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Species distribution patterns influenced by edaphic factors in Natural Forests of Tanintharyi Township

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Species distribution patterns influenced by edaphic factors in Natural Forests of Tanintharyi Township

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Abstract

Soil and vegetation are complexly interrelated so the growth and reproduction of terrestrial ecosystems such as forests cannot be understood without knowledge about the soil. Moreover, previous studies have confirmed that topography, and locations of the forests also influenced on tree species composition and their distribution pattern in association with different degrees of anthropogenic disturbances. Therefore, we examined the influences of topography and edaphic factors on species composition and distribution so that the research results are to be able to support integrated and sustainable management of the forests in Tanintharyi Mountain Ranges. The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, Southern part of Myanmar. To collect floral and structural data from the forests at the two sites (two reserved forests named Taungpharu reserved forest and Thein Kone reserved forest), we arbitrarily laid out 15 sample plots (30 m × 30 m) across those study sites. In each sample plot, we measured the diameter at breast height (DBH) and the height of all trees (with ≥5 cm DBH and ≥2 m in height). In the sample quadrats, soil samples were collected from two layers (0-10 cm, and 10-20 cm). For each bundle of soil sample, physical and chemical properties were analyzed. Physical properties include soil textural characteristics by examining particle size distribution (%) of sand, silt and clay. For soil chemical properties, we determined soil pH, total nitrogen (%), available phosphorous (%), extractable potassium (%) and organic matter content (%).Canonical correspondence analysis (CCA) ordination was conducted using the species matrix and environmental matrix. The 15 plots were put as row headings for both matrices. The total 67 species were put as column headings for the species matrix, while each cell contained the total basal area of each species that occurred in each plot. For the environmental matrix, we put the variables as topography (elevation), soil chemical and physical variables for each sample quadrat. In total, there are 940 individuals occupied by 67 species occurred in 29 families for all sample plots. Severe water percolation and subsequent leaching of salt compounds from the soil resulted in lower values of soil pH. The resulting soils are therefore, naturally moderate to strongly acidic soil. Most of the soils were sandy-loam, some were loam and silt loam, and only small numbers of soil samples indicated as clay-loam soil. CCA ordination resulted that the first three canonical axes explained 43% of the total variation in the species distribution data. The strong species-environment correlations of the CCA ordination indicate that most of the variation in species composition and distribution between stands is explained by the environmental variables used in this study. However, different degrees of anthropogenic disturbances had happened in this area: that can explain the rest variation percentage of species assemblages in this area and it indicates to conduct further studies in the future regarding the influences of human disturbances on forest growth.

Keywords: Canonical correspondence analysis, soil properties, species assemblages topographic factors.

တနင်္သာရီမြို့နယ်အတွင်းရှိ သဘာဝတောများ၏သစ်မျိုးများ ပျံ့နှံ့ပေါက်ရောက်မှုနှင့် မြေဆီလွှာဂုဏ်သတ္တိများအား ဆက်စပ်လေ့လာခြင်း

ဒေါက်တာဖြူဖြူလွင်၊ ဦးစီးအရာရှိ၊
သစ်တောသုတေသနဌာန၊ သစ်တောဦးစီးဌာန

စာတမ်းအကျဉ်း

အပင်များနှင့် ၎င်းတို့ရှင်သန်ပေါက်ရောက်ရာမြေဆီလွှာသည် အပြန်အလှန် ဆက်နွယ်နေသဖြင့် သစ်တောများကဲ့သို့ ကုန်းတွင်းပိုင်းဂေဟစနစ်များ၏ ရှင်သန်မှု ကြီးထွားမှု၊ မျိုးဆက်မှုတို့ကို လေ့လာရာတွင် မြေဆီလွှာဆိုင်ရာ သတင်းအချက်အလက်များ ပါဝင်မှသာ ခိုင်မာပြည့်စုံသည့် သတင်းအချက်အလက်များကို ပံ့ပိုးပေးနိုင်မည်ဖြစ်ပါသည်။ထို့အပြင် ယခင်သုတေသနများ၏တွေ့ရှိချက်များအရ သစ်တောများအတွင်းရှိ သစ်မျိုးများ ဖွဲ့စည်းပုံနှင့် တည်ဆောက်ပုံခြားနားမှုများသည် ၎င်းတို့၏ တည်နေရာ၊ မြေမျက်နှာသွင်ပြင် အပေါ်မူတည် သကဲ့သို့ လူတို့၏ ထိခိုက်စေမှုများနှင့်လည်း ဆက်စပ်နေကြောင်း သိရှိရပါသည်။ ယခုသုတေသနသည် တနင်္သာရီတောင်တန်းဒေသရှိ သစ်တောများအပေါ် မြေမျက်နှာသွင်ပြင်နှင့်မြေဆီလွှာဂုဏ်သတ္တိ များ၏ လွှမ်းမိုးမှုကို လေ့လာခြင်းဖြစ်သဖြင့် တနင်္သာရီ ဒေသရှိ သဘာဝတော များအား စဉ်ဆက်မပြတ်စီမံအုပ်ချုပ်မှုကို အထောက်အကူပြုသည့် သတင်းအချက်အလက်များကို ပံ့ပိုးပေးနိုင်မည်ဖြစ်ပါသည်။ ဤသုတေသနအား မြန်မာနိုင်ငံ တောင်ပိုင်း၊ တနင်္သာရီတိုင်းဒေသကြီး၊ မြိတ်ခရိုင်အတွင်းရှိ တနင်္သာရီမြို့နယ်တွင် ဆောင် ရွက်ခဲ့ပါသည်။ အဆိုပါမြို့နယ် အတွင်းရှိ တောင်ဖရူးကြိုးဝိုင်းနှင့် သိမ်ခွန်းကြိုးဝိုင်းအတွင်းရှိ သဘာဝတောများအတွင်း သစ်ပင်စာရင်းကောက်ယူခြင်း၊ တိုင်းတာခြင်းနှင့် မြေဆီလွှာ ဂုဏ်သတ္တိများအား လေ့လာခြင်းကို ဆောင်ရွက်ခဲ့ပါသည်။ အဆိုပါကြိုးဝိုင်းတောနှစ်ခု အတွင်းကျ ဖမ်းနည်းဖြင့် ချမှတ်ထားသော နမူနာကွက် (၁၅) ကွက်အတွင်း စာရင်း ကောက်ယူခဲ့ကာ နမူနာကွက်တစ်ခုချင်း၏ အရွယ်အစားမှာ ၃၀ မီတာပတ်လည်ရှိ စတုရန်း ပုံစံဖြစ်ပါသည်။ နမူနာကွက်များအားလုံးတွင် ကောက်ယူရရှိခဲ့သည့် အပင်အရေအတွက် အားလုံးမှာ ၉၄၀ ပင်ဖြစ်ကာ သစ်မျိုးစိတ် ၆၇ မျိုးနှင့် မျိုးရင်း ၂၉ မျိုးကို ကိုယ်စား ပြုပါသည်။ နမူနာကွက်တစ်ခုချင်း၏ မြေဆီလွှာဂုဏ်သတ္တိများ ဖော်ထုတ်ရာတွင် သဲ၊နုန်း၊ ရွံ့စေးပါဝင်မှုအချိုးအစား၊ ဓာတုဂုဏ်သတ္တိများဖြစ်သည့်

