyai riap yang besar.

Kata kunci: Limit diameter tebang, pohon inti, riap diameter, struktur tegakan

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INTRODUCTION

A Logged-over Forest is a natural production forest that has undergone a harvesting process, or trees of economic value have been cut down at a predetermined diameter, usually in logged-over forest areas that are included in production natural forest areas. However, in reality, many logged-over areas in natural production forest areas have poor stands; the growth of standing stands is not optimal due to the maintenance of maximum standing stands (Yusuf 2016).

In Indonesia, production forest management is generally carried out with a single silvicultural system, namely the Indonesian Selective Cutting and Planting Silvicultural System (TPTI). The implementation of the TPTI silvicultural system is considered unable to keep pace with the increasing demand for carpentry wood and other industrial raw materials due to a decrease in log production, a decrease in the area and the quality of production forests. So genuine efforts are needed to improve Indonesia's production forest management system, which is carried out more intensively to increase the productivity of natural production forests optimally and sustainably by balancing the ecological, economic and social aspects (Karmilasanti and Wahyuni 2018).

One of the efforts to increase the productivity and quality of tropical forests in Indonesia is selecting the Selective Cutting and Planting Line silvicultural system (TPTJ). It is previously called the Intensive Indonesian Selective Cutting and Planting (TPTII). It is better known as SILIN (Intensive Silviculture). This silvicultural system applies the basic principles of intensive silviculture, including: tree breeding, environmental manipulation, and protection against pests and diseases. PT. Balikpapan Wana Lestari (BWL) in the province of East Kalimantan applies the TPTJ silvicultural system in the management of production forests.

The TPTJ system is a silvicultural system applied in logged-over forest and secondary forest (entering the second cutting cycle). It requires that superior plants be planted in a 3 m wide planting line with a distance between the axes of the planting line along 20 m, the inter-planting line (located between the two planting lines) with a width of 17 m, cut down with a diameter limit of 40 cm. So, the natural forest left on the inter-planting line is cut down using a selective logging system.

Disadvantages of the TPTJ system from technical and ecological aspects include reduced species diversity, reduced structure, composition, and stand density (Tirkaamiana and Susilowati 2020). The implementation of the current TPTJ silvicultural system needs to be done because its application has not been tested until the final cycle of 35 years. One thing that can be evaluated is the development of vegetation on the line between plantings, namely natural stands with a width of 17 meters which are expected to maintain forest stability. Planting activities in logged-over areas can affect stand structure and species composition changes by making lines and previous harvesting activities (Pamoengkas and Zamzam 2017).

The increment information is the basis for determining management policies such as the length of the cutting cycle or rotation, the annual cutting allowance, the cutting diameter limit and the required silvicultural treatments. However, accurate incremental information is still minimal, so the Indonesian Selective Cutting and Planting System (TPTI) assumes an increment of 1 cm/yr. Without knowing the magnitude of the increment and the expected yield in the future, there is no guarantee whether the size of the annual cut allowance has led to the sustainability of production and the preservation of forest resources (Kuswandi and Nugroho 2019).

Based on the previous information on stand structure, diameter increment, and estimation of cutting cycles for residual stands in the inter-planting line in the TPTJ silvicultural system is very necessary to develop a forest concession plan based on the principle of sustainability. It is hoped that at the end of the harvesting cycle, it will be carried out in the planting line with its superior type and the inter-planting line with a selective logging system. This study aims to determine the stand structure average increment and estimate the cutting cycle of commercial types of residual stands on the inter-planting line managed by the Selective Cutting and Planting System (TPTJ) in the concession area of PT Balikpapan Wana Lestari (BWL) in North Penajam Paser, East Kalimantan Province.

METHOD

Research Location and Time Period

This research was conducted in the TPTJ block in the PT Balikpapan Wana Lestari (BWL) area in North Penajam Paser Regency, East Kalimantan Province. The research area coordinates 116o23'57" East Longitude, 1o7'15" South Latitude. The study was carried out for ± 1 year and 8 months.

