Diversity and Uses of Tree Species in the Deciduous Dipterocarp Forest, Mae Chaem District, Chiang Mai Province, Northern Thailand

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Abstract

This paper presents a study of tree species diversity of deciduous dipterocarp forest (DDF) in Mae Chaem District, Chiang Mai Province, northern Thailand and a review of traditional uses. The tree species diversity (diameter at breast height, DBH $\geq$ 5.0 cm) was surveyed in a 1-ha plot. We found 1,572 individuals, belonging to 25 tree species (23 genera and 18 families). *Dipterocarpus tuberculatus*, *Shorea obtusa* and *Gluta usitata* were the most dominant species in the forest. Trees generally showed high abundance in a small size class (DBH $\leq$ 10 cm), indicating a high potential for regeneration processes after past disturbances. The review of traditional knowledge on uses revealed that most species can be used for different purposes, depending on species and culture. In conclusion, conserving this DDF should focus on maintaining tree species diversity by preventing severe fire and unsustainable uses.

Keywords: Deciduous dipterocarp forest, Disturbances, Diversity, Forest regeneration, Traditional uses

Introduction

The deciduous dipterocarp forest (DDF) is one of the main dry forest types in Southeast Asia. It occurs in areas with restricted rainfall and a pronounced dry season (Rundel & Boonpragob, 1995; Bunyavejchewin, Baker, & Davies, 2011). In Thailand, DDF covers 18,569.5 km^2 or about 11% of the total forest area, distributed mostly in the northern region (Royal Forest Department, 2003). It was once recorded to be the most extensive forest type, covering about 45% of the total forest area (Rundel & Boonpragob, 1995). DDF is found in dry areas in the lowlands up to 900 m above sea level, with the annual rainfall between 1,000 - 1,500 mm, where soils are acidic, shallow, sandy and lateritic (Bunyavejchewin et al., 2011). This forest type is characterized by open canopy and abundance of grasses and herbs in the ground layer. Dominant tree species are in Dipterocarpaceae, including *Shorea obtusa*, *S. siamensis*, *Dipterocarpus tuberculatus* and *D. obtusifolius* (Rundel & Boonpragob, 1995; Gardner, Sidisunthorn, & Anusarnsunthorn, 2000; Bunyavejchewin et al., 2011). Most of the trees in DDF are deciduous and are shedding their leaves during the dry season. Leaves litter, together with the dry grass layer provide available surface fuel. Surface fires are a predominant characteristic and play an important role in maintaining species composition, forest structure and regeneration of DDF (Stott, Goldammer, & Werner, 1990; Himmapan & Kaitpraneet, 2008). Although, the dry forests are considered to be less species-rich than wet forests, they contain species that do not occur in other forest types (Elliott, Blakesley, & Hardwick, 2013). Tree species in dry forests normally do not share many species with wet forests (Murphy & Lugo, 1986), and even among dry forest types the variation in species composition is large (Lamotte, Gajaseni, & Malaisse, 1998). Hence, conserving the dry forests will conserve an ecosystem, suitable for species that match them.

Traditionally, DDF plays a direct role in providing construction materials, food, medicinal plants, fuel, resins and oils, dyeing and tanning materials and food for animals (Forest Herbarium, 2009). Therefore, it

contributes significantly to rural livelihoods. However, DDF in Thailand, especially in the northern region has a long history in facing problems with deforestation, especially for logging, chopping for fire wood, cattle browsing and frequent and severe burning (Forest Restoration Research Unit (FORRU), 2006; Marod & Kuntintara, 2009; Elliott et al., 2013). Most of the remaining forests in the region experience human disturbances, and many of these leave the forest in the form of small and fragmented patches of varying sizes (Wohlfart, Wegmann, & Leimgruber, 2014). Still, disturbed forests, changed in structure, may contain rare species and qualities that may be worth conserving, and patches could potentially maintain connectivity within the landscape. Moreover, the forests in many places benefit local people in their utilization of non-timber forest products (NTFPs), for food and medicinal plants, etc. In the efforts to educate future generations in nature conservation and sustainable use of NTFPs, the patches of DDF, can play an important role. Although, there are many studies on forest structure, species diversity and composition of DDF (e.g. Lamotte et al., 1998; Sahunalu, 2009; Bunyavejchewin et al., 2011), few studies combine this with traditional knowledge and use of the tree species found in DDF. This paper aims to clarify the tree species diversity of DDF in Mae Chaem District, Chiang Mai Province, northern Thailand and a review of traditional uses of the species, in order to build the knowledge for conservation and to contribute in educational efforts in societies with DDF remnants.

