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Composition and Structure of Mixed Deciduous Forests in Bago Yoma
(Case Study in Yedashe, Pyinmana, Taungdwingyi townships)

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ပဲခူးရိုးမဒေသ ရွက်ပြတ်ရောနှောသော တောစို၊ တောခြောက်များ၏ သဘာဝပေါက်ပင်များ၊ သစ်မျိုးစိတ်များ ရောနှော ပေါင်းစပ်ဖွဲ့စည်းပုံနှင့် ပင်စုတည်ဆောက်ပုံများအားလေ့လာခြင်း

ခင်သီတာထွန်း၊ ဦးစီးအရာရှိ
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

ပဲခူးရိုးမဒေသအတွင်း ပေါက်ရောက်လျက်ရှိသော ရွက်ပြတ်ရောနှောတောစို၊ တောခြောက်များသည် ဂေဟစနစ်နှင့်လူမှုရေးတွင် အလွန်အရေးကြီးသောအခန်းကဏ္ဍမှပါဝင်နေကြောင်းတွေ့ရှိရပါသည်။ ဒေသခံပြည်သူလူထု၏ ရေရှည်အကျိုးစီးပွားအတွက် ပဲခူးရိုးမဒေသသစ်တောများနှင့် ပတ်ဝန်းကျင်အားကာကွယ်ထိန်းသိမ်းရန် အလွန်အရေးကြီးပါသည်။ ပဲခူးရိုးမဒေသအတွင်း ပေါက်ရောက်လျက်ရှိသော ရွက်ပြတ်ရောနှောတောစို၊ တောခြောက်များ ရေရှည်တည်တံ့ခိုင်မြဲအောင် စီမံအုပ်ချုပ်နိုင်ရန်အတွက် အဆိုပါတောများ၏ သဘာဝပေါက်ပင်များနှင့် သစ်ပင်လုံးပတ်အတန်းအစားများအား ကောင်းစွာနားလည်ရန်လိုအပ်ပါသည်။ သို့ဖြစ်ပါ၍ ဤသုတေသနလုပ်ငန်းအား ရွက်ပြတ်ရောနှောသော တောစို၊ တောခြောက်များ၏ သဘာဝပေါက်ပင်နှင့် သစ်ပင်လုံးပတ်အတန်းအစားများအား လေ့လာဆန်းစစ်ရန် ပဲခူးရိုးမဒေသရှိ ပျဉ်းမနား၊ ရေတာရှည်နှင့် တောင်တွင်းကြီးမြို့နယ်များတွင် ဆောင်ရွက်ခဲ့ပါသည်။ ရွက်ပြတ်ရောနှော တောစိုများပေါက်ရောက်သည့် ပျဉ်းမနား၊ ရေတာရှည်နှင့် တောင်တွင်းကြီးမြို့နယ်အတွင်းရှိ တောများတွင် အပင်အမြင့်တိုင်းတာခြင်း၊ သစ်ပင်လုံးပတ်တိုင်းတာခြင်းနှင့် သစ်မျိုးခွဲခြင်းအစရှိသည့် သုတေသနလုပ်ငန်းများ လုပ်ဆောင်ခဲ့ပါသည်။ ဧရိယာ(၀.၁) ဟတ်တာရှိသောနမူနာအကွက် အစုလိုက်ကောက်ယူသည့် ပုံစံအသုံးပြု၍ ကောက်ယူရရှိသော ကိန်းဂဏန်းအချက်အလက်များကို သစ်မျိုး–ဧရိယာဆက်စပ်မှုရေးဆွဲဖော်ပြခြင်း၊ ရွက်ပြတ်ရောနှောတောအမျိုးအစားအလိုက် အရေးအကြီးဆုံး သစ်မျိုးများရွေးချယ်ဖော်ပြခြင်း၊ မျိုးဆက်ပင်များ ရေတွက်တိုင်းတာခြင်း၊ အပင်အမြင့် – သစ်ပင်လုံးပတ်ဆက်သွယ်မှုကို ပုံသေနည်းအသုံးပြု၍ တွက်ချက်ခြင်းအစရှိသည့် သုတေသနလုပ်ငန်းများ လုပ်ဆောင်ခဲ့ပါသည်။ သုတေသနရလာဒ်များအရ သစ်ပင်လုံးပတ် (၅) စင်တီမီတာနှင့်အထက် အပင်များအား တိုင်းတာတွက်ချက်ပ ါက ရွက်ပြတ်ရောနှောတောခြောက်များ ပေါက်ရောက်ရာဒေသ တောင်းတွင်းကြီးမြို့နယ်တွင် သစ်မျိုးအများဆုံး(၆၄)မျိုး တွေ့ရှိရပြီး ရွက်ပြတ်ရောနှောတောစိုများ ပေါက်ရောက်သည့် ရေတာရှည်နှင့် ပျဉ်းမနားမြို့နယ်များတွင် သစ်မျိုး(၅၇)နှင့် (၄၃)မျိုးသာတွေ့ရှိရပါသည်။ သစ်မျိုးများအလိုက် ပျံ့နှံ့ပေါက်ရောက်ပုံကို ပုံသေနည်းအသုံးပြု၍ တွက်ချက်ရာ၌ တောင်တွင်းကြီးဒေသရှိ ရွက်ပြတ်ရောနှောသော တောခြောက်များတွင် သစ်မျိုးအလိုက် အပင်များပိုမို၍ ပေါကြွယ်စွာ ပေါက်ရောက်နေကြောင်း တွေ့ရှိရပါသည်(ပျံ့နှံ့မှုအညွှန်းကိန်း= ၃.၆၂)။ သို့ရာတွင် အရေးကြီးဆုံး သစ်မျိုးများရွေးချယ်ဖော်ထုတ်ရာ၌ ကျွန်းသစ်မျိုးအား ရွက်ပြတ်ရောနှောသော တောစိုများပေါက်ရောက်သည့် ပျဉ်းမနားမြို့နယ်တွင် အညွှန်းကိန်းအများဆုံး(၄၁.၄၃%)ဖြစ်သည်ကို တွေ့ရှိရပါသည်။ သစ်မျိုးများ၏ သစ်ပင်လုံးပတ် အတန်းအစားအလိုက် ပျံ့နှံ့တည်ရှိမှုကိုလေ့လာရာတွင် သုတေသနပြုဆောင်ရွက်ခဲ့သည့် တောအမျိုးအစားတိုင်း၌ သစ်မျိုးအလိုက်အငယ်ဆုံး သစ်ပင်လုံးပတ် အတန်းအစား(၅–၉.၉စင်တီမီတာ)တွင် အပင်များအများဆုံး ပါဝင်ပေါက်ရောက်လျက် ရှိသည်ကိုတွေ့ရှိရပါသည်။ သို့ရာတွင်စီးပွားရေးအရ ရေးပါသော အဖိုးတန်သစ်မာသစ်မျိုးများဖြစ်သည့် ကျွန်းနှင့်အုပ်စု(၁) သစ်မျိုးများ၏ ပါဝင်မှုမှာ အလွန်ပင်နည်းပါးနေကြောင်းတွေ့ရှိရပါသည်။ အဖိုးတန်သစ်မျိုးများဖြစ်သည့် ကျွန်းနှင့်အုပ်စု(၁)ဝင် ပျဉ်းကတိုး၊ ပိတောက်ပင်များ၏ အပင်အမြင့်နှင့် သစ်ပင်လုံးပတ်ဆက်သွယ်မှုကို တွက်ချက်ရာတွင် ရွက်ပြတ်ရောနှောသော တောခြောက်များပေါက်ရောက်ရာ တောင်တွင်းကြီးဒေသရှိ အပင်များမှာ ပိုမို၍လွှမ်းမိုးလျက်ရှိသည်ကို

တွေ့ရပါသည်။ အပင်ငယ်များ၏ မျိုးဆက်မှုအခြေအနေအား လေ့လာရာတွင် တောင်တွင်းကြီးမြို့နယ်တွင် အပင်ရေ အများဆုံးတွေ့ရသော်လည်း အဖိုးတန်သစ်မျိုးများ၏ မျိုးဆက်နိုင်ရန်ပါဝင်မှုအညွှန်းကိန်းမှာ ပျဉ်းမနားမြို့နယ်တွင် ပိုမိုရှုံမြင့်မားနေကြောင်း တွေ့ရှိရပါသည်။ မျိုးဆက်ပင်များအား ရေတွက်ရာတွင် တောင်တွင်းကြီးမြို့နယ်အတွင်း မျိုးဆက်ပင်အရေအတွက် အများအဆုံး (၄၃၉)ပင် တွေ့ရှိရသော်လည်း ပဲခူးရိုးမဒေသအတွင်း အခြားသောသုတေသန တွေ့ရှိချက်များနှင့် နှိုင်းယှဉ်ပါက အလွန်ပင်နည်းပါးလျက် ရှိကြောင်းတွေ့ရှိရပါသည်။

Composition and Structure of Mixed Deciduous Forests in *Bago Yomas*(Case study in Pyinmana, Yedashe and Taungdwingyi townships)

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Abstract

Dry and moist upper mixed deciduous forests in *Bago Yomas* play an important role from both an ecological and socio-economic point of view. Protecting and conserving the environment of *Bago Yomas* is vitally important for the long term benefits of local communities. A better understanding of tree species composition and forest stand structure is thus of foremost importance for the sustainability of mixed deciduous forests in *Bago Yomas*. This study was conducted with main objectives to specify the tree species composition and forest stand structure of dry and moist upper mixed deciduous forests in the *Bago Yomas*. Patterns of woody regeneration in terms of species composition and diversity were studied in mixed deciduous teak bearing forest in Ngalaik reserve (Pyinmana tsp), Saingya reserve (Yedashe tsp) and Kinmundaung reserve (Taungdwingyi tsp). The measurements (diameter at breast height, total height, and species) were done. The data from a 0.1ha cluster sample plot were analyzed using species-area curve approach, important value index (IVI), diversity index and height-diameter function. A total of 43 species belonging 305 individuals in Pyinmana, 57 species with 801 individuals in Yedashe and 64 species with 716 individuals in Taundwingyi forests were identified. Plant species diversity was quantitatively higher in dry mixed deciduous forest of Taundwingyi (H' = 3.62) compared to the moist upper mixed deciduous forest of Yedashe (H' = 3.38) and Pyinmana (H' = 3.19). *Tectona grandis* showed the first position in the abundance of 45, dominance (0.46 m^2) and IVI (41.43%) of Ngalaik reserve (Pyinmana), the 4 th position in the abundance of 55, dominance (0.30 m^2) and IVI (17.24%) in Saingya reserve (Yedashe) and Kinmundaung reserve (Taungdwingyi) also composed in the 5 th position of 27, 0.30 m^2 and 11.63% IVI. In the diameter distribution of stem number, the smallest diameter class (5-9.9 cm) comprised with 203 individuals, 539 individuals in moist upper mixed deciduous forest of Pyinmana, Yedashe and 518 individuals in dry mixed deciduous forest of Taundwingyi. The size class distribution displayed a reverse J-shaped pattern. The largest number s of trees species were concentrated in the smallest diameter class in three investigated stands. Of which, the investigated stand structure with diameter proportion of teak, valuable hardwood tree species (Group I) and others show (16.7%, 17.2% and 66.0%) in Ngalaik reserve (Pyinmana), (6.5%,4.3% and 89.2%) in Saingya reserve (Yedashe) and (2.7%,15.4% and 81.85%) in Kinmundaung reserve (Taungdwingyi). The height-diameter functions covered diameter ranges of 5-38 cm for *Tectona grandis*, 5-23 cm for *Xylia xylocarpa* and 5-26 cm for *Pterocarpus macrocarpus* in Pyinman, Yedashe and Taundwingyi respectively. The height curves for Taungdwingyiteak standreflects the dominant position of with the total height of approximately about 17 meters with the dominated basal area. Under dry forest site conditions, the valuable hardwood species pyinkado and padauk stands had a maximum height of approximately 12 m and 15 m are also dominant in Taundwingyi forest. Regeneration density of sapling in three investigated reserves (Kinmundaung, Saingya and Ngalaik) was (222, 160 and 136) individuals in Taungdwingyi, Yedashe and Pyinmana respectively. Among these reserves, the commercial hardwood species *Tectona grandis*, *Xylia xylocapa* and *Pterocarpus macrocarpus* in Ngalaik reserve only exhibited the higher IVI value (22.57%), (21.24%) and (16.33%) than the others. In regeneration counting, there are 49 species with 439 seedlings/ha in Kinmundaung RF., 33 species with 355 seedlings/ha in Saingya RF. and 34 species with 260 seedlings/ha in Ngalaik RF. Among them, other lesser used species are taking parts the first position in regeneration density than the valuable commercial species (teak, pyinkado, padauk). A few numbers of seedlings of (teak, pyinkado, padauk) were only (5, 7, 4)in Ngalaik reserve (Pyinmana), (7, 3, 0) in Saingya reserve (Yedashe) and (4, 26, 2) in Kinmundaung reserve (Taungdwingyi) respectively. And it can be seen that regeneration density of these study areas is much less when compare with Kyaw Lwin study in the *Bago Yomas* (439) and Than Soe Oo study in Ngalaik Reserve (805).

