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# Preliminary Assessment on the Species Composition in the old Plantations

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# သက်ကြီးစိုက်ခင်းများတွင် သစ်မျိုးပါဝင်ပေါက်ရောက်မှုအား ကနဦးလေ့လာခြင်း

ဒေါက်တာဇာခြည်လှိုင်၊ ဦးစီးအရာရှိ

## စာတမ်းအကျဉ်း

ယခုတင်ပြထားမှုများသည် ကနဦးလေ့လာမှုများသာဖြစ်ပါ၍ ဤသုတေသနစာတမ်း အတွက် လေ့လာထားရှိသည့် သက်ကြီးစိုက်ခင်းများ၌ ဆောင်ရွက်ထားရှိသော စိုက်ပျိုးပြုစု နည်းလမ်းများ၏ အကျိုးသက်ရောက်မှုများကို ဆန်းစစ်လေ့လာမှုများပြုလုပ်ပြီး ဆက်လက် တင်ပြ သွားမည် ဖြစ်ပါသည်။ သစ်တောစိုက်ခင်းများအား ရေရှည်တည်တံ့စွာ စဉ်ဆက်မပြတ် စီမံ အုပ်ချုပ်မှုအတွက် ထိရောက် မှန်ကန်သည့် စီမံအုပ်ချုပ်မှုများဆောင်ရွက်နိုင်ရန် သင့်လျော်သည့် နည်းလမ်း များအား ဖော်ထုတ်ရန် လိုအပ်လျက်ရှိပါသည်။ သက်တမ်းငယ်သည့် စိုက်ခင်းများတွင် သစ်တော စိုက်ခင်းပြုစု ထိန်းသိမ်း နည်းများရှိသော်လည်း သဘာဝတော များကဲ့သို့ဖြစ်နေသည့် သက်ကြီး စိုက်ခင်းများ အတွက် စိုက်ခင်း စီမံအုပ်ချုပ်ရေးအစီအစဉ်များ လိုအပ်လျက်ရှိပါသည်။ သို့ဖြစ်ပါ၍ သဘာဝ တောများအား စီမံအုပ်ချုပ်မှု အစီအစဉ်များ ရေးဆွဲအကောင်အထည်ဖော် ဆောင်ရွက်သကဲ့သို့ သစ်တောစိုက်ခင်းများကိုလည်း စီမံအုပ်ချုပ်မှု အစီအစဉ်ရေးဆွဲ ဆောင်ရွက်ရာတွင် အထောက်အကူပြုသည့် သတင်းအချက်များ ပေးနိုင်ရန်အတွက် သက်ကြီးစိုက်ခင်းများတွင် သဘာဝအတိုင်း ဝင်ရောက် ပေါက်ရောက်လျက်ရှိသည့် သစ်မျိုးများနှင့် ပါဝင်ဖွဲ့စည်းပုံတို့ကို စိုက်ခင်းသက်တမ်း (၅၅)နှစ် ကျွန်းစိုက်ခင်း၊ (၆၄)နှစ် ပျဉ်းကတိုး စိုက်ခင်းနှင့် (၂၅) နှစ် သစ်မျိုး စုံစိုက်ခင်းတို့တွင် လေ့လာခဲ့ခြင်း ဖြစ်ပါသည်။ သက်ကြီး စိုက်ခင်းများတွင် သဘာဝ အတိုင်း ဝင်ရောက်ပေါက်ရောက်လျက်ရှိသည့် သစ်မျိုးများနှင့် ၎င်းတို့၏ဖွဲ့စည်းပုံ တို့သည် စိုက်ခင်း၏ မူလရည်ရွယ်ချက်၊ သစ်မျိုး၊ တည်နေရာနှင့် ရာသီဥတုတို့အပေါ်တွင် များစွာ မူတည်နေသောကြောင့် ဤကဲ့သို့သော သုတေသနများအား စိုက်ခင်းတည်နေရာ၊ ရာသီဥတုနှင့် သစ်မျိုးအလိုက် ထပ်မံဆောင်ရွက်ရန် လိုအပ်နေပါသည်။

**Preliminary Assessment on the Species Composition in the old Plantations**

Dr. Zar Chi Hlaing , Staff Officer

## Abstract

This article is the preliminary study as the mid-term findings of old plantations. Plantations or planted forests are established for many reasons such as conservation, production and amenity, and they can provide a wide range of environmental services. And the silvicultural management for the plantations/ planted forests is focused as one of the importance factors especially at the old plantations. Thus, the forest managers have to understand the species composition and structure at the plantations/ planted forest to implement the effective and suitable plantations/ planted forest management. This study aims to explore the current status of plant species in the old plantations, and the vegetation survey was conducted at (1) 1964 Teak plantation (55 years old), (2) 1956 Pyinkado plantation (64 years old) and (3) 1986 Mixed species plantation (25 years old) which were under the Hmawbi Research Station, Hmawbi Township. This study found that the distribution of diameter at bread height (DBH) classes conformed to a reverse "J" shape curve, with 44% of individual in all study plantations at the less than 5 cm DBH, 22% at the DBH class between 5.1 and 10.0 cm. The rest trees 34% is laying in larger diameter classes, and also, the almost half of the number of trees is with the DBH of less than 5.0 cm in each study plantation. There are 18, 14 and 17 plant species with 19, 12 and 15 families in the plantations of Teak, Pyinkado and Mixed species plantations, respectively. There are 1,175 trees per ha of stand density with 28.71 $m^2$ per ha of basal area, 471 trees per ha with 9.02 $m^2$ per ha, and 491 trees per ha with 13.78 $m^2$ per ha at the Teak plantation, Pyinkado plantation and Mixed species plantation, respectively. The overall population structure of species revealed that contribution of regeneration to the total population was high condition in which most of them are not the regeneration of original planted species of plantation. Thus, the growth, survival and reproduction potential of the commercial species showing "poor" or "no" regeneration it may be risk in future. Therefore, a systematic management plan is required for their sustainable utilization and effective production for the commercial and environmental (biodiversity) conservation.

