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Tree Species Richness and Diversity of Community Forestry in Uttaradit Province, Thailand

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ABSTRACT

The purpose of this study was to explore the characteristics of the structure, species composition and species diversity in the community forest at Uttaradit province, Lower North of Thailand. The vertical stratification of the tree canopy can affect the growth of young trees on the ground surface, especially that of saplings and seedlings. Ground species can establish themselves very quickly when the light intensity is high enough and especially when the light can penetrate directly to the ground during gap formation. The data of tree individuals have served to give insight into the stand density, basal area, and frequency number of DBH class ranges. There were a large number of DBH class ranges, but there were low DBH values. The species composition of community forest is low, rich and diverse, but in high density. The comparison between community forest in this study and other forest is that tree density is higher than other forests but number of species is similar or lower. Importance value index (IVI) is used to determine the dominant trees in each plot. The result showed that dominant trees of Ban-Khum (BK) are *Tectona grandis*, *Dalbergia cultrate*, *Strychnosnux-blanda*, *Terminalia corticosa* and *Microcos paniculata*. While the dominant trees of Ban-Lao (BL) plot are *Aporosa villosa*, *Dipterocarpus obtusifolius*, *Terminalia corticosa*, *Cananga odorata* and *Heliciopsis terminalis*. The dominant trees of Khao-Sak (KS) plot are *Azadirachta indica*, *Parinaria namense, Ziziphus jujube*, *Feronia limonia* and *Senna siamea*, and the dominant trees of Huai-Kan-Leang (HKL) are *Parashorea stellate*, *Xyliaxylo carpa*, *Cananga odorata*, *Lagerstroemia tomentosa* and *Cananga latifolia*, respectively. The Fisher's, Shannon-Wiener's index and Simpson's index in these studies are found to be lower than other forests. The size class distribution of trees in secondary mixed deciduous forest is shown to be on L-shape curve, which is high abundance of small trees.

INTRODUCTION

It is accepted that the tropical forest ecosystems have a very high biodiversity. These ecosystems also have high gross production and rapid decomposition rate of organic matter. However, Thailand has only 26.6% forest area, and more than 70% of the forest is not protected, and much of the non-protected areas have less biodiversity than protected areas due to human disturbance, but they are very important to people in rural areas. In Thailand, the Royal Forestry Department reported that 0.46 million hectares of the forest land had been destroyed annually during the past three decades. The situation of forest degradation has also continuously increased even in the protected areas and species diversity of Thailand biodiversity is in danger.

Tropical forest ecosystem has a very high biodiversity that is accepted in the generalness. This ecosystem also has high gross production and rapid decomposition rate of organic matter. Studies of secondary forest regeneration in South-east Asia have been made in Peninsular Malaysia (Symington 1933, Wyatt-Smith 1955, Kochummen 1966), Thailand (Kunstadter et al. 1978), the Philippines (Kellman 1969) and East Kalimantan (Kartawinata et al. 1980). Some of these studies dealt with secondary succession after agricultural land use, while others used experimental manipulation to compare secondary forest recovery under a range of conditions.

Although Thailand has not yet passed formal legislation that recognizes community forestry, over 8,300 community forests have been registered with the Ministry of Natural Resources and Environment's (MONRE), Royal Forest Department (RFD) covering approximately 500,000 ha, and there are over 3,500 additional community forests in the pipeline for registration. However, a major area of contention surrounding community forestry in Thailand is the illegality of community use of forests in national parks, reserves and sanctuaries. This impacts approximately 2 million people dependent on forest resources in these areas.

The research focused on the three following questions:

1. What are the ecosystem structures of the community forestry in northern Thailand, 2. What are the dominant species of the trees, saplings and seedling groups in community forestry in northern Thailand, and 3. What are the ecosystem species compositions of the community forestry in northern Thailand. The special objective was to compare structural characteristics of other community forestry in Thailand. The three basic ecological characteristics of community forestry should provide valuable information for sustainable forest management planning in this region of the country.

MATERIALS AND METHODS

Study site: This study was carried out in the community forestry of Uttaradit province, northern Thailand, during 2014-2015. A total of four community forestry areas from Uttaradit province namely, Ban-Khum (BK) in Lab-Lare district, Ban-Lao (BL) in Tron district, Khao-Sak (KS) in Thong-Seangkun district and Huai-Kan-Leang (HKL) in Faktha district were selected for the sruvey.