Methods and Materials

Study area

This study was conducted during 2011 – 2012 at the Somdej Ya Learning Community Demonstration School (18° 30′ N, 98° 23′ E), Mae Chaem District, Chiang Mai Province in northern Thailand. The terrain is mostly foothills and mountain ridges. The school is located on a slope, at 705 m above sea level. It comprises an area of DDF, approximately 108 rai (0.17 km^2) which is used by the school as a "nature classroom" and by local people for collecting NTFPs. The forest was severely disturbed by cutting of big trees for building houses, when people colonized the area about 30 years ago. The previous disturbances also included cattle grazing and cutting of trees for firewood. Fires during the dry season (February-April) are common. The annual rainfall in the district recorded in 2010 was 1,145 mm. The average temperature was 27.5 °C.

Tree sampling and data analysis

A permanent plot of one-hectare (100 m × 100 m) was established in the DDF for long-term monitoring of the vegetation. The edge effect was minimized by placing the plot at least 50 m from the forest edge. The plot was then divided into plots of 20 m × 20 m. Within these smaller plots, all trees $\geq$ 5.0 cm DBH (diameter at breast height) were counted, tagged and identified to species level. The DBH of each tree was measured with a diameter tape. Materials (leaves, flowers and fruits) from all tree species were collected as voucher specimens for species identification, compared with specimens in Herbarium of Department of Biology, Faculty of Science at Chiang Mai University. Scientific names follow The Plant List (http://www.theplantlist.org/) and Tem Smitinand's Thai plant names (Pooma & Suddee, (eds.), 2014). Quantitative data of tree abundance and species richness, density and basal area were calculated. DBH of tree species in the forest was divided into 10 cm size classes.

Review of traditional knowledge on uses of the tree species

Information on traditional uses of the species was gathered by searching on online databases (incl. Web of Science). We searched with scientific names, uses, ethnobotany and medicinal plants as the keywords. Publications in English with relevant content, including data from Asian countries, were considered.

Results

Tree species richness, density and size class distribution

In total, 1,572 individuals belonging to 25 tree species (23 genera and 18 families) were found within the 1-ha permanent plot in the DDF. Fagaceae contributed the highest number of species (n = 3), followed by Anacardiaceae, Combretaceae, Dipterocarpaceae, Myrtaceae and Rubiaceae (n = 2). The other 12 families contributed only with one species each. Of 1,572 individuals, *Dipterocarpus tuberculatus* accounted for the highest number of individuals (*n* = 866, 55.09%), followed by *Shorea obtusa* (*n* = 310, 19.72%) and *Gluta usitata* (*n* = 151, 9.61%). The tree basal area in the forest was 17.677 m^2/ha, and *D. tuberculatus* covered alone 11.064 m^2/ha (62.59%), followed by *G. usitata* (3.081 m^2/ha) and *S. obtusa* (1.313 m^2/ha), respectively (Table 1).

