Table of contents

ပဲခူးရိုးမအနောက်ဘက်အရပ်ရှိ ကျွန်းစိုက်ခင်းများ၏ သဘာဝမျိုးဆက်ပင်များ ရောနှောပေါင်းစပ် ဖွဲ့စည်းပုံနှင့် သဘာဝမျိုးဆက်ပင် အမျိုးအစားများအား လေ့လာဆန်းစစ်ခြင်း

ကျော်ဝင်း[၁၂] ၊ မြသန္တာတိုး[၁]
[၁]သစ်တောနှင့်ပတ်ဝန်းကျင်ဆိုင်ရာ တက္ကသိုလ်၊ရေဆင်း
[၂]သစ်ထုတ်ရေးဌာန၊ မြန်မာ့သစ်လုပ်ငန်း

စာတမ်းငယ်အကျဉ်းချုပ်

ပဲခူးရိုးမရှိ တောင်နဝင်းကြိုးဝိုင်းနှင့် အလယ်နဝင်းကြိုးဝိုင်းတို့တွင် သုတေသနပြုလုပ်ခဲ့ပါသည်။ ပေါက်ခေါင်းမြို့နယ်၊ ပဲခူးရိုးမ အနောက်ဘက်ခြမ်းတွင် တည်ရှိပါသည်။ အသက်အရွယ် အမျိုးမျိုးရှိသော ကျွန်းစိုက်ခင်းများကို သုတေသနပြုလုပ်ရန် လေ့လာခဲ့ပါသည်။ စိုက်ခင်းအသက်အရွယ် တစ်ခုစီတွင် နမူနာအကွက် (၁၀)ကွက်စီ ကောက်ယူခဲ့ပါသည်။ လုံးပတ် ၅စင်တီမီတာအောက်၊ အမြင့် ၁.၃မီတာနှင့်အထက် ရှိသော ပင်ပျိုများအား ၁၀မီတာပတ်လည် အကွက်ဖော်၍ သော်လည်းကောင်း၊ လုံးပတ် ၅စင်တီမီတာအောက်ရှိသော အပင်ပေါက်များအား ၄မီတာပတ်လည် အကွက်ဖော်၍ သော်လည်းကောင်း စာရင်းကောက်ယူခဲ့ပါသည်။ လေ့လာချက်အရ စိုက်ခင်းအားလုံးတွင် သစ်မျိုးစုစုပေါင်း ၅၀ တွေ့ရှိရပါသည်။ ဘင်္ဂပင်သည် အပေါများဆုံးနှင့် လွှမ်းမိုးမှု အားအကောင်းဆုံး သစ်မျိုးဖြစ်ကြောင်း တွေ့ရှိရပါသည်။ သစ်မျိုးများ ပေါက်ရောက်မှုသည် စိုက်ခင်းအသက်အရွယ်ပေါ် မူတည်၍ ကွဲပြားခြားနားကြသည်။ စိုက်ခင်းအသက် (၂၁)နှစ်အတွင်း အသက်အရွယ် ကြီးလာသည်နှင့်အမျှ အပင်အရေအတွက် လျော့နည်းသွားသော်လည်း သစ်မျိုးများပေါက်ရောက်ပျံ့နှံ့မှု များပြားသည်ကို တွေ့ရှိရပါသည်။ ပင်ကြပ်နှုတ်ခြင်း ဆောင်ရွက်မှုများ၊ လူတို့၏ ဝင်ရောက်နှောင့်ယှက်မှုများ၊ အခြားသော အနှောင့်အယှက်များဖြစ်သည့် မီးလောင်ခြင်းများ စသည်တို့သည် သဘာဝမျိုးဆက်ပင်များအား လျော့နည်းစေသော အကြောင်းအချက်များ ဖြစ်ပေသည်။ စနစ်တကျ ပြုစုခြင်း၊ ကောင်းမွန်သော စီမံအုပ်ချုပ်ခြင်း၊ ကာကွယ်ထိန်းသိမ်းခြင်းများ ပြုလုပ်ပါက ကျွန်းစိုက်ခင်းများရှိ သဘာဝ မျိုးဆက်ပင်များ ပိုမိုများပြားလာပေမည်။

Species Composition and Diversity of Natural Regeneration of Teak Plantations in Pauk Kaung Township,West Bago Yoma, Myanmar

Kyaw Win[*1,2], Mya Thandar Toe[1]

[*] Corresponding author's email: kyawwin.mte@gmail.com
[1] University of Forestry and Environmental Science, Yezin
[2] Extraction Department, Myanma Timber Enterprise

