Natural regeneration potential of Shorea pinanga Scheff and Shorea platyclados Slooten ex Endert. in Gunung Dahu research forest, Bogor-West Java

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Abstract. Natural regeneration potency is important component that ensure replenished of trees as older trees are died or harvested. Natural regeneration drives the change of stand structure by time. The objectives of this research were to analyze the potential and natural regeneration of S. pinanga and S. platyclados stand, and to analyze environmental factors that affect the natural regeneration of both species in Gunung Dahu Research Forest (GDRF). Natural regeneration potential of S. pinanga was very low, only 4 seedlings were found in 2 observation plots, while natural regeneration potential of S. platyclados was higher that had total number of 1874 seedlings observed. Environmental conditions such as slope and elevation were sufficiently support regeneration of S. platyclados at the seedling level.

1. Introduction
Tropical forests are known for their high diversity with ecological processes that run dynamically. The formation of patterns of diversity and structure of forest stands is closely related to environmental conditions, both biotic and abiotic factors. Dipterocarpaceae is a family of dominant’s species in Malaysian and Indonesian tropical forests, ecologically dominant and economically significant timber [1].

The distribution and abundance of Dipterocarpaceae species in Indonesia tend to decrease due to the conversion of forests into other functions as well as over-exploitation. Declining population without being balanced with conservation efforts can result in extinction [2]. Therefore, appropriate conservation efforts are needed to maintain and preserve natural forest resources. Conservation efforts can be carried out by developing artificial forests or plantations.

Gunung Dahu Research Forest (GDRF) is a man-made dipterocarp forest that aims to test the adaptability of various species of the Dipterocarpaceae planted outside its natural habitat, to determine growth rates, reveal silvicultural techniques both in nurseries and in the field, and to carry out ex-situ conservation strategies species in reliable and safe locations [1]. The GDRF is located in Pabangbon Village, Leuwiliang District, Bogor Regency – West Java with an area of around 250 ha. GDRF was established 1997 through the collaboration between Forest and Nature Conservation Research and Development Center (now the Forest Research & Development Center) and KOMATSU, Japan. At present, the area planted with meranti species is ± 160.7 ha consisting of meranti experimental plots (± 75 ha) and meranti collection plots (± 85.7 ha) [3].
Forest sustainability is closely related to the potential of natural regeneration. Natural forest regeneration will follow the process of colonization, stand formation, growth, and survival. Forest regeneration can be described from the dynamics of vegetation that occur from the presence of vegetation to reach reproductive phase. The factors that influence during the process take place can be natural or anthropogenic, such as social, economic, and culture that motivate people to use, maintain or eliminate vegetation [4].

Plantation can also perform its regeneration function naturally. The success of the natural regeneration process in plantations requires human intervention, such as maintenance activities to provide growth space for seedlings, saplings and supervision of disturbances. Estimating the potential of natural regeneration in plantations is important, because natural regeneration is one of the factors that can change stand structure of forests from time to time. The species existence of natural regeneration is also an indicator of the success of ex-situ conservation of this type. Shorea pinanga and Shorea platyclados are one of the species planted in planting test plots in the GDRF. Estimating the potential of natural regeneration of S. pinanga and S. platyclados species is important to determine the sustainability of forests in the future and the success of conservation of these species.

2. Method

2.1. Research site and Materials
The study was conducted of GDRF, an area in the Leuwiliang village, in this forest area, six plots were chosen to conduct vegetation data collection of the two namely Shorea pinanga and Shorea platyclados.

![Figure 1. Observation plot for natural regeneration of S. platyclados and S. pinanga at GDRF](image)

2.2. Procedure
An enumeration form was designed to collect data on individual seedlings and saplings such as height, distance from the mother tree, canopy density, elevation, and slope.

2.2.1 Determining the location of observation and data collection methods
Selected plots for Shorea pinanga were plot number 5 and 24, while for Shorea platyclados were plot number 4, 15, 20 and 21E. The plots were assigned based on the existence of fruiting parent trees or fruiting history.
2.2.2 Canopy closure
Canopy cover was measured using a densiometer. Measurements were made by putting densiometer at a distance of 30-45 cm from the body with a height gauge and parallel arms. Each point densiometer readings on wind direction thus capturing north, east, south and west. The canopy closure level was weighted as follow: 4 (100%), 3 (75%), 2 (50%), 1 (25%), and 0 if no shadow sky captured [5].