Sample plots: Forest community data were collected from permanent plots in 100 × 100 m quadrat that were divided into 25 sub plots of 10 × 10 m. A vegetation census was used to collect data on forest structure and species composition.

Data collection: All trees were recorded at DBH > 4.5 cm in each plot of 10 × 10 m, with five random subplots of 4 × 4 m within this plot. Finally, all tree heights ≤ 1.30 m were measured in five randomly located plots of 1 × 1 m, while all trees in five plots of 4 × 4 m were recorded for trees DBH ≥ 4.5 cm and height < 1.30 m (seedling). Analysis gives precise measures of the floristic composition, species density, basal area and ecological characteristics.

Data analysis: The study on forest structure and floristic composition was carried out by adopting the quantitative ecological methods as follows:

1. ***Stratification*:** Vertical structure showing vertical stratification of each plot stand was examined by using crown depth diagram based on measurements of tree height (H) and first living branch height (HB). The relationships between H and HB were also used for supplementary analysis.
2. ***The importance value index (IVI)*:** The importance value index (IVI) of each sample plot was determined as follows: IVI = Relative density (%) + Relative frequency (%) + Relative dominance (%). The relative density was determined from all standing trees of DBH exceeding 4.5 cm in the sample of 50 × 50 m^2 in size. The relative frequency was determined for one hundred sub-plots (10 × 10 m^2 in size), which is set by regular subdividing in the plot of 50 × 50 m^2 in size. The relative dominance was obtained from the basal area at breast height, which was calculated as $\pi D^{2/4}$ of each tree in the sample plot.
3. ***Species diversity*:** Species diversity of all standing trees of DBH ≥ 4.5 cm in each sample plot was determined by using diversity indices as follows:

The Shannon-Wiener index of species diversity (H) (Shannon & Weaver 1949) was estimated by:

$$H = -\Sigma i=1^s \, pi \log_2 p_i \qquad ...(1)$$

Where, pi = proportion of the number of individuals of species *i* to the total v number of individuals of all species (*i* = 1,2,..,S), S = total number of species in the sample area, $\log_2$ = logarithm to the base 2.

Fisher's index of species diversity (α) (Fisher et al. 1943) was estimated by:

$$\alpha = N(1-x)/x \qquad ...(2)$$

Where, N = number of individuals in the sample area, α = the Fisher's index of diversity, x = constant value.

The Simpson's index of species diversity (D) (Simpson 1949, Pielou 1969) was estimated by:

$$D = 1-\Sigma_{i=1N} N_i (N_i-1)/(N(N-1)) \qquad ...(3)$$

Where, D = Simpson's index, N = total number of individuals of species.

***4. The richness indices (R1 and R2)*:** The richness indices were calculated in the form of richness index 1 (R1) (Margalef 1958) and richness index 2 (R2) or Menhinick's index (Menhinick 1964) as follows:

$$R\,1 = S-1/In(N) \qquad ...(4)$$

$$R\,2 = S/\sqrt{N} \qquad ...(5)$$

Where, S = total number of species, N = total number of individuals of all species, ln = natural logarithm.

The evenness index (E) (Pielou, 1969) is used:

$$E = H/H_{max} = H/\log_2 S \qquad ...(6)$$

Where, E = species evenness, H = Shannon-Wiener index of species diversity, H_{max} = maximum of Shannon-Wiener index of species diversity, S = total number of species, Log_2 = logarithm to the base 2.

The results of the study on quantitative ecological parameters were compared with this forest and similarly the difference to other forest types was discussed.

RESULTS AND DISCUSSION

Community composition and ecological status of community forest: The study areas are composed of different dry dipterocarp forests and mixed deciduous forests (Table

1). The selected community forest showed differences in terms of various forest structural attributes such as density, diversity, species richness and total basal cover.