Abstract

The study was conducted at South Nawin and Middle Nawin Reserved Forests. It was located in Pauk Kaung Township, West Bago Region, Myanmar. Different age series (7, 8, 10, 11, 12, 17, 18 and 21 years old) of teak plantations were selected for the study. Using stratified random sampling design, a total of ten sample plots were established in each aged plantation. Saplings (DBH < 5cm, H ≥ 1.3m) and seedlings (H < 1.3m) were measured at quadrats of 10m x 10m and 4m x 4m accordingly. The species richness, Importance Value Index (IVI), Shannon Weiner Index (H'), Shannon Evenness (E), Simpson Diversity Index were employed to assess the natural regeneration (NR) of woody species. As the results, a total of 50 species was recorded from the entire study plots. Binga (*Mitragyna rotundifolia*) was the most dominant and common species in all plantations according to IV ranking. The result of one-way ANOVA test indicated that species composition and diversity was significantly different among different plantation ages. Overall, species composition and species diversity increase in older plantations while the density of NR decrease. Tending operation, human interventions and other disturbances such as severe fires are likely contributing to the decline of NR. It is concluded that, if silvicultural treatment, sound management and protection mechanism are instituted, it will help restore and augment the natural regeneration of teak plantation in the study area.

Keywords: regeneration, species composition, diversity, teak plantations

1. Introduction

Tropical forests are relatively stable in their species composition. These forests constitute over half of the world's standing timber representing 75% of the world's wood products (Thomas & Baltzer, 2002). Later, tropical forests are dwindling through areas due to both natural processes and human actions. The critical well-known factors of deforestation are clear-cutting and logging (Houghton, 2007). Myanmar is one of the countries experiencing deforestation and forest degradation. The deforestation rate between 2010 and 2015 was estimated to about 546,000 ha per year (Phyu, 2019). Bago Yoma, home of natural teak, is also severely harmed in its forest cover. Profoundly accessible areas, heavy exploitation and illegal cutting are the main causes of deforestation because of rapidly increasing population pressure (Mon et al., 2012). Due to rapid deforestation, large-scale plantation forestry began in the 1980s although small-scale forest plantations started as ahead of time as of late 1850s in Myanmar (Tint, 2002). In addition to the plantation establishment, reforestation of degraded lands in the tropical regions can invert some of the degradation processes. Forest department is annually catering for teak plantations about 10,274 ha yr^{-1} contributing 43% of all plantations. As compared with degraded forests, teak plantations will have natural regeneration after plantation establishment.

Regeneration is the process by which a tree species restore itself through it seedlings in its habitat in response to deforestation, and so forth (Fayiah et al., 2018). Regeneration is a critical part of forest management since it keeps up the desired species composition and diversity after various disturbances (Khumbongmayum et al., 2005). Understanding the processes of natural regeneration is of crucial importance to both ecologists and foresters (Slik et al., 2003). The quantitative study on teak regeneration in Bago mountains has been explored by some researchers. Win (2015) explored the regeneratin status of teak in fallow lands of East Bago Yoma. Ei (2015) studied private teak plantations programs with its natural regerantion and social significance in local livelihoods. Recognizing that species composition and diversity of natural regeneration of teak varies with geologic and climatic condition, this study was conducted in teak plantations of West Bago Yoma hypothesizing that natural regeneration of teak plantations becomes increased within the early stages 21 years old.

2. Objectives

The objectives of this study are to explore the species composition and the species diversity of natural regeneration under different age series of teak plantations. The findings will contribute to the role of teak plantations with ecological perspectives focusing on the status of natural regeneration.

3. Materials and Methods

3.1 Study Area Descriptions

This study was conducted in teak plantations of Nawin and Middle Nawin Reserved Forests (SNW & MNW Reserved Forests) in Pauk Kaung Township, Pyay District, Bago Yoma which also known as home of teak, Myanmar. It was situated between 18° 54' 17" North Latitudes and 95° 45' 52" East Longitudes (Waston, 1923) as shown in Figure 1. The mean annual rainfall of the study area is about 1657mm and the mean annual temperature is about 26.8°C (Phyo Sithu, 2018). Eight sample plantation ages (7, 8, 10, 11, 12, 17, 18 and 21 years old) were selected in this study. In each plantation age, 10 plots were inventoried in the study sites. The studied plantations are in terms of private and governmental plantations. Private plantations are allowed by government after 2006 while forest department has been implementing the plantation establishment that began in 1980s (Aye, 2011). 12 year old plantation is the oldest in private plantation because government allows the plantation establishment to private companies in 2006. In private plantations, tending operation such as thinning activity was done at the age of 8 and 12 years old plantations. This study was carried out to conduct the research on the regeneration status of teak plantations within the early stages of 21 years old because this study would like to know the trend of natural regeneration at the young stage of teak plantations.

