EFFECTIVENESS OF SELECTIVE GIRDLING IN ENHANCING THE GROWTH PERFORMANCE OF PLANTED *DRYOBALANOPS BECCARII* UNDER REFORESTATION AT GUNUNG APENG, FR, SARAWAK.

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This dissertation is submitted in partial fulfillment for the requirements for The Degree of Bachelor of Science with Honors
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DECLARATION

I hereby declare that the Final Year Project Report is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously submitted for any other degree at UNIMAS or other institutions.

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LIST OF ABBREVIATIONS

UNIMAS- University Malaysia Sarawak

FR- Forest reserved

RGD- Relative growth rate in diameter

RGH- Relative growth rate in height

T1- Control treatment

T2-Slashing treatment

T3-Girdling treatment

DB05- Areas planted with *Dryobalanops beccarii* in the year 2005

DB07- Areas planted with *Dryobalanops beccarii* in the year 2007

n.d.-no date

FAO- Food and Agriculture Organization

et al. - and others

spp- pecies

DBH- diameter breast height

h- Height

FC-Foot –candle

ANOVA- analysis of variation

n- Number of tree

m- Meter

Cm-centimeter

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Effectiveness of Selective Girdling in Enhancing the Growth Performance of Planted *Dryobalanops beccarii* under Reforestation at Gunung Apeng, FR, Sarawak.

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ABSTRACT

A study on the assessment on the growth performance of planted *Dryobalanops beccarii* under the reforestation at Gunung Apeng, FR, Sarawak with selective girdling treatment was carried out. The objective of this study was to investigate the suitable silviculture treatment on the growth performance of planted *Dryobalanops beccarii* under reforestation in Gunung Apeng, FR, Sarawak. In this study, *Dryobalanops beccarii* were planted in line planting in the study plot 2005 and 2007 were chosen. The height of tree, stem diameter and survival rate were measured. The monitoring period on the growth performance of *Dryobalanops beccarii* was 60 and 90 days after silviculture treatment were applied. Based on the observation in the field, there were some factors which affected the growth performance of *Dryobalanops beccarii* which were canopy openness, planting technique and topography of the area. The study showed that the survival rate of *Dryobalanops beccarii* showed 100 % after silviculture treatment. The result showed that there was significance different of relative growth rate in diameter (RGD) among control, slashing and girdling treatment after 60 days of silviculture treatment and also significance different among control and girdling treatment after 90 days of silviculture treatment in the study plot 2007. Girdling treatment showed the highest RGD in both the study plot 2005 and 2007 which indicated that the effectiveness of the girdling treatment as compared to the control and slashing treatment.

Keyword: reforestation, silviculture, growth performance, survival rate, *Dryobanops beccarii*

ABSTRAK

Satu kajian mengenai prestasi tumbesaran *Dryobalanops beccarii* di bawah penanaman hutan semula di Gunung Apeng, hutan simpanan, Sarawak dengan rawatan girdling telah dijalankan. Objektif kajian ini adalah untuk menyiasat rawatan silvikultur yang sesuai ke atas prestasi tumbesaran *Dryobalanops beccarii* yang ditanam di bawah penanaman hutan semula di Gunung Apeng, hutan simpanan, Sarawak. Dalam kajian ini, *Dryobalanops beccarii* ditanam dalam penanaman baris dalam plot kajian 2005 dan 2007 telah dipilih. Ketinggian pokok, diameter batang dan kadar kelangsungan hidup pokok telah dinilai. Tempoh pemantauan ke atas prestasi tumbesaran *Dryobalanops beccarii* adalah 60 dan 90 hari selepas rawatan silvikultur telah digunakan. Berdasarkan pemerhatian dalam bidang ini, terdapat beberapa faktor yang menjejaskan prestasi tumbesaran *Dryobalanops beccarii* iaitu keterbukaan kanopi, teknik penanaman dan topografi kawasan penanaman. Kajian ini menunjukkan bahawa kadar kelangsungan hidup *Dryobalanops beccarii* menunjukkan 100% selepas rawatan silvikultur. Hasil kajian menunjukkan bahawa terdapat perbezaan yang signifikan antara kadar pertumbuhan relatif dalam diameter (RGD) di kalangan control, slashing dan girdling rawatan selepas 60 hari rawatan silvikultur dan juga perbezaan yang signifikan antara kumpulan control dan girdling rawatan selepas 90 hari rawatan silvikultur dalam plot kajian 2007 . Girdling rawatan menunjukkan RGD yang tertinggi di kedua-dua plot kajian 2005 dan 2007 yang menunjukkan bahawa keberkesanan rawatan girdling berbanding dengan kawalan dan menurunkan rawatan.