နိုက်ထရိုဂျင်၊ ဖော့စ်ဖရပ်စ်၊ ပိုတက်ဆီယမ်၊ မြေချဉ်ငံဓါတ်နှင့် မြေဆွေးပါဝင်မှုရာခိုင်နှုန်းတို့ကို ဖော်ထုတ်ခဲ့ပါသည်။ သစ်မျိုးများ၏ ပျံ့နှံ့ဖွဲ့စည်းပုံနှင့် မြေဆီလွှာဂုဏ်သတ္တိများ၊ မြေမျက်နှာသွင်ပြင်တို့၏ ဆက်စပ်မှုကို ဖော်ထုတ်နိုင်ရန်အတွက် Canonical correspondence analysis –CCA (အချက်အလက်များအားလုံးအား တပြိုင်တည်း ထည့်သွင်းဆန်းစစ်ခြင်း) နည်းလမ်းအား အသုံးပြုတွက်ချက်ခဲ့ပါသည်။ မိုးများသည့် ဒေသဖြစ်ခြင်းကြောင့် မိုးရေစီးဆင်းမှုပြင်းထန်ခြင်းနှင့်အတူ မြေမျက်နှာပြင်ရှိ ဆားဓါတ်များအားတိုက်စားမှုများသဖြင့် မြေဆီလွှာ ချဉ်ငံဓါတ်မှာ အက်ဆစ်ဓါတ်များသည်ကို တွေ့ရှိရပါသည်။ အများစုမှာ သဲဆန်သောမြေ အမျိုးအစားဖြစ်ပြီး အချို့မှာ နုန်းဆန်သောမြေနှင့် ရွှံ့ဆန်သောမြေများကိုလည်း အနည်းငယ် တွေ့ရှိရပါသည်။ CCA ရလဒ်အရ သစ်မျိုးစိတ်များ ကွဲပြားမှု၊ ပျံ့နှံ့တည်ရှိမှုအပေါ်တွင် မြေဆီလွှာဂုဏ်သတ္တိ လွှမ်းမိုးမှုကို ခိုင်မာစွာတွေ့ရှိရပါသည်။ ကိန်းဂဏန်းအားဖြင့် တနသ်ာရီ မြို့နယ်အတွင်းရှိ သဘာဝတောများအတွင်း သစ်မျိုးများပျံ့နှံ့တည်ရှိမှု၊ သစ်မျိုးစိတ်ကွဲပြားမှု များအား ၄၃ ရာခိုင်နှုန်းခန့် ရှင်းပြနိုင်သဖြင့် သစ်မျိုးစိတ်များအပေါ် ပတ်ဝန်းကျင် အခြေအနေလွှမ်းမိုးမှုဆိုင်ရာ သုတေသနစာတမ်းအနေဖြင့် ခိုင်မာစွာ သက်သေပြနိုင်သော တွေ့ရှိမှုတစ်ခု ဖြစ်ပါသည်။ ကျန်ရှိသော ရာခိုင်နှုန်းများအနေဖြင့် လူတို့၏လုပ်ရပ်များ ကြောင့်လည်း ပါဝင်ကြောင်း ယခင်သုတေသနရလဒ်များအရ တွေ့ရှိခြင်းကြောင့် ယခုသုတေ သန၏ နောက်ဆက်တွဲ အနေအဖြင့် ဆောင်ရွက်မည်ဆိုပါက လူတို့၏ ပယောဂကြောင့် သစ်တောများအပေါ် အကျိုးသက်ရောက်မှုများကို ဆက်လက်လေ့လာနိုင်မည်ဖြစ်ပါသည်။