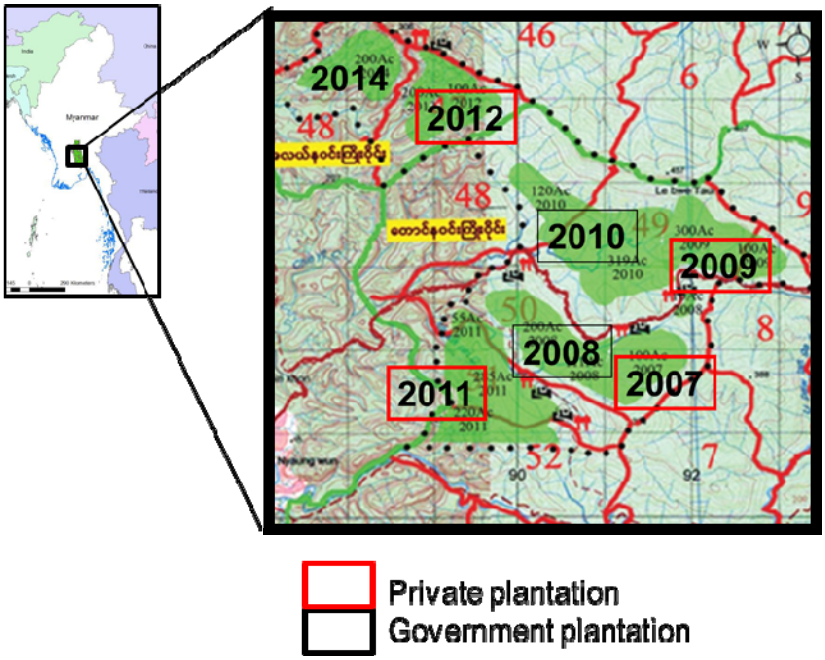

Figure 1. Map of Study Area

3.2 Data Collection and Sampling

This study was carried out by using stratified random sampling design. A set of sample plots was laid out in the representative areas of the selected teak plantations. In total, 80 sample plots were established in 7, 8, 10, 11, 12, 17, 18 and 21 years old teak plantations respectively. Saplings ($D < 5cm$, $H \geq 1.3m$) and seedlings ($H < 1.3m$) were enumerated in 10m x 10m plots and 4m x 4m plots respectively. The diameters at breast height were measured only for saplings. The identification of tree species was done in the field. Specimen of unknown species were identified in Botany Department of University of Forestry and Environmental Science. Vegetation sampling was conducted from December, 2018 to January, 2019 in order to minimize the impact of hot seasons.

3.3 Analysis of Species Composition

The species composition was represented by an importance value (IV). Important Value Index (IVI) was used to get the ecological noteworthiness of a species, in this manner allowing a correlation of the ecological centrality of species. Important value index (IVI) is calculated as the sum of relative abundance, relative frequency and relative dominance of each species. Relative Abundance is calculated as the percentage of each species on total stem number per hectare. Relative Frequency is percentage of each species contribution to the sum of absolute frequency. Frequency is the occurrence or absence of a given species in a subplot (Lamprecht, 1989) and is calculated as the total number of subplots in which species occurs and is expressed as percentage. Relative frequency is therfoe calculated as the percentage of the total of the frequencies of all species. Relative Dominance is the percentage of each species' basal area of all species. Abundance is the quantity of a given species per hectare. It is considered as the number of individuals per species and relative abundance as the percentage of each species of the total stem number per hectare. Dominance is the degree of inclusion of a species as an expression of the space it occupies. It is determined as the sum of the individual stem basal area in m^2.

Diversity Indices was used in this study for diversity measurement. Shannon Diversity Index (H') was used to portray the species diversity in a community and accounts for both abundance and uniformity of the species present (Shannon 1948). Shannon Evenness (E) index which is a basic structural composition index mirroring the dominance species was calculated. Shannon evenness ranges a value between 0 and 1. The value 1 represents a situation being complete evenness (i.e. all species are equally abundant). High evenness occurs when species are equal or virtually equal in abundance. When the number of species decrease, the value of Shannon evenness goes to zero. Simpson's Diversity Index indicates the most abundant species however it is less delicate to species richness. Simpson's diversity index emphasizes on the common species. Simpson's diversity index ranges from 0 to 1 in which 0 represents infinite diversity and 1 represents no diversity. The closer it is to 1, the less different the community. Simpson's diversity index measures the probability that two individuals randomly selected from a sample will belong to the similar species. It shows the dominance measure because such index is weighted towards the abundance of the commonest species as opposed to providing a measure of species richness.

Species composition and species diversity were expressed by using descriptive statistics. Species composition and species diversity were compared between plantation ages using one-way ANOVA test. All statistical analyses were performed using IBM SPSS (version 20.0) and Excel 2010.

4. Results

4.1 Overall Species Composition of natural regeneration

A total of 50 species are found as natural regeneration in eight aged plantations (Table 1). Among 50 species, 12 species (24%) and 14 species (28%) were separately found as saplings and seedlings respectively. Nearly have of the species are found in both sapling and seedling stages.

Table 1.Composition of natural regeneration under different aged teak plantations

	No. of Species	% of total Spp.
Species as both sapling and seedling	24	48%
Sapling species	12	24%
Seedling species	14	28%
Total species richness	50	100%

All species of eight plantations are listed and illustrated in Figure 2. Some of the economically significantly species defined by Myanma Timber Enterprise such as *Tectona grandis*, *Albizzia lebbek*, *Albizzia odoratissima*, *Albizzia procera*, *Chukrasia tabularis*, *Dalbergia cultrata*, *Lagerstroemia speciosa* , *Xylia xylocarpa*, etc. were found in the present study. Among those economically important species, some species such as *Tectona grandis* (Teak), *Albizzia lebbek*, *Albizzia odoratissima Albizzia lebbeck*, *Melanorrhoea usitata* and *Terminalia tomentosa* were found as only seedlings.