The results showed that number of species in all the plots in the present study was nearly to other forests (Table 2). It is probable that the moisture content of soils in MEF and DEF in this comparison is higher than other forests in other sites. It is recognized that moisture is one of the important factors that control species composition of each forest; this result is also supported by Pongumpai (1976) and Glumphabutr et al. (2006). Number of species depends on soil moisture in the forest and it will increase as soil moisture gradient increases from dry dipterocarp forest to mixed deciduous forest, dry evergreen forest, hill evergreen forest towards the moist evergreen forest, respectively (Ogawa et al. 1965). Compared to other forests in Thailand, for example, moist evergreen forest at Khao Khitchakut National Park (Glumphabutr et al. 2006), dry evergreen forest at Khao Soi Dao Wildlife Sanctuary, (Glumphabutr et al. 2006), dry Dipterocarp forest at HuaiKhaKhaeng Wildlife Sactuary, (Srikansa & Gajaseni 1999), secondary dry Dipterocarp forest at Kalasin Forest area, (Kanzaki 1991), mixed deciduous forest at Huai Kha Khaeng Wildlife Sactuary, (Srikansa & Gajaseni 1999), KhaoKaset Forest area, (Khopai 2006), KhunKorn Waterfall Forest park, (Nukool 2002), ThungSalaengLuang National Park (Chattanong 2013), number of species in forest community BK and HKL is higher than dry dipterocarp forest in HuaiKhaKhaeng Wildlife Sanctuary, but lower than other forests.

Tree density: The density of trees with DBH ≥ 4.5 cm is given in Table 2. The community forest showed lower tree density than other forests, because it is abundant in small trees. Table 2 also shows the comparison of tree density in the present study plots with other forest types in various locations in Thailand. The KS showed higher tree density than BK, BL and HKL, because it is abundant with small trees.

Basal area: The percentage of basal area is also different among community forest and natural forest. Compared to other forest types in various sites (Table 2), it is clearly indicated that percentage of basal area of all present studied

Table 1: Geographical coordination of the study area.

Name	Location	Altitudes (m. ASL)	Forest types	Dominant species
Ban-Khum (BK) Lab-Lare district	N: 19°36'164" E: 59°93'35"	320	MDF	*Dipterocarpus obtusifolius*
Ban-Lao (BL)Tron district	N: 19°22'762" E: 62°06'29"	118	MDF	*Aporosa villosa*
Khao-Sak (KS)Thong-Seangkun district	N: 19°34'277" E: 65°63'89"	435	MDF	*Azadirachta indica*
Huai-Kan-Leang (HKL)Faktha district	N: 19°91'633" E: 71°36'54"	550	MDF	*Parashorea stellata*

*MDF is mixed deciduous forest

Table 2: Number of species, tree density and basal area of community forest and some forest types in Thailand, only trees with DBH ≥ 4.5 cm were included.

Land Use	Forest Types	Area	No. of species ($sp.ha^{-1}$)	Tree density ($tree.ha^{-1}$)	Basel area(%)	Source
Community Forest	MDF	BK	21	664	1.351	Present study
Community Forest	MDF	BL	10	286	0.599	Present study
Community Forest	MDF	KS	13	786	1.258	Present study
Community Forest	MDF	HKL	21	664	0.121	Present study
Natural Forest	SMDF	Thung SalaengLuang National Park	35	2,205	-	Podong et al. (2013)
Natural Forest	MDF	HuaiKhaKhaeng Wildlife Sactuary	21	780	-	Srikansa & Gajaseni (2000)
Natural Forest	MDF	KhaoKaset Forest area	33	959	-	Khophai (2006)
Natural Forest	MDF	KhunKorn Waterfall Forest park	62	358	0.358	Nukool (2002)
NaturalForest	DDF	HuaiKhaKhaeng Wildlife Sanctuary	14	720	-	Srikansa & Gajaseni (2000)
NaturalForest	SDDF	Kalasin Forest area	22	1,444	0.069	Kanzaki (1991)
NaturalForest	MEF	KhaoKhitchakut National Park	135	1,510	0.480	Glumphabutr et al. (2006)
NaturalForest	DEF	KhaoSoi Dao Wildlife Sanctuary	138	1,355	0.399	Glumphabutr et al. (2006)

plots is higher than all those forests. Actually, mixed deciduous forest is generally known as a very productive forest. In addition, compared to the mixed deciduous forest in other sites in Thailand (Table 1), the results show that the percentage of basal area of BK, BL, KS and HKL in present study is higher than those forests, while BL is lower due to the abundance of small trees in this forest.

