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SAVING A FOREST: THE COMPOSITION AND STRUCTURE OF A DECIDUOUS FOREST UNDER COMMUNITY MANAGEMENT IN NORTHEAST THAILAND

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ABSTRACT

This study investigated the composition and structure of a 560-ha deciduous forest in Northeast Thailand that has been under community protection and management since the 1980s. The site had a long history of timber harvesting for local and regional needs until the 1970s, with strict protection against tree cutting beginning in the late 1980s. We established 31 temporary circular plots in the forest to sample trees 10 cm diameter (dbh) (0.97 ha), saplings 2.5–9.9 cm dbh (0.09 ha), seedlings 2.5 cm dbh (0.01 ha), and vines/woody climbers. We recorded 97 species in 48 families. *Sindora siamensis* var. *siamensis, Xylia xylocarpa* var. *kerrii, Erythrophloeum succirubrum,* and *Bauhinia saccocalyx* were the most important species in this forest, and accounted for about 92% of all recorded stems 2.5 cm dbh. Leguminosae, Papilionoideae was the most abundant family in this forest. Species composition and stand structure reflected the forest's degraded condition from persistent disturbances. However, the forest appeared to be regenerating and the villagers had been able to harvest several non-timber forest products to supplement their livelihoods. We compared species composition and forest structure of Khok Bung Preu forest with other similar forests types in Thailand. Khok Bung Preu was less diverse than forests under protection management in Thailand. Without the initiative of the community leaders, the existing forest would have been converted to agriculture in the 1970s. As a result, Khok Bung Preu forest contains a fairly diverse flora and apparently regenerating tree community. Yet persistent disturbances and rarity of several species, combined with the isolation of this fragment, indicate that proactive management should be implemented. Protection against encroachment, illicit felling, charcoal making, setting fire, grazing, and hunting wildlife should assist natural succession of the forest. Moreover, regeneration can be facilitated by planting indigenous tree species attractive to wildlife, and by protecting seed dispersal agents, particularly frugivorous birds and bats. Long-term monitoring is needed to demonstrate both the trajectory and rate of forest recovery or degradation, and the effects of village users on forest condition.

Key words: Community forestry, disturbances, diversity, remnant forest, structure, Thailand

INTRODUCTION

Forest cover in Thailand has decreased substantially during the last 30 years due to heavy commercial logging of trees followed by large-scale conversion of forest land to non-forest uses. Forest cover in Thailand has decreased from 53% in 1961 to 23% in 1995 (FAO, 1999) and 17% by 1999 (PRAYURASIDDHI *ET AL.*, 1999), which may have resulted

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in greatly reduced forest biodiversity. In particular, the northeast region of Thailand has undergone almost total conversion between 1960 and 1990 (WESTER & YONGVANIT, 2005), from primarily deciduous forest cover to agriculture interspersed with degraded forest patches.

Conservation of biological diversity in Thailand requires not only protected area conservation, but also efforts to restore and preserve remaining forests outside protected areas (VANDERGEEST, 1996; WITTAYAPAK & DEARDEN, 1999; JOHNSON & FORSYTH, 2002). Local level community-based forest management (CBFM) is seen as one possible strategy for forest conservation, as local communities can contribute to conservation under the appropriate conditions, and when certain levels of control are vested to them (OSTROM, 1990; THAPA, 1998; WEBB & KHURSHID, 2000; WEBB & GAUTAM, 2001). Traditional or informal (i.e., not state-sanctioned) CBFM is widespread throughout Asia (ASCHER, 1995; POFFENBERGER, 1999) and formalized community forestry programs are gaining popularity in several Asian countries (e.g., FISHER, 1989; GLIMOUR, 1990; BARTLETT, 1992; VANDERGEEST, 1996; ARNOLD, 1998; POFFENBERGER, 1999; WITTAYAPAK & DEARDEN, 1999; CHAUDHARY, 2000; SATO, 2000; WEBB & GAUTAM, 2001; DELANG, 2002; JOHNSON & FORSYTH, 2002; VANDERGEEST, 2003).