Table 1 Density and basal area of tree species in the deciduous dipterocarp forest at the Somdej Ya Learning Community Demonstration School, Mae Chaem District, Chiang Mai Province, Thailand

No.	Scientific name	Family	Density (no./ha)	Basal area (m^2/ha)
1	*Anneslea fragrans* Wall.	Pentaphylacaceae	30	0.271
2	*Bridelia retusa* (L.) A. Juss.	Phyllanthaceae	4	0.015
3	*Buchanania cochinchinensis* (Lour.) M. R. Almeida	Anacardiaceae	2	0.029
4	*Catunaregam spathulifolia* Tirveng.	Rubiaceae	1	0.002
5	*Cratoxylum cochinchinense* (Lour.) Blume	Hypericaceae	9	0.048
6	*Dalbergia oliveri* Prain	Fabaceae	17	0.085
7	*Dillenia aurea* Sm.	Dilleniaceae	36	0.284
8	*Dipterocarpus tuberculatus* Roxb.	Dipterocarpaceae	866	11.064
9	*Gluta usitata* (Wall.) Ding Hou	Anacardiaceae	151	3.081
10	*Lithocarpus polystachyus* (Wall. ex A. DC.) Rehder	Fagaceae	2	0.011
11	*Lophopetalum wallichii* Kurz	Celastraceae	1	0.003
12	*Memecylon scutellatum* (Lour.) Hook. & Arn. var. *scutellatum*	Melastomataceae	1	0.003
13	*Myrsine seguinii* H. Lév.	Primulaceae	1	0.003
14	*Palaquium garrettii* Fletcher	Sapotaceae	1	0.012
15	*Quercus brandisiana* Kurz	Fagaceae	4	0.015
16	*Quercus kerrii* Craib	Fagaceae	19	0.403
17	*Schleichera oleosa* (Lour.) Merr.	Sapindaceae	6	0.136
18	*Shorea obtusa* Wall. ex Blume	Dipterocarpaceae	310	1.313
19	*Strychnos nux-blanda* A. W. Hill	Loganiaceae	11	0.052
20	*Syzygium cumini* (L.) Skeels	Myrtaceae	16	0.088
21	*Terminalia alata* B. Heyne ex Roth	Combretaceae	1	0.004
22	*Terminalia chebula* Retz. var. *chebula*	Combretaceae	5	0.052
23	*Tristaniopsis burmanica* (Griff.) Peter G. Wilson & J. T. Waterh. var. *rufescens* (Hance) J. Parn. & NicLugh.	Myrtaceae	51	0.621
24	*Walsura trichostemon* Miq.	Meliaceae	2	0.008
25	*Wendlandia tinctoria* (Roxb.) DC.	Rubiaceae	25	0.074
	Total		1,572	17.677

The diameter size class distribution of dominant tree species in terms of density and basal area, and all trees in the forest are presented in Figure 1. In this study, size classes were defined as: small (DBH ≤ 10 cm), medium (DBH 10.1 -30 cm) and large (DBH 30.1-50 cm). *D. tuberculatus* had higher number of stems in the small size class than the medium and large size classes, respectively (Figure 1 a). This was the same pattern as for all tree species combined (Figure 1 d). *S. obtusa* had higher number of individuals in the small size class than in the medium class, and it had no stems in the large size class (Figure 1 b). *G. usitata* had higher stems in the medium size class than in the small and the large size classes, respectively (Figure 1 c).