Importance value index (IVI): The relative density, relative frequency, relative dominance and importance value index in each plot are shown in Table 3. The importance value index (IVI) is used to determine the dominant trees in each plot. The result showed that the dominant trees of BK are *Tectona grandis*, *Dalbergia cultrate*, *Strychnos nux-blanda*, *Terminalia corticosa* and *Microcos paniculata*. While the dominant trees of BL plot are *Aporosa villosa*, *Dipterocarpus obtusifolius*, *Terminalia corticosa*, *Cananga odorata* and *Heliciopsis terminalis*. The dominant trees of KS plot are *Azadirachta indica*, *Parinaria namense*, *Ziziphus jujube*, *Feronia limonia* and *Senna siamea*, and the dominant trees of HKL are *Parashorea stellate*, *Xyliaxylo carpa*, *Cananga odorata*, *Lagerstroemia tomentosa* and *Cananga latifolia*, respectively.

The IVI has been used for determining dominant species and its association in various forest communities by many ecologists such as Sahunalu & Dhanmanonda (1995), Bunyavejchewin (1983) etc.

Species diversity: Species diversity determined by Fisher's index (α), Shannon's index (H) and Simpson's index (D) in MEF, HEF and DEF is presented in Table 4. For most indices, there are differences between BK, BL, KS and HKL. Compared to natural forests, the Fisher's index in these study areas was found to be lower than other forests e.g., hill evergreen forest at Huay Nam Dang, Chiang Mai (Suksomut 1987), mixed deciduous forest at KhunKorn Waterfall, Chiang Rai (Nukool 2002), except mixed deciduous forest at Namprom Dam, Chai Yaphum (Handechnon 1990), moist evergreen forest at KhaoKhitchakut, Chantaburi (Glumphabutr et al. 2006), dry evergreen forest at KhaoSoi Dao, Chantaburi (Glumphabutr et al. 2006) and secondary mixed deciduous forest at ThungSalaeng Luang National Park, Phitsanulok (Podong 2013).

Richness indices are given in Table 4. These indices show proportion between number of species and tree density in each forest type. From the results, the richness index

Table 3: Relative density, relative frequency, relative dominance and important valueindex of trees (DBH ≥ 4.5 cm) in BK, BL, KS and HKL plot.

Plot	No	Scientific name	% Relative density	% Relative frequency	% Relative dominance	IVI (%)
BK	1	*Tectona grandis*	21.23	1.41	32.37	55.01
	2	*Dalbergia cultrate*	14.62	1.09	14.46	30.17
	3	*Strychnos nux-blanda*	9.94	0.66	6.02	16.62
	4	*Terminalia corticosa*	8.28	0.55	6.20	15.03
	5	*Microcos paniculata*	6.48	0.43	3.91	10.82
		Other species	39.45	95.86	37.04	172.35
		Total	100	100	100	300
BL	1	*Aporosa villosa*	33.08	2.60	34.26	69.94
	2	*Dipterocarpus obtusifolius*	24.43	1.92	25.30	51.65
	3	*Terminalia corticosa*	12.98	1.02	13.44	27.44
	4	*Cananga odorata*	6.11	0.48	6.32	12.91
	5	*Heliciopsis terminalis*	5.85	0.46	6.06	12.37
		Other species	17.55	93.52	14.62	125.69
		Total	100	100	100	300
KS	1	*Azadirachta indica*	53.15	1.52	40.10	94.77
	2	*Parinaria namense*	23.78	0.68	39.68	64.14
	3	*Ziziphus jujube*	5.59	0.16	3.85	9.60
	4	*Feronia limonia*	3.50	0.10	3.91	7.51
	5	*Senna siamea*	4.20	0.12	3.17	7.49
		Other species	9.78	97.42	9.29	116.49
		Total	100	100	100	300
HKL	1	*Parashorea stellata*	15.09	0.80	12.45	28.34
	2	*Xyliaxylo carpa*	15.09	0.80	9.10	24.99
	3	*Cananga odorata*	7.55	0.40	16.55	24.50
	4	*Lagerstroemia tomentosa*	7.55	0.40	6.02	13.97
	5	*Cananga latifolia*	7.55	0.40	4.29	12.24
		Other species	47.17	97.20	51.59	195.96
		Total	100	100	100	300