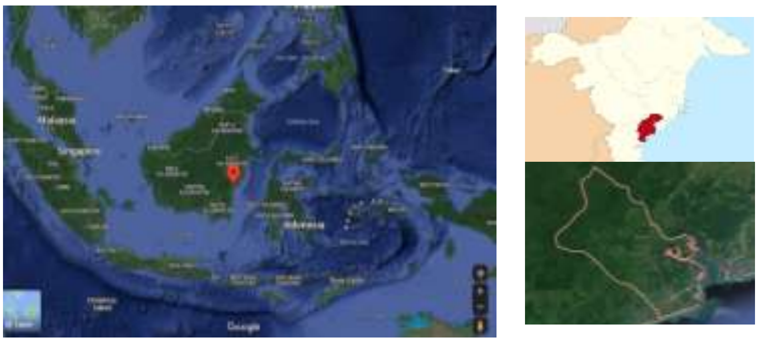

Figure 1. Location of the Study

Research Tools and Materials

The materials used in this study were commercial stands (Dipterocarpaceae and Non-Dipterocarpaceae) after 1 year (Et + 1) to 3 years (Et + 3) felling in the inter-planting line in the TPTJ block in the PT BWL area. The equipment used is work map, phiband, shunto clinometer, distance measuring tape.

Data Collection and Research Procedure

The parameters of the residual stands were measured in the inter-planting line within the TPTJ block in 3 PUPs (Permanent Plots) measuring 100 mx 100 m (1 ha), each of which was made in the TPTJ block after logging 1 year (Et + 1) for PUP 1, 2 years (Et + 2) for PUP 2, and 3 years (Et + 3) for PUP 3, with 3 replicates as shown in Figure 2. Parameters observed in the study are the diameter and increment, and the number of trees of all types of standing stands for the pole level (10 cm – 19.9 cm) and trees (diameter 20 cm) in the inter-planting line.

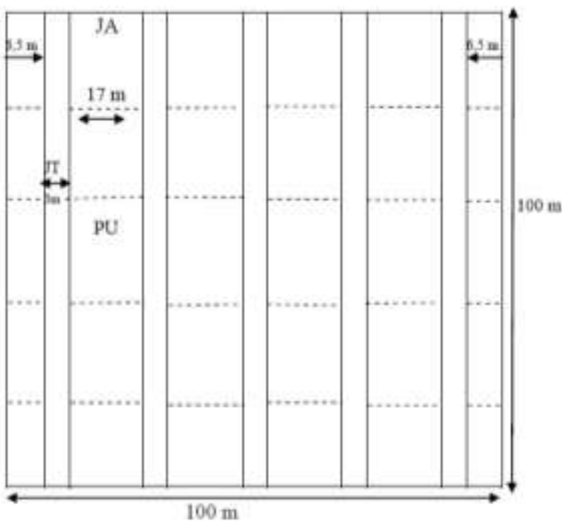

Figure 2. PUP layout

Data Analyses

The estimation of the cutting cycle and the diameter limit of cutting standing stands in the between the line is calculated based on the average diameter increment data with the B2PD (2013) formula approach, as follows: R = (C – M) / I or C = M + (I x R), where: R = Cutting Cycle, C = Cutting Diameter Limit, M = Nucleus Tree Diameter Limit, I = Diameter Increment.

RESULTS AND DISCUSSIONS

Distribution of Trees

Based on observations of the presence of tree species (diameter 20 cm) and pole level (10 cm – 19.9 cm), which are in the inter-planting line in the TPTJ silvicultural system, commercial and non-commercial tree species are found as shown in Table 1.

The types of trees found in the line between as many as 28 species consisting of 18 commercial tree species and 10 non-commercial trees are guided by the Indonesian Trade Timber Grouping (Djarwanto et al. 2017).

Table 1. Types of Commercial and Non-Commercial Trees Found in Residual Stands on the Inter-Planting Line of TPTJ Blocks at PT BWL