**Key words:** Old plantation, Species composition, Stand density and basal area.

**Preliminary assessment on the species composition in the old plantations**

## 1. Introduction

Plantations/ planted forests are established by planting and/ or deliberate seeding native or introduced species, either on land previously not classified as forest (afforestation, implies a transformation of land-use from non-forest to forest), or on previously forested land (reforestation) (Kollert and Sabogal, 2017). They are established for many reasons such as conservation, production and amenity, and they can provide a wide range of environmental services. In 2010, the global plantations/ planted forests areas are estimated at 264 million hectares (ha), of which three-quarters was grown for productive purposes and one-quarter for protective purposes (Kollert and Sabogal, 2017). In 2005-2010, the planted forests area increased by an average of almost 5 million ha per year, with most of the expansion occurring in Asia (especially China, India and Viet Nam). The global area of planted forest area is projected to increase to 300 million ha by 2020 with the planted species vary by region. In Myanmar, extensive teak plantations were formed in the 1970s, and a further large-scale plantation program was launched commencing from 1980 (Hlaing, ZC. 2012). It is the time now that those commercial plantations should be assessed and evaluated to understand their silvicultural performance including growth, production potential and social and environmental implications. It is therefore expected that this study will provide factual status of commercial plantations in the study sites to help foresters, forest manager and decision makers review plantations forestry in Myanmar and make changes if necessary. And the silvicultural management for the plantations/ planted forests is focused as one of the importance factors especially at the old plantations. Thus, the forest managers have to understand the species composition and structure at the old plantations to implement the effective and suitable plantations/ planted forest management and to fulfill the ultimate goal of plantation. Currently, one of the most important research challenges is how to manage the old-aged plantations/ planted forests for timber and bioenergy production while maintaining and/ or improving environmental condition such as habitat and biodiversity conservation (Marchi et al., 2018). To solve this challenge, firstly we have to understand the species compositions and structure as the present conditions of the old plantation.

Species is one of the major analytical characteristics of the plant communities (Malik at al., 2014) which is an assemblage of plant species growing together in a particular location with a define association with each other (Singh et al., 2016). Knowledge of species composition and diversity of tree species is of utmost importance not only to understand the structure of forest community, and the planning and implementation of conservation strategy of the community (Malik at al., 2014; Malik and Bhatt 2015), but also for the silvicultural management of the old plantation which looks like the natural forest. Moreover, the assessment of forest community composition and structure is very helpful in understanding the status of tree population, regeneration, and diversity for conservation purposes (Mishra et al., 2013). Moreover, the development and death or decay of plant species alters the pattern of the species distribution in a community (Mandal and Joshi, 2014), and the study of species/ vegetation include the investigation of species compositions and the sociological interaction of species in communities (Mueller-Dombois and Ellenberg, 1974). Plants growing together in the same community have a mutual relationship among themselves and with the environment (Mishra et al., 1997). While

studying the species composition in the forest, the regeneration is also one of the importance factors at the management purpose. Regeneration potential is the ability of a species to complete the life cycle (Singh et al., 2016). Regeneration is a key process for the existence of species in a community under varied environmental conditions (Khumbongmayum et al., 2005). In forest management, regeneration study not only depicts the current status but also hints about the possible changes in forest composition in the future (Singh et al., 2016). At the same time, the reliable data on regeneration trends are required for successful management and conservation of natural forests (Eilu and Obua, 2005).

Considering above facts, there is less of the study about the species composition of old plantations and the suitable tending operations for the plantation/ planted forest management. In the present study, we address the first part as the current status of plant species in the old plantations which will be treated as natural forest. After examining he current condition of old plantation, we will apply the tending operations, and then explore the effective and suitable operations for the plantation/ planted forest management, especially for the old plantation management.

## 2. Materials and Methods

### 2.1 Study area

This research was conducted in three plantations where was located at the Hmawbi Research Station – (1) 1964 Teak plantation (55 years old), (2) 1956 Pyinkado plantation (64 years old) and (3) 1986 Mixed species plantation (25 years old) (Figure 1). These plantations are located at 17° 8' 4.77" N and 96° 0' 12.45" E with the elevation around 85 ft. This area is at the edge (Southern part) of Bago Yoma, and the forest type is dry upper mixed deciduous. The average rainfall was 227.22 mm and average temperature of 27.6° C between the year 2009 and 2018 (Figure 2). These plantations were under the training forest area of Central Forest Development Training Center (CFDTC).

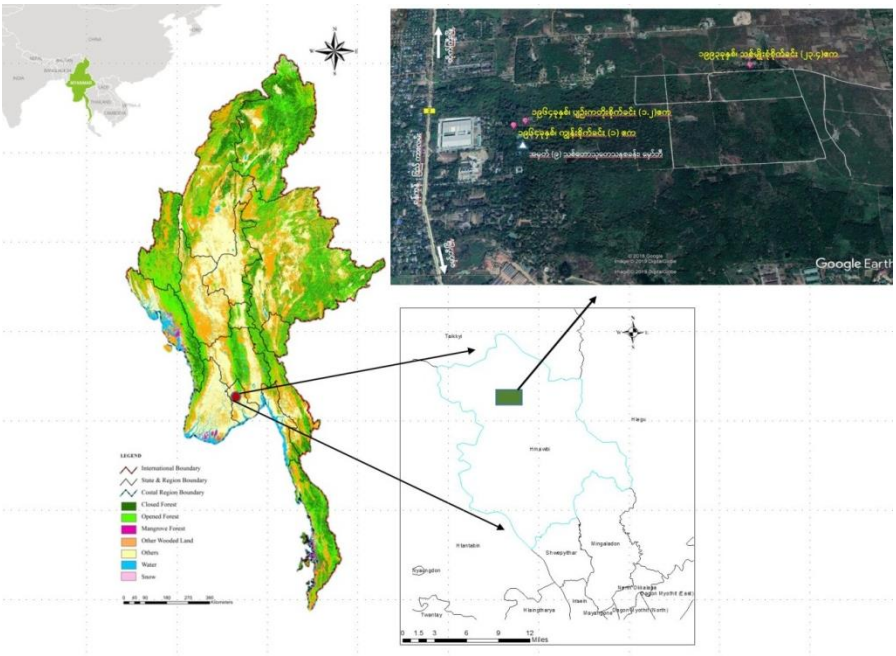



Figure 1. Location of study area

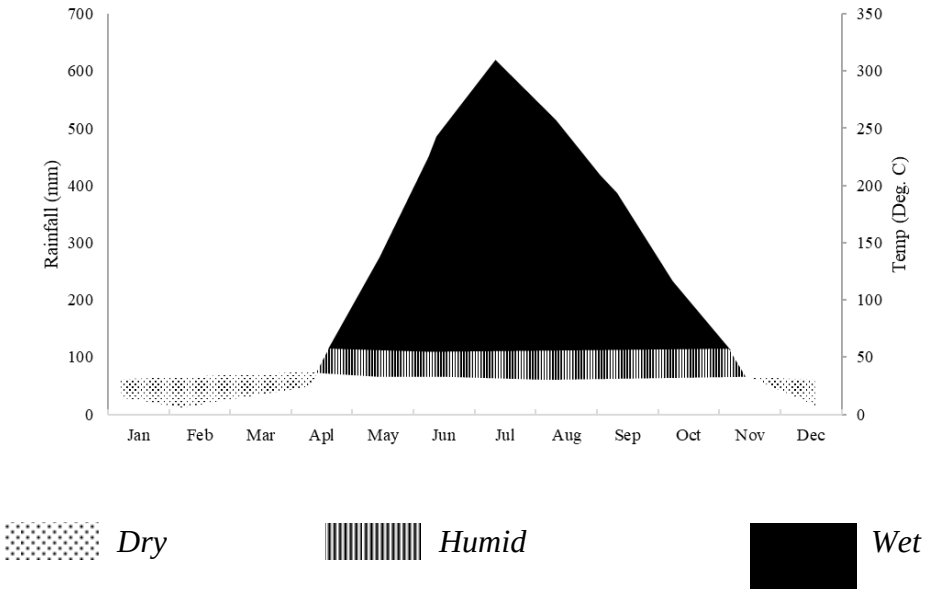



Figure 2. Climatic diagram of Hmawbi Township (2009 – 2018)