2.2.3 Slope and elevation
Slope was measured using a clinometer. Clinometer is a simple tool used to measure the elevation angle formed between the flat line with a line that connects a point on the flat line with the end point of an object. GPS were used to measure elevation. Elevation data point/location will be recorded automatically at the GPS enabled with units of meters above sea level.

2.2.4 Mapping seedling distribution
Map of seedling distribution were processed using ArcGIS and Photoshop applications based on the distance data and azimuth position of the parent tree seedlings obtained in the field.

3. Results and discussions

3.1 Natural regeneration of Shorea pinanga and Shorea platyclados
Shorea pinanga had fewer seedlings compared to that of Shorea platyclados.

![Figure 2](image)

**Figure 2.** The number of individual Seedlings per plot observations.

Shorea platyclados natural regeneration can be found in plot number 20 and 4, both plots have suitable conditions for reproduction, that almost every year the mothers tree has flowering and fruiting. Seedling dispersal patterns influenced by fruit spreading patterns, whether through water, wind, and animals vectors. Individuals will be clustered in certain favorable places, where there is no disruption to the individual growth [6]. According to Soegianto [7], the pattern of spread of the organism in nature is rarely found in a uniform pattern (regular), but generally have clumped pattern. Individuals will be spread uniformly if all environment condition is very supportive. If the environment condition is not supportive, individuals will be spread randomly. The distribution patterns of S. pinanga and S. platyclados in each observation plot shown in Figure 3 – Figure 6.
Figure 3. Distribution of mother trees and their seedling at plot number 24

Figure 4. Distribution of mother trees and their seedling at plot number 4
Figure 5. Distribution of mother trees and their seedling at plot number 15

Figure 6. Distribution of mother trees and their seedling at plot number 20
Mature and optimal physiological maturity level of fallen seeds will develop into healthy seedlings. Trees with good phenotype, indicated by its diameter, height and canopy, will produce high number of seedlings [8]. Table 1 showed that *Shorea platyclados* produced high number of seedling compare to *Shorea pinanga*. Growth performance show that *Shorea platyclados* has higher value for both average height and diameter compare to *Shorea pinanga*.

**Table 1.** Average height and diameter of the mother trees at selected plots

| No plot | Average Height (m) | Average Diameter (cm) | Number of Seedlings |
|---------|-------------------|-----------------------|---------------------|
| 5 SPi   | 10.1              | 24.6                  | 0                   |
| 24 SPi  | 10.5              | 21.1                  | 4                   |
| 4 SP    | 17.3              | 41.1                  | 526                 |
| 15 SP   | 19.1              | 42.2                  | 9                   |
| 20 SP   | 21.85             | 40.3                  | 1339                |
| 21E SP  | 20.04             | 36.8                  | 0                   |

3.2 Environmental Factors
Environmental factors affects the condition of a stand. Natural regeneration process, in particular the presence of seedlings growth, is influenced by environmental factors such as light intensity, temperature, and humidity [9]. Table 2 showed environment condition for each of the plot.

**Table 2.** Abiotic condition of stand

| No plot | Elevation (masl) | Density (%) | Slope (%) |
|---------|-----------------|-------------|-----------|
| 5 SPi   | 803             | 62.82       | 50        |
| 24 SPi  | 873             | 68.28       | 35        |
| 4 SP    | 803             | 62.82       | 50        |
| 15 SP   | 853             | 80.5        | 40        |
| 20 SP   | 728             | 84.92       | 40        |
| 21E SP  | 730             | 84.66       | 70        |

*S. pinanga* or locally known as tengkawang grow naturally in many areas of Borneo. According to Istomo and Hidayati [10], this species usually grow on latosol soil at an altitude of 500 m above sea level, acidic pH (4.6-4.9), and good CEC (16.25 to 19.40). There were only 2 *S. pinanga* seedlings found in plot 24. The existence of dense undergrowth may halter the seedling growth at this plot. Seedling will grow optimally if they get enough light intensity for the growth process [11]. Dense undergrowth have blocked the sunlight to penetrate into the forest floor.

A densed-high undergrowth of fern in plot number 24 (height more than 1m) considered to become major constraint for seed germination. This undergrowth condition may haltered natural regeneration [12]. There will be high competition for both light and nutrient between seedling and undergrowth and dense undergrowth is not favorable to support seedling germination. Weeding this densed undergrowth is needed to ease seedlings from their competitors.