Species distribution patterns influenced by edaphic factors in Natural Forests of Tanintharyi Township

1. Introduction

Tropical forests are more diverse terrestrial ecosystem than temperate forests, sub-tropical forests and other ecosystems (Devi and Yadava 2006). But nowadays, those tropical forested areas are facing numerous challenges to ensure their sustainability (Sarvade, Gupta, and Singh 2016). Myanmar possesses one of the richest biodiversity in the Indo-Pacific region and has one of the highest proportions of forest cover in mainland Southeast Asia (FRA 2005). However, forest areas of Myanmar are also under severe pressure from population growth, increased resource utilization and demand for resources from neighboring countries (Aung et al., 2004).

The Taninthayi (Tenasserim) Mountain Range, along the border between Myanmar and Thailand, covers a global important terrestrial eco-region with a transition zone from continental dry evergreen forests common in the north to semi-evergreen rain forests to the south. As a consequence, they contain some of the highest diversity of both flora and fauna not only in Myanmar but in Southeast Asia Region. Similarly, the outstanding biodiversity features and diversity of the Taninthayi Range are vulnerable due to poaching, fragmentation and encroachment for agriculture, illegal logging, settlements inside and around the park, and human-elephant conflicts. Unsustainable harvesting of non-timber forest products is prevalent throughout the eco-region. Some areas have been subjected to seasonal forest fires, the impacts of which are unclear. Therefore, long-term viability of biodiversity in the Taninthayi depends on promoting systematic management of the natural forests. This can provide the natural habitats for the wildlife species as well as the fulfilling of the basic needs of the people (adapted from the project proposal: Capacity Building for Strengthening Transboundary Biodiversity Conservation of the Tanintharyi Range in Myanmar).

Knowledge of forest structure, composition and diversity at different levels of human disturbance would facilitate the creation and implementation of more effective conservation measures. Understanding the response of forest vegetation to different intensities of human disturbance would help to identify where conservation efforts should be given priority, and thereby enable the efficient use of limited conservation funds (James et al. 2001, Bhuyan et al. 2003).

In addition, the functioning of most ecosystems is generally influenced by availability of nutrients (Kaushalendra Kumar Jha, 2014). Soil and vegetation are complexly interrelated so the growth and reproduction of terrestrial ecosystems such as forests cannot be understood without knowledge about the soil (B. Takoutsing, et al., 2015). Moreover, different tree species can differ significantly in their influence on soil properties as well as soil fertility (Augusto et al. 2002). Accordingly, the species composition, diversity and their distribution are dependent on the factors: topography (elevation, slope, aspect, etc,.), their locations (distance from settlements, roads, etc.,), and edaphic factors (soil properties). Therefore, we examined the influences of topography and edaphic factors on species composition and distribution so that the research results are to be able to support integrated and sustainable management of the forests in Tanintharyi Mountain Ranges.

2. Methodology

2.1 Study Area

The study was conducted in Tanintharyi Township located within Myeik District, Tanintharyi Region, southern part of Myanmar. It is located between 11º20´ to 13º10´ North Latitude and 98º40´ to 99º40´ East Longitude. Tanintharyi Township is bordered with Thailand in east, Dawei District in north, Boatpyin Township in south, and Kyunsu Township, Myeik Township and Pulaw Township in west respectively. The area of the township is 4380.18 square miles (11344.61 km^2). About 64.33% of the area of the whole township was forested lands covering the area as 7298.57 km^2. Among those forested areas, 4735.32 km^2 has been declared and demarcated as reserved forests and recognized as permanent forest estate (PFE) administered by Forest Department (unpublished data, Tanintharyi Township Forest Department). In total, there are six reserved forests in this township and those are Taungparu reserved forest, Mayingyi reserved forest, Thakyet reserved forest, Thein Kone reserved forest, Ngawon reserved forest, and Ngawon extension forest. There are two proposed protected areas; namely Tanintharyi National Park and Leynyar extension National Park covering the area of 4447.85 km^2.

The total number of village tracts (group of villages) was nineteen while there are 214 villages representing those nineteen village tracts in Tanintharyi Township. The major ethnic groups residing in the township are Bamar, Tai-Shan, Kayin and Mon (unpublished data from General Administration Department, Tanintharyi Township). Some parts of the area are resided by the natives while some areas were occupied by the people migrated from other regions of Myanmar. Those people came to this area as the labors of palm oil companies doing agricultural business by growing extensive areas of palm oil plantations in that area. . Later on, those labors resided in that area by many reasons including marriage with local residents, doing farming, and other businesses for their livings (survey by the author).

Although the proportion of forested areas was quite high, deforestation and forest degradation also happened in this area. The main drivers of deforestation include conversion of forests for extensive agriculture (palm oil plantations), clearing forests for conducting small-scaled agriculture by local people (doing orchards to grow areca palm trees) and settlement. Forest degradation in this area was caused mainly by illegal logging, hunting, collection of firewood and other forest products. However, the degree of deforestation was relatively higher than that of forest degradation. Accordingly, fragmentation is the major problem in that area followed by the impact of deforestation as mosaic pattern. This can lead to altering species composition, biodiversity and fragmentation of natural habitats for wildlife species.