## 2.2 Methods

Field measurement was carried-out in June 2019. The vegetation was analyzed via random sampling to obtain the most representative composition of the plantation area. The vegetation survey was carried out using the square-shaped random sample plot (0.04 ha) which was conducted in each studied plantation. In the squared-shaped plot, the circular plot (0.03 ha) was paid out at the center of the plot (Figure 2). The sample plots were marked with GSP point to know the location of sample plots and to measure every two years, i.e., the interval measurement will be conducted in the sample plots to explore the species composition including regeneration of the old plantations. The measured variables from both shapes of sample plots were recorded separately. All stands in these sample plots were measured as species name, total height, diameter at breast height and the number of individual. The DBH until 1.00 cm was measured which was aimed to explore the regeneration of plantations and to know the before treatment condition of old plantations. After recording the desirable variables, the tending operations such as pruning, weeding, cutting the dry/ death trees were applied in the circular-shaped plot.

There are 4 plots (0.16 ha), 6 plots (0.24 ha) and 8 plots (0.32 ha) in Teak plantation, Pyinkado plantation and Mixed plantation, respectively, which are set also up based on the plantation area.

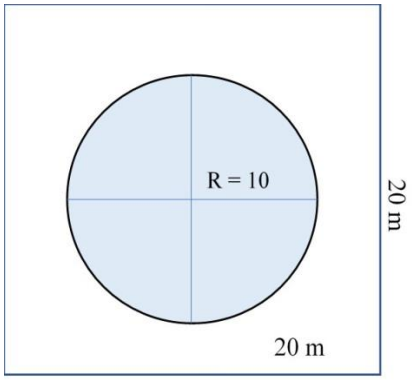



Figure 3. Layout of sample plot

The dominance of the plant species was determined using the importance value index (IVI) of the species. Botanical names were used according to "Botanical exploration in Myanmar, 2003 (W. John Kress *et al.*, 2003)". To assess the general condition of forest vegetation, the density-diameter histogram was developed. Vegetation composition was evaluated by analyzing the frequency, density, and IVI, using the following formula given by Mishra (1968) and Curtis and Mclntosh (1951). Species richness "S" was determined by tabulating the number of woody species in each plot according to Whittaker (1976). Shannon-Weiner's diversity index "H" (Shannon and Weiner 1963), species dominance "D" (Simpson 1949), and Hill diversity index number N0, N1, N2 were calculated.

Frequency = $\frac{Total\ no.of\ quadrats\ in\ which\ the\ species\ occured}{Total\ no.of\ quadrats\ studied}$ x 100

Relative frequency (%) = $\frac{Frequency\ of\ a\ species}{Frequency\ of\ all\ species}$ x 100

Density = $\frac{Total\ no.of\ a\ species}{Total\ no.of\ quadrats\ studied}$

Relative density (%) = $\frac{Number\ of\ individual\ of\ a\ species}{Number\ of\ individual\ of\ all\ species}$ x 100

Abundance = $\frac{Total\ no.of\ individual\ of\ a\ species}{Total\ no.of\ quadrats\ in\ which\ the\ species\ occured}$

Relative dominance (%) = $\frac{Basal\ area\ of\ a\ species}{Basal\ area\ of\ all\ the\ species}$ x 100

IVI = Relative frequency + Relative density + Relative dominance

Basal area is considered as the portion of ground surface occupied by a species (Greig-Smith, 1983). Basal area measurement was based on the following formula:

Total basal cover (TBC) = Mean basal area of a species x density of that species

Mean basal area (MBA) = $\pi r^2$ ($cm^2$)

MBA = $\frac{C^2}{4\ x\ \pi^2}$ , where C is the average circumference of one individual of that species, and MBA is expressed as $cm^{-2}$ $plant^{-1}$ (Mishra, 1968).

Simpson's index (D)

$D = 1 - \Sigma pi\text{^}2$ , where *pi* is the relative density.

Shannon-Weiner's index (H)

$H = -\Sigma pi\ Log\ pi$ , where *pi* is the proportional abundance of the $i^{th}$ species in the community.

Hill diversity indices were calculated by using the following formula:

N0 = S, where S is the total number of species;

N1 = $e^H$, where H is the Shannon-Weiner's index; and

N2 = 1/D, where D is Simpson's index.

## 3. Results and Discussion

### 3.1 Size-class distribution

The distribution of diameter at bread height (DBH) classes conformed to a reverse "J" shape curve, with 44% of individual in all study plantations at the less than 5 cm DBH, 22% at the DBH class between 5.1 and 10.0 cm. The rest trees 34% is laying in larger diameter classes (*Figure 4*). And also, the almost half of the number of trees is with the DBH of less than 5.0 cm in each study plantation (*Figure 5 - Figure 7*).

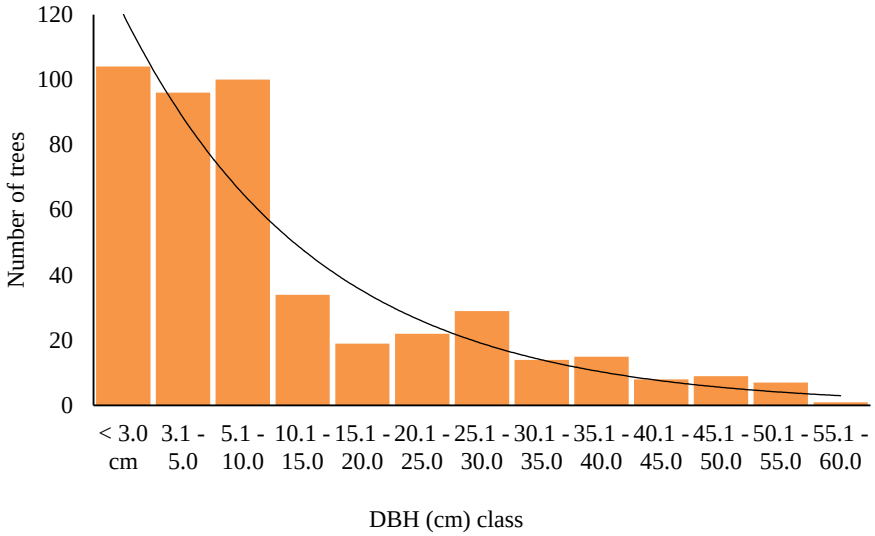



Figure 4. Distribution of tree in different size classes at all study plantations