Key words: Mixed deciduous forests, Species-area curves, Important value index, Species diversity, Stand structure

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Composition and Structure of Mixed Deciduous Forests in *BagoYomas*(Case Study in Pyinmana, Yedashe and TaungdwingyiTownships)

1. Introduction

1.1 Forest status of Myanmar

Forest cover 40% of the earth's land surface home to more than 70% of land living plants and animals; forest resources provide a wide range of ecological, and economical benefits. More than 2.5 million peoples depend on tropical forests for water, fuel wood, and other resources (Masterantonio and Francis, 1997). Tropical forests found in more than 80 countries and occupied 37% of the total land area of the tropical regions, about one-third of the world's forest cover in 1990 (FAO,1997). The tropical forest in particular have high productive and protective value, an estimate of 10-30 million species is found in tropical forest alone and they comprise very complex ecological communities of different species that have unique ecological importance (Sandalow, 2000).

The tropical forests of South-East Asia are characterized by a variety of evergreen, semi-evergreen and deciduous tree cover types, often in close proximity depending on soils, local site conditions and climate. The deciduous 'monsoon' forests of South-East Asia occur as the valuable 'mixed deciduous forests', stretching from northeastern India, through Myanmar and Thiland to Laos. Myanmar is a tropical country with enrich natural resources. It is situated between north latitude 10° and 28° and eastern longitudes 93° and 103° and bordered on the north and northeast by China, on the east and southeast by Laos and Thiland, on the south by the Andaman Sea and the Bay of Bengal, and on the west by India and Banbladesh. Natural forests cover of Myanmar is about 49% of the total land area (FAO 2009).

Floristic composition and structure studies are essential for their values in understanding the extent of plant biodiversity in forest ecosystems (Parthasarathy, 2001). The forests of Myanmar are very diverse in flora and fauna and are ecologically complex. These ecological factors cause trigger both seed production and germination in the natural state. All these seedlings contribute to the stand structure and composition of the forests which includes large, medium and small size trees of various species. In sustained yield forest management, tree population are maintained in a 'normal' or 'balanced' or 'desirable' stand structure with higher number of small trees and gradually decrease when size increases. An assessment of composition and structure of selected forest types will follow with an assessment of the potential and possibilities for future forest management. Floristic composition, structure and natural regeneration of the forests are critical to know in the present day.

Myanmar's primary source of forest products are natural forests, providing teak and other hardwood timber and performing valuable protective services. Forests are owned by the state and are classified legally as reserved forests (30%) and public forest or unclassified forests (70%). 37.8% of the total forest area and 19% of the country's land area (13 million hectares) are categorized as permanent forest estate (PFE). Among them, 3.3 million hectares are in designated conservation reserves. Within the PFE, 9.7 million hectares are designated as production forests which consist of 8.3 million hectares of mixed deciduous and 1.4 million hectares of evergreen forests. Several forest types are distributed in everywhere of Myanmar including *BagoYomas*. *BagoYomas* is enriched with mixed deciduous forests located in transition between the Dry Zone in the north and Highest Rainfall Zone and Deltaic Zone in the south comprising mixed deciduous forests as the natural vegetation in this region. Evergreen, particularly riverine evergreen forests are also found including the dry forest and deciduous dipterocarp forest (Forest Department, 2003)

Mixed deciduous forests are the most important forests in Myanmar. Moist upper mixed deciduous forest is characterized by *Tectonagrandis*, *Xyliaxylocarpa*, *Bambusapolymorpha* and *Cephalostachyumpergracile*, *Dendrocalamushamiltonii*and*Dendrocalamusmembranaceus*. Dry upper mixed deciduous forest is characterized by the presence of *Tectonagrandis,Xyliaxylocarpa*, *Terminaliatomentosa*, *Terminaliachebula*,*Pterocarpusmacrocarpus*, *Cephalostachyumpergracile*, *Bambusapolymorpha* and *Dendrocalamus stratus*. Lower mixed deciduous forest is characterized by the presence of *Xyliaxylocarpa*, *Terminaliatomentosa*, *Anogeissus acuminate*, *Homaliumtomentosum*. These forest types are situated in the *BagoYomas* (a low range of hill) and also extend from Ayeyarwady watershed to the lower foothills of the RakhineYomas. The total area of mixed deciduous forest is 134,069 km^2 (Forest Department, 1998).

1.2Problem statement

In *BagoYomas*, the forest situation had also undergone changes due to current plant successions, shifting cultivation, annual recurring forest fires, etc, and to biotic interferences in the form of illegal felling and marketing of fuelwood, charcoal and timber by both the major rural population and the unscrupulous timber traders. Because of forest fire, the teak forest in the middle and northern region of the *BagoYomas* has become more open with fewer observable teak seedlings and saplings and consequently the invasive bamboos are exerting its presence in the naturally open areas (Keh, 2003). The increasing population with the ever greater demand for forest produce and land for agriculture brings about the degradation of the forests (Kyaw, 2000). This reduction has not been due to the weakness of the management system but to the indiscriminate cutting and the lack of, or insufficient appropriate silvicultural treatments, resulting most probably from many constraints beyond the control of the forestry organization (Gyi& Tint, 1995). Therefore, to know about the basic ecological information, including floristic composition and structure of the forest, is necessary for the extractiont of quality timber from those remaining forests and for implementing appropriate silvicultural treatment of this area. To date, there are no detailed descriptions and quantitative assessments of forest floristic and structure in the *BagoYomas*.

Until now, factual data and estimation of forest resources are still lacking or, if available, are not complete and reliable or up to date about the degrading forests in the *Bagoyomas*. In addition, international publications with regard to forest stand structure, species composition and regeneration density of degrading stands in *BagoYomas* region have not been available. This study will evaluate floristic composition, structure and regeneration potential of *BagoYomas* forests. The present study will provide part of this much-needed information for planning and implementing appropriate silvicultural treatment of this area. The development and institutionalization of information and up-dating of existing data is a top priority in this study.

2. Research objectives

The objectives of this study are:

i. To investigate the current condition of the mixed deciduous forestsin terms of tree species composition, species diversity, and forest stand structure

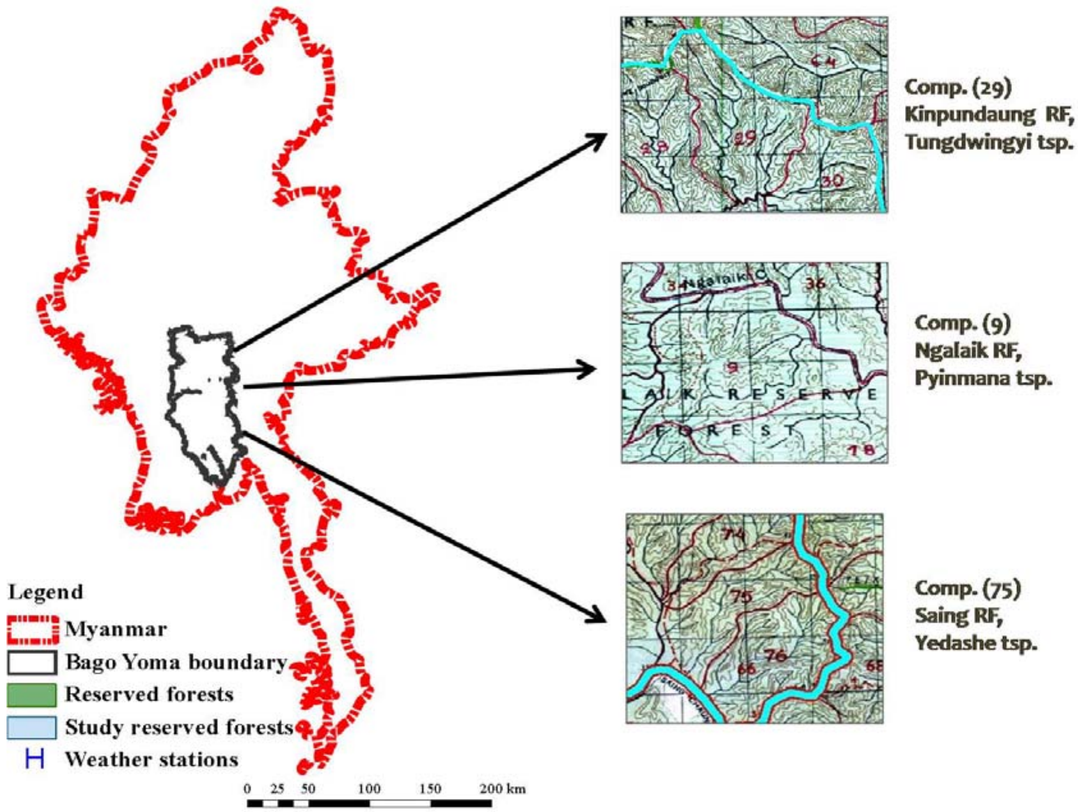
ii. To assess species abundance and richness of the regeneration of the these forests

3.Materials and Methods

3.1 Study areas

The investigation was carried out in natural teak forests located in three different localities, namely, Yedashe, Pyinmana and Taungdwingyitownship. They are located in the *BagoYomas* region, which is a legendary place of the best natural teak forests. In Yedashetownship, the research plots are situated in compartment 75, Saingya Reserved Forest (18°50' N and 96°08' E). In Pyinmana township the research was carried out in Ngalaik Reserved Forest, compartment 9 (19° 56' N and 95°□ 56' E), which is situated in northeastern part of the *BagoYomas*. Both Yedashe and Pyinmana townships represent the moist upper mixeddeciduous forest type. In Taungdwingyi, investigation was carried out in compartment 29, Kinmundaung Reserved Forest (19° 43' N and 95° 42' E) which is confined to the dry upper mixed deciduous forest.

Figure 1: Map showing the location of study areas



3.2 Silvicultural analysis and species diversity measures

3.2.1. Silvicultural analysis

3.2.1.1. Sampling design

SimpleRandom sampling survey was carried out for structure analysis of the dry upper mixed- and moist upper mixed deciduous foreststands. The minimum representative area was decided into 1 hectare (10000 m^2) according to Lamprecht (1989). In this study, ten sample plots each covered an area of 1000 m^2 (40 m x 25 m) that was subdivided into subplot (B) and subplot (C).

3.2.1.2. Sample plot design adopted and data collection

The sampling design used in this study for analyzing species composition, diversity and stand structure of the investigated stands is shown below:

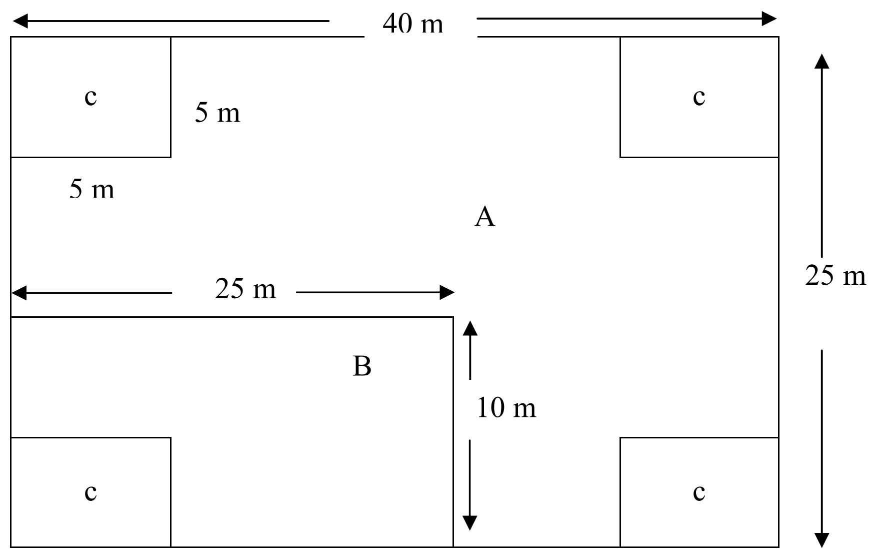


Figure 2: Sample plot design

In subplot (A) 1000 m^2 (40 mx25 m), all trees with DBH ≥ 5 cm were recorded and the following variables were measured for all trees: species, tree density, total treeheight and DBH. In subplot (B) 250 m^2 (25 m x 10 m), sapling with height > 1.3 m, DBH < 5 cm were recorded. In subplot (C) 25 m^2 (5 mx5 m), counted seedlings (0.3 m < height < 1.3 m) for four plots per sampling unit.

DBH: It was determined at 1.3 m from the ground for the trees without buttress and at the height of 0.3 m above the buttress swell for the trees with buttresses.

Height: Tree height was measured by using Sunnto in two investigated forests.

Field data were analyzed by using Microsoft Excel 2007 and STATISTICA 7. Tree species identification was carried out by using a guide book of ' A Checklist of the trees, Shrubs, Herbs, and Climbers of Myanmar' , (W.John Kress, Robert A.defilipps, Ellen Farr & Yin YinKyi).

3.2.2. Species diversity measures

(a) SHANON Diversity Index

$H' =_{i=1} -\Sigma\ pi.\ Ln\ pi$

Where, H’ = index of species diversity

S= numbers of species in the sample

Pi = proportion of total sample belonging to "i^{th}" species

Ln = the theoretical maximum value of diversity by a given number of totalspecies (S) found in the sample

The Shannon index can be applied only on random samples drawn from a large community in which the total number of species is known. The index is assumed that individuals are randomly sampled from and 'indefinitely' large population and all species are represented in the sample (Pielou 1975, cited in Magurran 1988). Species richness and measures of diversity such as the Shannon and Simpson indices have also been useful to define and compare forest communities (Leps, 2005).