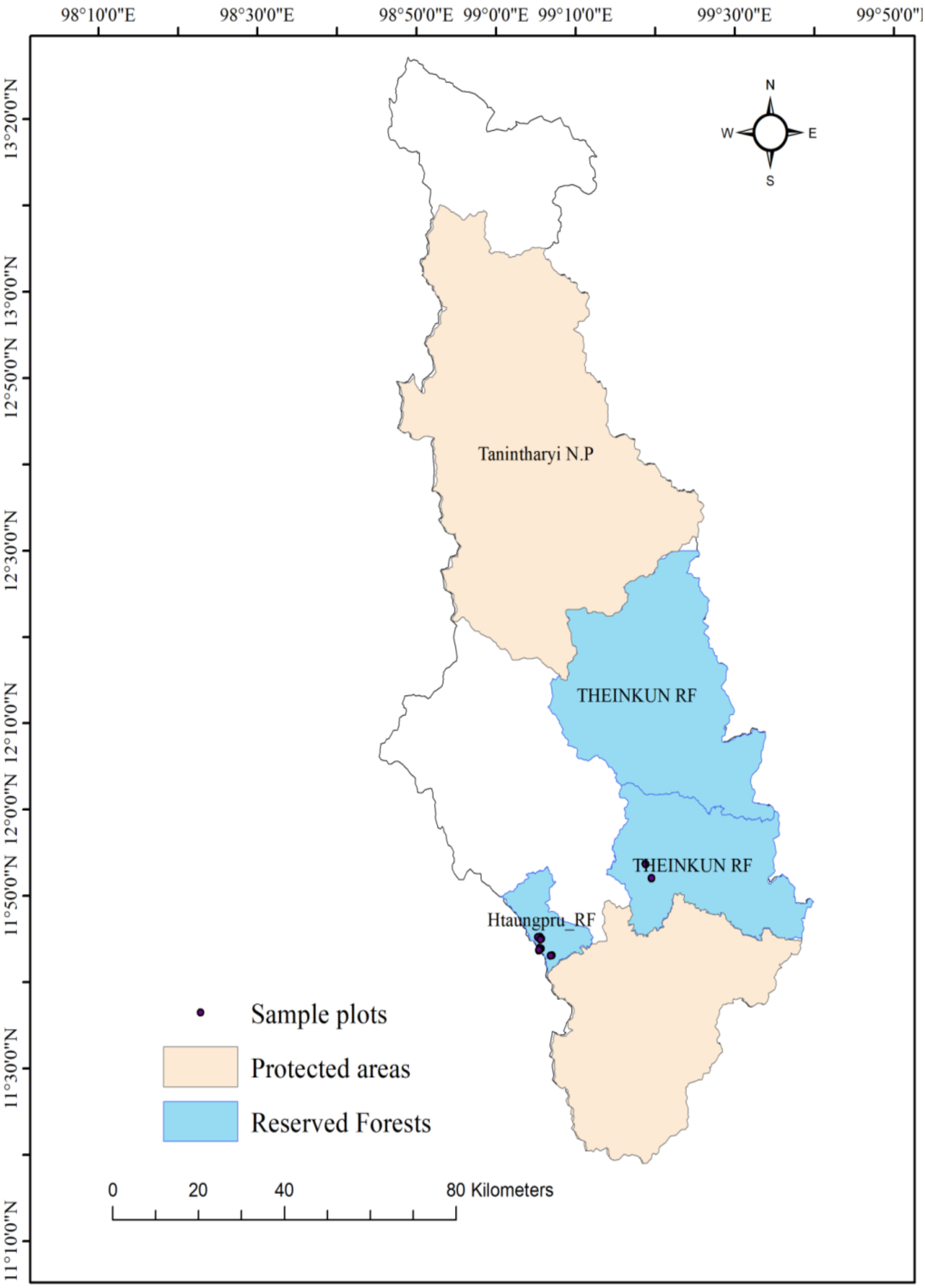

Figure 1. Study Area which is Tanintharyi Township, Tanintharyi Region and location of sample villages

2.2 Data collection

2.2.1 Forest Inventory and soil sampling

To collect floral and structural data from the forests at the two sites (two reserved forests named Taungpharu reserved forest and Thein Kone reserved forest), we arbitrarily laid out 15 sample plots (30 m × 30 m) across those study sites. Eleven plots were sampled in Taungpharu reserved forest while the rest four plots were laid out in Thein Kone reserved forest (Figure 1). To reduce the effect of spatial autocorrelation for covering the variation of floral composition, sample plots were separated from each other by at least 500 m. To avoid sampling early stages of regeneration, we selected forests with a minimum canopy height of 12 m. Data were collected from November 2018 to January 2019. In each sample plot, we measured the diameter at breast height (DBH) and the height of all trees (with ≥5 cm DBH and ≥2 m in height). We measured tree heights using a Vertex IV hypsometer (Haglöf Sweden AB). For multi-stemmed individuals, we measured each stem with DBH ≥5 cm. Specimens of leaves, shoots, fruits, seeds, flowers, and barks wherever available were collected from each species with their local names for the later identification. The specimens were sent to the Herbarium of Forest Research Institute, Myanmar, for taxonomic identification. We followed the nomenclature of Kress et al. (2003) and Gardner et al. (2000) for identification. For forest inventory, we only measured trees, while other plants, such as climbers, shrubs, and herbs, were excluded.