Kata kunci: penanaman hutan semula , silvikultur, prestasi tumbesaran, kadar kelangsungan hidup, *Dryobanops beccarii*

1.0 Introduction

Forest is an important natural resource as it can manage to yield a variety of commodities of economic importance and for sustainably harvested (Freedman, 2012). It plays the role in regulate the climate, acts as large purifiers of airs by absorbing carbon dioxide, and giving out oxygen, preserve drinking water quality in watersheds, moderating stream flow and flooding, controlling surface runoff and erosion, buffering against pollutants, and preventing sedimentation and eutrophication of waterways (Wilder & Kiviat, 2009). Hence, the management of the forest is very important as the indigenous tree species in the forest will become less or extinct due to improper conservation, logging or reforestation.

The tree family Dipterocarpaceae plays an important role in the ecology and economics of Asian forest and the dipterocarp trees are dominated in the forests in Borneo, Sumatra, Java, the Malay Peninsula, and the wetter parts of the Philippines (Corlett & Primack, n.d.). Forest in Sarawak is very extensive and richness with lot of tree species such as *Dipterocarpaceae* family. However, continuing exploit of these resources will result in the tree species become exhausted. Therefore, enrichment planting under reforestation and forest plantation are very crucial in order to change the composition of forest to become more diverse and richness. Enrichment planting has a highly effective in rehabilitating of the degraded forest (Appanah & Weinland, 1993). Silviculture treatment is used widely in the management of forest with the aim for conservation of the indigenous tree species to promote the growth of the indigenous tree species.

Girdling is the most suitable treatment out of all silviculture treatment in terms of changing light environment (Cohen, 1999). The survival rates and the growth of seedlings are determined majority by the canopy openness and quality of light (Pena et al., 2002). The genus *Shorea* (Dipterocarpaceae) had demonstrated that in the artificial shade experiments, partial shade often provides the best growth environments followed by different respond to light intensity by various species (Aston, 1995 & Tennakoon, 2005). In addition, the replanting of indigenous tree species should be matched with the light intensity required by the tree species to promote growth high survival and growth rates (Ramos & Del Amo, 1992).

Girdling is considered as an effective silvicultural treatment to increase the abundance of snags in the forest as important structures since the last decade of the twentieth century (Franklin et al., 1997; McComb, & Lindenmayer, 1999). Some studies proved that the percentages of girdled trees with leaves are lighter in color compare to non-girdled tree and the leaf sizes of girdled tree are smaller than normal trees (Tate, 1980). This means that the canopy of the forest is open widely than before applying the girdling treatment and more sunlight can penetrate in the forest which later, promote better growth of shade tolerant trees. Therefore, it is necessary to understand the effect of girdling on the growth performance of planted trees under enrichment planting for reforestation purpose.

1.1 Problem statement

Under the forest management practice, silviculture activities are important in order to promote better growth of trees for enhancement of species diversity and conservation of indigenous species. The knowledge and study of girdling treatment is still lacking in forest management, especially under artificial planting. In addition, silviculture treatment in forestry practice involved various techniques such as girdling and pruning. By applying the suitable silvicultural treatment, it may promote better growth performance of the planted tree species.

1.2 Objectives

The objective of this study is to investigate the suitable silviculture treatment on the growth performance of planted *Dryobalanops beccarii* under reforestation in Gunung Apeng, FR, Sarawak. Silviculture treatments that are applied in this study are slashing (representing the current silvicultural treatment being applied in reforestation area in Sarawak), selective girdling on existing tree species and no silviculture treatment study plot as the control. Comparison of the growth performance of the planted indigenous tree species under the applied silviculture treatment was clarified and the relationship between silviculture treatment applied and the growth performance and survival rate of the Dipterocarp species was revealed. Assessment on the appropriate silvicultural approach of this study is important as such information could be as guidelines for future management practice within the reforestation area.