(b) SHANON Evenness (E)

E= H/Hmax

Where, E= evenness measure (range 0-1)

H= Shanon- Wiener function

Hmax = ln (S); theoretical maximum value of diversity by a given number of total species (S) found in the sample

High evenness occurs when species are equal or virtually equal in abundance. The species diversity is high when evenness values increases.

3.2.3. Stand Structure

3.2.3.1. Horizontal Stand Structure

3.2.3.1.1. Importance-Value-Index (IVI)

(a) Dominance

Dominance is considered as an equivalent of the space a plant is occupying in the stand. It can be defined as the horizontal projection of the plant at ground level. The relative dominance is the percentage of a species in the basal area of a stand.

(b) Abundance

Abundance is considered as the number of tree per species. The relative abundance is the percentage of each species in total stem number per hectare.

(c) Frequency

Frequency is considered as the occurrence or absence of a given species in the subplots. The relative frequency is the percentage of the total of the absolute frequencies of all the species.

Importance-Value-Index (IVI) is the sum of relative abundance, relative dominance and relative frequency (Curtis &Mcintosh 1951, quoted in Lamprecht 1989). This index can also permit a comparison of the ecological significance of species in a given forest type. Importance-Value-Index (IVI) can be mathematically expressed as follow.

IVI= R.A+ R.F+ R.D

Where,

Relative abundance (R.A) = percentage of each species on total stem number per hectare

Relative frequency (R.F) = percentage of each species contribution to the sum of absolute frequency

Relative dominance (R.D) = percentage of each species basal area on sum of basal area of all species.

Relative Basal area (R.B.A) stands for the dominance of the species

Relative dominance can be obtained from the relative basal area and can be calculated as follow

Relative basal area (R.B.A)

$$\textbf{R.B.A=} \frac{\text{Total basal area of a given species}}{\text{Sum of total basal area of all species}} \textbf{ x 100}$$

3.2.3.2. Vertical Structure

The selection of regression functions is to be based on the behavior of the curve within the range of diameter measurements and the statistical parameters, such as coefficient of determination (r^2) and correlation coefficient (r). The following functions were tested in this study.

1. *Parabel 2. grade equation* $h = a + b.d + c.d^2$
   (*RPODAN* 1965)
2. *PRODAN's equation* $h = 1.3 + \frac{d^2}{a + b.d + c.d^2}$
3. *PETTERSON* $h = 1.3\left[\frac{d}{a + b.d}\right]^3$
   (*DRAMER and AMCA* 1996)
4. *PETTERSON's equation* $h = 1.3 + \left[\frac{d}{a + b.d}\right]$
5. *Logarithmic equation* $h = a + b.\ln d$
6. *KORSUN's equation* $h = \exp\left[a + b.\ln d + c.(\ln d)^2\right]$
7. *FREESE's equation* $h = \exp\left[a + b.\ln d + c.d\right]$

where ***h*** is the total tree height and ***d*** the diameter at breast height of trees and a, b, and c are the constants.

4. Results and Discussion

4.1 Tree species diversity and composition

4.1.1. Species-area curve

The representative sampling area for analysis of species composition in the investigated forest types can be determined by using species area curves. Lamprecht (1989) described that the species area curves are the best criterion for the determination of the minimum study area and smaller trees including young trees are also required to be surveyed for analysis of stand structure and dynamics processes. According to Cain and Castro (1959), when an enlargement of the sample area by 10% results in species number increases less than 10%, a total sample area is considered to be representative area. On the other hand, the curve rises sharply and then flattens out to become parallel with the x-axis (quoted in NyuntKhaing, 2013); the minimal area is regarded as the point where the curve begins to flatten (Cain 1938; Greig-Smith 1983). In this study, ten squares sub-plots; each covering an area of 10,000 m^2 has been used for vegetation analysis. The species area curves for the three study areas are shown in figure (3).

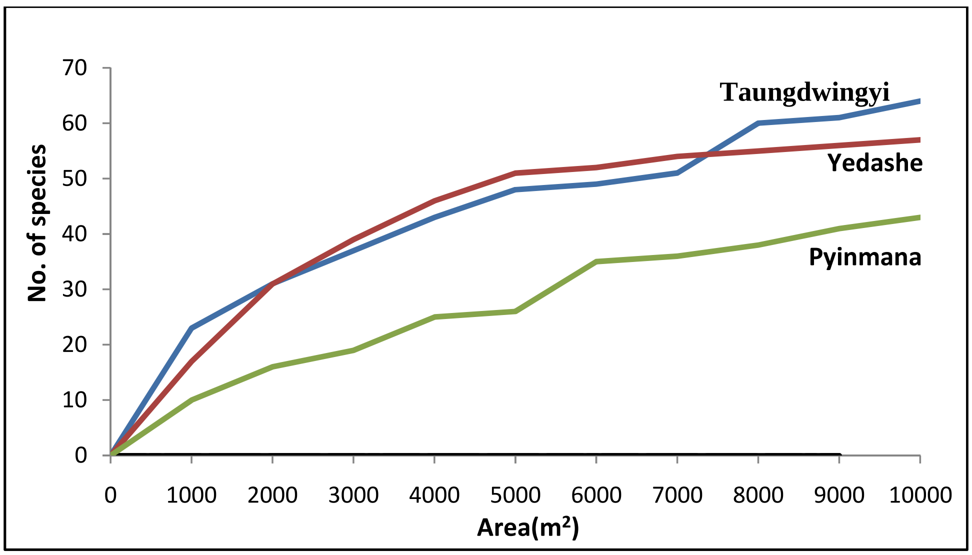


Figure (3): Species-area curves for the three study (Sample area =10 sub-plots x 1000 m^2)

For the determination of a minimum representative area for a tree species spectrum, it is common by showing so-called species-area curve: having 0.5 -1 ha in moist forest and less in dry forest are enough to plot the species area curves (Lamprecht, 1969). In this study, the species-area curves of Taungdwingyi and Pyinmana performed a strong progression until 8000 m^2, then; the curves became flat to parallel x-axis (Figure 2). In the case of Yedashe forest, the specie-area curve tended to flatten at 6000 m^2 and become parallel to x-axis. From this point onwards a further enlargement of the survey area would not increase the number of new species spectrum. Thus, the species area curves proof that an almost complete tree species survey was carried out. The forests in Taungdwingyi and Yedashe had the higher number of species than Pyinmana forest. The total numbers of species were 64, 57, and 43 respectively.

4.1.2. IVI for floristic composition

The importance-value-index (IVI) is used as a tool to accurately indicate and identify the important species in a community (Curtis and Meintosh 1951). This is determined via a combination of three parameters: relative abundance, relative frequency and relative dominance. The ecological significance of a species can be compared by IVI in a given forest type (Lamprecht, 1986). Lamprecht (1989) statesthat the same IVI value for the characteristic species should indicate the same or at least similar stand composition and structure, site requirement and comparable dynamics, thus, similar reactions to silvicultural measures could be expected.

To have a quick overview on the floristic composition of different study area in the three townships, the important silvicultural parameter and IVI for species level are given in the following tables (1a, b, c). Among the Reserve Forests in the three townships, Kinmundaung RF in Taungdwingyi township showed a typical dry upper mixed deciduous forest type with dominant tree species of Teak (*Tectonagrandis*), Pyinkado (*Xyliaxylocarpa*), Thitya(*Shoreaobtusa*), Ingyin (*Pentacmesiamensis*) Panka (*Termanaliachebula*), Lein (*Terminaliapyrifolia)*, Hnaw (*Adina cordifolia)* and Tauk-kyan (*Terminaliatomentosa*). It can be seen that there is a strong representation of Teak (*Tectonagrandis*) in allNgalaik RF, Saingya RF and Kinmundaung RF in relation to its IVI ranking.

Species with high IVI value in a given area can also be considered as representative species of a forest type studied and they should be taken into account ecologically important species in applying suitable silvicultural treatments such as timber stand improvement. To conductpropersilviculturaltreatments for mixeddeciduousforests flourishing in different localities with different floristic compositions, the importance of teak's associates should be taken into account for the well being of teak and subsequently so as to obtain optimum benefits from those forests.

There is a variation between the numbers of trees ≥ 5 cm DBH in three forest types: a total of 801 trees per hectare in Saingya RF, 716 trees per hectare in Kinmundaung RF and 305 trees per hectare in Ngalaik RF. This may be the result of several sites factors and regeneration behavior of the species. For tropical lowlands, a basal area of about 30 m^2 per hectare is considered as a pantropical average according to Dawkins, 1957, Lamprecht, 1989& Phillips, 1931. In this study, the basal area 2.34m^2 per hectare in Ngalaik RF., 4.89m^2 per hectare in Saingya RF. and 5.94m^2 per hectare in Kinmundaung RF. These do not behave as expected.

By comparing theinvestigated stands from a floristic point of view, teak (kyun) is the most abundant species in Pyinmana and Yedashe stands, and follows the 5th position in Taungdwingyi Township. Teak is the most abundant species in all study areas, whereas the basal area per ha of teak in Yedashe Township is 0.30 m^2 (6.7% of total basal area), 0.46 m^2 (16.4 %) in Pyinmana Township and only 0.30 m^2 (3.7 %) in Taungdwingyi Township. Therefore, the currently adopted silvicultural practices in teak bearing forests should be reviewed and redressed in order to restock teak regeneration; unless any remedial measures are implemented, the devaluation of teak forests will continue.Forest canopies were quite opened and other economically not important species were found in higher number individually as compare to those of teak and other valuable species such as pyinkado, padauk. In such forests, gap planting, line planting or any other methods of enrichment planting of teak and commercial species need to be carried out followed by intensive tending operations.

Table 1 (a). Abundance, dominance, frequency and importance value index (IVI) for 20 species with highest importance value index in the **Saing** RF arranged in descending order of IVI

Rank	**Species**	**Abu. N/ha**	**Domi. m^2/ha**	**Frequency (%)**	**Rel. Abu(%)**	**Rel. Dom(%)**	**Rel. Freq.(%)**	**IVI**
1	Madama	69	0.26	100	8.61	5.40	4.20	18.21
2	Bebya	54	0.33	100	6.74	6.75	4.20	17.70
3	Thayingyi	60	0.29	100	7.49	5.93	4.20	17.63
4	Kyun	55	0.30	100	6.87	6.17	4.20	17.24
5	Binga	60	0.23	90	7.49	4.64	3.78	15.91
6	Pyinkado	40	0.29	90	4.99	5.87	3.78	14.65
7	Zaungbalway	41	0.20	80	5.12	4.02	3.36	12.50
8	Than thay	34	0.19	90	4.24	3.93	3.78	11.95
9	Nipase	19	0.33	60	2.37	6.72	2.52	11.61
10	Mahlwa	31	0.15	90	3.87	3.04	3.78	10.69
11	Yone	29	0.16	80	3.62	3.36	3.36	10.34
12	Phetwun	29	0.16	80	3.62	3.23	3.36	10.21
13	Hninnykoe	22	0.24	60	2.75	4.89	2.52	10.16
14	Lethtoke	29	0.09	80	3.62	1.77	3.36	8.75
15	Nabe	17	0.13	90	2.12	2.61	3.78	8.51
16	Phet than	21	0.14	60	2.62	2.86	2.52	8.01
17	Tayaw	17	0.09	70	2.12	1.82	2.94	6.88
18	Gyo	20	0.07	60	2.50	1.44	2.52	6.46
19	Thitmagyi	7	0.19	30	0.87	3.84	1.26	5.98
20	Seikchee	13	0.08	50	1.62	1.70	2.10	5.43
	Sub Total	667	3.91	-	83.27	80.00	65.55	228.81
21-57	Others	134	0.98	-	16.73	20.00	34.45	71.19
	Grand Total	**801**	**4.89**	**-**	**100.00**	**100.00**	**100.00**	**300.00**

Table 1 (b). Abundance, dominance, frequency and importance value index (IVI) for 20 species with highest importance value index in the **Kinmundaung** RF arranged in descending order of IVI

Rank	**Species Name**	**Abundance (N/ha)**	**Dominance (m^2/ha)**	**Frequency %**	**Re Abu. (N/ha)**	**Re Domi (m2/ha)**	**Re Freq. %**	**IVI**
1	Kathit	59	0.73	70	8.24	12.36	3.29	23.89
2	Pyinkado	59	0.35	90	8.24	5.94	4.23	18.41
3	Binga	55	0.24	100	7.68	4.11	4.69	16.49
4	Thitpakan	46	0.30	70	6.42	5.12	3.29	14.83
5	Kyun	27	0.30	60	3.77	5.04	2.82	11.63
6	Phet won	25	0.25	30	3.49	4.20	1.41	9.10
7	Kyetyoe	11	0.29	50	1.54	4.87	2.35	8.76
8	Thadi	27	0.19	30	3.77	3.28	1.41	8.46
9	Padauk	18	0.17	60	2.51	2.95	2.82	8.28
10	Taung ma gyi	17	0.15	70	2.37	2.60	3.29	8.26
11	Yone	23	0.13	60	3.21	2.20	2.82	8.23
12	Thaukkyant	23	0.12	60	3.21	2.10	2.82	8.13
13	Tayaw	20	0.15	60	2.79	2.46	2.82	8.07
14	Madama	8	0.27	40	1.12	4.51	1.88	7.51
15	Ingin	22	0.12	50	3.07	2.02	2.35	7.44
16	Seikchee	16	0.10	70	2.23	1.67	3.29	7.19
17	Di du	12	0.13	60	1.68	2.21	2.82	6.71
18	Yin ma	17	0.08	60	2.37	1.27	2.82	6.46
19	Shit sha	17	0.09	50	2.37	1.55	2.35	6.27
20	Sitt	4	0.28	10	0.56	4.80	0.47	5.83
	Sub Total	506	4.47	-	70.67	75.27	53.99	199.93
21-64	Others	210	1.47	-	29.33	24.77	46.01	100.11
	Total	**716**	**5.94**	**-**	**100.00**	**100.00**	**100.00**	**300.00**