Figure 2. List of species and their composition: Species in box are commercially important species in Myanmar defined by Myanma Timber Enterprise

4.2 Species Composition of natural regeneration under different aged plantations

The number of families and species found in different aged plantations was shown in Figure 3. Saplings led to decrease until the plantation age reached at 12 years. Saplings were eminently abundant in 17-year-old plantation while the seedlings were abundant in 8 year old plantation. The comparison of species composition and plantation ages showed that the number of family was significantly different in both saplings and seedlings among all plantation ages. Species richness was also significantly different in both saplings and seedlings among all plantation ages.

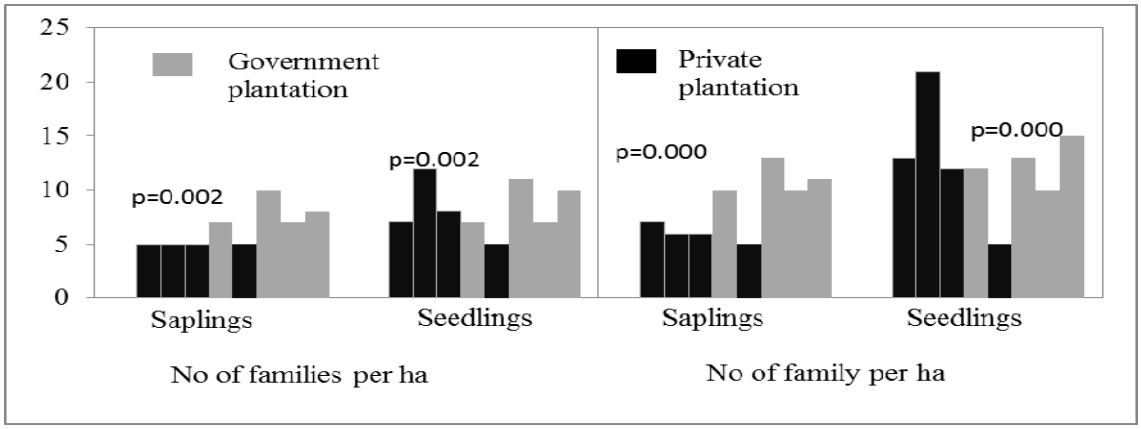

Figure 3. Number of families and species found in different aged plantations

The densities of saplings and seedlings were shown in Figure 4. Seedlings were eminently abundant in 7 year old plantation and it later decrease when the age get older. The lowest number of seedlings was obviously found in age 12 which is recently conducted for thinning. In contrast, the saplings were obviously absents in age 18 and 12 while it was abundantly located in 11 year old plantation. The densities of both saplings and seedlings were fluctuated among all plantation ages. Well-established saplings and seedlings were occasionally observed, for instance, age 11 for saplings age 17 for seedlings. Seedlings were abundantly found in all plantations compared to saplings. Low quantity in seedling density in the 12 year old plantation was probably caused by tending operation.

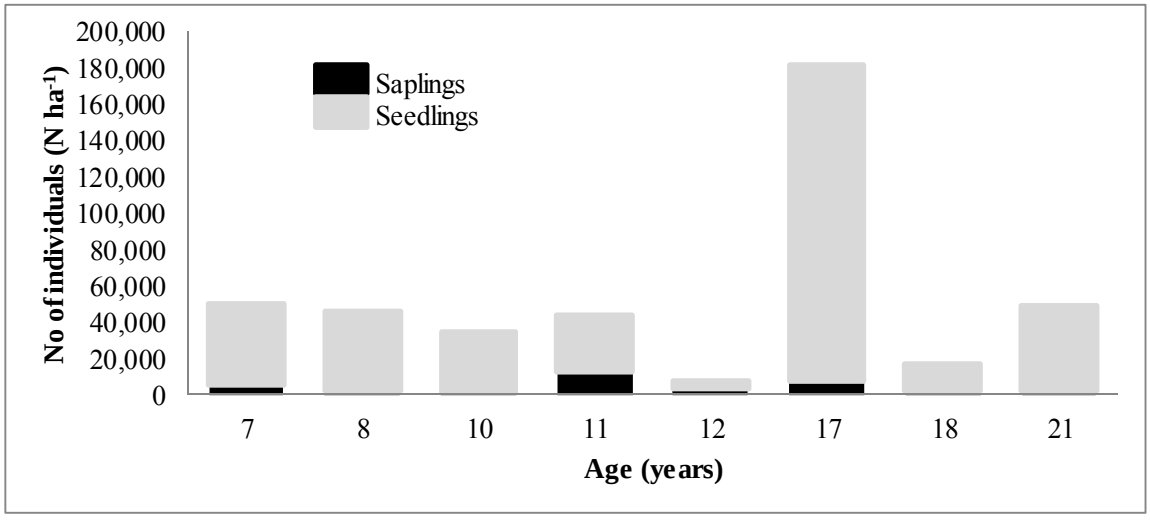

Figure 4. Sapling and Seedling densities of different aged plantations

Compared to other seedlings, the teak seedlings are found in some plantation ages (i.e. 8 years old to 11 years old), but more seedlings of teak species were established at 21 years old. Figure 5. It occupies only about 12% of the total seedling densities. Other commercial species are also found in all plantations.