No	Region Name	Botanical Name	Ethnic Group	Group
1	Palado	*Aglaia sp*	Meliaceae	Non Commercial
2	Bakil	*Artocarpus anisaphilus*	Moraceae	Non Commercial
3	Keledang	*Artocarpus lanceofolius*	Moraceae	Non Commercial
4	Kenanga	*Cananga sp*	Annonaceae	Non Commercial
5	Kemayau	*Dacryodes rostrata*	Burseraceae	Non Commercial
6	Keranji	*Dialium indum*	Fabaceae	Commercial
7	Keruing	*Dipterocarpus sp*	Dipterocarpaceae	Commercial
8	Durian	*Durio dulcis*	Bombaceae	Commercial
9	Dahu	*Dracontomelon dao*	Annacardiaceae	Commercial
10	Kapur	*Dryobalanops lanceolata*	Dipterocarpaceae	Commercial
11	Kayu arang	*Dyospiros borneensis*	Ebenaceae	Commercial
12	Ulin	*Eusideroxylon zwageri*	Lauraceae	Commercial
13	Kempas	*Koompassia exelsa*	Caesalpiniaceae	Commercial
14	Bungur	*Lagerstromia speciosa*	Lytraceae	Commercial
15	*Dukuh*	*Lansium sp*	Meliaceae	Non Commercial
16	*Medang*	*Litsea sp*	Lauraceae	Commercial
17	*Rambutan*	*Nephelium sp*	Sapindaceae	Non Commercial
18	*Benuang Bini*	*Octomeles sumatrana*	Tentramelaceae	Commercial
19	*Nyatoh*	*Palaquium sp*	Sapotaceae	Commercial
20	*Ki Sawo*	*Planchonello obovata*	Sapotaceae	Non Commercial
21	*Tepis*	*Polyalthia glauca*	Annonaceae	Commercial
22	*Bayur*	*Pterospermum sp*	Sterenliaceae	Commercial
23	*Kedongdong*	*Santiria sp*	Burseraceae	Commercial
24	*Meranti kuning*	*Shorea acuminatissima*	Dipterocarpaceae	Commercial
25	*Meranti Sarang punai*	*Shorea parvifolia*	Dipterocarpaceae	Commercial
26	*Meranti merah*	*Shorea leprosula*	Dipterocarpaceae	Commercial
27	*Jambu-jambuan*	*Syzygium*	Myrtaceae	Non Commercial
28	*Sowang*	*Xanthostmemon*	Myrtaceae	Non Commercial

Regeneration of tropical forests is limited by the distribution of seeds of the surrounding species. In the early phase of forest clearing, pioneer species will be abundant, influenced by the type and characteristics of the seeds/seeds and natural agents of seed dispersal, such as wind and wildlife (Reid et al. 2015).

Graphs of the distribution of the number of trees for commercial and non-commercial species groups in the inter-planting line in PUP 1 after 1 year of felling (Et + 1), PUP 2 after 2 years of felling (Et + 2), and PUP 3 after 3 years of felling (Et + 3) as shown in Figures 3,4, and 5.

Distribution of the number of trees for Commercial and non-commercial species based on diameter class on the line between PUP 1 to PUP 3 in PT BWL as shown in Figures 2 to 4. It can be seen that the number of trees for all types (commercial and non-commercial) is inversely proportional to diameter class or it forms an inverted "J".

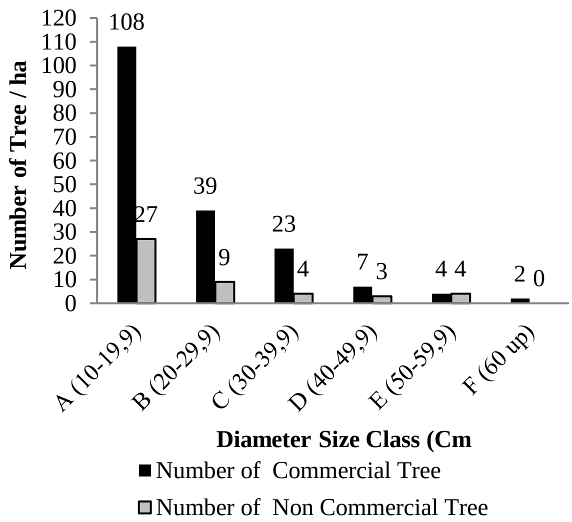

Figure 3. Number of Commercial and Non-Commercial Trees by Diameter Class on the Line Between PUP 1 (Et + 1) TPTJ Block at PT BWL

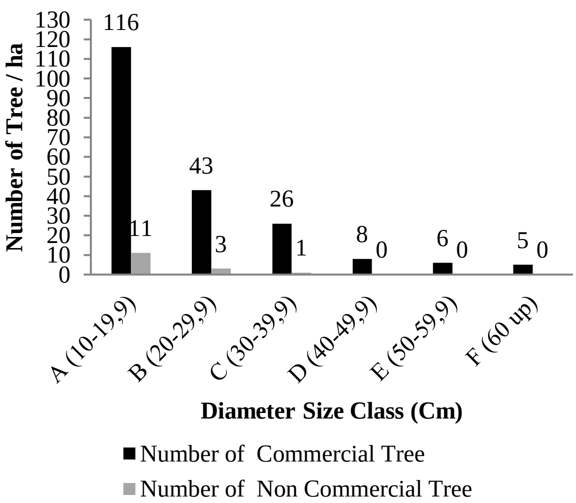

Figure 4. Number of Commercial and Non-Commercial Trees based on Diameter Class on the Line Between PUP 2 (Et + 2) TPTJ Block at PT BWL