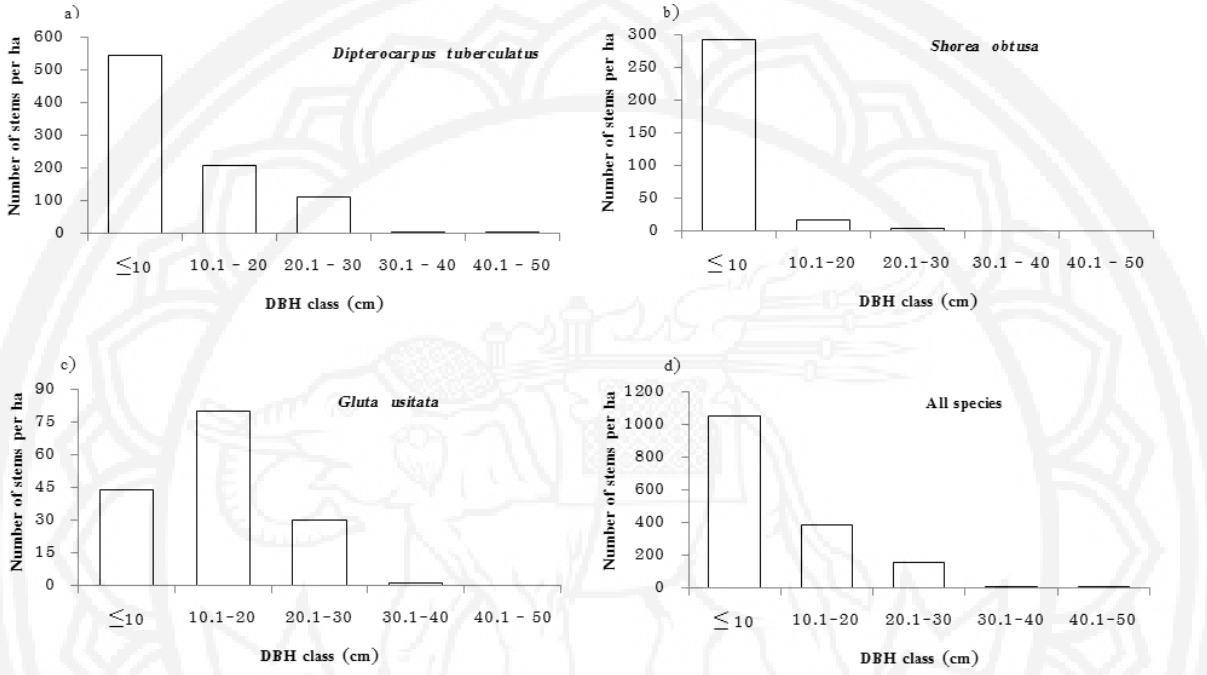

Figure 1 Diameter size class distributions of a) *Dipterocarpus tuberculatus* b) *Shorea obtusa* c) *Gluta usitata* and d) all tree species

Traditional knowledge on uses of the tree species

Gathered information from Asia show that, 24 of 25 tree species found in this study represent a broad spectrum of traditional uses. The obvious uses are as wood for fires, construction materials (incl. music instruments) and charcoal, and other plant parts for tanning, dyeing, detergents, food sources and many medicinal remedies (Table 2). Twenty two tree species have medicinal value for treating various ailments (Appendix 1).

Table 2 Review of traditional knowledge on uses of the tree species found in the deciduous dipterocarp forest, Mae Chaem District, Chiang Mai Province, Thailand

Scientific species/ Family	Main uses	Tribe/Country	References
Anneslea fragrans Wall. (Pentaphylacaceae)	Fencing, firewood and food	Lawa, Thailand	Schmidt-Vogt, 2001
	Dyeing red color Timber	Karen, Thailand Lawa, Thailand	Wangpakapattanawong, Kavinchan, Vaidhayakarn, Schmidt-Vogt & Elliot, 2010
	Medicine*	Tai Yai, Thailand	Khuankaew, Srithi, Tiansawat, Jampeetong, Inta, & Wangpakapattanawong, 2014

Table 2 (Cont.)