in these study areas was found to be lower than other forests, except mixed deciduous forest at Namprom Dam, Chai Yaphum (Handechnon 1990). Distribution of individuals among species is called species evenness. Evenness is maximum when all species have the same number of individuals and decrease in the species diverges away from the evenness. The E index is one of the evenness index. There is not much difference among the other forests. Their evenness indices are moderately high. Actually, the Shannon-Wiener's index and Simpson's index are a product of richness and evenness. Species richness is weighted by species evenness, and formulae are available, which permit the diversity to be estimated (Barbour et al. 1980). Shannon-Weiner's index and Simpson's index of species diversity are composed of two components. The first is the number of species in the community, which is called species richness. The second component is species evenness or equitability. Evenness refers to how the species abundance is distributed among the species (Ludwig & Reynolds 1988). If the relative abundance was assumed to be linearly related to the significance for the system (Pielou 1969), for this study, Simpson (1949) proposed a useful method for diversity measurement. The Simpson's index of diversity gives very little weight to rare species, while Shannon-Wiener's index is most sensitive to rare species (Barbour et al. 1980).

DBH class distribution: Size class distributions of trees with DBH larger than 4.5 cm are typical of natural regeneration, with high stem counts in the smaller size classes. Actually, the reverse J-shape or L-shape is shown as balance maintenance. This trend was usually shown in various primary forests in Thailand (Glumphabutr et al. 2006). However, some forest types did not show L-shape that its trend showed very few numbers of small size classes due to poor natural regeneration and survival rate. In addition, there was dense bamboo on the ground floor, which affected to the germination and generation of trees (Sahunalu et al. 1995).

In present study, diameter distribution of trees with DBH larger than 4.5 cm this plot. This trend is in L-shape. In community forest frequency of trees in this DBH size class is large, from 6 cm and gradually decreases relatively to DBH class increasing. However, this is rather high density in small size class, and has very little number of large trees in SMDF and this trend also shown reverse J-shape or L-shape but the biggest tree is less than 90 cm in DBH. This outcome indicated that some limiting factors such as soil, topography play an important role on the tree growth.

CONCLUSION

The purpose of this study was to explore the characteristic of structure, species composition and species diversity in community forestry at Uttaradit province, northern Thailand. The species composition of forest community has low richness and diversity, but has high density. The comparison between community forest of this study and other forests shows that tree density is higher than other forests but number of species is similarity or lower. Species diversity compared to other forests indicates that The Fisher's, Shannon-Wiener's index and Simpson's index in these studies were lower than the other forests. Assessment of diversity status is important for their sustainable utilization, manage-

Table 4: Species diversity indices in the various forest types of Thailand.

Forest	Land Use	Diversity index			Richness index		Evenness	Source
		Fisher (α)	Shannon (H)	Simpson (D)	R_1	R_2	(E)	
MDF, BK	Community Forest	3.501	1.134	0.125	1.870	0.528	0.545	Present study
MDF, BL	Community Forest	3.625	0.592	0.199	1.800	0.4637	0.285	Present study
MDF, KS	Community Forest	2.862	0.832	0.345	1.591	0.5913	0.400	Present study
MDF, HKL	Community Forest	4.032	1.087	0.108	2.73	1.761	0.523	Present study
SMDF, ThungSalaengLuang National Park, Phitsanulok	Secondary Natural Forest	8.051	2.078	0.726	4.466	0.778	0.627	Podong et al. (2013)
MDF, HuaiKhaKhaeng Wildlife Sactuary, Uthaitani	Natural Forest	9.573	4.280	0.959	5.940	1.688	0.815	Suksomut (1987)
MDF, KhaoKaset Forest area, Chonburi	Natural Forest							
MDF, KhunKorn Waterfall Forest park, Chiangrai	Natural Forest	14.540	3.578	0.817	7.274	2.741	0.671	Nukool (2002)
MDF, Namprom Dam, Chaiyaphum	Natural Forest	8.007	3.466	0.916	3.574	2.271	0.912	Handechnon (1990)
MEF, KhaoKhitchakut National Park	Natural Forest	35.864	3.978	0.961	18.306	3.474	0.811	Glumphabutr et al. (2006)
DEF, KhaoSoi Dao Wildlife Sanctuary	Natural Forest	38.460	4.093	0.974	18.997	3.749	0.831	Glumphabutr et al. (2006)

ment and conservation. In this study, the overall population structure of tree species was highest followed by saplings and adult trees. It shows that the overall generation status of tree species in the study area is “good” and the future community forest may be sustained unless there is any major environmental stress or interference exerted by human activities.

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