Table 1(c). Abundance, dominance, frequency and importance value index (IVI) for 20 species with highest importance value index in the **Ngalaik** RF arranged in descending order of IVI

Rank	**Species Name**	**Abundance N/ha**	**Dominance m^2/ha**	**Frequency %**	**Re. Abu. %**	**Re Domi %**	**Re. Freq. %**	**IVI**
1	Kyun	45	0.46	90	14.75	19.86	6.82	41.43
2	Padauk	28	0.25	80	9.18	10.50	6.06	25.74
3	Kabaung	16	0.18	50	5.25	7.72	3.79	16.76
4	Yinma	18	0.11	80	5.90	4.56	6.06	16.52
5	Pyinkado	20	0.09	70	6.56	3.96	5.30	15.82
6	Lettogyi	17	0.12	50	5.57	5.15	3.79	14.52
7	Didu	17	0.08	70	5.57	3.51	5.30	14.38
8	Phetthan	11	0.10	70	3.61	4.27	5.30	13.18
9	Madama	16	0.08	50	5.25	3.53	3.79	12.56
10	Kyetyoe	9	0.12	50	2.95	5.07	3.79	11.81
11	Tayaw	9	0.10	60	2.95	4.21	4.55	11.71
12	Thitpakan	8	0.11	50	2.62	4.67	3.79	11.08
13	Gyo	11	0.04	60	3.61	1.59	4.55	9.74
14	Seikchee	7	0.05	40	2.30	2.17	3.03	7.49
15	Nabe	6	0.03	50	1.97	1.28	3.79	7.03
16	Yinma	8	0.03	40	2.62	1.26	3.03	6.92
17	Kathit	4	0.07	30	1.31	3.13	2.27	6.71
18	Htaukkyan	7	0.03	20	2.30	1.47	1.52	5.28
19	Mahwla	5	0.02	20	1.64	1.00	1.52	4.15
20	Dwani	3	0.02	30	0.98	0.78	2.27	4.03
	Sub Total	265	2.10	-	86.89	89.68	80.30	256.87
21-43	Others	40	0.24	-	13.11	10.16	19.70	42.98
	Total	**305**	**2.34**	-	**100.00**	**100.00**	**100.00**	**300.00**

4.1.3. Species diversity

Due to variation in biogeography, habitat, and disturbance, species diversity varied greatly from place to place. Srivastava et al. (1995) reported that the community characters differ with concern of aspect, slope, and altitude even in the same vegetation types. The diversity of trees is fundamental to the total tropical rainforest diversity as trees provide resources and habitat structure for almost other forest species (Canon et al., 1998). Quantification of tree species diversity is also an important aspect as it provides resources for many species (Cannon et al., 1998).

The species diversity conservation is the important one among many endeavors to attain the sustainability. The following discussion deals not only with the presence or absence of a certain species but also takes into account the different abundances of species. Typical for any given species-rich ecosystem is the feature that many species with only individuals are found in combination with a few species, which are represented, by high numbers of individuals. The investigated forest types showed this tendency very clearly (See Figure 3a, b, c). Amongthethreeforests, Pyinmanaforesthadmore rare species with only one tree per hectare compared to theYedasheandTaungdwingyi forest; a total of 16 rare species per hectare in the former forest while about 11 and 9 species/ha in the latter two forests.

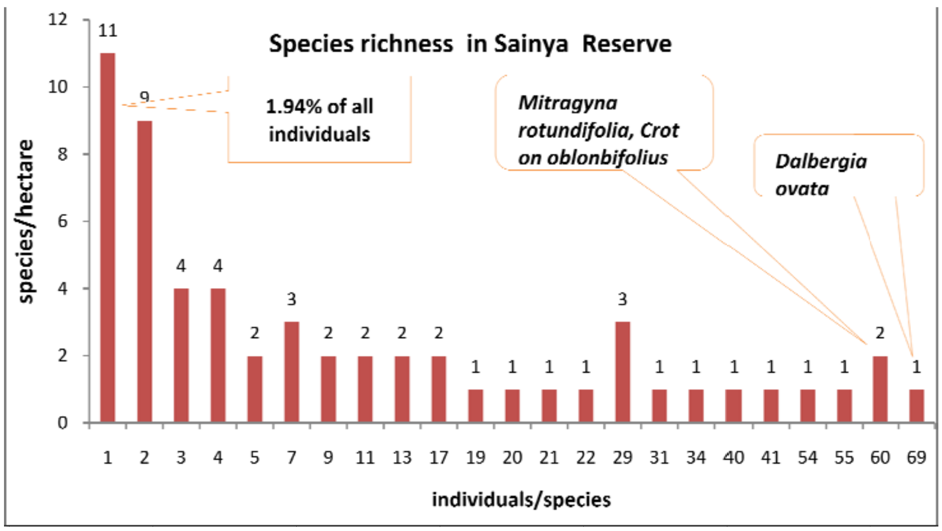


Figure (4a): Species richness in Yedashe forest

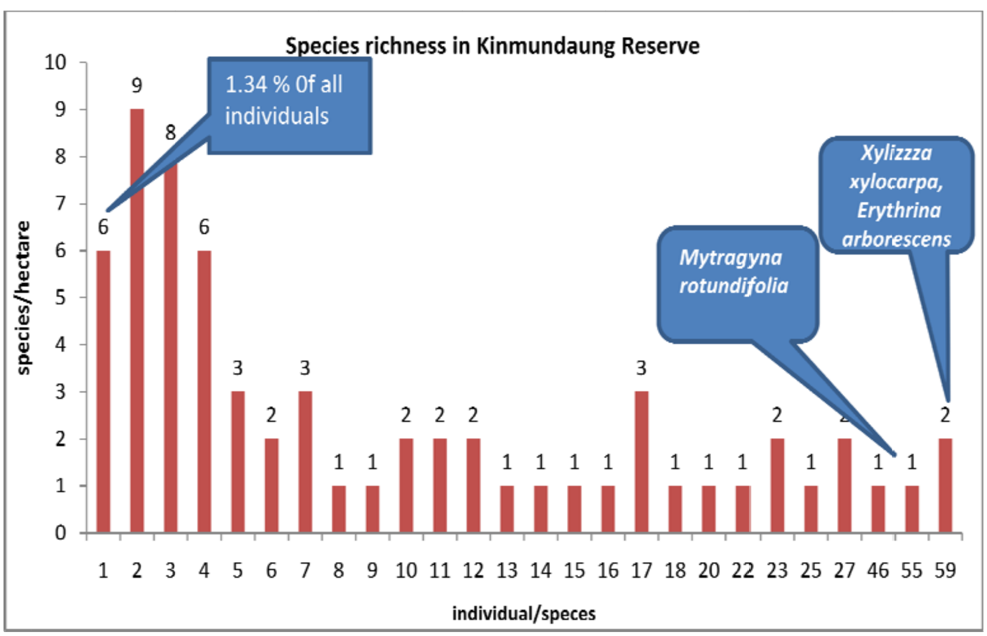


Figure (4b): Species richness in Taungdwingyi forest

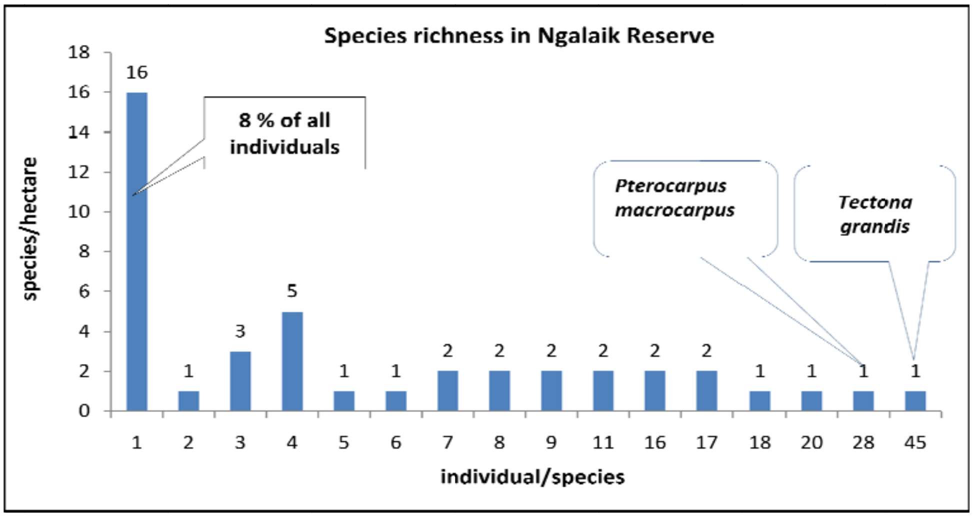


Figure (4c): Species richness in Pyinmana forest

A sustainable management system for natural forests faces the problem to protect a large number of rare tree species that make up for the bulk of species density.Neverthelessthe rare species representedonly8 %, 1.94 % and 1.34 % of the absolute number of trees in Pyinmana,Yedashe, and Taungdwingyi forest as shown in figure. This finding conforms to Isilet. al. (1997) finding.

Diversity index also assumes that all species are represented in the sample. The index is applied for comparison of diversities and differences between the stands. Species diversity is often expressed by the Shannon-Wiener Index (H').TheShannonIndexplace more emphasize on the rare species. As evenness and composition of species are also important complementary measurements, Shanon (E) evenness is being used.

According to Weidelt (2000), quoted in KyawLwin (2001), diversity indices are more useful to measure the species diversity of a forest stand than the species density and mixture ratio. Shannon Index(H') and Shannon's Evenness (E) is calculated for all investigated stands. E is between 0 and 100 and the value 100 indicates that all species have equally abundance. For investigated stands, the calculated values of diversity index are given in table (**1**).

$$H' = - \sum P_i \,.\, \ln(P_i) \; ; \qquad P_i = n_i/N$$

where,

P_i = proportion of i_{th} species (n_i/N)
n_i = number of the species i
N = total number of individual of all species

Table (2): Shannon Indexand evenness of three investigated stands, DBH≥ 5 cm in the subplot A

Study Areas	Number of species per ha	Number of trees per ha	Individuals per species per ha	H'	E (%)
Pyinmana	43	305	7.1	3.19	84.8
Yedashe	57	801	14.1	3.38	83.6
Taungdwingyi	64	716	11.2	3.62	87.1

According to the results by calculating Shannon Index(H'), Taungdwingyi forest is more heterogeneous than Yedashe and Pyinmana forests. It can be observed that the species in dry mixed deciduous forest of Taungdwingyiwas more diverse than the other mixed deciduous forests in Yedashe and Pyinmana. Evenness refers to how the species abundance is distributed among the species (Ludwig and Reynolds, 1988). The value of Shannon evenness showed that the abundance of species was more evenly distributed in Taungdwin forest than in Yedashe and Pyinmana forests.

4.1.4. Species richness

Species richness is commonly expressed as the number of species (i.e. tree species over a specified minimum diameter at breast height) per hectare, which can also be seen as species density. In forest vegetation analysis in Pyinmana, Yedashe, and Taungdwingyi forests, the numbers of tree species over 5 cm dbh per hectare were 43, 57, and 64 respectively.The common species densities of mixed (moist) deciduous forest in Southeast Asia vary about 120 species per ha (Whitmore, 1975). Hence, the species richness valuesin the study areas are relativelylow: eventwo and three times lower than the common densities of Southeast Asia. But, it should be taken into account that the study areas were seriously degraded for long period.

The highest species richness was found in Taungdwingyi, i.e. dry upper mixed deciduous forest. The stand of Pyinmana forest hadafew species comparison withthestand of Yedashe forest, i.e. moist upper mixed deciduous forest. The most common species found in Taungdwingyiforestwerepyinkado (*Xyliaxylocarpa*), kathit*(Erythrinaarboresens)* and madama (*Dalbergia ovate)* in Yedasheand teak (*Tectonagrandis*) in Pyinmana forest.

4.2 Stand Structure

4.2.1 Distribution of tree species (individuals) by DBH class

The diameter distribution of stem numbers in the forest is one important parameter for regulating the forest in line with the SFM measures. From the stem number with diameter distribution pattern, it is able to know where, when and how cutting regime or silvicultural treatments are needed. In normal distribution, the smaller DBH classes have the bigger stem numbers and gradually declining to bigger DBH classes. The investigated stands in the present study followed the normal distribution and development pattern. In this study, it can clearly be seen that there are highernumber of trees in small diameter classes in all investigated stands as shown in the figures (5a, b, c). The reserve of small-diameter trees in mixed deciduous tropical forest is adequate to replace the losses in large diameter trees. Natural sustained yield is therefore completely assured as described by Lamprecht (1986).