It means that the larger the diameter class, the smaller the number of trees and vice versa, the smaller the diameter class, the greater the number of trees. The highest number of trees is at the smallest diameter, namely the pole level with 10 cm – 19.9 cm. It decreases gradually in the larger diameter class, where the largest diameter class is 60 cm up. This is understandable because the structure of the distribution of individual trees is mostly at small diameters and gradually decreases at larger diameters. The forest microclimate and topography strongly influence the stand structure of tropical forests (Muscarella et al. 2020). The opening of the forest canopy supports the growth of saplings to develop into poles and saplings so that there are more of them than trees with larger diameters.

It is also following research conducted by Istomo and Rendra (2017) in the PT Barito Puetra TPTJ area in Central Kalimantan, that the stand structure from the smallest diameter to the largest diameter in the logged-over areas of LOA 2002, LOA 2007, and LOA 2012, as well as primary forest, is increasing. The graph decreases as it forms an inverted "J" which means that the stand characteristics are not the same age (natural forest). It can be said that the forest condition is still classified as normal.

As the diameter of the tree increases, the fewer the number of trees found in that diameter class. The general form of the diameter class distribution follows the shape of an inverted "J" exponential curve, meaning that the larger the diameter class, the smaller the density (Istomo and Dwisutono 2016). Stand structure describes the relationship between diameter class and the number of trees (Herianto 2017).

The number of commercial tree species per hectare for the pole level on the inter-planting line in PUP 1 is 108 trunks, PUP 2 has 116 stems, and PUP 3 has 159 stems.

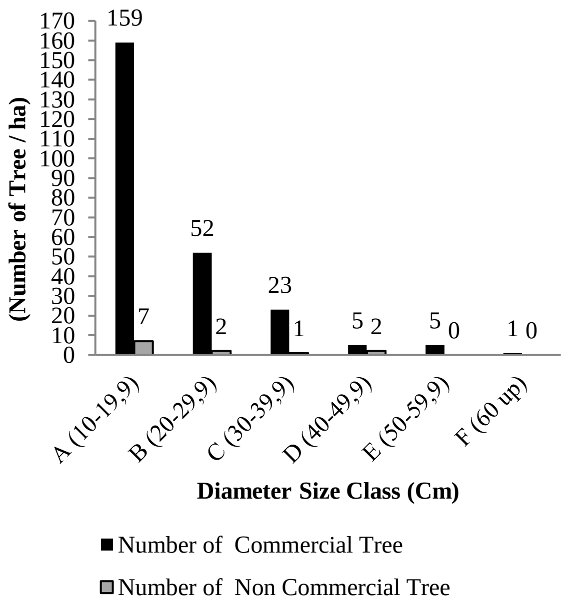

Figure 5. Number of Commercial and Non-Commercial Trees based on Diameter Class on the Line Between PUP 3 (Et + 3) TPTJ Block at PT BWL

The number of trees at pole level increased according to age of the plant or the age of the residual stands, starting from 1 year to 3 years of logging. Meanwhile, the number of trees is relatively the same for commercial and non-commercial types. Thus, there is no need for enrichment planting or enrichment planting for secondary/logged-over forest in the inter-planting line in the TPTJ block in the PT BWL concession area. This is because the number of trees at the pole level is more than 75 trunks/ha, and the number of nucleus trees (commercial species with a diameter of 20 cm) is more than 25 trees/ha. Enrichment is required if all levels of vegetation (trees, poles, saplings, and seedlings) are not met from the required adequacy rate. In contrast, if one of the existing vegetation per hectare is met, then enrichment is not necessary (Karmilasanti and Fajri 2017).

Figures 3 to 5 also show that for the distribution of the number of trees in PT BWL, the number of non-commercial tree species is much less than the number of commercial tree species in each diameter class. The decreasing number of non-commercial tree species is due to the increasing demand for wood. On the other hand, the number of commercial tree species is decreasing, so there is a shift in the use of non-commercial wood that was previously not cut down and used to become a commercial type that is cut down and utilized. Historically, PT BWL has been operating for a long time, since before the seventies and has had two cutting cycles, so commercial species have been decreasing. Increased harvesting intensity resulting in a larger 'gap' can increase species richness and species diversity in the early stages of clearing and reduce shade (Kern et al. 2014).