2.0 Literature Review

2.1 Status of forest in Malaysia

In the total number of forest cover, Sarawak dominates 9.2 million hectares forest while Peninsular Malaysia covers 5.9 million and there is just 4.4 million hectares forest in Sabah which is the state with least forest (Yong, 2006). Malaysia is a tropical rainforest characterized by high rainfall, with definitions setting minimum normal annual rainfall between 1750-2000mm and it can be found around the equator between the Tropics of Cancer and Capricorn all around the world, in Asia, Africa, Central and South America, Australia and Pacific Islands (Harding, 2010). About 5.87 million hectares or 45% of its total land area that cover by the tropical rainforest in Peninsular Malaysia (Abdul. Rahman., Koh, & Richard, 2011). Tropical rainforest has high richness biodiversity and most complex terrestrial ecosystems supporting a variety of life form species on the Earth (Phillips, 1996). It offers a rich source of medicinal plants, high-yield foods, and a myriad of other useful forest product. There are four main layers that typically divided the tropical rainforest with each different layer which adapted of different species of animal and plant for life. The four main layers are the emergent, canopy, understory, and forest floor layers (Harding, 2010).

Tropical rainforest give a lot of beneficial to the world especially humankind. It provides the sources of food, medicine and timber, home to indigenous people, climate control, ascetic value, habitat for flora and fauna and another (Zagata, 2012). There are more than 1.6 billion people that value by the United Nations Food and Agriculture Organization (FAO) who rely on forests for their livelihood and they use the forest resource to generate income (Smith, 1986). However, tropical rainforest are scarce resource in the 21st century (Butler, 2012). Even

thought, the forests have provide a lot of benefits and important services to natural system and humankind, but the problem of deforestation is still suffers by the forest in most country (Le et al., 2011). The highly exploitation of the forest by the human causes only 8.6 billion acres of forest remain (Callahan, 2001).

2.2 Family of Dipterocarpaceae.

The forest of Indonesia and Malaysia is amazed with the giant tree from the member of the dipterocarp family. The tree family Dipterocarpaceae plays a dominant role in the ecology and economics of Asian forests in a way that no comparable family plays in other rainforest regions (Poore, 1989). In addition, the dipterocarps also consists of important timbers for domestic needs in the seasonal evergreen forest of Asia. It is also sources of variety of minor products on which many forest dwellers are directly dependent for their survival (Panayotou & Ashton, 1992). Forest is exploited beyond their limit, ultimately threatening the survival of species in the past and current scenario (Chandra, 2011).

Dipterocarpaceae which in the species-rich a seasonal , lowland forests of Borneo, shade tolerant tree is the dominant tree family in the forests of Southeast Asia that forms a high proportion of the emergent and main canopy strata of the forest (Manokaran, 1996). It is distributed widely throughout Kalimantan, Sumatra, Java, Bali, Nusa Tenggara, Sulawesi and Maluku (Tata, Wibawa, & Joshi, 2008).Kalimantan has the richest and widest endemic distribution of Dipterocarpaceae in the world and followed by Sumatra (Tata et al., 2008).

The genus Dipterocarpus is well known for the timber value of its species in the family Dipterocarpaceae (Puttaswamy, Kushalappa, Ajayan, & Sathish, 2010). The common species

from the Dipterocarpus family are *Anisoptera* spp, *Dipterocarpus* spp, *Dryobalanops* spp, *Hopea* spp, and *Shorea* spp. Most of the timber-rich lowland dipterocarp forests were converted to cash crops plantation of rubber, oil-palm and cocoa in the past (Appanah, 1993).

2.3 Reforestation and its importance in forest management.

Deforestation is a major issue in much area in the world (McDermott, 2009). Nigeria has the world's highest deforestation rate and has removed 36 % of its trees in the past decades (McDermott, 2009; Butler, 2005). Nigeria and Sudan were the 2 largest countries that loss of natural forest during the 2000-2005 periods followed by Africa (Butler, 2005). The impact of deforestation is very huge as it is forcing the indigenous forest communities out of rainforest, the plants and animals lost their habitat or either becomes extinct. One of the largest areas of tropical rainforest in the world is Indonesia. However, deforestation of Indonesia tropical rainforest is the main issues that the world concern as it is rapidly losing its tropical rainforest at a rate of approximately 5 million acres a year (Schoen, 2004).