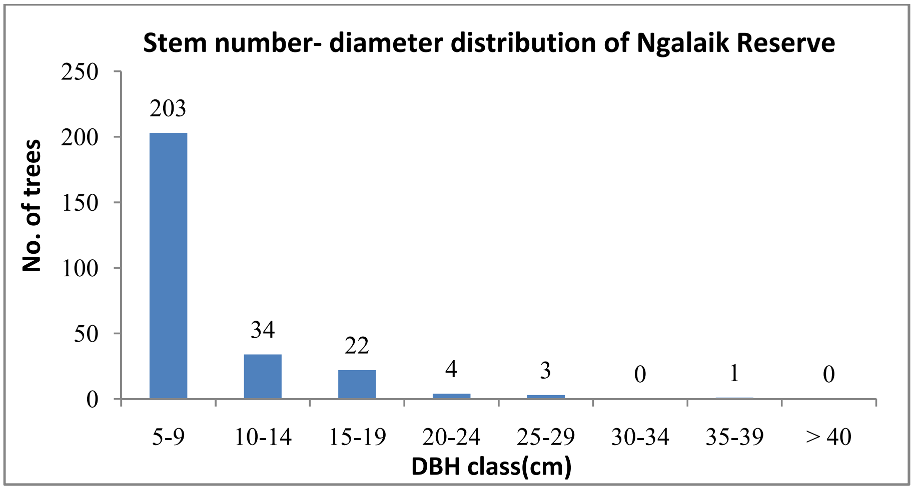


Figure (5a): Distribution of individuals by DBH class in Ngalaik Reserve in Pyinmana forest

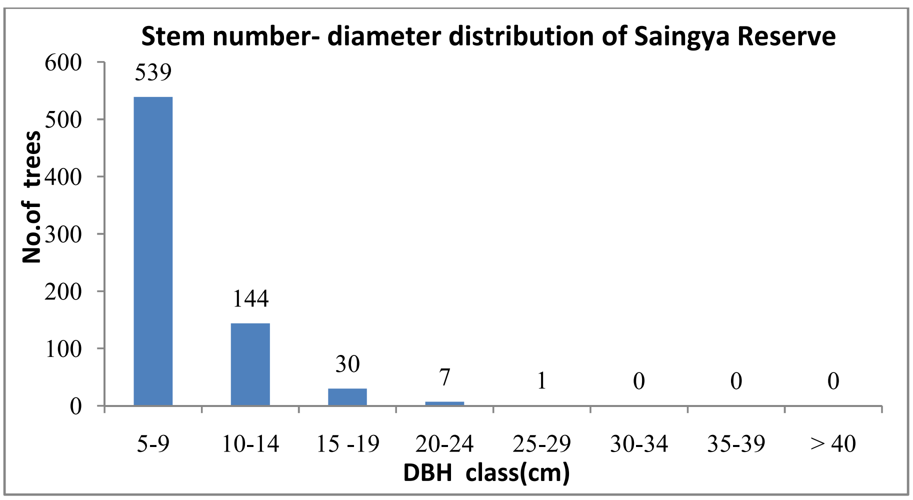


Figure (5b): Distribution of individuals by DBH class in Saingyareserve in Yedashe forest

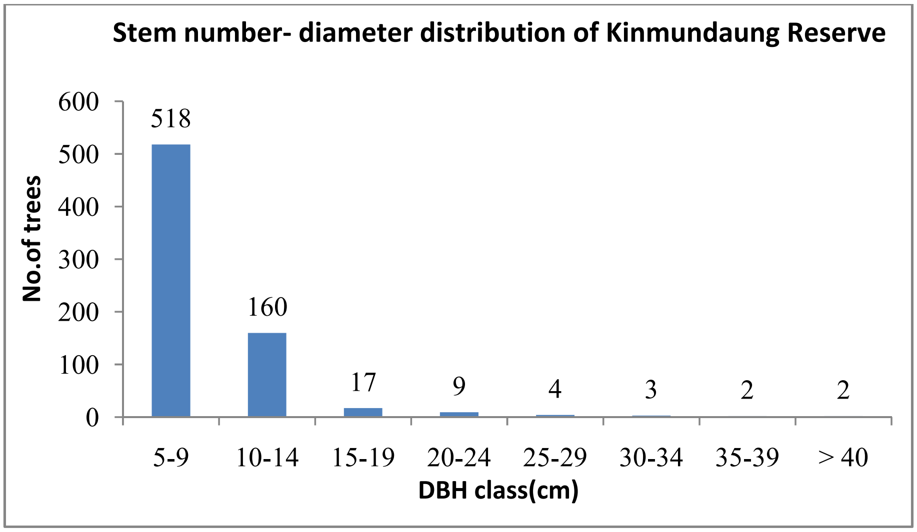


Figure (5c): Distribution of individuals by DBH class inKinmundaung reserve in Taungdwingyi forest

The investigated areas Ngalaik Reserve in Pyinmana forest and KinmundaungReserve inTaungdwingyihad a totalof716 treesper hectare and 305 treesperhectare respectively. It is observed that teak and Group (I)representedabout3.7 %, 13.9% of total growing stock in the former forest standand 16.4%, 16.4% in the latter forest stand.The lesser used species occupied higher percentage in the total growing stock (i.e. 82.2% and 67.0%). Therefore, the suitable measures such as gap or line enrichment planting are necessaryto implement by mixing with other valuable commercial species such as Teak, Pyinkado, and Padauk, etc. in these forests.

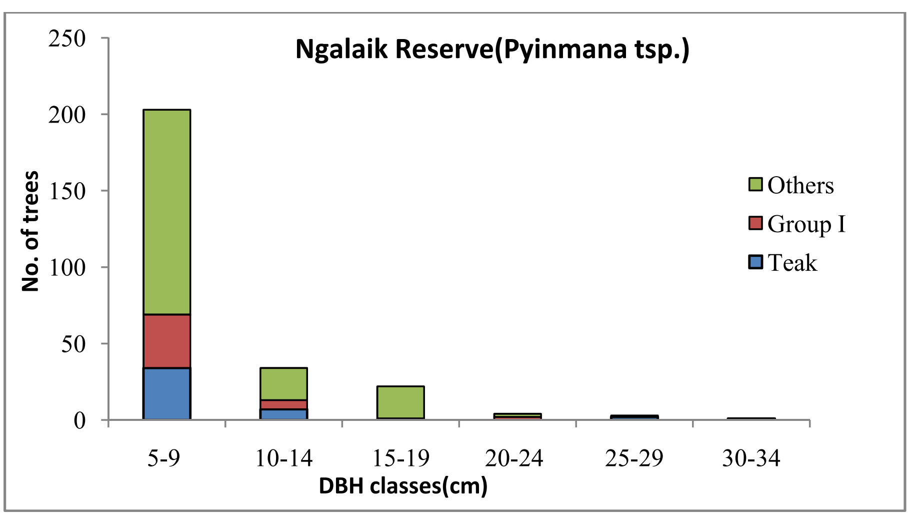


Figure (6a): Stand Structure of Teak and Group I species in Pyinmana forest

Similarly, the Yedashe forest at compartment 75, Saing Reserve had an average number of trees of 801 per hectare. Figure (5a, b, c) shows the stand structure with diameter proportion of Teak, valuable hardwood tree species (Group I) and otherassociated tree species. The tree number-diameterdistribution, as a consequence of the dynamism, showedhigherstocksin lower diameter classes, representing about 74.7% of the tree numbers in diameter classes (5+cm and 10+ cm), of which only 6.7% is teak in SaingReserve in Yedashe forest. The valuable hardwood tree species (Group I) are also poorly represented in all diameter classes. Althoughthe stand structure for all speciesinSaing Reserve (Figure 4a, b, c)follows the ideal structure withhigher number of trees in thesmaller diameter classes,in qualitative assessment, it is observed that Teak and Group Ispeciesrepresentedabout6.7% and 4.9% of the total growing stocks. The lesser-used species occupied the rest of the growing stock, i.e. 88.3%. Therefore,enrichment planting with appropriate commercial tree species might be the most suitable practice in order to improve the quality of mixed deciduous forests in BagoYoma.

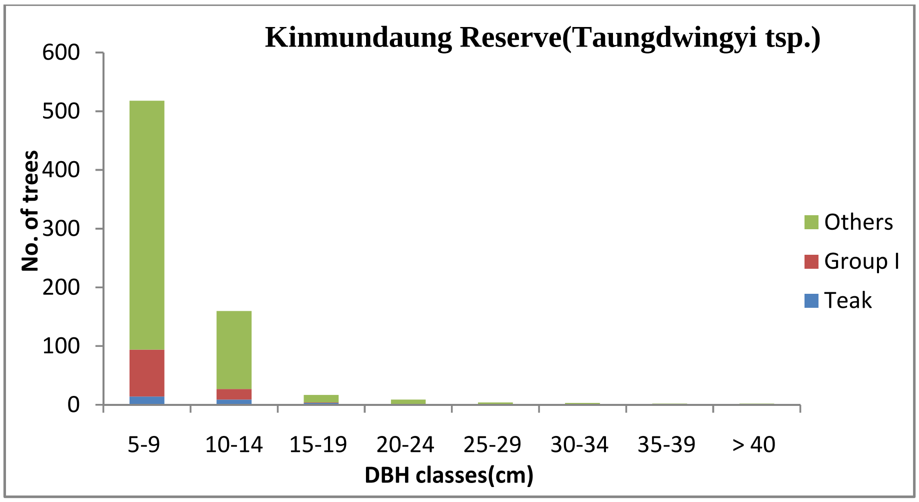


Figure (6b): Stand Structure of Teak and Group I species in Taungdwingyi forest

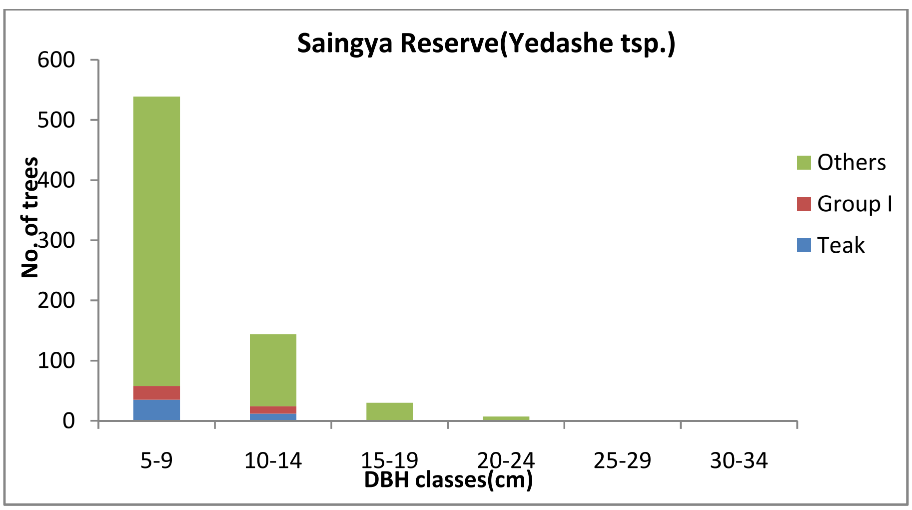


Figure (6c): Stand Structure of Teak and Group I species in Yedashe forest

4.2.2 Vertical Structure

4.2.2.1 The height-diameter distribution

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 Larr and Akca, 1997). According to Philip (1994), stand height is usually expressed by mean height, stand height curve, or top height. Height-diameter functions are effective and useful measurements for predicting tree height in forest mensuration. The selection of regression functions is to be based on the behavior of the curve within the range of diameter measurements and the statistical parameters, such as coefficient of determination (r^2) and correlation coefficient (r). This study provided the best suited functions for the predominant mixed deciduous forest tree species of BagoYomas. These height-diameter functions covered diameter ranges of 5-38 cm for *Tectonagrandis*, 5-23 cm for *Xyliaxylocarpa* and 5-26 cm for *Pterocarpusmacrocarpus* in Pyinman, Taundwingyi and Yedashe Township.

The results showed that the PETTERSON's and KORSUN's model give better regression coefficients for all height curves of teak trees (Figure 7a). A comparison of the height curves for teak reflectedthe dominant position of Taungdwingyi stand with total treeheight of approximately 17 m with dominated basal area. The stand of Yedashe Township had lower total treeheightsthan the Taungdwingyi stand and the tallest trees reachedtheheight of about 14 m while Pyinmana teak stand show poor performance.