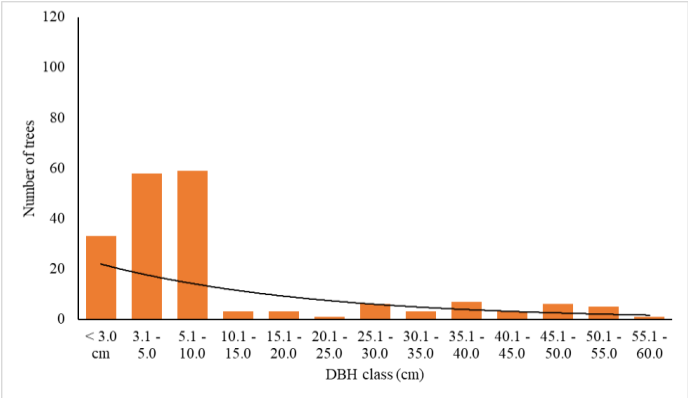



Figure 5. Distribution of tree in different size classes in Teak plantations

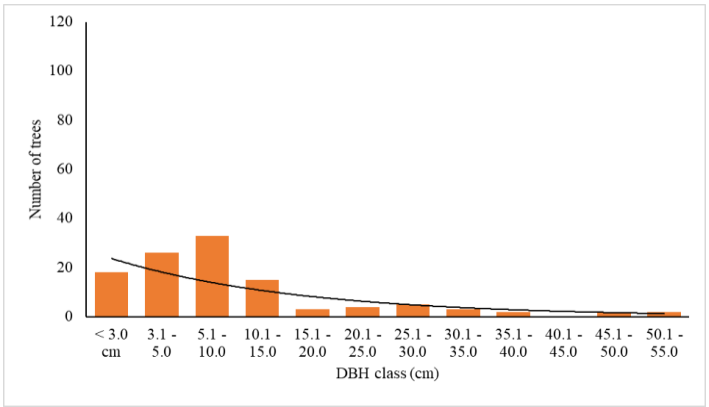



Figure 6. Distribution of tree in different size classes in Pyinkado plantations

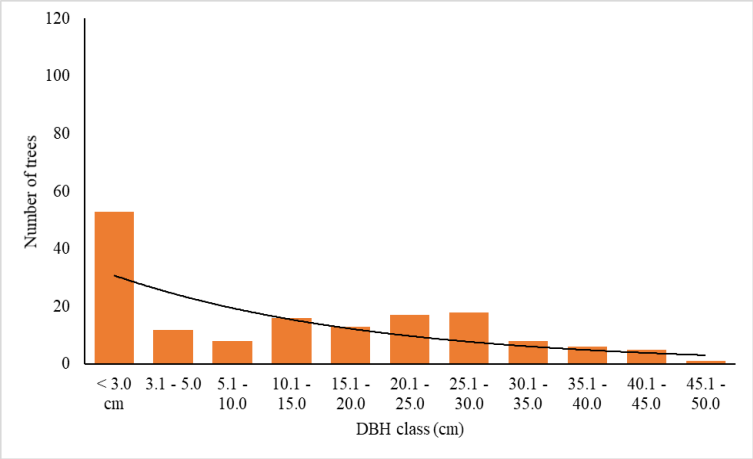
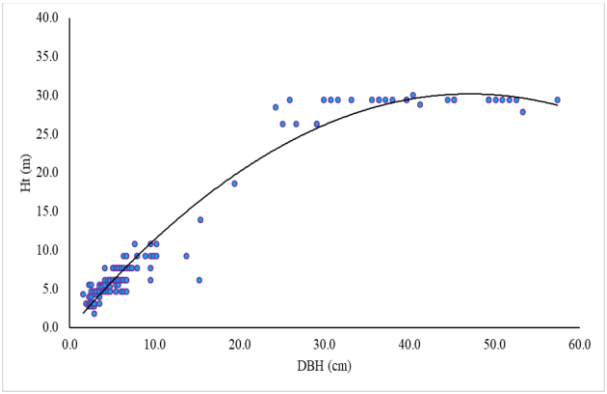


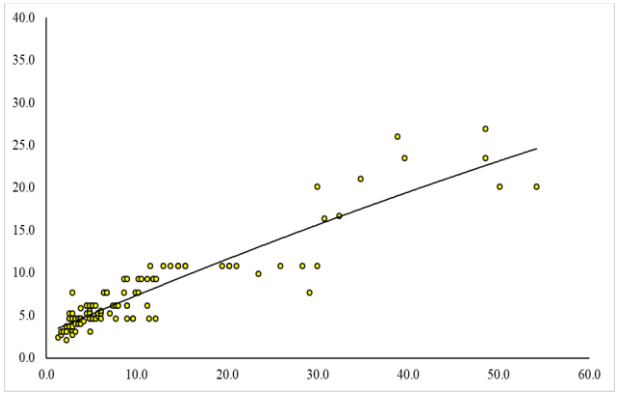

Figure 7. Distribution of tree in different size classes in Mixed species plantations

The tree height is a dimensional characteristic, which is required to estimate the volume of the standing trees, to predict the future growth, and to determine the site quality and site index of a stand (Van Laar and Akca 1997). Stand height is usually expressed by mean height, stand height curve, or top height. In this study, the tree total height was measured and was used for stand height curve (Figure *8*). The stand height, which is the relationship between tree height and tree diameter, is curvilinear and non-linear regression models, the majority being linear sable by a transformation of variables, have been proposed to fit a stand height curve (Kyaw 2003).

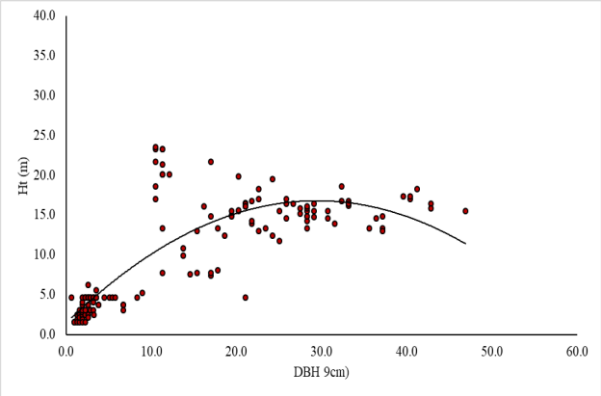
Dominance diversity curve (D-D curve) for each of study plantation is shown in (Figure *9* - *Figure 11*) in which a few species have relatively high IVI. The highest IVI values are that of *Tectona grandis* (91.69) followed by *Xylia xylocarpus* (54.39) in Teak plantation (Figure *9*), 75.49 of *Xylia xylocarpus* and 36.24 of *Simarouba glauca* are the highest IVI in Pyinkado plantation (Figure *10*), and 66.93 IVI of *Pterocarpus macrocapus* is followed by 43.44 of *Millettia pendula* in the Mixed species plantation (*Figure 11*).