In Thailand, community management of forests occurs outside protected areas, although often the efforts of communities to protect or claim forests for their use has led to confrontation, conflict, and in some cases violence (MATSUMURA, 1994; POFFENBERGER, 1999; WITTAYAPAK, 2002). Moreover, there has been wide publicity and controversy surrounding the proposed Thai Community Forestry Bill since the early 1990s (POFFENBERGER, 1999), which has been under discussion and revision by a series of national governments, yet has failed to pass through parliament.

In order to evaluate whether CBFM can serve as a significant conservation tool in Thailand, researchers need to investigate the impacts of CBFM on forest composition and structure. Given the high diversity of forest types, biogeography, cultures, landscapes, and community management objectives in Thailand, the most reliable approach to understanding CBFM's potential contribution to conservation is through case studies and site-specific investigation. To date, there has been very little scientific investigation on the composition and structure of community managed forests in Thailand (but see KIJTEWACHAKUL *ET AL.*, 2004).

This study investigated the vegetation composition and structure in a community-managed forest in Northeast Thailand. Khok Bung Preu, a remnant community-protected forest in Nakhon Ratchasima Province, is an important component of the livelihoods of several villages that access and manage it. It is a well-publicized forest in Thailand because of its history in which the villagers overcame significant—sometimes violent—barriers, and has strong leadership and effective management. This forest is considered a "successful community forest" from a social perspective, but requires quantitative study to ascertain the biological success of community protection and management.

MATERIALS AND METHODS

Study Area

Khok Bung Preu is a remnant, lowland deciduous forest located in Dan Khuntot District, Nakhon Ratchasima Province, Northeast Thailand (Fig. 1). It is an isolated 560-ha forest fragment surrounded mainly by agricultural land and settlements. The topography is flat and at an elevation of 240 m msl. The soil is a well-drained sandy loam. The climate is tropical seasonal monsoon with a rainy period from June to October and a mean annual rainfall of about 950 mm (Fig. 2). There are three seasons, namely hot and dry from March to April, rainy from May to October, and dry from November to May. The mean monthly temperature is 27°C with the mean maximum of 31°C in April and minimum of 23°C in December (Fig. 2). During the dry season, temperatures can reach 40°C or more. The mean monthly humidity of the study area is 70%. The vegetation is highly susceptible to fire in the dry season.