Scientific species/ Family	Main uses	Tribe/Country	References
Bridelia retusa (L.) A. Juss. (Phyllanthaceae)	Firewood and fencing	Champasak , Lao PDR	Natuhara, Imanishi, Kanzaki, Southavong, & Duangvongsa, 2012
	Medicine*	Tai Yai, Thailand	Khuankaew et al., 2014
	Food (fruits)	Odisha, India	Nayak & Basak, 2015
Buchanania cochinchinensis (Lour.) M. R. Almeida (Anacardiaceae)	Medicine*	India	Puri et al., 2000; Kala, 2009; Malik, Chaudhury, Panwar, Dhariwal, Choudhary, & Kumar, 2012
	Oil and food (kernels from seeds/nuts)	India	Kumar, Vengaiah, Srivastav, & Bhowmick, 2012
	Food (fresh ripen fruits, seed kernels and oil)	India	Malik et al., 2012
Catunaregam spathulifolia Tirveng. (Rubiaceae)	Leech repellent (fruit exocarps)	Lao PDR	Vongsombath, de Boer, & Pålsson, 2011
	Detergent, leech repellent (fruits) and medicine*	Ethnic groups in Annamite Mountains, Lao PDR	de Boer, Lamxay, & Björk, 2012
	Medicine*	Songkhla, Yuan and Karen, Thailand	Neamsuvan, Singdam, Yingcharoen, & Sengnon, 2012; Inta, Trisonthi, & Trisonthi, 2013; Junsongduang, Balslev, Inta, Jampeetong, & Wangpakapattanawong, 2014
Cratoxylum cochinchinense (Lour.) Blume (Hypericaceae)	Medicine*	Lahu, Thailand	Anderson, 1993
	Vegetable (leaves)	Lawa, Thailand	Schmidt-Vogt, 2001
	Black teeth	Perak, Malaysia	Zumbroich, 2009
	Vegetable and fencing	Champasak, Lao PDR	Natuhara et al., 2012
Dalbergia oliveri Prain (Fabaceae)	Traditional musical instrument, Ranad (wood)	Thailand	Rujinirun, Phinyocheep, Prachyabrued, & Laemsak, 2005
	Medicine*	Tai Yai, Thailand	Khuankaew et al., 2014
Dipterocarpus tuberculatus Roxb. (Dipterocarpaceae)	Resin (stem), leather tanning (bark, leaves) and medicine*	Countries in Southeast Asia	Shiva & Jantan, 1998
	Timber, resin and charcoal	Central, Lao PDR	Kosaka, Takeda, Sithirajvongsa & Xaydala, 2006
Gluta usitata (Wall.) Ding Hou (Anacardiaceae)	Burmese lacquer, furniture and umbrella handles, firewood (resinous sap and wood) and medicine*	Thailand	Elliott et al., 1997
Lithocarpus polystachyus (Wall. ex A. DC.) Rehder (Fagaceae)	Medicine*	Akha and Tai Yai, Thailand	Anderson, 1993; Khuankaew et al., 2014
	Food (fruits)	Karen, Thailand	Wangpakapattanawong et al., 2010

Table 2 (Cont.)

Scientific species/ Family	Main uses	Tribe/Country	References
Lophopetalum wallichii Kurz (Celastraceae)	Food (leaves)	Central, Lao PDR	Kosaka et al., 2006
	Timber	Champasak, Lao PDR	Natuhara et al., 2012
	Medicine*	Northern, Thailand	Inta et al., 2013
	Cosmetic use, baldness treatment	India	Narayanaswamy & Ismael, 2015
Memecylon scutellatum (Lour.) Hook. & Arn. var. *scutellatum* (Melastomataceae)	Mordant in silk dyeing (dried leaves)	North Eastern, Thailand	Kongkachuichay, Shitangkoon, & Chinwongamorn, 2002
	Black teeth (tar of stem)	Central highlands, Vietnam	Zumbroich, 2009
Myrsine seguinii H. Lév. (Primulaceae)	Firewood	Karen and Lawa, Thailand	Wangpakapattanawong et al., 2010
	Medicine*	Myanmar and Japan	Yang et al., 2014
Palaquium garrettii Fletcher (Sapotaceae)	Medicine*	Temuan Aborigins of Malaysia	Islam, Sulaiman, Kapitonova, & Jamallullail, 2007
Quercus brandisiana Kurz (Fagaceae)	Firewood	Xieng Khouang, Lao PDR	Lehmann, Greijmans, & Shenman, 2003
Quercus kerrii Craib (Fagaceae)	Firewood	Xieng Khouang, Lao PDR	Lehmann et al., 2003
	Medicine*	Tai Yai, Thailand	Khuankaew et al., 2014
Schleichera oleosa (Lour.) Merr. (Sapindaceae)	Medicine*	Lombok	Hadi & Bremner, 2001
	Food (fruits)	Thailand and Champasak, Lao PDR	Gardner et al., 2000; Kosaka et al., 2006, Natuhara et al., 2012; Cruz-Garcia & Price, 2011
	Against ticks (seeds)	Lao PDR	de Boer, Vongsombath, Pålsson, Bjørk, & Jaenson, (2010).
Shorea obtusa Wall. ex Blume (Dipterocarpaceae)	Medicine*	Akha and Tai Yai in Northern, Thailand	Anderson, 1993; Inta et al., 2013; Khuankaew et al., 2014
	White resin and host for lac insect	Burma and countries in Southeast Asia	Shiva & Jantan, 1998
	Timber and food	Lawa, Thailand	Schmidt-Vogt, 2001
	Timber, resin and soil improvement (leaves)	Central, Lao PDR	Kosaka et al., 2006
	Timber, resin	Champasak, Lao PDR	Natuhara et al., 2012
Strychnos nux-blanda A.W. Hill (Loganiaceae)	Medicine*	Petchabun, Yasothon and Northern, Thailand	Chuakul, 2000, Chuakul, Saralamp, & Boonpleng, 2002; Inta et al., 2013