(a)




(b)




(c)

Figure 8. Stand height curves (total tree height) of all species of (a) Teak plantation, (b) Pyinkado plantation, and (c) Mixed species plantation

*Tectona grandis* (Teak), *Streblus asper* (Oakhne) and *Carallia brachiate* (Maniawga) in the Teak plantation and *Pterocarpus macrocarpus* (Paduak) and *Swietenia macrophylla* (Mahawgani) in the Pyinkado plantation are among the most frequent species while *Simarouba glauca* (Si-thabye), *Microcos paniculata* (Myayar), *Markhamia stipulate* (Mahlwa) and *Ailanthus triphysa* (Odein) are among the least frequent tree species in both old plantations. Even though Teak specie was the main species of this Teak plantations which are 55 years old, *Xylia xylocarpus* (Pyinkado) is found as the dominance species (Appendix: *Table 3*).

The 2 species via. *Pterocarpus macrocarpus* (Padauk) and *Millettia pendula* (Thinwin) with the high frequency, stand density, and high DBH among other species, are observed in the mixed species plantation while *Mitragyna parvifolia* (Htein), *Homalium tomentosum* (Myauk-chaw) and *Careya arborea* (Banbwe) are the least frequent tree species in this plantation. Although there are the most frequent tree species and high stand density (Appendix

Table 5), this distribution pattern revealed that the species community is highly heterogeneous in their composition which done not allow the dominance of a species. The dominance distribution of species resulted in a log-normal distribution pattern which further signifies that the species community is also heterogeneous in nature (*Figure 11*).

Density and frequency distributions of trees contribute to the structure of the forests (Yam and Tripathi, 2016). Most of the species had low frequency which mean that most of them would be expected in typical species abundance distribution. In Teak plantation, no Teak seedlings are found which shows due to the age of trees and site conditions leading to unfavorable conditions for the growth of seedlings and saplings. The perpetuation of a species depends on the presence of adequate number of individual of different growth phases or developmental phases of that species (Yam and Tripathi, 2016). While some species could possess with a relatively small stock of juveniles, other depends on a large stock of juveniles to compensate for mortality (Shankar, 2001).

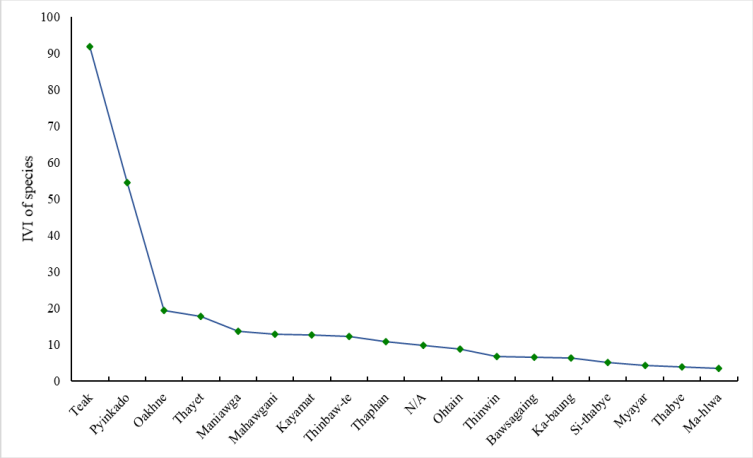



Figure 9. The important value index (IVI) of the species at the Teak plantation

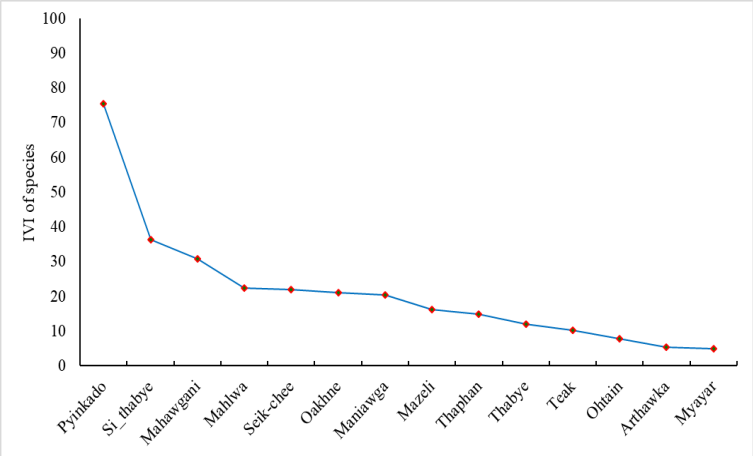



Figure 10. The important value index (IVI) of the species at the Pyinkado plantation

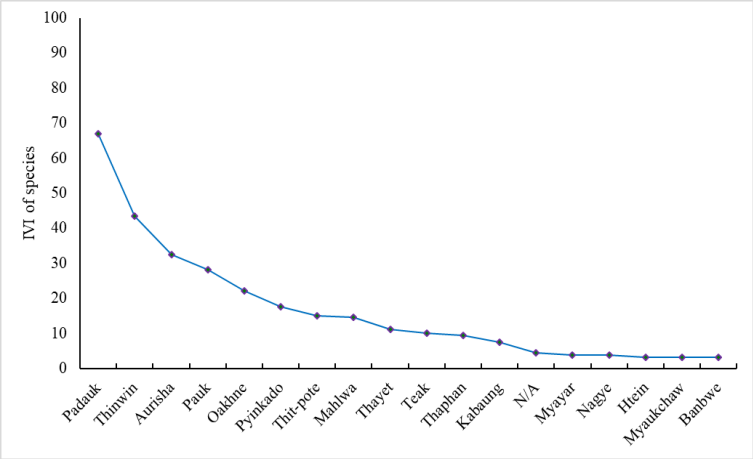



Figure 11. The important value index (IVI) of the species at the Mixed species plantation

### 3.2 Vegetation composition

A total of 35 species were identified within the study plantations, representing 22 families (*Figure 12*). In which, 6 species are found in all study plantations: *Xylia xylocarpa, Tectona gradis, Streblus asper, Ficus glomerata, Markhamia stipulate* and *Microcos paniculata* (*Figure 13*). There are 18, 14 and 17 species with 19, 12 and 15 families in the plantations of Teak, Pyinkado and Mixed species plantations, respectively. Moreover, 60% of total species of the Teak and Pyinkado plantations are found as the same species in all study plantations.