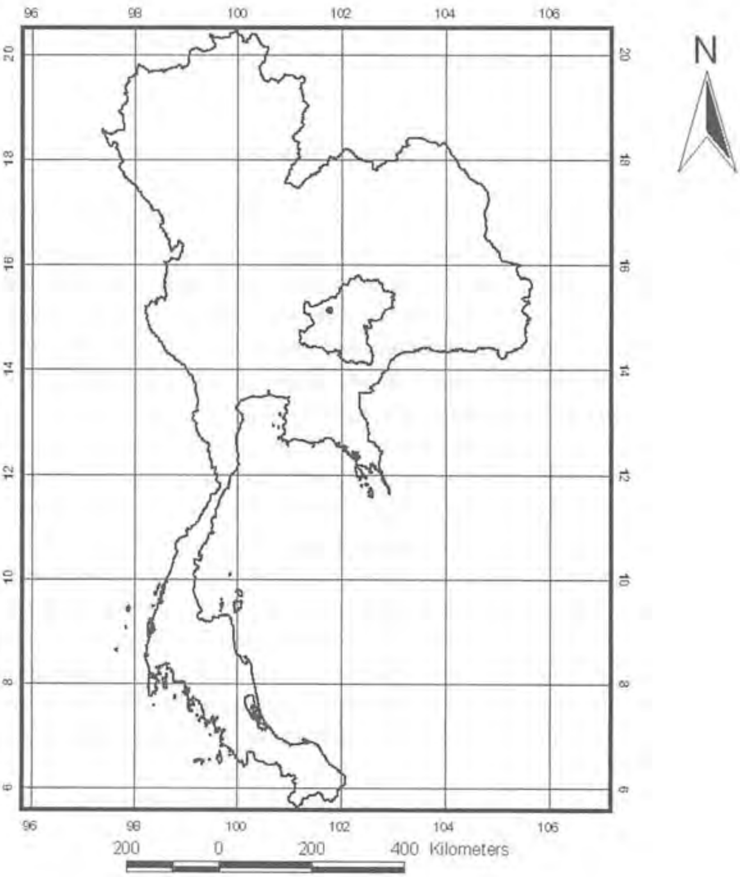

Figure 1. Study area. Black dot showing the location of Khok Bung Preu forest in Nakhon Ratchasima Province in Northeast Thailand.

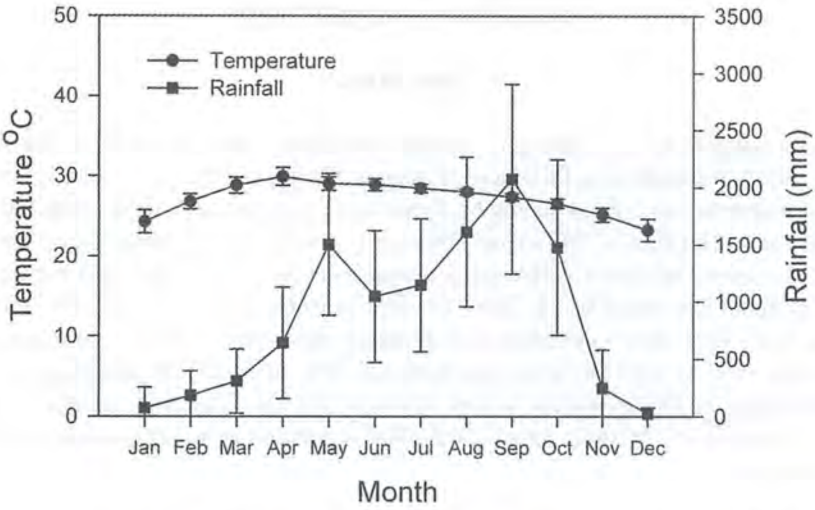

Figure 2. Meteorological data (1981–2001) from meteorological station number 431201 based in Nakhon Ratchasima. Source: Meteorological Department of Thailand.

Survey Design

To understand the history of the site and contemporary management patterns, key informant interviews and opportunistic informal group discussions were held with people living in the vicinity of the forest. Key informants were purposively selected among elderly villagers, village leaders, township administrative officials, local forest officials, and members from the forest management committee. Informal group discussion and key informant interviews provided us the information on site history, history of community forest formation, forest management practices, and forest resources use.

We investigated the vegetation composition and structure of Khok Bung Preu community forest by using a 3-stage random sampling method to establish 31 0.03-ha temporary sample plots. Using GPS combined with mapping of the existing forest patch from an orthorectified Landsat ETM+ image (acquisition date February 18, 2002), we established a temporary transect that bisected the forest in a N–S direction. Subsequently we randomly selected 31 points along the transect. At each point, we randomly chose a direction (east or west) by flipping a coin, randomly selected a distance between each point and the edge of the forest using a random number generator, and then entered that coordinate into the GPS. After finding the coordinate on the ground, we established the center of each vegetation plot. In this way, every point in the forest had an equal chance of being selected as a plot location. The final plot locations are shown in Figure 3.