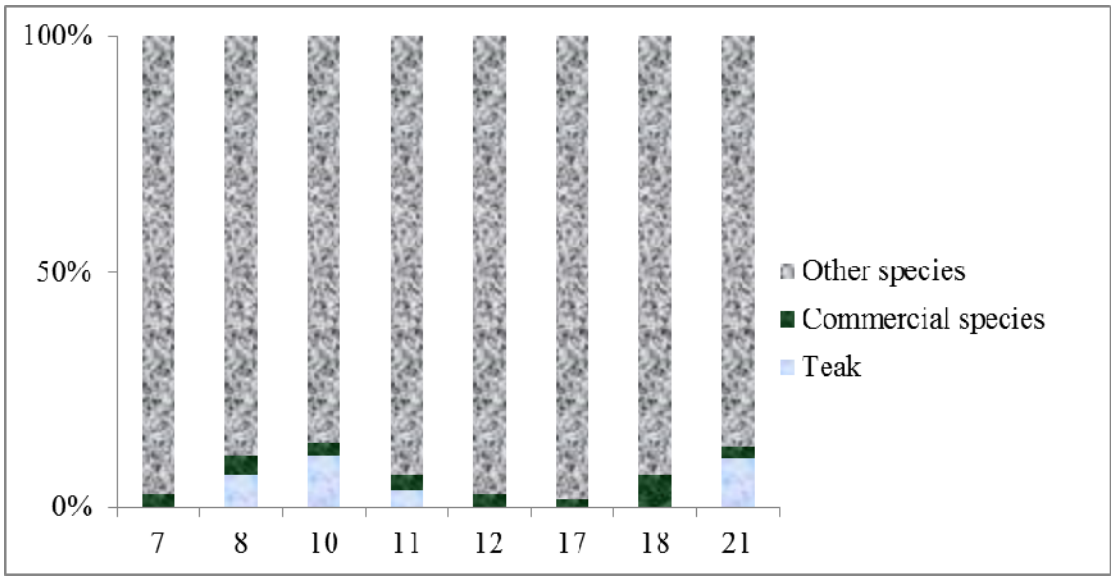

Figure 5. Seedling densities of different aged plantations

4.3 Important Value for Saplings

The IV of top five highest IV species of saplings were shown in Figure 6. The top five IV species are assumed as a typical natural regeneration of teak plantations covering 67% to 100% of total IVI. The top five highest IV species is recognized as *Mitragyna rotundifolia* (37%), *Millettia pendula* (20%), *Dalbergia ovata* (11%), *Bauhinia racemosa* (9%) and *Anogeissus acuminata* (9%) for 7 year old, *Mitragyna rotundifolia* (41%), *Xylia xylocarpa* (39%), *Wendlandia glabrata* (6%), *Lagerstroemia macrocarpa* (6%) and *Anogeissus acuminata* (4%) for 8 year old, *Mitragyna rotundifolia* (53%), *Xylia xylocarpa* (12%), *Oroxylum indicum* (11%), *Dalbergia ovata* (8%) and *Dalbergia rimosa* (8%) for 10 year old, *Millettia pendula* (30%), *Mitragyna rotundifolia* (19%), *Stereopermum neuranthum* (12%), *Anogeissus acuminata* (10%) and *Lagerstroemia speciosa* (8%) for 11 year old, *Mitragyna rotundifolia* (70%), *Terminalia pyrifolia* (12%), *Albbizia procera* (10%), *Dolichandrone serrulata* (4%) and *Lagerstroemia macrocarpa* (4%) for 12 year old, *Mitragyna rotundifolia* (33%), *Dalbergia ovata* (27%), *Anogessius acuminata* (12%), *Lagerstroemia villosa* (6%) and *Garuga pinnata* (3%) for 17 year old, *Cordia grandis* (23%), *Microcos paniculata* (12%), *Mitragyna rotundifolia* (12%), *Stereopermum neuranthum* (12%) and *Diospyros montana* (9%) for 18 year old, *Stereopermum neuranthum* (21%), *Mitragyna rotundifolia* (17%), *Homalium tomentosum* (10%), *Stereopermum fimbriatum* (10%) and *Pterospermum semisagittatum* (9%) for 21 year old respectively..

In all plantations, *Mitragyna rotundifolia* occupied the largest portion of dominance and 37% of IVI in 7 year old, 41% in 8 year old, 53% in 10 year old, 19% in 11 year old, 70% in 12 year old, 33% in 17 year old, 12% in 18 year old and 17% in 21 year old. Among the highest

IV species, *Mitragyna rotundifolia* was the most dominant species and common species in different plantation ages.