At the 55 years old Teak plantation, 18 species are found with 46% of *Xylia xylocarpus*, 16% of *Tectona grandis* and 38 % of the rest 16 species. The DBH range of Teak is between 24 and 57 cm that shows there is no regeneration of *Tectona grandis*, i.e. no sapling and seedling in the plantation. 1,175 tree $ha^{-1}$ and 28.71 $m^2$ $ha^{-1}$ of stand density and average basal area are observed (Table 1), and the biggest DBH (180.33 cm) and the highest (30.07 m) are found at *Tectona grandis*.

The 64 year-old Pyinkado plantation is the oldest one among the studied plantation. 14 species with 471 tree $ha^{-1}$ are recorded at the Pyinkado plantation. *Xylia xylocarpus* with 43% is the largest species which is followed by *Carallia brachiata* of 13%. Average basal area (9.02 $m^2$ $ha^{-1}$) is observed with the biggest DBH of 54.16 cm and the highest of 26.97 m of *Xylia xylocarpus*. Moreover, the regeneration of *Xylia xylocarpus* is also observed which has 39% of total number of *Xylia xylocarpus*.

There are 18 species in the mixed species plantation, *Petrocarpus macrocarpus* and *Millettia pendula* are mostly found such as 33% and 27%, respectively of total number of trees in the mixed plantation. Stand density and average basal area are 491 trees $ha^{-1}$ and 13.78 $m^2$ $ha^{-1}$ while the diameter class size at breast height (DBH) ranged from 0.64 to 46.88 cm (Table 1). The biggest DBH (46.88 cm) tree is *Petrocarpus macrocarpus*, that was followed by *Millettia pendula* (42.84 cm) and *Xylia xylocarpus* (42.84 cm). The tree species attained the highest (m) were *Petrocarpus macrocarpus* (23.56 m) which are followed by *Tectona grandis* (21.70 m).

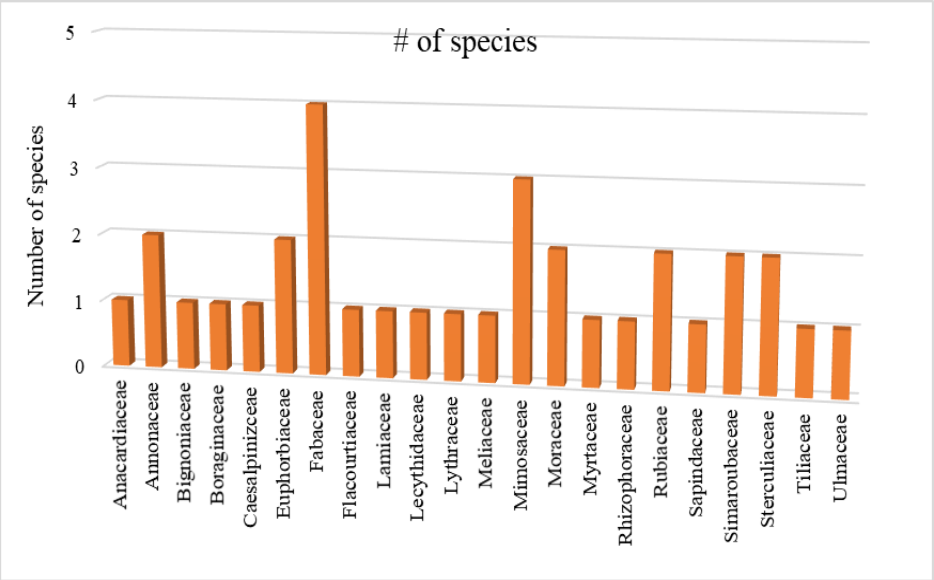



Figure 12. The number of species according to the plant families in all study plantations

The present study recorded average of 208 trees per ha in the study old-aged plantation (54 and 65 years old) and 288 trees per ha in the 25 years old plantation, in which the calculated trees are greater than 5 cm DBH. Although the study plantations were established as the demonstration/ trial plantations in the training forest of CFDTC, there are no records for the silvicultural operations and other tending operations in these plantations. Based on the recorded stand density by individual species, the second time mechanical thinning was done in both Teak plantation and Pyinkado plantation, and the plants were planted with the spacing of 9 by 9 ft. According to the recorded number of trees in the sample plots, the stand density per ha seems the high number in the old plantations (*Table 1*).

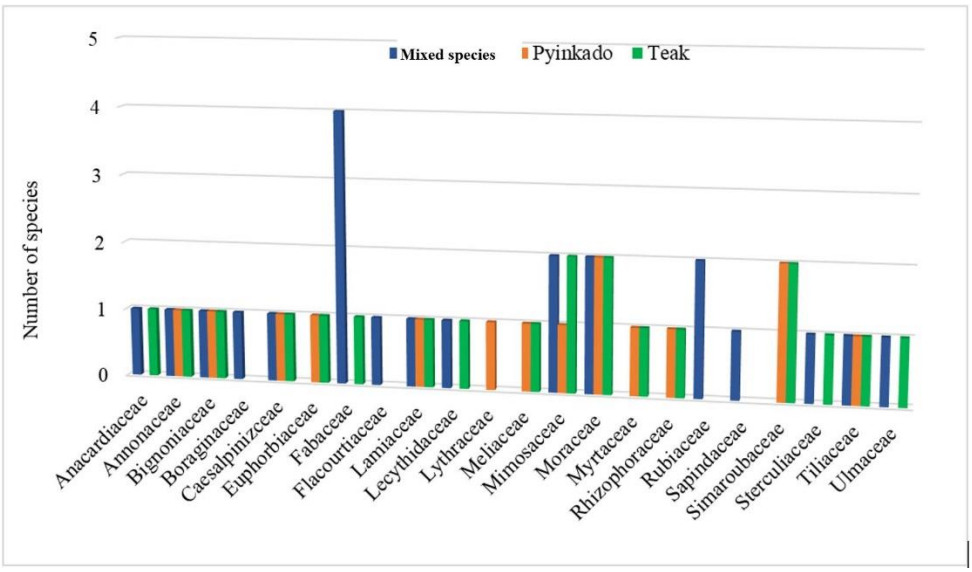



Figure 13. The number of species with their plant families in each study plantations

Table 1. Descriptive information of study plantations

| | **Ave. DBH (cm)** | **Ave. Ht (m)** | **Tree/ ha** | **Ave BA ($m^2$/ ha)** |
|---|---|---|---|---|
| **Teak plantation** | 10.91 (±13.89) | 9.70 (±9.00) | 1,175 | 28.71 |
| **Pyinkado plantation** | 10.71 (±11.41) | 7.57 (±5.07) | 471 | 9.02 |

| | | | | |
|---|---|---|---|---|
| **Mixed species plantation** | 14.10 (±12.63) | 9.82 (±6.70) | 491 | 13.78 |

### 3.3 Species diversity

Species diversity expresses the degree of evenness of the mixture of species. The typical species frequency distribution was that many species with only few individuals were found in combination with a few species, which were represented by high numbers of individuals (Kyaw 2003). Diversity was the greatest if each species contributed the same proportion to the number of individuals of the forest community (Bruenig 1989). *Figure 14*, *Figure 15* and *Figure 16* show for all trees in each studied plantation more or less the same phenomena. There are 22% of only one individual of species in Teak plantation, 21% in Pyinkado plantation and 29% in the mixed species plantation.