In the sample quadrats, soil samples were collected from two layers (0-10 cm, and 10-20 cm). These two depths are typically used in soil analysis because they represent chemical and textural characteristics of the top soil layer that result from different processes during soil formation (Santos, 2007: cited in Martins, et al., 2015).Three sample points were laid out in each sample quadrat by locating triangle from the center of the sample quadrat. This mean three replicate measurements were applied for soil sampling.

2.2.2 Laboratory analysis

Soil samples were analyzed in the soil laboratory of Forest Research Institute, Yezin. Replicated soil samples from the same layer of the sample quadrats were pooled for the laboratory analyses. Consequently, there were two soil samples from two layers for each sample quadrat. For each bundle of soil sample, physical and chemical properties were analyzed. Physical properties include soil textural characteristics by examining particle size distribution (%) of sand, silt and clay. For soil chemical properties, we determined soil pH, total nitrogen (%), available phosphorous (%), extractable potassium (%) and organic matter content (%).

2.2.3 Data analyses

For numerical analyses, we organized our collected data into two matrices: namely species matrix and environmental matrix. The 15 plots were put as row headings for both matrices. The total 67 species were put as column headings for the species matrix, while each cell contained the total basal area of each species that occurred in each plot. For the environmental matrix, we put the variables as topography (elevation), soil chemical and physical variables for each sample quadrat. The summarized information of each sample quadrat and the study area include species richness, diversity and evenness indices, the dominant tree families and species. Data analyses were conducted by using Biodiversity R package developed in R-statistics. To determine stand structural characteristics, we calculated the mean DBH (cm), maximum tree height (m), total basal area (m^2), and stem density for each plot. We first classified DBH values of all measured stems into classes at 5-cm intervals. We then prepared the stem-diameter distribution for graphical illustration.

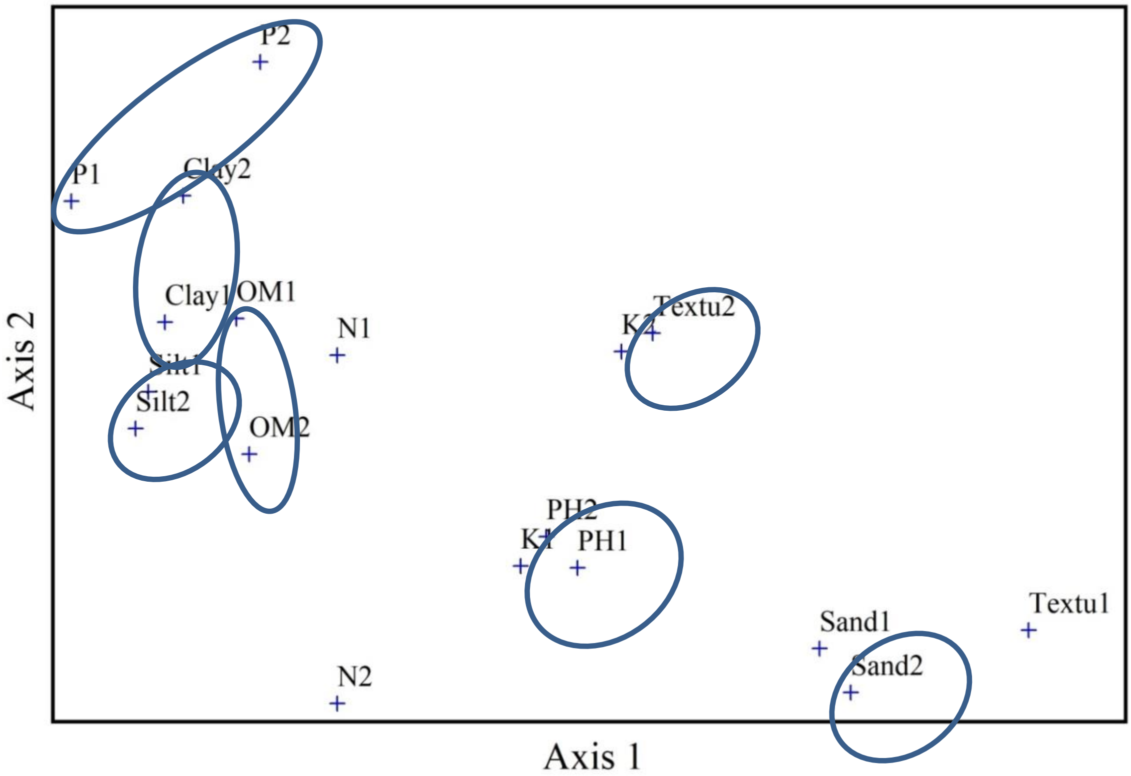

Figure 2. Principal component analysis examining the correlations of the 18 soil variables from two different layers in 15 quadrats in natural forests of Tanintharyi Township. The first two principle components (PCs) explained 54.55% of the toral variance (40.73% and 13.82% for PC1 and PC2 respectively). Oval shapes indicate collinear relationships within individual soil properties among two layers. P = Avaliable phosphorous; OM = Organic matter; K = Extractable potassium; N = Avaiable nitrogen; 1 = 0-10 layers; and 2 = 10-20 layer.