Vegetation plots were concentric circles of 1, 3, and 10-m radius, totaling 0.01, 0.09, and 0.97 ha, respectively. In each 1-m plot all woody stems with a diameter at 1.3 m height (dbh) 2.5 cm or with a height less than 1.0 m (referred to as seedlings) were identified and tallied. In the 3-m plots, all woody stems with a dbh 2.5–9.9 cm (saplings) were identified, and the dbh and height recorded. In the 10-m plots all trees with dbh 10 cm were identified and measured for dbh and height. In all plots, vines/woody climbers were

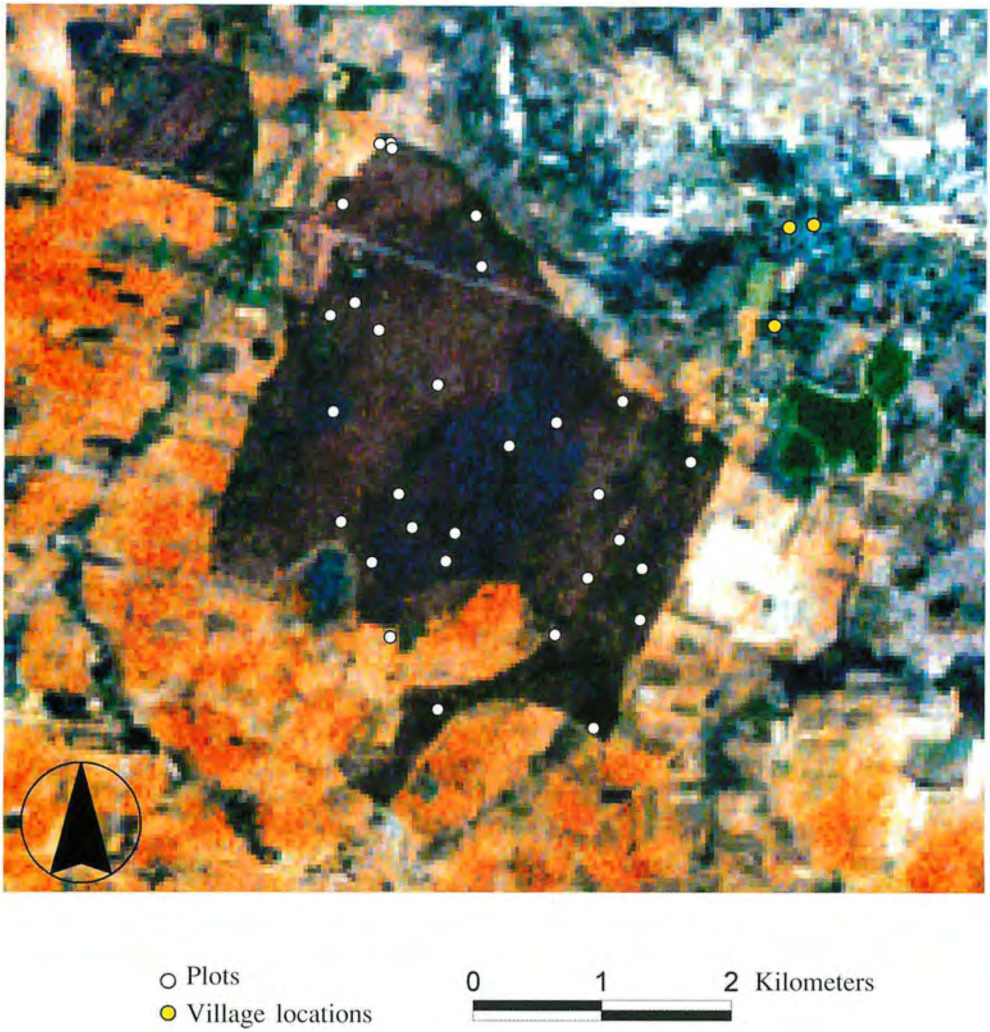

Figure 3. Landsat ETM+ WRS 2-tile image of path 128 and row 50 (acquisition date February 18, 2002) showing Khok Bung Preu forest (purple) in Northeast Thailand. White points are the locations of 31 randomly selected sample plots. Three plots are very close in the northern most part of the forest, and two plots are within 50 m of each other and are represented by a single point. Yellow points are the locations of the three main user and management group villages. Agricultural lands surround the west and south side of Khok Bung Preu; degraded barren lands and settlements are to the northeast of the forest.

identified and tallied. Tree diameters were measured using a diameter tape and heights were calculated using a SUUNTO® clinometer. Voucher specimens were collected and identified by J. F. Maxwell, and deposited in the herbarium of Chiang Mai University, Thailand.