The present study plantations are dominated by Moraceae, Mimosaceae, Lamiaceae, Meliaceae and Fabaceae (*Figure 12* and *Figure 13*). The use of species-individuals diagram provides a clear insight into species diversity (Yam and Tripathi, 2016). The relative abundance of species is one of the most fundamental aspects of community structure (Sugihara 1980). This study shows a few species are very rare while most species are abundance (*Figure 14*, *Figure 15* and *Figure 16*). Moreover, the greater species diversity indices indicate more species richness.

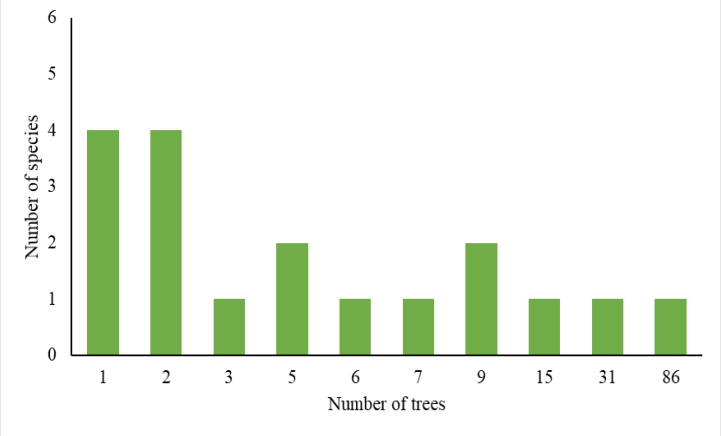



Figure 14. Number of species based on individual tree per species in the Teak plantation

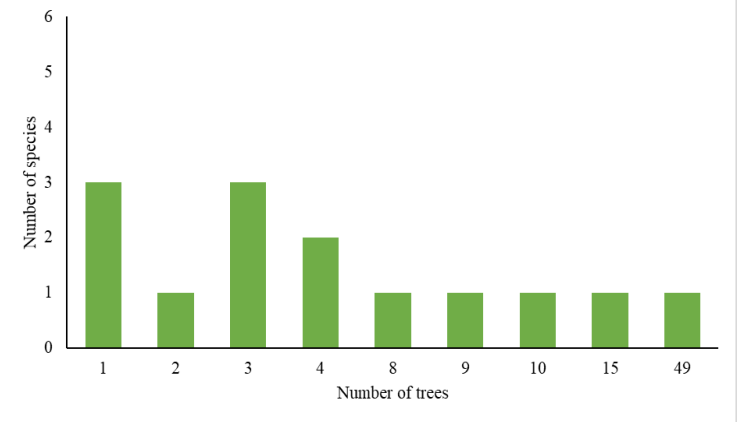



Figure 15. Number of species based on individual tree per species in the Pyinkado plantation

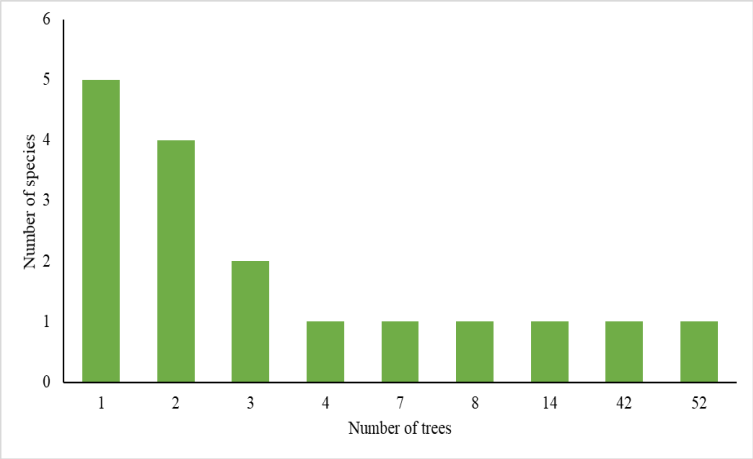



Figure 16. Number of species based on individual tree per species in the Mixed species plantation

The diversity indices are better measures of the species diversity of forest than the species density and mixture ration and more informative than species counts alone (Kyaw 2003). So we calculate species diversity indices. Table 2 describes the plant species richness, Shannon-Weiner diversity index, Simpson's diversity index and Hill's diversity index of the two study sites. Species richness of 18, 14 and 17 are observed in Teak plantation, Pyinkado plantation and Mixed species plantation, respectively.

Table 2. Species diversity indices of the study plantations

| | Teak plantation | Pyinkado plantation | Mixed species plantation |
|---|---|---|---|
| **Diversity indices** | | | |
| Species richness (S) | 18 | 14 | 17 |
| Simpson's diversity index (D) | 0.75 | 0.77 | 0.80 |
| Shannon-Weiner's diversity index (H) | 0.84 | 0.85 | 0.89 |
| Species evenness | 0.79 | 0.87 | 0.79 |
| **Hill's diversity index** | | | |
| N0 (Species richness) | 18 | 14 | 17 |
| N1 | 3.53 | 3.16 | 3.53 |
| N2 | 1.33 | 1.30 | 1.25 |

Structure, composition and function are the important attributes of forest ecosystems which change in response to climate, topography, soil and disturbances (Mandal and Joshi, 2014). And also, the communities are determined in relation to soil condition, slope angle, elevation, regional climate and topography. Moreover, the vegetation of any place is the outcome of interaction of many factors such as gradients, the elevation, soil, species composition and biotic interferences (Timilsina et al., 2007). These above-mentioned factors, along the forest succession, are responsible for both local and landscape level variation in the

forests (Bliss, 1963). Thus, not only plant species composition and structure but also the function of the old plantations should be explored to know the succession of the old plantations.