Diameter Increment

From the diameter measurement data on the line between the TPTJ blocks at PUP 1, PUP 2, and PUP 3 at PT BWL, several graphs of diameter increment for commercial and non-commercial types based on diameter class are shown as shown in Figures 6, 7, and 8.

From the observations, the average diameter increment for both commercial and non-commercial types based on the overall diameter class was not much different in PUP 1 after 1 year of logging (Et + 1), PUP 2 after 2 years of logging (Et + 2), and PUP 3 after 3 years of logging (Et + 3), as in Figures 5, 6, and 7 above. The difference in diameter increment for each diameter class is very small. However, non-commercial types in PUP 1 for the largest/last diameter class, in PUP 2 for the three largest/last diameter classes, and in PUP 3 for the two largest diameter classes, the diameter increment appears to be zero. It is not the increment of trees is zero but the number of non-commercial trees that are not in that

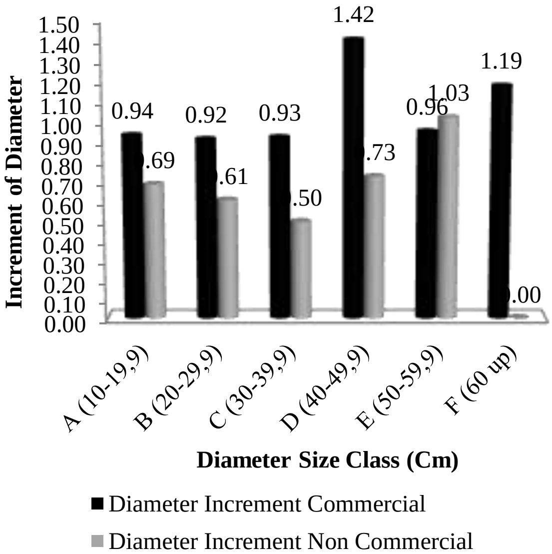

Figure 6. Diameter Increment for Commercial and Non-Commercial Types based on Diameter Class on the inter-planting line of PUP 1 (Et + 1) TPTJ Block at PT BWL

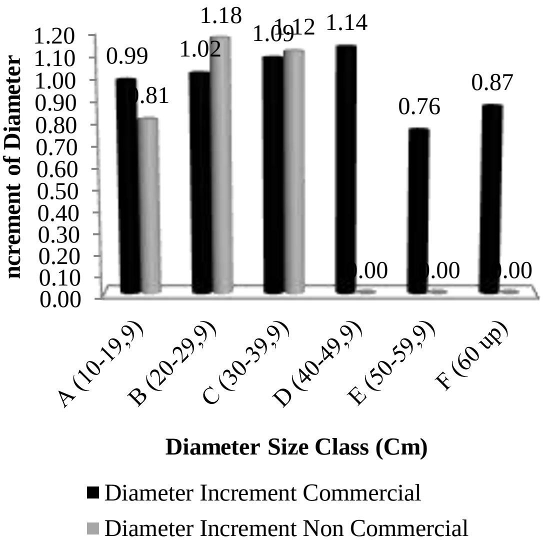

Figure 7. Increment of Diameter for Commercial and Non-Commercial Types based on Diameter Class on the inter-planting line of PUP 2 (Et + 2) TPTJ Block at PT BWL

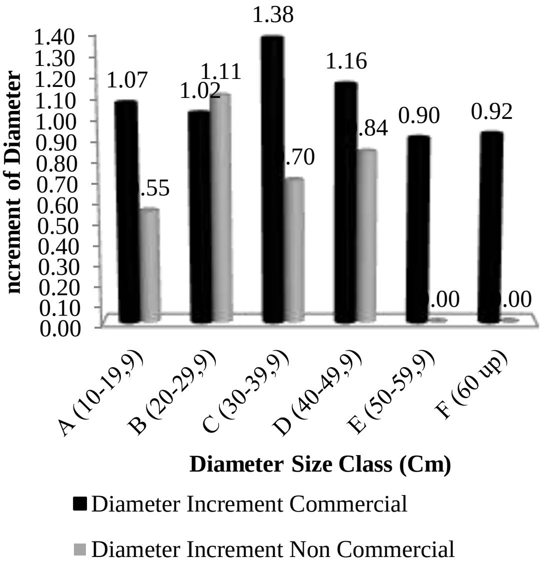

Figure 8. Increment of Diameter for Commercial and Non-Commercial Types based on Diameter Class on the inter-planting line of PUP 3 (Et + 3) TPTJ Block at PT BWL

diameter class. The average diameter increment for all diameter classes and all PUP (1-3) for commercial tree species in the inter-planting line is 1.04 cm per year and for non-commercial species is 0.65 cm per year. In general, the diameter increment of logged-over natural forest has slow growth.