Canonical correspondence analysis (CCA) ordination was conducted using the species matrix and environmental matrix. Since we measured soil samples from two layers in sample quadrats, there were high numbers of environmental variables which is soil properties (9 properties x 2 layers = 18 variables). Accordingly, the data were reduced by applying principle component analysis (PCA) of the correlations among environmental variables to identify and remove strongly related (collinear) variables prior to performing the CCA analysis. As resulted by PCA ordination, we selected the lower layer (15-30 cm) as a proxy layer for the entire soil profile to be applied in CCA (Figure 2). CCA was performed to determine the association between species and soil conditions. In CCA, environmental variables with a correlation of greater than 0.6 with major three axes were interpreted as strong variables that influenced species composition and their distribution. Both PCA and CCA ordinations were performed by PC-ORD software (McCune & Mefford 1999).

3. Results and Discussions

3.1 Species composition and stand structural characteristics

In total, there are 940 individuals occupied by 67 species occurred in 29 families for all sample plots. Still, there are 20 individuals as unknown species which could not be identified taxonomically because of incomplete specimens as well as inaccessible location to collect their specimens. The five most common families are Euphorbiaceae (143 individuals), Dipterocarpaceae (104 individuals), Lauraceae (101 individuals), Myrtaceae (80 individuals), and Anacardiceae (63 individuals). The results of family composition show that those forests are relatively tropical evergreen forests.

We applied both 1st order and 2nd order estimators while the 1st order Jackknife estimator of species richness confirmed that the number of species would be 89 while the 2nd order estimated that the number of species to be found in this area would be 104. The Shannon diversity index value showed higher diversity for the study sites (3.498) while the typical values are generally between 1.5 and 3.5 in most ecologically studies, and the index is rarely greater than 4.0 (Magurran 2004). The value of Simpson diversity index (1-D) was 0.959 indicating the higher diversity values and possessing less single most dominant species in this area. On the other hand, The Shannon Evenness was found as 49.32% that means the number of individuals represented by each tree species are not evenly distributed across the study site. The results of species richness, diversity indices and evenness values were shown in table 1.

Table 1. Species richness, stem density, diversity and evenness of natural forests of Tanintharyi Township

No.	Variables	Results
1	No. of species	67
2	No. of Families	29
3	Density (no. of stems/ha)	696
4	Jackknife estimate of species richness (1st order)	89
5	Jackknife estimate of species richness (2nd order)	104
6	Shannon Diversity Index (H)	3.498
7	Simpson Diversity Index (1-D)	0.959
8	Shannon Evenness (E%)	49.32

Stand structure of natural forests of Tanintharyi Township was firstly shown by the values of mean DBH (Diameter at breast height in cm), total basal area (in m^2), and average top heights of the trees (in m) (Table 2) for each sample quadrat (30 x 30 m). As the trees in those plots ranges by different sizes from small trees to large trees, the values of standard deviation (SD) became larger (Table 2). The mean DBH values range from 11.22 cm (plot 05) to 33.57 cm (plot 15) as the largest. The total basal area of the plots was ranging from 1.24 m^2 to 4.78 m^2. The mean top height of the trees was found 11.59 m as the lowest through 22.06 m as the highest.

Table 2. Stand structural components of the plots in natural forests of Tanintharyi Township, Tanintharyi Region

Plots	**Mean DBH (cm)**	**Total BA(m^2)**	**mean top height (m)**
P01	16.66 (±11.97)	1.94	17.10(±8.82)
P02	22.30(±19.34)	4.62	18.20(±10.72)
P03	23.82(±17.29)	2.78	22.06(±10.17)
P04	22.51(±18.06)	3.64	16.41(±9.48)
P05	11.22(±7.87)	1.13	11.71(±6.08)
P06	18.52(±14.04)	2.70	17.71(±11.72)
P07	21.25(±18.35)	3.81	18.26(±10.94)
P08	19.00(±16.32)	2.89	21.41(±13.09)
P09	28.82(±26.59)	4.78	18.52(±9.58)
P10	17.43(±12.83)	3.33	14.63(±7.16)
P11	22.49(±21.06)	3.40	16.09(±11.65)
P12	15.06(±17.28)	3.40	11.59(±6.09)
P13	22.77(±20.23)	4.78	14.94(±9.00)
P14	14.68(±12.97)	3.51	12.18(±5.20)
P15	33.57(±18.43)	1.24	19.96(±5.59)
Grand Total	**18.98 (±17.01)**	**47.94**	**15.85**(±9.55)

We also identified the stem-diameter distribution of the trees found in all sample plots to define the stand structure of the forests (Figure 3). We firstly classified the stems into ten classes with 5 cm diameter intervals. The highest number of stems was found in the smallest diameter classes meaning the highest proportion of small trees in the forest. However, the diameter distribution curve did not follow the inverse-J shape which is the typical form of undisturbed natural forests. According to this finding, we can prove that those forests have been disturbed especially anthropogenic disturbances such as logging, pole cutting, etc., in previous time. But it seems there is still no disturbance at this current time.