Table 2 (Cont.)

Scientific species/ Family	Main uses	Tribe/Country	References
Syzygium cumini (L.) Skeels (Myrtaceae)	Vinegar, wine and juice (fruits) fodder, food for silkworms (leaves) and timber	India and Philippines	Morton, 1987
	Medicine*	Lahu, Karen and Tai Yai, Thailand	Anderson, 1993, Junsongduang et al., 2014; Khuankaew et al., 2014
	Food (fruits)	Champasak, Lao PDR, and Kalasin, Thailand	Cruz-Garcia & Price, 2011; Natuhara, et al., 2012
Terminalia alata B. Heyne ex Roth (Combretaceae)	Medicine*	Nepal, Lao PDR and TaiYai, Thailand	Taylor, 1996; Kosaka et al., 2006; Natuhara et al., 2012; Khuankaew et al., 2014
	Charcoal, timber and soil improvement (leaves)	Central, Lao PDR	Kosaka et al., 2006
	Pole and timber	Champasak, Lao PDR	Natuhara et al., 2012
Terminalia chebula Retz. var. *chebula* (Combretaceae)	Medicine*	Lisu in Yunnan, China, and Karen, Lawa, Tai Yai, Thailand	Ji, Shengji, & Chunlin, 2004, Junsongduang et al., 2014; Khuankaew et al., 2014
	Food (fruits) and medicine*	Champasak, Lao PDR	Natuhara, et al., 2012
	Tanning and dyeing (fruits)	India	Onial et al., 2015
Tristaniopsis burmanica (Griff.) Peter G. Wilson & J. T. Waterh. var. *rufescens* (Hance) J. Parn. & NicLugh. (Myrtaceae)	Medicine*	Kutchum, Yasothon, Thailand	Chuakul et al., 2002
	Vegetable and medicine*	Champasak, Lao PDR	Natuhara et al., 2012
Walsura trichostemon Miq. (Meliaceae)	Medicine*	Thailand	Sichaem, Aree, Khumkratok, Jong-aramruang, & Tip-pyang, 2012
Wendlandia tinctoria (Roxb.) DC. (Rubiaceae)	Vegetables (inflorescences) and medicine*	Manipur, India	Khumbongmayum, Khan, & Tripathi, 2005
	Food	Lawa, Thailand	Schmidt-Vogt, 2007
	Medicine*	Tai Yai and Northern, Thailand	Inta et al., 2013; Khuankaew et al., 2014