The results of the study on the increment of three types of meranti (*Shorea leprosula*, S*horea parvifolia*, *Shorea johoriensis*) in the area of PT Suka Jaya Makmur, Ketapang Regency, West Kalimantan, obtained the average increment of Meranti species in the TPTI block of 1.03 cm/year and in the TPTJ block of 2.43 cm/year (Selfiany et al. 2017). The average increment for commercial types in the TPTJ block at PT BWL is 1.04 cm/year, which is not much different from the average increment for meranti in the TPTI block at PT Suka Jaya Makmur 1.03 cm/year. This is because, in the TPTJ system, the trees in the inter-planting line stand with the same treatment given to the TPTI system. The growth of commercial tree species in the inter-planting line in the TPTJ system at PT BWL is approximately the same as the growth of the Meranti species in the TPTI system at PT Suka Jaya Makmur. Meanwhile, the Meranti increment in the TPTJ block as measured by Selfiany (2017) is in the planting line. The average increment of commercial species in the inter-planting line at the TPTJ block at PT BWL for the 10-19 cm diameter class is 1.00 cm/year, and for the 20-29 cm diameter class, it is 1.07 cm per year.

Marsono (1990) stated that the average increment of un-maintained dipterocarp stands in 10-19 cm diameter class was 0.64 cm. Several factors inhibit its growth, including genetic factors, irregular density, uneven light intensity, competition for nutrients, and environmental factors such as temperature, humidity, and biological factors that support it, such as mycorrhizae. Shorea species are superior species, have economic value, and are fast-growing. The results showed that the average diameter increment of this plant was relatively high, ranging from 1.28 cm to 1.71 cm or an average of 1.44 cm. On the other hand, the results of Susanty(2001) in the 10-year logged-over area found that the annual diameter increment of the meranti group had a higher annual diameter increment (0.589 – 1,330 cm/year) compared to the non-meranti Dipterocarpaceae group (0.434 – 0.861 cm/year) and non-Dipterocarpaceae (0.352 – 0.783 cm/yr). The results of Abdullah and Darwo's research (2015) showed that the diameter increment (CAI) in the natural forest stands of Buru Island was 1.3 cm/year in the diameter class 10–20 and 0.78 cm/year in the largest diameter class of 40 cm and above. The CAI of the commercial species group was greater than that of the non-commercial species group. Meanwhile, the CAI of the Dipterocarpaceae and Myrtaceae families was higher than that of the Burceraceae, Fagaceae, Guttiferae and Lauraceae families.

Based on observations, the average increment in PUP 1 is 0.98 cm/year, PUP 2 is 1.18 cm/year, and PUP 3 is 1.08 cm/year. The average increment of commercial species in each PUP (1 to 3) does not show a significant difference, and this is because there is no treatment for maintaining stands in the inter-planting line, especially for nucleus trees. These namely trees are expected to be felled in the next cutting rotation, as with the TPTI system. The incremental diameter of the commercial type, when compared to the incremental diameter of the non-commercial type, there are differences in each PUP and in almost every diameter class. The increment in diameter for the commercial type is always greater than the increment for the non-commercial type, except in PUP 1 for the diameter class 20 -29.9 cm and diameter class 30-39.9 cm. This is because the number (N) of commercial species in each PUP and in each diameter, class is always greater than that of non-commercial species. The larger number of trees in each diameter class causes commercial species to become dominant and co-dominant trees. The canopy gets full sun light from above and partly from the side so that light utilization is more optimal than non-commercial species with fewer trees for each diameter class. It causes non-commercial species to become co-dominant trees, mid-trees and even depressed trees with their crowns that get little sunlight from above through the holes in the canopy roof and tiny from the side.

Optimal light intensity will accelerate the transpiration rate on the leaves stomata opening, thereby affecting the photosynthesis rate. The existence of a maximum photosynthesis process will accelerate the growth of plant diameter and height (Tirkaamiana, Partasasmita, and Kamarubayana 2019).