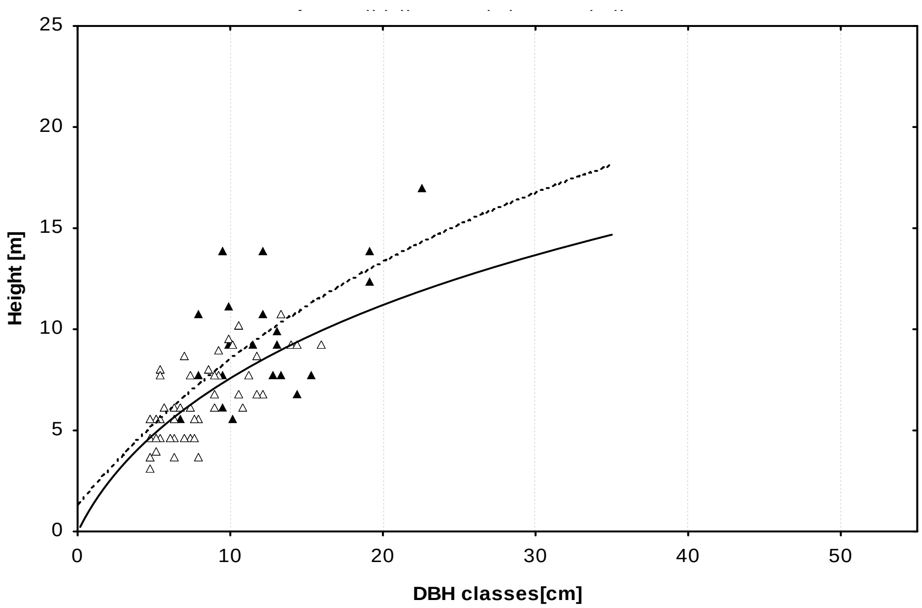


Figure (7a). Stand height curves of teak trees (≥ 5 cm DBH) fitted by PETTERSON's equation in Kinpundaung Reserve and KORSUN's equation in Saing Reserve

h

$h_{Yedashe}$=exp((.284703)+(.626222)*log2(x)+(-.03081)*(log2(x))^2) (***r*** = 0.73)

$h_{Taungdwingyi}$= 1.3+((x)/(1.10239)+(.027845)*x)) (***r*** = o.62)

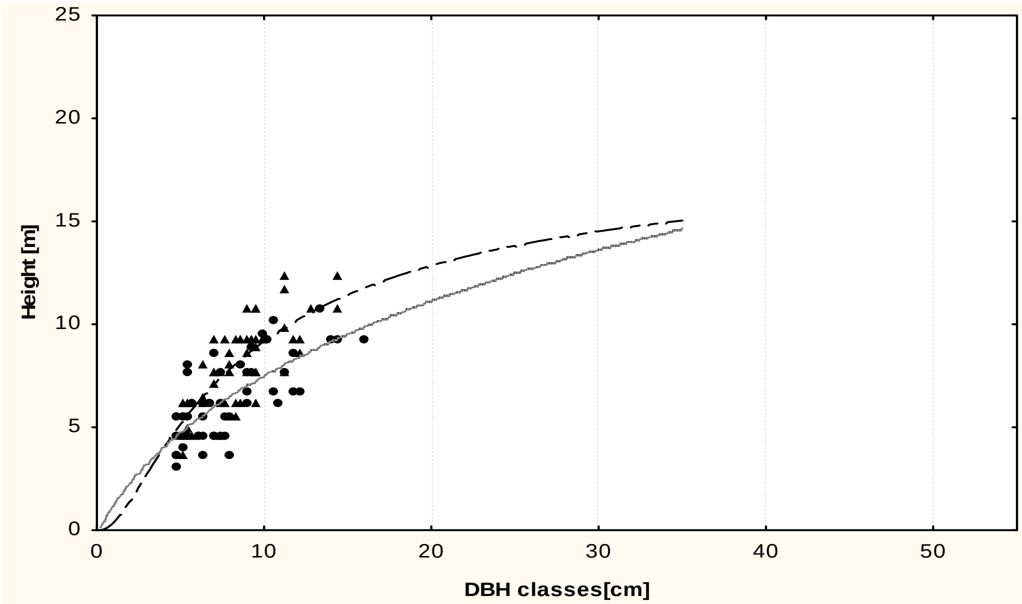


Figure (7b) Stand height curves of pyinkado trees (≥ 5 cm DBH) fitted by PETTERSON's equation in Kinpundaung Reserve and KORSUN's equation in Saing Reserve

In this study, the height curves for pyinkado trees of Taungdwingyi and Yedashe stands were also fitted by Petterson's and Korsun's equation. These stand had similar height-diameter distribution curves (Figure 7b). Pyinkado in the Taungdwingyi stand had a maximum height of approximately 12 m with a mean dbh of 8.5 cm while the maximum height of Pyinkado in Yedashe stand was approximately 11 m with a mean dbh of 8.9 cm.

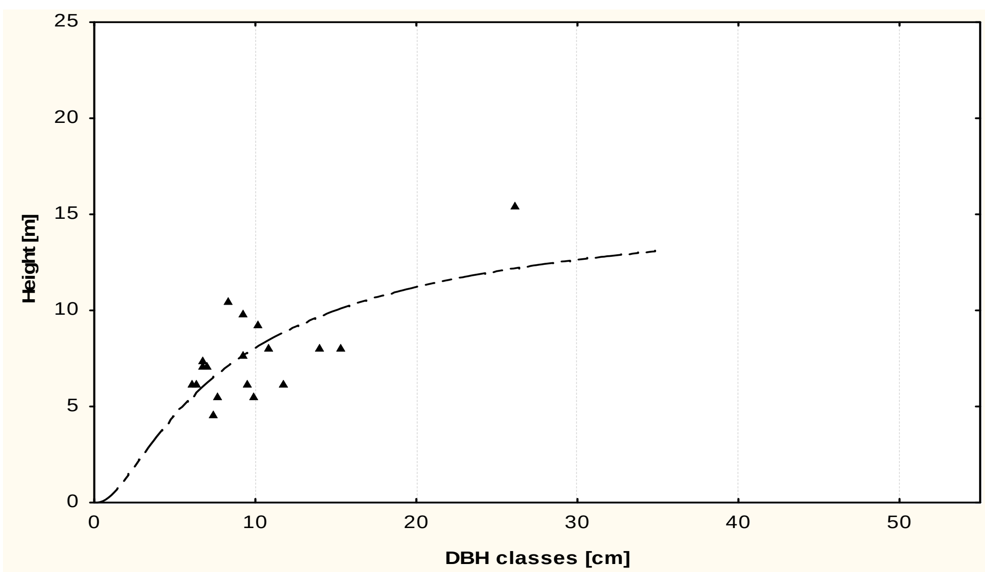


Figure (7c) Stand height curve of padauk trees (≥ 5 cm DBH) in KinpundaungRreserve fitted by PETTERSON's equation

$h_{Taungdwingyi}$= 1.3*((x)/((1.13659)+(.430677)*(x)))^3 (r = o.64)

In the above figure (7c), theheight curve for padauk trees in KinpundaungRreserve were also fitted by Petterson's model which was found to be the best fitted model with better regression coefficients at the significant level of 95%. Padauk trees were dominant in Taungdwingyitownship with thetotaltreeheight of about 15 m under dry forest site conditions. In Pyinmanapadauk trees performed as co-dominant species, which reached only total height of 9-10 m. As the Yedashestandwasdominated by teak and pyinkado, a height curve for padauk trees of TaungdwingyiTownshipwasfitted. The values of correlation coefficient (r) of Teak and Group (I) in three investigated stands with different equation model fittingweregiven in table (2).

Table(3): The value of correlation coefficient (r) with different equation model testing

No.	Equation Model	Correlation Coefficient(r)									
		Pyinmana tsp.			Yedashe tsp.		Taungdwingyi tsp.				
		teak	padauk	ingin	teak	pyinkado	teak	pyinkado	padauk	thitya	ingin
1.	Parable 2 grade eq.	0.12	0.22	0.98	0.73	0.71	0.65	0.76	0.78	1	0.77
2.	Prodan's eq.	0.27	0.23	0.99	0.73	0.72	0.65	0.76	0.76	1	0.77
3.	Petterson	0.18	0.15	0.95	0.73	0.64	0.64	0.76	0.64	0.99	0.74
4.	Petterson's eq.	0.17	0.15	0	0.70	0	0.62	0.76	0.70	0.99	0.76
5.	Logarithmic eq.	0.14	0.16	0.86	0.73	0.67	0.65	0.76	0.67	0.98	0.74
6.	Korsun's eq.	0.22	0.16	0.99	0.73	0.71	0.65	0.76	0.77	1	0.77
7.	Freese's eq.	0.19	0.17	0.99	0.73	0.71	0.65	0.76	0.78	1	0.77

4.3. Natural regeneration

The composition, distribution and density of seedlings and saplings can reflect the future status of the forest. According to Lamprecht(1989), seed production must be adequate to ensure more or less uninterrupted availability of viable seeds from several species. The lack of the dormancy of the seeds of many tropical forest trees has to face serious implication for silviculture, especially of species that fruit infrequently.

The other important factors for germination and establishment of seedlings are climatic and edaphic conditions.Flushes of seedlings will intermittently carpet the forest floor, and natural regeneration of the forest will based on a great extent on whether they can survive well. According to Weidelt(1998), quoted in Than SoeOo(2000), " the presence of seedlings does not mean the natural regeneration is established, may be ephemeral".

Brown (1998) points out that the type and degree of disturbance is one of the most important factors needed in controlling the nature of forest regeneration. According to

Richards (1996), species which are abundant as seedlings are sometimes relatively rare in the adult trees. The first priority is to ensure the presence of adequate regeneration of the commercial species under natural regeneration system of management (Wyatt-Smith, 1987).

Composition and density of seedlings and saplings in three investigated stands would indicate the regeneration status of these three forests. To evaluate the regeneration potential of the degraded forest stands, regeneration counting for all species was carried out in forty squares sub-plots-each sub-plot covering an area of 25 m^2. Total sample area for regeneration counting for all species is 1 ha, 10% of the total sample plot area of each stand. Well-established seedlings reaching height between 0.3 m and 1.3 m were recorded.

4.3.1 Dominance, abundance and frequency of saplings

Table 4(a) Abundance, dominance, frequency and IVI of sapling in Kinmundaung reserve, DBH < 5cm

Species Name	Abundance (No. of tree)	Dominance (BA)	Frequency %	IVI
Binga	32	0.041757	80	35.12
Let htoke	17	0.025937	30	18.84
Thitbagan	15	0.020855	60	18.81
Pyinkado	15	0.020616	50	17.88
Ingin	16	0.021293	30	16.85
Yone	8	0.008603	50	10.74
Shit shar	7	0.01167	40	10.45
Padauk	7	0.010674	40	10.12
Khu than	6	0.007289	40	8.54
Nabe	6	0.007241	40	8.53
Others	93	0.125406	710	135.75
Total	**222**	**0.30134**	**1170**	**300.00**

Tree densities of saplings in three investigated forests, Kinmundaung Reserve in Taungdwingyi, Saing Reserve in Yedashe and andNgalaik Reserve in Pyinmana forest, were 222, 160 and 136 individuals per hectare. Among these reserves, the commercial hardwood species *Tectonagrandis*,*Xyliaxylocapa* and *Pterocarpusmacrocarpus* in NgalaikReserve exhibited higher IVI value (22.6), (21.2) and (16.3) than those inthe two otherreserves.Butthestand densities of economically less valuable tree species in all three reserves were highest position in IVI values. Among them, *Mitragyinarotundifolia* was the dominant species with thehighest IVI value (41.9), (35.1) in SaingandKinmundaungReservewhile*Bombaxinsignis*hadthehighest IVI value (27.1) in NgalaikReserve. Based on the IVI values it can be saidthatthe economically less valuable species dominated the three investigated stands.

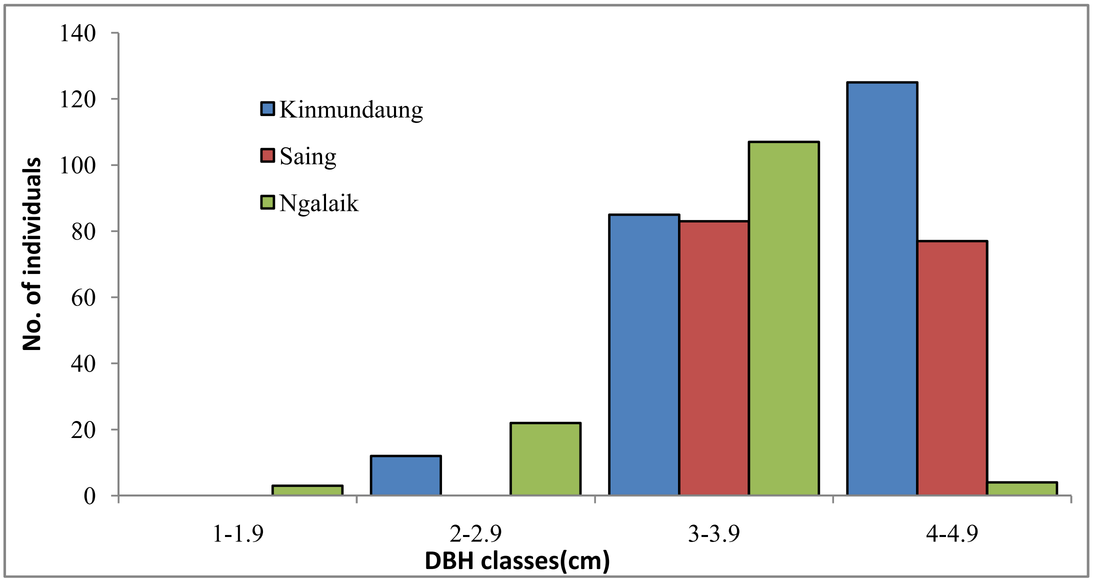
Table 4(b) Abundance, dominance, frequency and IVI of sapling in Ngalaik reserve, DBH < 5cm