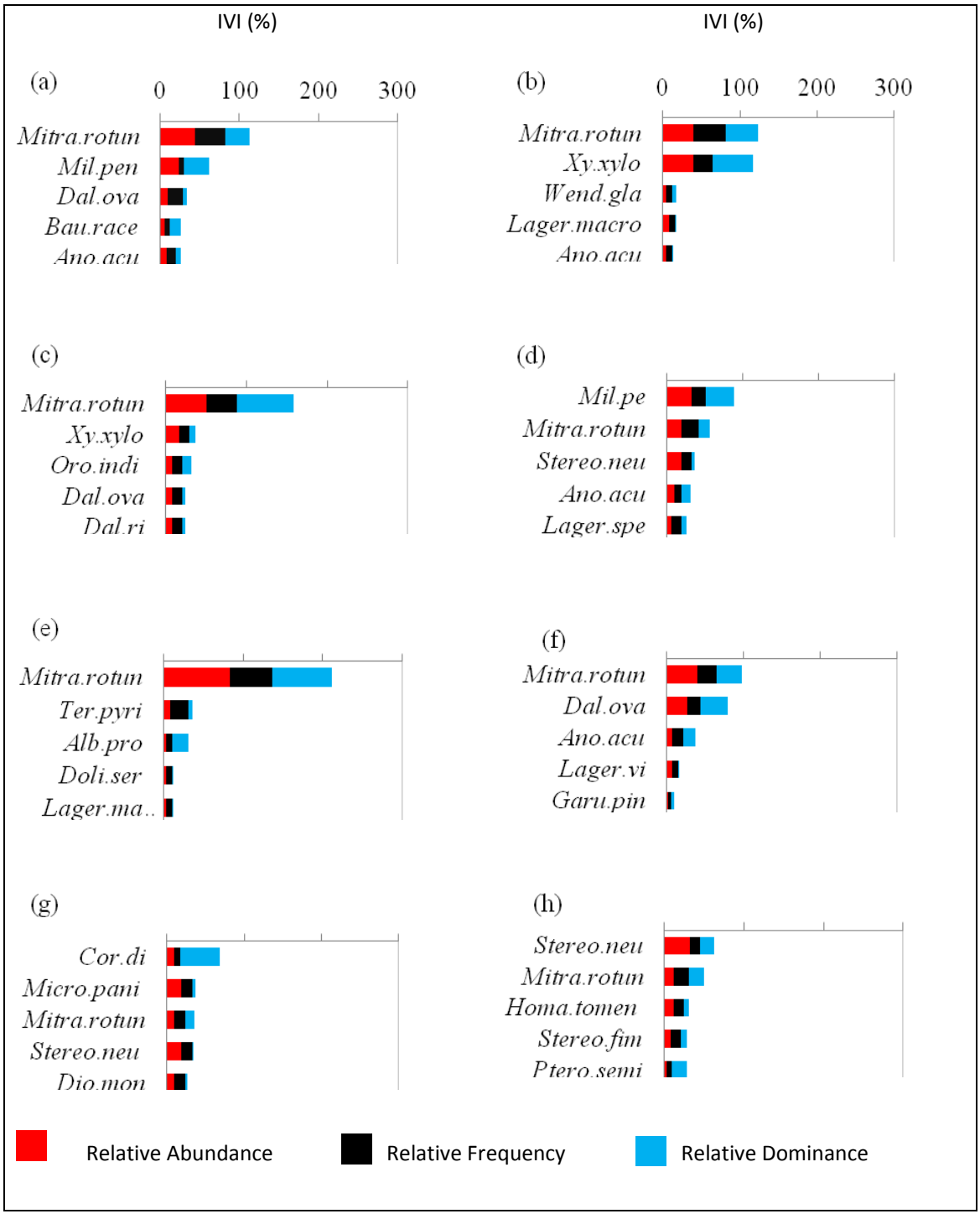

Figure 6. Top five IV saplings under 7, 8, 10, 11, 12, 17, 18 and 21 years old plantation (a) to (h)

4.4 Species Diversity of Natural Regeneration

The calculated values of diversity indices for all plantations were summarized in Table 2.

For saplings, in terms of Shannon Wiener index, 18 year old had the highest value among all plantations. According to the calculation of Shannon Evenness (E), which is based on the abundance of species, the saplings are more distributed in 18-year-old plantation. According to Simpson's diversity index, 18 and 21 year old plantations exhibited the highest value among the sites due to its wide range of topographic condition. It can be observed that the species in 18 and 21 year old plantations are more diverse than other plantations. Simpson's diversity index value of 12 year old plantation was less than that of other plantations which means that the saplings were less diverse in 12 year old plantation than other plantations.