Figure 8. Residual Stands of Commercial and Non-Commercial Types in the Inter-planting Line of 3 years logged

Figure 9. Nucleus Tree of Commercial Species (Dipterocarpaceae) on the inter planting line of 1 year logged

Cutting Cycle

Calculation of the cutting cycle in the inter-planting line in the TPTJ silvicultural system at PT BWL is based on the cutting diameter limit. It is set at 40 cm up according to the Ministry of Environment and Forestry (2014), and the nucleus tree diameter limit is 20 cm; the cycle or cutting cycle can be calculated using the B2PD formula (2013) approach as follows :

R (cutting cycle) = (40 cm – 20 cm): 1.04 cm/yr
= 20 cm : 1.04 cm/year
= 19.23 rounded up = 19 years

However, if the cutting cycle or cycle is determined according to the Ministry of Environment and Forestry (2014) which is 25 years and the diameter limit of the nucleus tree is 20 cm, then the cutting diameter limit is:

C (limit cutting diameter) = 20 cm + (1.04 cm/yr x 25 yrs)
= 20cm + 26cm
= 46 cm

The research on Meranti plant growth modeling in the planting line of the TPTJ system at PT Gunung Meranti area in Central Kalimantan Province conducted by Wahyudi et al. (2010), predicts the diameter growth of *Shorea leprosula* using 3 equation models, including Model 2: Polynomial equation. The model predicts the achievement of meranti (*Shorea leprosula*) in diameter of 50 cm and above (51.73 cm) at the age of 30 years. Compared with the research results by Wahyudi et al. (2010) at PT Gunung Meranti, the estimation of the cutting cycle at PT BWL is still faster or the prediction of achieving a larger diameter.

Another model in the meranti growth model research conducted by Wahyudi et al. (2010) is Model 3, using polynomial equations in 5 groups of plant increments. There are five sub-models of plant growth based on the incremental class. Of the five sub-models, one of them is the sub-model with the fast growth class (1.89 cm/yr), resulting in the following equation:

$Y = 0{,}0217x^2 + 2{,}0425x + 0{,}5739$, with the coefficient of determination (R^2) = 99.57%,

Where Y : final diameter; x : time of year. By assuming calculation of the cycle at PT BWL applied the B2PD formula approach (2013), the cycle of standing stands in the inter-planting line is 19 years for a cutting diameter limit of 40 cm. By using the polynomial equation model, the Meranti diameter achieved on the line planting is predicted to be 47.21 cm. Therefore, the 19-year cycle is classified according to the TPTJ system because at the same time (after 19 years), the predicted plant diameter in the planting line has reached 40 cm up (47.21 cm).

The 30-year TPTI cutting cycle is the most suitable because the stand density has recovered to its original state as the basis for determining sustainable production forest management (Wahyudi et al. 2012). Meanwhile, the rehabilitation of degraded natural forests using the Selective Cutting and Planting Line (TPTJ) system requires very high costs and a long investment, one harvesting cycle of 25 years (Elias and Suwarna 2019).

The cutting cycle of standing stands in the inter-planting line at PT BWL with the B2PD formula (2013) approach is predicted for 19 years, and the diameter is 40 cm. The prediction of the cutting cycle at PT BWL for 19 years is still safe because the condition of the regeneration of commercial stands for 10-19 cm diameter class is quite good and tends to increase. The increasing number of trees 1 (one) year after felling (PUP 1) as many as 108 trees/hectare up to 3 (three) years after felling (PUP 3) increased by 159 trees per hectare.

CONCLUSIONS

The structure of the residual stands for all types (commercial and non-commercial) is inversely proportional to the diameter class of the tree or the graph decreases as it forms an inverted “J”, meaning that the larger the diameter class, the smaller the number of trees and vice versa. The average diameter increment on the inter-planting route for commercial species is 1.04 cm/yr and for non-commercial types is 0.65 cm/yr. By estimating the cycle of residual commercial species in the inter-planting line at the age of 19 years to reach the cutting diameter limit of 40 cm up, the nucleus tree left at least 25 trees per hectare. The standing cutting cycle stays in the inter-planting line, simultaneously with the cutting cycle of the main crop in the planting line. The productivity of the residual stand left from selective logging in the inter-planting line will significantly help increase the overall stand productivity in the TPTJ system.

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