*Appendix 1 Details on the medicinal uses of the tree species

Discussion and Conclusions

Compared with the DDF in Sakaerat Reserve, Nakhon Ratchasima, where the species richness of trees (DBH $\geq$ 5.0 cm) were 37 species and the stem density was 602 stems/ha (Lamotte et al., 1998), the DDF in Mae Chaem district, Chiang Mai had relatively high density (1,572 stems/ha), but low species

richness (25 species). *D. tuberculatus* contributed to the very high proportion of the total number of stems and basal area in the forest. This species is commonly found in DDF, but it tends to be very dominant in degraded forests, especially along ridge crests (Forest Restoration Research Unit (FORRU), 2006). The species was also listed by The Royal Forest Department of Thailand (RFD) as the most abundant forest tree in Chiang Mai (Gardner et al., 2000). The dominant tree species in this study, *D. tuberculatus*, *S. obtusa* and *G. usitata*, are similar to the dominant tree species found in the DDF with annual fires in Mae Taeng, Chiang Mai (Wattanasuksakul, Khamyong, Sri-ngernyuang, & Anongrak, 2012). These dominant species are very common in dry open and degraded areas (Gardner et al., 2000), and *G. usitata* is common in fire-prone DDF in northern, Thailand (Elliott et al., 1997; Gardner et al., 2000). Three tree species in Fagaceae; *Lithocarpus polystachyus*, *Quercus brandisiana* and *Q. kerrii*, were found in the DDF. The members in this family, especially *Quercus* and *Castanopsis* are abundant in slightly fire-damaged areas. However, where the fires are frequent, they may be rare or absent (Gardner et al., 2000; Forest Restoration Research Unit (FORRU), 2006). Diameter size class distributions of tree species in the DDF generally showed a high abundance of relatively small trees, with DBH below or equal to 10 cm. This pattern indicated a high potential for regeneration processes after past disturbances. However, *D. tuberculatus* and *S. obtusa* showed a high contribution to this regeneration pattern, indicating that they will continue to dominate in this forest. This may be because the two dipterocarp species are well adapted to fire and drought (Scott, Goldammer & Werner, 1990; Wanthongchai, Bauhus, & Goldammer, 2014). Scott (1986) showed that *S. obtusa* seedlings recovered well after low-intensity fires. Moreover, the dipterocarp species in the DDF generally disperse their fruits during the dry season after a peak period of fire (Sukwong, Dhamanitayakul, & Pongumphai, 1975), and that burning of the forest floor could facilitate the germination of seeds in the coming rainy season.

People living around the forest and students in the Somdej Ya Learning Community Demonstration School benefited from the DDF for firewood, and as food source from mushrooms, insects and oak fruits. Leaves of *D. tuberculosis* were very commonly used for thatching, and resin was used for torches (personal observations by authors). *G. usitata* is well known for its resinous sap, producing lacquer for traditional Thai crafting (Chayamarit, 2007). The review on traditional knowledge on uses of the tree species revealed that most tree species have been and can be used for different purposes. *Terminalia chebula*, often reported used in traditional medicinal remedies, is also used in modern healthcare (Chotchoungchatchai, Saralamp, Jenjittikul, Pornsiripongse, & Prathanturarug, 2012). Although, this study does not investigate the present situation concerning knowledge of traditional use of plants in Mae Chaem area, it is clear that the traditional knowledge systems for use of medicinal plants are still present here (Junsongduang et al., 2013, 2014). It is also worth mentioning that the knowledge of medicinal plants is important in modern healthcare in the Thai Traditional Medicine (TTM) (Chotchoungchatchai et al., 2012). At the same time, modernization and the formal education system cause local knowledge erosion (Wester & Yongvanit, 1995). Conserving forest areas, maintaining the traditional knowledge and building new knowledge about uses of the species, could potentially contribute to sustainable development. Medicinal plant knowledge appears to evolve continually by trial and error (de Boer et al., 2012), but since the modernization of the society leads to young people leaving the villages, the continuity in development and transfer of knowledge between the generations is broken. New ways of knowledge transfer should be considered, such as including knowledge of forest

species, traditional and new knowledge, in local school curriculums.

Although, the DDF in Mae Chaem was previously disturbed, the forest clearly showed a high potential for regeneration processes, and contained useful tree species. Thus, management of this forest may need to put efforts on maintaining tree species diversity by control severe fires, together with ensuring sustainable uses as key success factors.

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