For seedlings, 10 year old plantation had the highest value in terms of Shannon Wiener Index (H'). According to the calculation of Shannon Evenness (E), which was based on the abundance of species, the seedlings are less distributed in 18 year old plantation. Simpson index value of 17 year old plantation is less than that of other plantations which means that the seedlings are more diverse in 17 year old plantation than other plantations.

When compared to the species diversity of different age series of teak plantations, the result was expressed as Table 2. A comparative analysis revealed that Shannon Wiener Index (H') was significantly different in both saplings and seedlings among all plantation ages. Shannon evenness (E) was significantly different in terms of saplings among all plantation ages. Simpson's diversity index (D) was not significantly different in this study.

Table 2. Species Diversity of Natural Regeneration among Different Plantation Ages

Plantation Ages (years)	**7**	**8**	**10**	**11**	**12**	**17**	**18**	**21**	**p-value**
Saplings									
Shannon Wiener Index (H')	1.6	1.3	1.5	1.9	0.7	1.8	2.2	2.1	0.002*
Shannon Evenness (E)	0.8	0.7	0.8	0.8	0.4	0.7	1	0.9	0.013*
Simpson's Diversity Index (D)	0.7	0.7	0.8	0.8	0.3	0.8	0.9	0.9	0.1
Seedlings									
Shannon Wiener Index (H')	2.1	2.5	2.3	2.1	1.5	1.3	2.1	2.1	0.017*
Shannon Evenness (E)	0.8	0.8	0.9	0.9	0.9	0.5	0.2	0.9	0.196
Simpson's Diversity Index (D)	0.8	0.9	0.9	0.9	0.9	0.6	0.9	0.9	0.064

*95% Significant level

5. Discussion

5.1 Natural regeneration of teak plantations

The density of natural regeneration leads to decrease after the plantation age reaches until 12 year old. It is likely due to tending operation and other disturbances such as severe fires. Depending on field investigations, species are more abundant in the 17 year old plantation which is not affected by human interventions because it is situated in inaccessible areas.

The fundamental difference in species composition in terms of no of family and species richness may be due to a wide range of topographic condition and difference in disturbance intensities. This may be the result of several sites factors and regeneration behavior of the species (Htun, 2015). Species composition and species richness are important indicators for extrapolating the biodiversity (Husch et al., 2002) and may strongly depend and/or be influenced by the applied management practices.

Mitragyna rotundifolia (Binga), the most abundant species in all plantations except 11, 18 and 21 years old plantations had high IV values. This may be due to the site condition which was favorable for the development of teak. In addition to the above-mentioned assumptions, *Mitragyna rotundifolia* could be considered as the characteristics species of all plantations. In this study, the growth of *Mitragyna rotundifolia* responds rapidly and extraordinarily to the disturbances e.g. severe fires. Other species are present with a low abundance in all plantations. The top five IV species may assume as the resistant species. While the resistant species have been replaced, the vulnerable species have been disappeared because of the aggravation. These resistant species seem favorable to develop under teak plantations. Be that as it may, species distribution was different among plantation ages. The reason for the variation of species in different plantation ages may be due to soil factors and human interventions. The dominance of *Mitragyna rotundifolia* could be as a result of habitat adaptation and favourable environmental conditions which encourage the establishment of species.

The saplings were less diverse in 12 year old plantation than other plantations because thinning which effect on the natural regeneration was done at this age. However, species are more diverse when the plantation age reaches within the 21 years old. Ei (2015) also stated that species diversity becomes increased within the early ages of 10 to 20 years. However, species diversity in its regenerated vegetation started decreasing obviously at its age of 30 years (Ei, 2015). The result found a total species in the present study was less than the previous study which was reported by Ei (2015). Diversity is greatest if each species adds to a similar extent in the number of individuals in the forest community (Magurran, 1988). Due to variation in biogeography, habitat, and disturbance, species diversity varied greatly from place to place (Htun, 2015). Strict monitoring on the status of the regeneration/ plantation ought to be carried out to improve the forest conditions (Nagendra, 2007).

5.2 Implications for teak plantation management

The basic information about the composition of the forest is of indispensable significance to examine the management system (Sein, 2015). The species composition and diversity of natural regeneration can reflect the future status of the forest (Htun, 2015). For successful sustainable forest management practices, it is necessary to clarify the species composition and diversity of natural regeneration. A better understanding of species composition and diversity of natural regeneration is thus of chief significance for the sustainability of forest management (Khaing, 2014). To ensure natural regeneration, the type and degree of disturbance are one of the most important factors needed in controlling the nature of forest regeneration.

There is a need to develop an adequate strategy and action plan for the conservation and management of teak plantations. Forest management interventions will be required to manage the current disturbances and anticipated unsettling disturbances (Dale et al., 2000). The management plans must be accompanied by regular forest inventories to control the past management and update and adjust future sustainable management activities to avoid further loss in natural regeneration. It is necessary to befit suitable silvicultural operations to improve

the systematic and sustainable management of teak plantations. Suitable silvicultural treatment and proper management ought to be practised in order to encourage the species composition and species diversity of natural regeneration sustainably in the study sites. Therefore, the currently adopted silvicultural practices in teak plantations ought to be reviewed and redressed so as to develop the status of natural regeneration. The forest field authorities need to be trained in silviculture practices. In order to conserve the teak plantations sustainably, strict policies and sustainable conservation plans ought to be implemented.