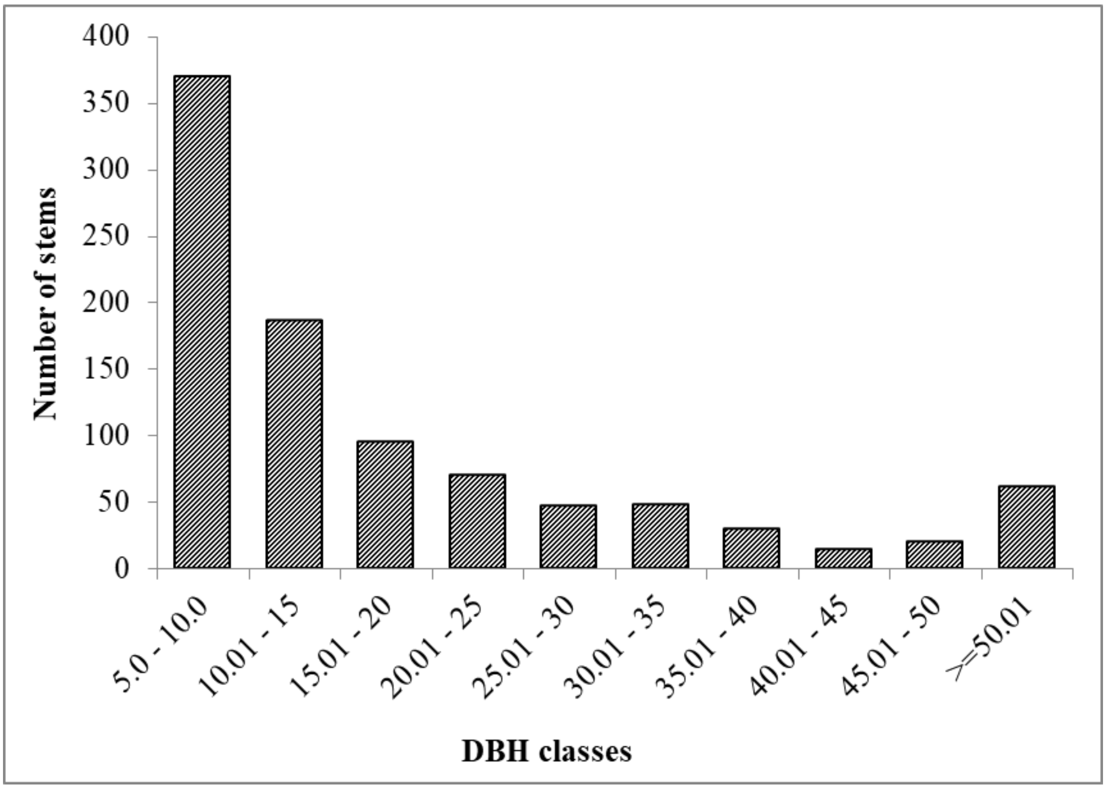

Figure 3. Stem-diameter distribution of the natural forests in Tanintharyi Township, Tanintharyi Region

3.2 Association between species distribution and edaphic factors

Table 3 summarized the physical and chemical properties of soil samples collected from two different layers in the 15 quadrats (30 x 30m) in Taungparu reserved forest and Theinkone reserved forest of Tanintharyi Township. The soil pH of the study area (4.22±0.36) indicates markedly low values and it could be the nature of the forests as they belong to tropical rain forests located in areas with high precipitation. Severe water percolation and subsequent leaching of salt compounds from the soil resulted in lower values of soil pH (Juo & Franzleubbers 2003). The resulting soils are therefore, naturally moderate to strongly acidic soil (SRDI 1976: cit. f Biswas et. al., 2012). The organic matter content of the sampled soils ranged 4.27 (±1.39), indicating a relatively high content of organic matter in the soils (Biswas et. al., 2012) resulted from the accumulation of litters and decomposition under severe rain. Soil water holding capacity is largely determined by soil texture (Ramade 1981) with sandy soils mostly having low water-holding capacity, whereas soils with higher clay content often have a higher capacity. The results show that most of the soil samples were composed with higher sand content followed by silt content and then lastly by some proportion of clay content. As a result, most of the soils were sandy-loam, some were loam and silt loam, and only small numbers of soil samples indicated as clay-loam soil.

Table 3. Physiochemical properties (mean±SD) of soil collected from different layers in 15 quadrats (30 x 30 m) in Tanintharyi Township, Tanintharyi Region

Soil layers	Soil PH	Total N (%)	Ava_P (%)	Ext K (%)	OM (%)	Sand(%)	Silt(%)	Clay(%)
0-10cm	4.14 (0.41)	0.0946 (0.056)	0.00006 (0.00004)	0.006 (0.004)	5.53 (2.39)	52.2 (14.54)	48.4 (15.27)	15.2 (5.92)
10-20cm	4.22 (0.36)	0.0595 (0.0229)	0.00007 (0.00006)	0.006 (0.003)	4.27 (1.39)	48.4 (15.27)	31.47 (10.4)	19(8.43)