The number of forest decline within these 10 years is very high and the condition will be even worse if deforestation happening without taking any action to conserve it. A study has reported that Malaysia is destroying its forest more than 3 times faster than the combination of the entire Asia especially deforestation rate in Sarawak has increased tremendously (Forest Carbon Asia, 2011). Meanwhile, a lot of effort had been done by the government and all the society to protect the world's rainforest before the rainforest to decline in a more extreme rate and to safeguard the property of humankind and the natural resource of the forest. Hence,

reforestation project is necessary to prevent indigenous tree species from getting extinction as the indigenous tree species can give a lot of benefits to human being and environment.

The objective of reforestation is to regenerate forests, with the hope to restore the environmental and economic benefits they provide and the activities of reforestation can also provide a wealth of social benefits (Jacobson, 2012). The most important thing in reforestation is the trees can provide food source and natural habitat for other life form and the soil, biodiversity, and climate of the forest can be stabilize and maintain in many ways in reforestation (Jacobson, 2012). In addition, reforestation can conserve the indigenous trees as many of the indigenous trees in the forest have higher risk to become extinct due to habitat loss and impact left from forest degradation (Zein, 2011). Recent year the effort of reforestation has increased. Therefore, the aim of reforestation project is done to conserve the tree species before they are getting extinction and maximize the population of them.

Reforestation is a long term endeavor as the process of reforestation starting from cleared land will take at least 50 years in the tropics and even more than 100 years for the extra- tropical zone (Le, Smith, Herbohn, & Harrison, 2011). The ecology of the indigenous tree species is also important in reforestation as it can affect the growth performance of the indigenous tree species. According to Flint (2012), growth can be defined as an irreversible or permanent change of an organism, either in size or volume, with simultaneous gains dry weight and the growth of the trees species is influenced by many factors, with light intensity being one of the most important. The success of reforestation can be measured at different level in the reforestation project. Taking assessments on the effect of silviculture treatments on the growth performance of the indigenous tree species at the early stage of the reforestations project will be one of the contributed to the future success of reforestation.

2.4 Factors that promote natural growth of Dipterocarp species

The growth of the tree species are affected by some factors. Different tree species has different adaptability. Some tree species require full sunlight while some tree species prefer growth in shading area. Environmental factors such as light intensity, soil fertility, mineral nutrient, water holding capacity have a great influence on the survival and growth performance on the tree species. The changing of the environment will affect the tree growth as the tree need respond to the change of the environment to make them more attempts to the changing.

Sunlight is very important to our human being and the entire organism. The organism need energy to survive and some organism are absorbing the energy from the sunlight and they use the sunlight to produce sugar and other organic compound such as lipids and protein (Bailey, 2012). The sugar that they produce is used to provide energy for the organism and this process is known as photosynthesis (Bailey, 2012). The vegetative and flowering stages of growth are indirectly influenced by light although there is a natural growth cycle for every plant (Smestad, 2012). Many studies have been carried out to investigate the relation of light intensity toward the growth performance of indigenous tree species. The tree species can be classified as shade-tolerant or light demanding on the studies of light intensity toward the growth of the indigenous species (Vincent, 2002). Growth of different tree species has different effect of light. Most of the Dipterocarp species show a positive seedling growth response with the increment of light availability (Vincent, 2002). The species with high light demanding will have a faster growth performance compare to shade tolerant species. In a forest, the light intensity for tree species are different from one species to another species because there may have some disturbances which prevent the tree species receive sunlight.

Soil is one of the importance microenvironment factors which influence the growth of tree species. It is the natural medium for adaptation of tree and health soil is crucial for the development and growth of tree. It determines which tree species will grow best and yield the highest timber product volume, time needed to grow a timber crop, and acceptable economic return from forest management which yield by the landowner (USDA Forest Service, n.d.). Furthermore, the soil features including soil depth, soil texture and drainage is another important factors that affect the survival and growth of seedlings (Vincent, 2008). Soil can help the tree take in nutrient and develop strong root system (Crawford, 2012). Soil fertility is a measure of the nutrients available in the soil for tree growth. The nutrient such as nitrogen, calcium, magnesium and sulphur are the nutrient which can obtain from the soil and the tree cannot survival without them (Department of Primary Industries, 2012). For example, Dipterocarps are highly affected by soil fertility and water availability of the soil (Vincent, 2002).