6. Conclusion

This study highlights the species composition and diversity of woody regeneration of teak plantations under different plantation ages. In the early developmental age of teak, the regenation of teak generally respond the decrease in its density and increase in species richness and diversity when the plantationage gets older. However, such process was particularly found in private plantations reflecting that tending operation had significant effects on species composition and diversity of natural regeneration. External disturbances such as severe fires are likely contributing to the decline of the composition of NR. In addition, one species such as ***Mitragyna rotundifolia*** composed as a dominant species of NR in all plantations of the study area. Proximity to its mother trees, original site qualities and well-developed adaptatability of the species are likely the reasons that would help for the species to effectively survive in the area of teak plantations. Regeneration of teak are found as only in seedlings in younger stage of teak plantation. Since the maintenance of NR is crucial to the success of forest management, suitable silvicultural treatment and proper management should be practiced. The management systems and silvicultural treatment will be highly advantageous to save and maintain the natural regeneration. The recommendation therfore should be made at the regional and national levels to ensure sustainable management for the natural regeneration of teak plantations.

Reference

Aye, Y. Y. (2011). Carbon Content of 15-year-Old *Xylia xylocarpa* and *Pterocarpus macrocarpus* Plantations in Katha District, Myanmar.

Dale, V., Joyce, L., McNulty, S., & Neilson, R. (2000). The interplay between climate change, forests, and disturbances. *Sci Total Environ, 262*, 201–204.

Department, F. (2019).

Ei. (2015). Potential of Monoculture Teak Plantations for Multifunctional Forests in the Bago Mountains, Myanmar. Kyoto.

Fayiah, M., Singh, S., Mengesha, Z., & Chen, B. (2018). Regeneration Status and Species Diversity of a Mix Dey Deciduous Forest: A Case of Barah Forest, Jabalpur, Madhya Pradesh, India. *Indian Journal of Tropical Biodiversity, 26*(1), 17-29.

Houghton, R. (2007). Balancing the global carbon budget. *The Annual Reviews of Earth and Planetary Sciences, 35*, 313-347.

Htun, K. T. (2015). Composition and Structure of Mixed Deciduous Forests in Bago Yoma (Case Study in Yedashe, Pyinmana, Taungdwingyi townships). *Forest Research Institute, 16*.

Husch, B., Beers, T., & Kershaw, J. J. (2002). *Forest mensuration.* (J. W. Sons, Ed.) New York (NY).

Khaing, N. (2014). Sturcture and Composition of Dry Deciduous Forests in Central Myanmar. *Forest Research Institute, 4*.

Khumbongmayum, A., Khan, M., & Tripathi, R. (2005). Survival and growth of seedlings of a few tree species in the four sacred groves of Manipur, Northeast India. *Current Science, 88*, 1781-1788.

Kress, W. J., A.DeFilipps, R., Farr, E., & Kyi, Y. Y. (2003). A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar. *Washington D.C Press, 45*, 1-590.

Magurran, A. E. (1988). Ecological Diversity and Its Measurement. University College of North Wales. Bangor, USA: Springer, Dordrecht.

Mon, M. S., Mizoue, N., Htun, N. Z., Kajisa, T., & Yoshida, S. (2012). Factors affecting deforestation and forest degradation in selectively logged production forest: A case study in Myanmar. *Forest Ecology and Management*, 190-198.

Nagendra, H. (2007). Drivers of reforestation in humandominated forests. *Proc Natl Acad Sci, 104*, 15218–15223.

Phyu, A. S. (2019). Myanmar third-worst for deforestation rate, says UN. *Myanmar Times, Sunday*.

Sein, C. C. (2015). Assessment on the Species Composition and Stand Structure of Three Different Mixed Deciduous Forest Types in Alaungdaw Kathapa National Park. *Forest Research Institute, 15*.

Slik, J., Kebler, P., & Van Welzen, P. (2003). Macaranga and Mallotus species (euphorbiaceae) as indicators for disturbance in the mixed lowland dipterocarp forest of east Kalimantan (Indonesia). *Ecological Indicators, 2*, 311-324.

Thomas, S., & Baltzer, J. (2002). Tropical Forests in Global Perspective. *Encyclopedia of Life Sciences*.

Tint, K. (2002). Review of Forestry Related Legislation, Policy and Practice and Their Impacts/ Implication on Sustainable Forest Management (SFM) and on the Model Forest Approach to SFM in Myanmar. Yangon, Myanmar.

Waston, H. (1923). A Note on the Pegu Yoma Forests. Rangoon: Office of the superintendent, Government printing, Burma.

Win, R. N. (2015). Analysis of shifting cultivation practices and Teak Regeneration and Soil Nutrient on Fallow Lands in Bago Mountains, Myanmar. *Forest Research Institute*.