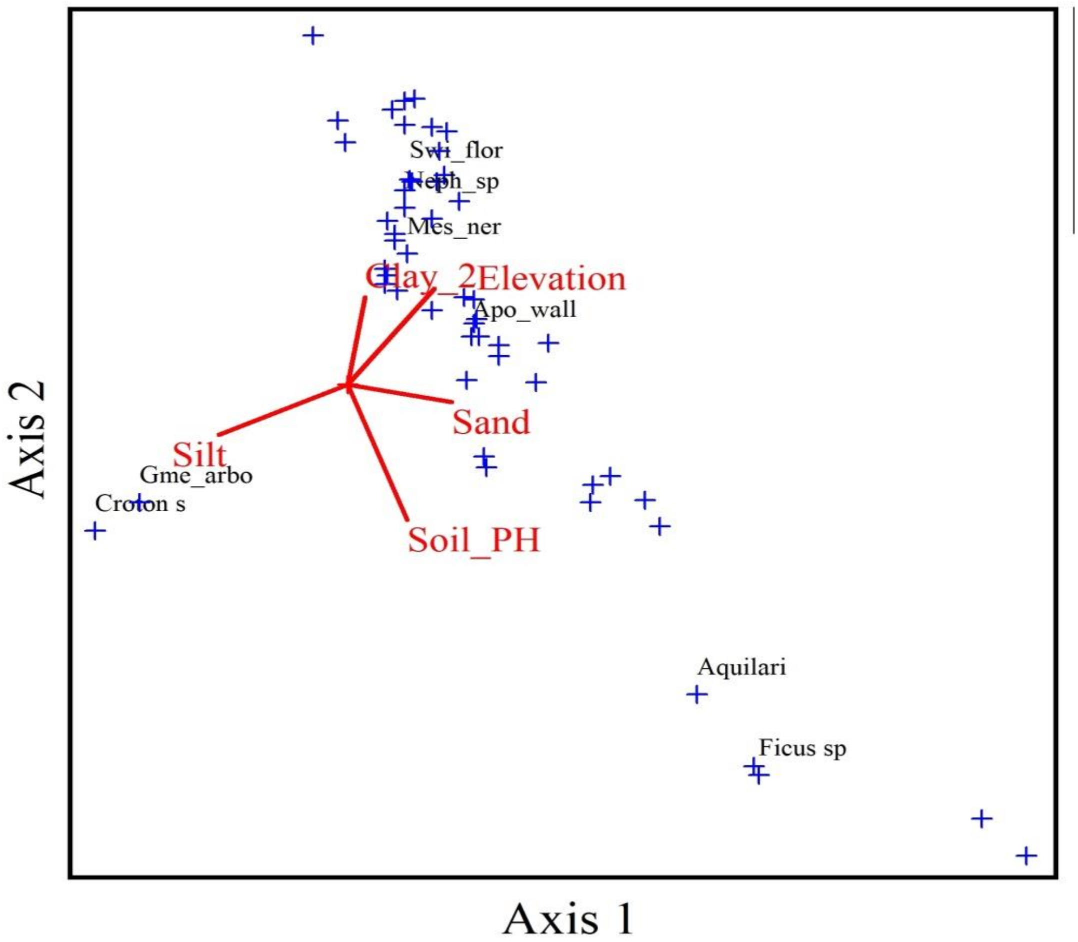

Figure 4. Canonical Correspondence analysis (CCA) ordination based on the basal area of woody plant species and selected nine environmental variables of sample quadrats (topography and edaphic factors)

CCA ordination resulted that the first three canonical axes explained 43% of the total variation in the species distribution data (Table 4). The first CCA axis was strongly and positively correlated with silt content and negatively correlated with elevation, available phosphorous, and proportion of potassium. The second CCA axis was strongly and positively correlated with soil pH. Those correlation coefficients revealed that the first axis is a topographic gradient as well as associated with soil physiochemical properties. The second axis is a soil acidity and alkalinity gradient. Some species such as *Gmelina arborea*, and *Croton* species preferred soils dominated with silt texture (Figure 4). *Ficus* species and *Aquilaria* species are dominant in soils with higher pH values. Most species prefer clay soils with low pH values located in higher elevation. This indicates that the different species distribution pattern is associated with topography, and edaphic factors.

Table 4. Summary of CCA of 67 species found in 12 sample quadrats (Environmental variables that are strongly correlated with any of major three CCA axes are indicated by asterisks (i.e., correlation coefficient greater than (0.6) with any major axes.)

	Axis 1	**Axis 2**	**Axis 3**
Eigen value	0.803	0.507	0.372
Species-Environment correlations	0.994	0.992	0.963
% of variance explained	20.5	13.0	9.5
Cumulative % explained	20.5	33.5	43.0
Correlations			
Elevation*	-0.624	-0.280	-0.001
Soil PH*	0.114	0.872	-0.112
Total Nitrogen	0.408	0.030	0.297
Available Phosphorous*	-0.508	-0.067	-0.429
Potassium*	-0.659	-0.131	-0.308
Organic matter	0.277	-0.062	-0.044
Sand(%)	-0.389	0.361	0.308
Silt (%)*	0.660	-0.088	-0.443
Clay (%)	-0.315	-0.413	-0.084

4. Conclusion

The strong species-environment correlations of the CCA ordination indicate that most of the variation in species composition and distribution between stands is explained by the environmental variables used in this study. However, different degrees of anthropogenic disturbances had happened in this area: that can explain the rest variation percentage of species assemblages in this area and it indicates to conduct further studies in the future regarding the influences of human disturbances on forest growth.

5. Acknowledgements

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7. Photo records

Collecting soil samples in sample quadrats

Natural Forests in Tanintharyi Township, Tanintharyi Region

Collection of specimens for taxonomic identification

Measuring stand structural attributes of the forests

Measuring stand structural attributes of the forests

Field survey team