Species Name	Abundance (No. of tree)	Dominance (BA)	Frequency %	IVI
Didu	12	0.01023	70	27.09
Kyun	11	0.00891	50	22.57
Pyinkado	10	0.00968	40	21.24
Lettokegyi	8	0.00664	50	18.34
Tayaw	6	0.00614	50	16.42
Padauk	7	0.00522	50	16.33
Yinmar	7	0.0061	40	15.82
Phet than	8	0.00518	30	14.43
Yindaik	6	0.00522	40	14.29
Htautkyan	7	0.00613	20	13.25
Others	54	0.042	330	120.238
Total	**136**	**0.11147**	**770**	**300.00**

Table 4(c) Abundance, dominance, frequency and IVI of sapling in Saing reserve, DBH < 5cm

Species Name	Abundance (No.of tree)	Dominance(BA)	frequency %	IVI
Binga	26	0.032	80	41.88
Madama	21	0.027	60	34.07
Gyo	14	0.017	70	25.73
Lethtoke	14	0.018	50	23.54
Zaungbalay	11	0.014	70	22.29
Kyun	11	0.013	50	19.33
Bebya	7	0.009	40	13.69
Pyinkado	7	0.008	30	11.75
Than thay	5	0.005	50	11.48
Thayingyi	4	0.005	40	9.956
Others	40	0.049	310	86.30
Total	**160**	**0.197**	**850**	**300.00**

4.3.2 Diameter-frequency distribution of Saplings



Figure(8a): Distribution of individuals by DBH classes, DBH < 5cm

The above figure gave diameter structure of saplings and corresponded to the trees with < 5 cm dbhinan area of 2500m^2. Considerably, lower numbers of individuals were found in the lower diameter classes(i.e. 1-1.9 and 2-2.9cm): contributing to 2.2% (1-1.9 cm) and 16.2% (2-2.9cm) of total sapling density inNgalaikReserve and about 5.4% (2-2.9cm) inKinmundaungReserve. In Saing Reserve saplings in these diameter classes were missing.The higher diameter classes (i.e. 3-3.9 and 4-4.9cm) comprised higher number ofindividuals in all investigated stands with the exception ofNgalaikforest, in which a few individuals werefound in the highestdiameter class of 4-4.9cm. Inthe high diameter class of 3-3.9 cm the numbers of individuals amounted to38.3%, 51.88%, and 78.7% of total sapling densityinthe Kinmundaung, Saing and NgalaikReserves while the individuals in the highest diameter class of 4-4.9cm were 56.3% and 48.1%in the Kinmundaung and SaingReserves. In the case of NgalaikReserveonly 2.9% of the total sapling density was found in the highest diameter class 4-4.9 cm.

4.3.3. Distribution of sapling (individuals) by height classes

The vertical structure of the natural regeneration in 2500 m^2 of three investigated stands is shown in figure (8b). The structural differentiation of the saplings exhibited irregular distribution with higher number of sapling individuals in the middle height classes such as 2.5-3 m, 3.5-4 m, and 4.5-5 m. In the height class of 2.5-3 m, Ngalaik Reserve had the highest number of saplings (48 individuals per 2500 m^2); followed by Saing Reserve (38 individuals) and Kinmundaung Reserve (34 individuals). In the height class of 3.5-4 m, Saing Reserve possessed the highest number of saplings (65 individuals per 2500 m^2); followed by Kinmundaung Reserve (57 individuals) and Ngalaik Reserve (35 individuals). Additionally, in the height class of 4.5-5 m, Kinmundaung Reserve comprised the highest number of saplings (82 individuals per 2500 m^2); followed by Saing Reserve (34 individuals) and Ngalaik Reserve (28 individuals). In all investigated stands, the lower number of saplings were found in the height classes of 5.5-6, 6.5-7, and >7 m.

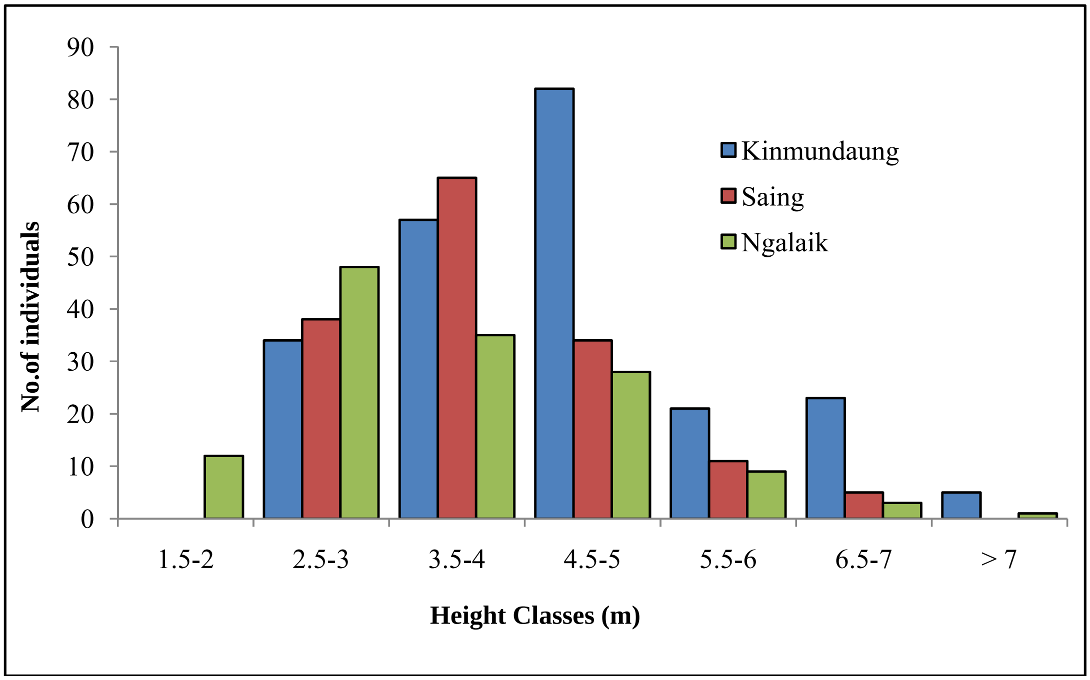


Figure (8b) Distribution of individuals by height classes, DBH < 5cm

The successful regeneration of a certain species is dependent upon the factors: (1) climate, (2) soil, (3) capacity of seed for ready germination, (4) conditionsconducive to establishment of the seedling and (5) method of management. In thepresent study, it was found that there were 49 species with 439 seedlings/ha in Kinmundaung Reserve, 33 species with 355 seedlings/ha in Saing Reserve, and 34 species with 260 seedlings/ha in Ngalaik Reserve in the samplingarea of 1,000 m^2in thecompartment C.

According to the researchfindingsshown in table (5):of the 49 tree species found in KinmundaungReserve in TaungdwingyiTownship, only two species such as **madama**and**yinma**hadthehigheest number of seedlings; of the 33 tree species found inSaingya Reserve in Yedashetownship, only two species such as **lettokgyi**and**madama**; of the 34 tree species found inNgalaik Reserve in Pyinmana Township, only two species such as **yinma**and **kabaung**showedthe highest numbers of seedlings per 1,000 m^2.The most economically important species of BagoYoma, Teak (*Tectonagrandis*), regenerated infrequently with 7seedlings in Saingya Reserve, 5 seedlings in Ngalaik Reserve, and no seedling was found in Kinmundaung Reserve. This may be due to the influence of the anthropogenic disturbances that have taken place over the past 50 years, thuscausingsevere forest degradation,deforestation, and loss of teak mother trees.

Table (5). Regeneration density of 20 species possessing the highest density in three Reserves

Sr.	Kinmundaung Reserve		Saing Reserve		Ngalaik Reserve	
	Species	**No.of seedlings**	**Species**	**No.of seedlings**	**Species**	**No.of seedlings**
1	Madama	70	Lettokgyi	78	Yinma	30
2	Yinma	48	Madama	52	Kabaung	27
3	Dwani	36	Tha yin gyi	44	Didu	20
4	Khuthan	30	Baebya	40	Madama	20
5	Binga	29	Ma hlwa	29	Gyo	19
6	Thin win	28	Zaungbalw ae	27	Phat than	18
7	Pyinkado	26	Seikchee	11	Ta yaw	15
8	Thitpankan	19	Than thay	8	Let htoke	14
9	Ingin	11	Kyun	7	Yin ma	13
10	Ngu	10	Bin ga	6	Na gye	12
11	Lettokgyi	9	Hingoke	6	Seikchae	9
12	Oshit	9	Kyaungshar	5	Kyetyoe	7
13	Phet won	8	Kyetyoe	5	Ma hlwa	7
14	Poke thin ma myatkhauk	8	Phet than	4	Pyinkado	7
15	Yindaik	7	Gyo	3	Kyun	5
16	Mahlwa	6	Kabaung	3	Thitseint	5
17	Thaukkyan	6	Na be	3	Padauk	4
18	Ziphyu	6	Pyinkado	3	Zaungbalwae	4
19	Gyo	5	Ku than	2	Binga	2
20	Kyaungsha	5	Lein	2	Leza	2
	Sub total	376	Sub total	338	Sub Total	240
	Others	63	Others	17	Others	20
	Total	**439**	**Total**	**355**	**Total**	**260**

Yinma took the first position in seedling density among all species found in Ngalaik Reserve, while the regeneration density of Teak was in the 15th position,Pyinkado and Padauk, the twoeconomicallyimportant species, were in the 14th and 17th position. Based on these findings, it can be seen that economicallyimportant species such as teak, pyinkado and padauk were not in the higher position when ranking the seedling density from the highest to lowest.

Similarly, teak and pyinkadotook the 9th and 18th position in seedling density found in Saingya Reserve while pyinkadotook the 7th position in Kinmundaung Reserve. The densities ofseedlings recorded in the present study were relativelylower than those in

KyawLwin’s(2003)study in the *BagoYomas*and ThanSoeOo’sfindings in Ngalaik Reserve (2000).

5. Conclusions and Recommendations

The condition of the forest had deteriorated (Suzuki, 2004) due to the factors causing forest degradation which had been going on for centuries and had become more intensive now due to the very fast population increase and its accompanying social and economic stresses (Keh.1996). In light of this, the urgent need is obvious to determine the current status of stand structure and composition, natural regeneration and growth of natural teak forests, and the effective ways to replenish these degrading forests. This study deals with the stand structure and composition of mixed deciduous forests. The investigation was carried out in three different natural teak bearing forests in the *BagoYomas*, located in Yedashe, Pyinmana, and Taungdwingyi Township. Both Yedashe and Pyinmana study areas are classified as ‘moist upper mixed deciduous forest type' and Taungdwingyi Township is of ‘dry upper mixed deciduous type'.

Species composition is one of the most important problems confronting natural forest management because composition determines economic values well as natural regeneration potential. In this study, the numbers of tree species per hectare (≥ 5 cm dbh) are found to be 57, 43 and 64 in Yedashe, Pyinmana and Taungdwingyi Township respectively. Although Taungdwingyi study area can be classified as dry upper mixed deciduous type, it has a large abundance of tree species, a high degree of heterogeneity and locally changing mixtures. Both Pyinmana and Yedashe forests are described as moist upper mixed deciduous forest type, the former has less species compared to latter (Yedashetownship). Among the investigated forests, Taundwingyi forest has highest species diversity according to theShannon Index. A total of 16 species have only one individual per species in Pyinmana Township while about 11 and 6 species in Yedashe and Taungdwingyitownship. In teak forest there is large number of rare species present in the habitat that determines the species diversity (Bebarta, 1999).

The species–area curve for all trees with ≥ 5 cm dbh indicates that the Taungdwingyi forest has the highest number of species per hectare. The species richness for all investigated stands are in the order of Taungdwingyi>Yedashe>Pyinmana forest. By comparing the investigated stands from a floristic point of view, the total basal area per hectare in Taungdwingyi Township is 5.94 m^2, 4.99 m^2 in Yedashe and only 2.34 m^2 in Pyinmana Township respectively.

In stand structure analysis, dbh is an indispensable parameter in describing dominance in a stand. Stand number-diameter distribution is an especially important tool to describe the horizontal structure of a stand. In sustained forest management, tree populations are maintained in a desirable stand structure with higher number of small trees and sloping down as the size increases. The structure of the diameter distribution in a stand, which may vary greatly from site to site and forest type to forest type, and the status of advance growth regeneration are vital in silvicultural treatment. The diameter class distribution patterns for these investigated forest types were in the form of reversed ' J-shaped" curve, indicating the adequate representation of small trees in the lower diameter classes. The maximum numbers of species were encountered in lowest girth at breast height class (5-10 cm) while species numbers gradually decrease with increasing girth classes. This finding collaborated the fact that the density and species richness have consistently decrease with increasing girth class of tree species from 30 to more than 211 cm girth at breast height as described by Reddy et al.,(2008) in undisturbed forest.