## 4. Conclusion

Assessment of the species composition, structure of the old plantations is important for these plantations' sustainable utilization, management, and conservation of the biodiversity. In this study, the girth class density distribution of species showed that most trees were present in smaller girth classes and only a few in higher classes resulting reverse J-shaped patterns, in the old aged plantations. The overall population structure of species revealed that contribution of regeneration to the total population was high condition in which most of them are not the regeneration of original planted species of plantation. It shows that this is not fixed with the purposes of plantation, i.e commercial species plantation, especially for the Teak plantation. Thus, the growth, survival and reproduction potential of the commercial species showing "poor" or "no" regeneration it may be risk in future. Therefore, a systematic management plan is required for their sustainable utilization and effective production for the commercial and environmental (biodiversity) conservation.

Based on this study findings, there will be further study which is the examining the effect of tending operations treatment to the regeneration of species in the old plantations.

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**Appendix (1)**
**Photos of studied plantations and sample plots**

**Appendix (2)**

Table 3. Overall stand density (individual/ ha), species' ave DBH (cm) and Ht (m) in the Teak Plantation

| No. | Plant Species | | Ave. DBH_cm | Ave. of Ht_m | Density/ ha |
|---|---|---|---|---|---|
| 1 | Thabye | *Eugenia praetermissa* | 4.77 | 6.20 | 6 |
| 2 | Thayet | *Mangifera sylvatica* | 19.40 | 18.60 | 6 |
| 3 | Mahlwa | *Markhamia stipulata* | 2.86 | 2.79 | 6 |
| 4 | Thinbaw-te | *Polyalthia longifolia* | 15.27 | 6.20 | 6 |
| 5 | Kabaung | *Celtis cinnamomea* | 2.70 | 2.33 | 13 |
| 6 | Bawsagaing | *Leucaena leucocephala* | 3.34 | 6.05 | 13 |
| 7 | Myayar | *Microcos paniculata* | 4.45 | 5.43 | 13 |
| 8 | Thinwin | *Millettia pendula* | 3.98 | 6.20 | 13 |
| 9 | Si-thabye | *Simarouba glauca* | 5.20 | 5.68 | 19 |
| 10 | Odein | *Ailanthus triphysa* | 6.62 | 7.13 | 31 |
| 11 | Thaphan | *Ficus glomerata* | 4.07 | 4.84 | 31 |
| 12 | Maniawga | *Carallia brachiata* | 3.87 | 5.12 | 38 |
| 13 | Unknown | - | 5.00 | 6.42 | 44 |

| | | | | | |
|---|---|---|---|---|---|
| 14 | Kalamet | *Mansonia gagei* | 2.93 | 4.03 | 56 |
| 15 | Mahawgani | *Swietenia macrophylla* | 3.54 | 4.58 | 56 |
| 16 | Oakhne | *Streblus asper* | 6.13 | 5.64 | 94 |
| 17 | Teak | *Tectona grandis* | 39.95 | 28.97 | 194 |
| 18 | Pyinkado | *Xylia xylocarpa* | 5.40 | 6.24 | 538 |

Table 4. Overall stand density (individual/ ha), species' ave DBH (cm) and Ht (m) in the Pyinkado Plantation

| **No.** | **Plant Species** | | **Ave. DBH_cm** | **Ave. of Ht_m** | **Density/ ha** |
|---|---|---|---|---|---|
| 1 | Seik-chee | *Bridelia ovata* | 19.40 | 10.85 | 4 |
| 2 | Myayar | *Microcos paniculata* | 5.41 | 4.65 | 4 |
| 3 | Thibaw-te | *Polyalthia longifolia* | 6.05 | 5.58 | 4 |
| 4 | Teak | *Tectona grandis* | 8.20 | 4.65 | 8 |
| 5 | Odein | *Ailanthus triphysa* | 10.28 | 8.78 | 13 |
| 6 | Thabye | *Eugenia praetermissa* | 5.52 | 5.17 | 13 |
| 7 | Si-thabye | *Simarouba glauca* | 25.33 | 10.85 | 13 |
| 8 | Mazeli | *Cassia mimosoides* | 14.17 | 8.68 | 17 |
| 9 | Oakhne | *Streblus asper* | 11.91 | 5.19 | 17 |
| 10 | Mahlwa | *Markhamia stipulata* | 7.08 | 5.58 | 33 |
| 11 | Maniawga | *Carallia brachiata* | 8.13 | 6.03 | 38 |
| 12 | Thaphan | *Ficus glomerata* | 4.49 | 5.02 | 42 |
| 13 | Mahawgani | *Swietenia macrophylla* | 7.94 | 5.89 | 63 |
| 14 | Pyinkado | *Xylia xylocarpa* | 13.10 | 9.34 | 204 |

Table 5. Overall stand density (individual/ ha), species' ave DBH (cm) and Ht (m) in the Mixed species plantation

| No. | Plant Species | | Ave. DBH_cm | Ave. of Ht_m | Density/ ha |
|---|---|---|---|---|---|
| 1 | Acacia | *Acacia* spp. | 31.53 | 13.95 | 3 |
| 2 | Pauk | *Butea monosperma* | 29.10 | 15.50 | 3 |
| 3 | Banbwe | *Careya arborea* | 0.95 | 1.55 | 3 |
| 4 | Myaun-chaw | *Homalium tomentosum* | 1.27 | 1.55 | 3 |
| 5 | Htein | *Mitragyna parvifolia* | 1.91 | 2.48 | 3 |
| 6 | Thayet | *Mangifera sylvatica* | 15.90 | 9.77 | 6 |
| 7 | Myayar | *Microcos paniculata* | 2.55 | 4.65 | 6 |
| 8 | Nagye | *Pterospermum semisagittatum* | 1.91 | 4.34 | 6 |
| 9 | Teak | *Tectona grandis* | 14.55 | 20.93 | 6 |
| 10 | Thaphan | *Ficus glomerata* | 2.65 | 3.82 | 9 |
| 11 | Unknown | - | 2.23 | 2.58 | 9 |
| 12 | Kabaung | *Celtis cinnamomea* | 1.67 | 2.95 | 13 |
| 13 | Mahlwa | *Markhamia stipulata* | 4.05 | 3.54 | 22 |
| 14 | Thit-poke | *Dalbergia kurzii* | 1.83 | 2.25 | 25 |
| 15 | Pyinkado | *Xylia xylocarpa* | 18.78 | 10.60 | 34 |

| | | | | | |
|---|---|---|---|---|---|
| 16 | Oakhne | *Streblus asper* | 5.55 | 4.65 | 44 |
| 17 | Thinwin | *Millettia pendula* | 14.45 | 9.45 | 131 |
| 18 | Padauk | *Pterocarpus macrocarpus* | 21.60 | 14.91 | 163 |