The presence of mycorrhizae also plays a role in the growth of the tree. Lack of mycorrhizae can prevent the seedling growth and can contribute to the failure in forest plantation management (Vincent, 2008). Mycorrhizae has a symbiotic relation with the tree and help the roots of plants exchange nutrients and may protect the plant from pathogens, support helpful bacteria, improve soil aggregation, assist in water transport and gain, and stimulate plant growth through auxin production (Nijjer, Rogers, & Siemann, 2004).

2.5 Introduction to silviculture treatment

Silviculture is the art and science of controlling the establishment, growth, composition and quality, health, protection and utilization of stands of trees or forests to meet the diverse needs and values of forest owners and society on a sustainable basis and it is also to maintain and enhance the utility of the forest for any defined management purpose (The Institute of Foresters of Australia, 2008). According to Matthews (1991), silviculture system can be defined as the process by which the crops constituting a forest are tended, removed, and replaced by new crops, resulting in the production of stands of distinctive form.

Conservation and preservation of forest cover, biodiversity and ecosystem integrity are some of the goals of sustainable forest management (Sayer et al, 1995). Many efforts were proposed to improve forest management including, improved road planning, liana cutting on harvestable trees, seed tree retention, higher harvest diameter limits and liberation of future crop trees. Silvicultural treatments are generally performed to improve yields of commercially valuable tree species by increasing their recruitment and growth rates (Graaf, 1986; Lamprecht, 1989; Fredericksen, 2000; Louman et al., 2001; Fredericksen & Putz, 2003).

Silviculture treatment has a lot of benefits. One of the benefits from silviculture treatment is the nature of the forest can be improve through silviculture. One of the ways is to control of stand structure and process. The stand structure and process of the forest can be altered by some factors. According to Smith (1986), silviculture is forest architecture aimed at the design of stands with outward shape and internal construction that will serve the intended purposes, be in harmony with the environment, and withstand the loads imposed by environmental influences. Furthermore, control composition, facilitating harvesting,

conservation of site quality; protection and reduction of losses are the ways which can be improve by the silviculture (Smith, 1986).

The application of silviculture treatment is well-know and practiced by lot of the forester to manage the forest. The Institute of Foresters of Australia was highly supported and encourages the practices of silviculture treatment. It stated that the use of a variety of silvicultural system and practices in native forest that are economically socially and environmentally appropriate for the forest type in which they are applied (The Institute of Foresters of Australia, 2008). Meanwhile, greater use of sivilcuture intervention in native forests, to maintain and improve their health, regenerative capacity and productivity, according to the priorities attached to the various goods and services (The Institute of Foresters of Australia, 2008).

According to James (1914), the range of silvicultural treatments depends on the biological requirements and growth characteristics of the site where they are growing which including the physical, chemical, climatic, soil and biological features of the area that influence tree development and growth and silvicultural practices can regulate the availability of water, nutrients and sunlight to the selected trees as the trees require water, nutrients, carbon dioxide and sunlight to grow. Therefore, the goals of silvicultural treatment can be fulfill and the nature of the forest can be conserve through the practices of the silvilcultural practices.

2.6 Silvicultural techniques applied in forest management

Silviculture can be defined as a way to produce and contribute a forest; treat the forest by apply the knowledge of silvics; the theory and practice of controlling forest establishment, composition, structure and growth (Spur, 1979). The variety treatment of silviculture apply to forest can use for different purpose. Foresters need to analyze the problem of the tree in the forest and apply a suitable silviculture treatment to solve the problem. Economics, ecology, and society are the three themes that must understand the complex interaction of silviculture (Stovall, 2012). According to Michigan Society of America Foresters (2008), the proper choice of silvicultural treatments depends on the interaction of timber types, forest conditions, forest wildlife and the landowner's objectives.

Clear cutting system is one of the silvicultural practices use to preserve the forest. It involved the removal of almost all the standing trees within a limited area of the specific purpose of regenerating a new forest (Helms, 1998). It is the easiest and most efficient method of silviculture because of the reason the trees are planted in rows and evenly spaced during reforestation which make it so simple and efficient (Asta, 2012). Clear cutting system allows the improvement of the yield and quality of the new crop through introduction of superior indigenous and exotic species, provenances, and cultivars and in addition, it also can afford complete overhead light, and important consideration for light-demanding species (Matthews, 1989). However, the disadvantages of the clear cutting system also persist where by area under such practice are prone to erosion especially on the steep hillsides where the soil is unstable to landslips, while it affords to safeguard against the rapid run-off of precipitation (Matthews, 1989).