Height curves, which show the two dimensional view of vertical and horizontal structure of a stand, are drawn to compare the different sites. There are seven models to explain the diameter-height relationship. Among the model tested in this study, PETTERSON (DRAMER and AMCA 1996) ,Petterson's eq. and KORSUN's eq.gave the best fit over the others for teak and Group 1 of all investigated stands. The composition of stand height curves showed a significant site variation. Yedashe teak stand showed a superior diameter-height growth than the stand of Taungdwingyi Township while Pyinmana Township, showed poor performance. The height curves of pyinkado and padauk trees from all study areas, of which, Taungdwingyi township was best fitting by PETTERSON (DRAMER and AMCA 1996)model with the results of better correlation coefficients. The stands of teak and Group 1 from Pyinmana, Yedashe and Taungdwingyi Township showed a clear site variation in decreasing order respectively. These curves could be used as the basic guidance to differentiate the site conditions of natural teak forests.

Tree regeneration density of sapling (DBH < 5 cm) in three investigated reserves (Kinmundaung, Saingya and Ngalaik) was 222, 160 and 136 individuals of Taungdwingyi, Yedashe and Pyinmana forests respectively. Among these reserves, the commercial hardwood tree species *Tectonagrandis*,*Xyliaxylocapa* and *Pterocarpusmacrocarpus* in Ngalaik reserve only exhibited the higher IVI value (22.57), (21.24) and (16.33) than the two reserves. The diameter distribution of natural regeneration in three investigated stands occupied with higher individuals in the two highest diameter classes (3-3.9 and 4-4.9) except Ngalaik stand in the diameter class of (4-4.9). But it can be seen that regeneration density of these study areas in three reserve forests is much less when compare with KyawLwin study in the *BagoYomas* (439) and ThanSoeOo study in Ngalaik Reserve (805). Improvement felling are made in these stands that had grown beyond the sapling stage to improve the species composition, growth increment and quality of the growing stocks by removing trees of lesser-used species.

The following results can therefore be deduced; _

1. According to the species-area curves, a minimum representative area have been reached in a total sampled area of 1 ha each for all study areas of Pyinmana, Yedashe and Taungdwingyitownship at which an increase in the species number remained below 10 % with a 10 % expansion of the sample plot.
2. The Taungdwingyi study area display the largest number of tree species (64 spp. /ha) and the highest degree of heterogeneity among the study areas. The Pyinmana stand has the lowest species number (43 spp. / ha) as well as species diversity and the Yedashe stand is between the above two study areas.

3. The maximum observed stand basal area is 5.94 m^2/ha with 716 stems (≥ 5 cm dbh per ha) in Taungdwingyi township, 4.99 m^2 with 801 stems in Yedashe and the minimum is 2.34m^2 with 305 stems in Pyinmana township.
4. In the diameter-height relation, PETTERSON (DRAMER and AMCA 1996), Petterson's eq. and KORSUN's eq.model gives best result over others for all stands of teak and Group 1. The height curves of teak stands show a clear variation. Taungdwingyi teak stand shows a superior diameter- height growth than the other stands of Yedashe while Pyinmana teak stand show poor performance. The height curves of pyinkado stands in Taungdwingyi and Yedashe had similar height-diameter distribution. Taungdwingyipadauk stand is the most dominant one with the results of better regression coefficient.
5. In horizontal distribution, kyun (*Tectonagrandis)* is the most abundant species with highest IVI values in Pyinmana Township. Its sub-dominant species are padauk (*Pterocarpusmacrocarpus*), kabaung (*Strychnosnux-blanda*), and Yinma (*Chukrasiavelutina*). In Yedashe Township madama (*Dalbergia ovate*) is highest IVI value and sub-dominant species are bebya (*Cratoxylonneriifolium*), thetyingyi (*Croton oblongifolius*) and kyun (*Tectonagrandis*). In Taungdwingyitownship, kathit (*Erythrinaarborescens*) is the most abundant species with highest IVI values and its associate species are pyinkado (*Xyliaxylocarpa*) and Binga (*Mitragynarotandifolia*).

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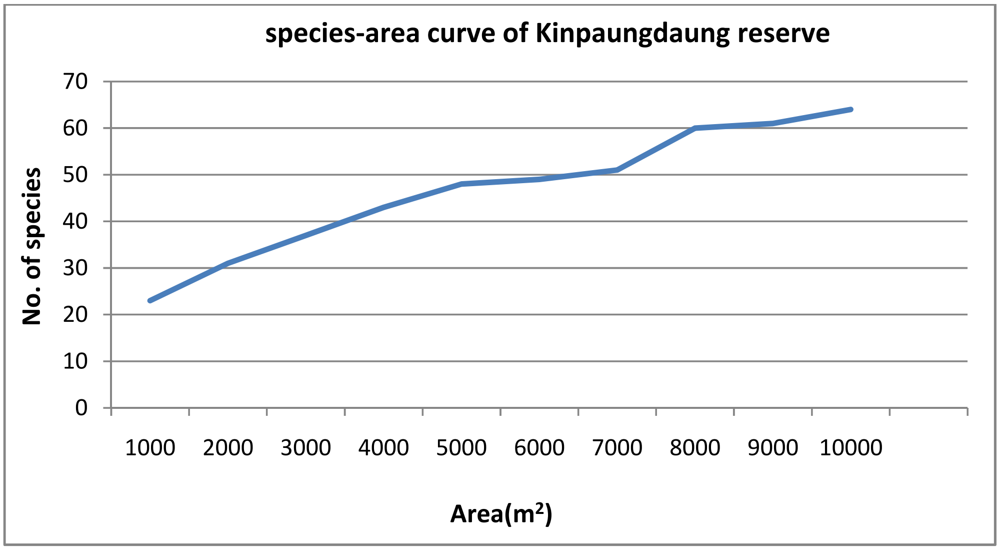
Appendix-1


species-area curve of Kinpaungdaung reserve
No. of species
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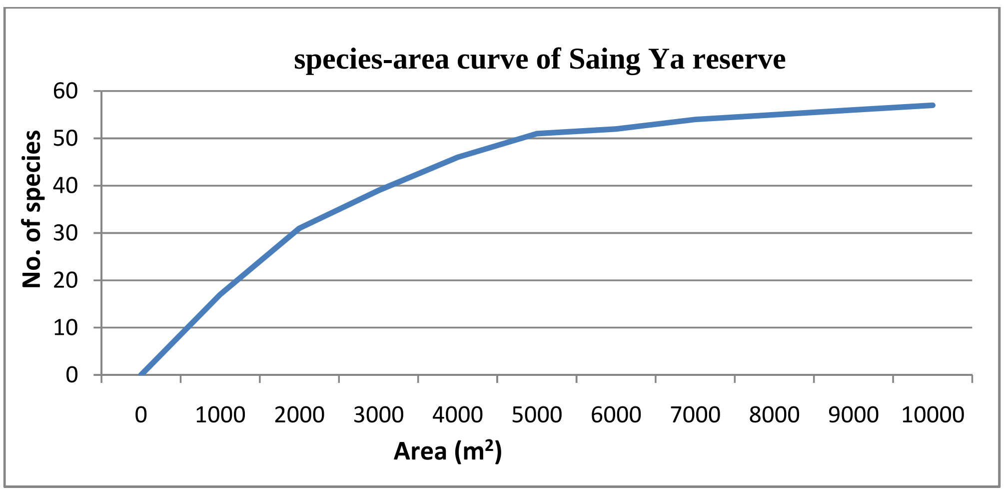
10
20
30
40
50
60
70
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Area(m²)


species-area curve of Saing Ya reserve
No. of species
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20
30
40
50
60
0
1000
2000
3000
4000
5000
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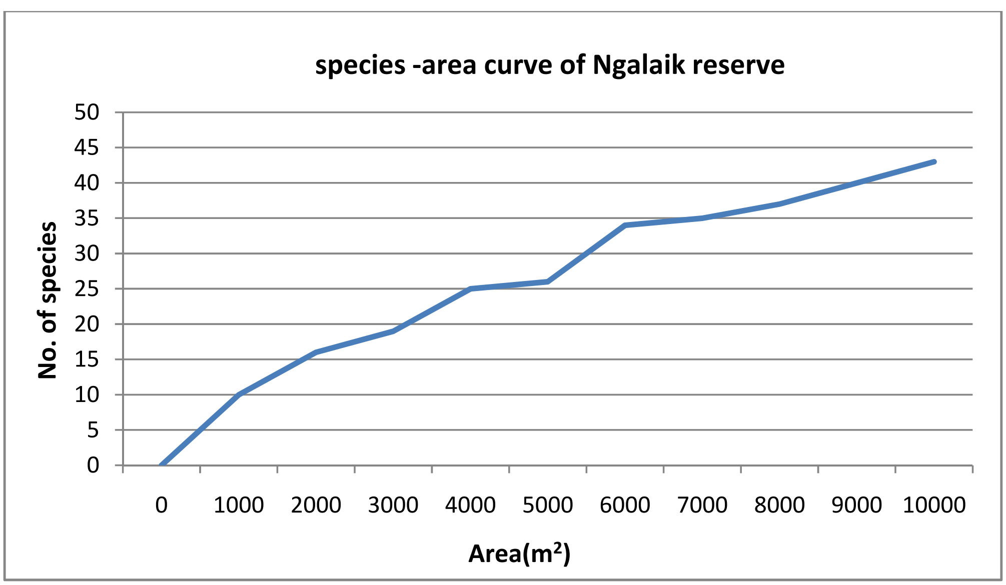
8000
9000
10000
Area (m²)


species -area curve of Ngalaik reserve
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15
20
25
30
35
40
45
50
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Area(m²)

Appendix-2

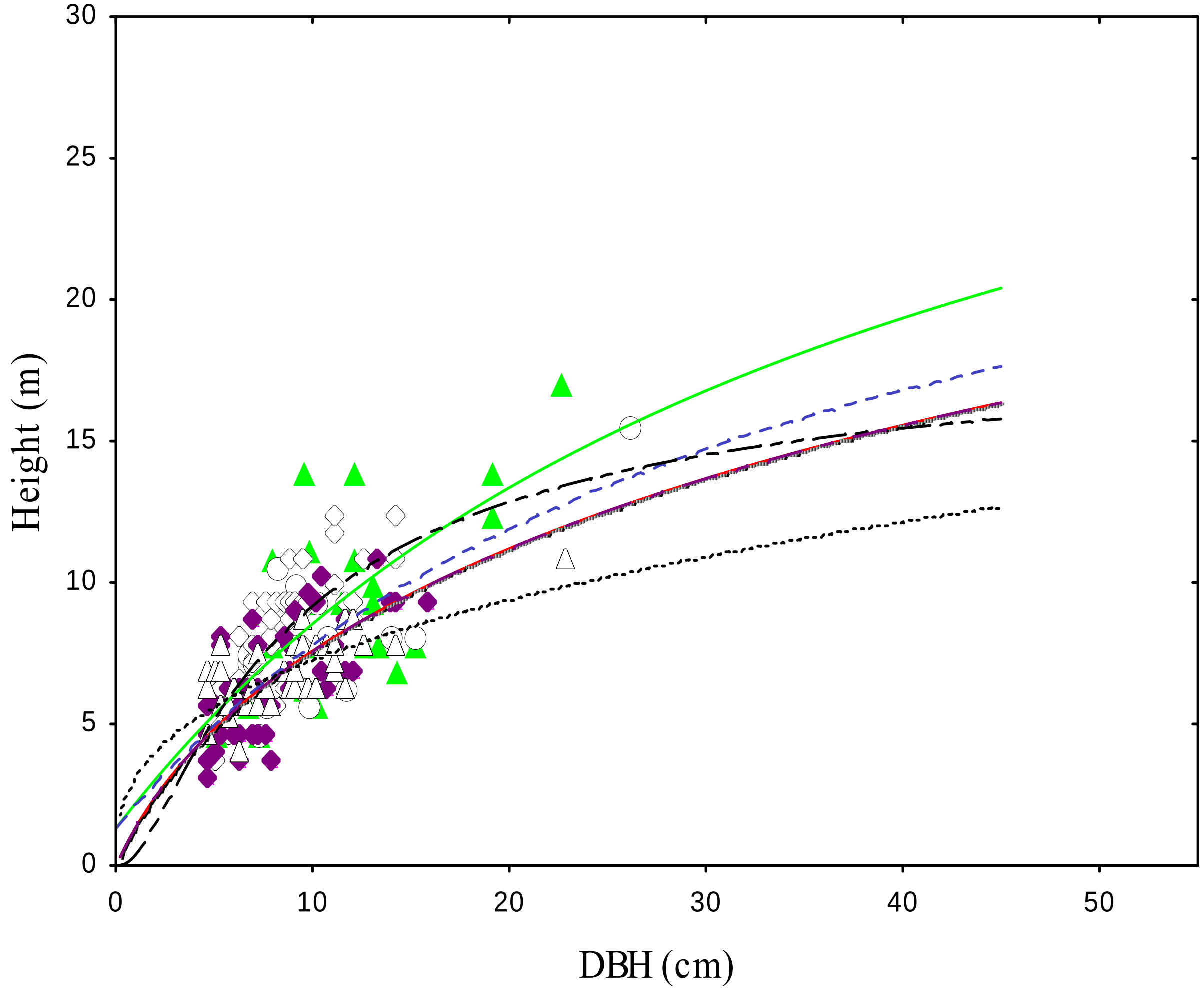

Figure: Stand height curves of Teak, Pyinkado, Padauktrees (≥ 5 cm DBH) in threeReserveinTaungdwingyi, Pyinmana and Yedashe forests