Habitat suitability play an important factor to determining growth and natural regeneration capability. GDRF which is located in high altitude in fact become a marginal habitat for *S. pinanga* (lowland species) but not for *S. platyclados* (hily species). Marginal habitat together with the occurrence of densed undergrowth may become the major factors for inhibiting the existence of natural regeneration on plot 24. Hence, weeding may neccesary to give spaces for fallen seeds to germinate into seedlings.

Different condition found in plots 5 where the plot has no seedlings. Plot 5 were planted in 1998 with an area of 1.4 ha and there are 40 mother trees bear to fruit and the fruits were abundant. A lack of saplings in plot 5 due to condition that this plot always visited by many people and are established
as tourist destination. Natural regeneration will be optimal if abundant natural regeneration has not been disturbed by pests, diseases and humans [13].

Seed of S. pinanga are categorized as recalcitrant that will decompose and lost its viability in short time. Open-compacted forest floor will not support seed germination. Seed germination require at least 90% of shade [14]. A very intensive use of plot 5 as a tourist destination attract many visitors, hence this led to the condition of forest floor in this plot to be very open, clean and compact. Reconsidering the use of this plot as a tourist site need to be done if management intend to support natural regeneration in this plots since the effect of this function is visible in halting the natural regeneration.

S. platyclados has higher numbers of seedlings counting for 1471 compare to that of S. pinanga. GDRF was suitable habitat for S. platyclados that known as hill species. S. platyclados grow naturally as hill species from 700-1000 m asl and showed rather less growth performance when planted at low land site [15]. The slope ranged between 40-70% with the altitude of the plot was 700 – 860m asl. Soil structure was sandy clay loam and sandy loam with the reddish-brown latosol [3]. Plot 20 considered to be the suitable habitat for S. platyclados where natural regeneration preserves in abundant amount.

Plot 21E has similar environment condition as that of plot 20. However, mother trees in this plot was recorded to experience only one time fruiting. The slope was also very steep (more than 70%) and at this site local community still cultivating bamboo. The forest floor hence has 10–12 cm thick of bamboo litter. In addition, the fern was also density. These factors may inhibit seed germination and as a result the absence of natural regeneration.

Plots 15 were planted in 1999 with a total area of 2.8 ha and there were only 8 parent trees. Conditions on this plot was also similar to that plot 24, where the forest was originally planted but now the condition was resembled natural forests. There were a lot of undergrowth dominated by Melastoma sp. and ferns whose height has reached more than 1 meter. The conditions in this plot characterized by dense undergrowth and pushed the seedlings to have high competition for light and nutrients. According to Uuttera et al. [16], the competition for light and nutrients causing natural selection. Plants that grow faster will remain alive while the slower will experience death.

In contrast to the plot 15, S. platyclados on plots 4 has abundant seedlings (526 seedlings). Total area of plot 4 is 1.6 ha and there were 27 mother trees have recorded to bear fruit. However, this plot has other function on as tour area, similar to that of plot 5. This function distrubed the occurence of natural regeneration (seedlings).

There are many factors that inhibit the occurrence of natural regeneration due to various pressures from human activities such as fire, the presence of the invasion of the dominant species, presence and invasive exotic species, micro-climatic conditions, poor soil and the absence of seed bank. During the observations in the field, there has been the activity of frequent artificial clearing of forest floor including seedlings happened in plot 4. This activity altered the occurrence of natural regeneration and reduce the survivorship of the seedlings significantly. Management needs to reconsider the use of this plot as tourist or visitors destination if they want to support the natural regeneration in this area.

According to Abdurachman and Soegianto A [17], the availability of large number of seedlings was not affected by the number of trees, but influenced by the season of fruits and seeds ability to germinate. Based on recorded note, plot 21E only fruiting one time, while plot 20 and 4 experienced their fruiting quite regularly (almost every year). This has led plot 20 and 4 to have abundant seedlings.

4. Conclusion
Natural regeneration of S. pinanga in GDRF was very low, only 4 seedlings were found in 2 observation plots, while natural regeneration of S. platyclados was high with the occurrence of 1874 seedlings in 4 observation plots. There is the need to support the natural regeneration by lessen the human disturbance and carried out several silviculture activities (e.g weeding at a very dense undergrowth in certain plots).
Acknowledgments
Deep gratitude was delivered to Pusat Litbang Hutan for providing GDRF as our research site. Authors also thankful to Project Collaboration Pusat Litbang Hutan – Komatsu for supporting the research budget and support the attendance in this International Conference on Tropical Silviculture 2019.

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