The field work was conducted during November and December, 2003, after the rainy season and during the beginning of the dry season. Therefore, our results underestimate the total density and diversity of the ground flora.

To verify the adequacy of the sampling effort, we calculated the average species-area curves (OSTROM, 1990) of trees, saplings, and seedlings separately. The mean curve suggested that our results provided a very good picture of the composition and structure of the forest.

Data Analysis

Abundance, basal area, frequency, and importance values for trees and saplings of each species were computed (COX, 1990). The importance value index (IVI) is the sum of relative abundance, relative basal area, and relative frequency. Rarefaction curves were constructed to express the expected number of species from a randomly selected number of individuals from the forest. Presence-absence data for seedlings and vines/woody climbers were analyzed to compute species relative frequencies in the forest.

Diversity indices—mathematical measures of species diversity in a community—provided information about community composition taking the relative abundances of different species into account. Tree and sapling diversities were determined using species richness indices N_0 (absolute richness), R_1 (MARGALEF, 1958), and R_2 (MENHINICK, 1964). We also calculated two widely used measures of species diversity indices, Simpson's λ (SIMPSON, 1949) and Shannon's H' (SHANNON & WEAVER, 1949) as well as two species dominance indices, N_1 (number of dominant species) and N_2 (number of very dominant species) [HILL, 1973]. Two evenness indices, Pielou's J or E_1 (PIELOU, 1975; 1977) and E_5 (HILL, 1973), were also computed. The BASIC program SPDIVERS.BAS (LUDWIG & REYNOLDS, 1988) was employed to compute the indices using stems ha^{-1}.

The composition and structure of Khok Bung Preu forest was compared with other published studies from Thailand. However, one difficulty with comparisons is that nomenclature for forest types in Thailand differs among researchers. MAXWELL (2004) has identified the ambiguities of forest type nomenclature for Thailand, and he suggested a simplified vegetation classification for the country. After considering MAXWELL's (2004) classification, we used studies that we were confident to be similar to the Khok Bung Preu forest.

RESULTS

Site History

The original Thai Khorat and Lao settlements in the study area were reportedly established around the 1830s, through migration from Da Nok and Da Nai in Nakhon Ratchasima Province. The population in 2004 in Tambon Sra Charokhea (Sub-district) was

5678 (males 2816 and females 2862) with a density of 67 people/km^2 and unevenly distributed around the forest. Approximately 90% of the people living around the forest are farmers growing rice, corn, chilies, cassava, and rearing animals such as chickens and cattle. The average land holding of each household is 2.40 ha. Old houses, temples, shops and other structures in the area are constructed of wood, whereas new structures are made from bricks and concrete due to depletion of timber from the forest.

The history of the forest, as told by the elders of the villages, is one of continuous forest destruction leading to collective action to protect the remaining degraded forest from conversion to agriculture. Aside from the immediate conversion of the initially vast and intact forest to agriculture by the original settlers, the histories we heard were only able to confirm that the forest had continuously shrunk since the original settlements were founded. Intensive harvesting of forest trees was prevalent in Khok Bung Preu since the 1950s, mainly for producing charcoal, railway sleepers, and wood for buildings in the surrounding villages. As population density increased, the conversion of forest to permanent agriculture escalated.

The idea of conserving the forest arose in the 1970s when the remaining forest covered approximately 1520 ha. One of the conservation-oriented village headmen opposed conversion of this forest to agricultural land. He was later assassinated by unknown killers who were reportedly hired by someone outside the villages to encroach on this forest for agricultural conversion. After the assassination, approximately 900 ha were converted to agricultural fields. Local village leaders, realizing the danger of deforestation, began a process of convincing the other villagers of the importance of sustainable forest protection and established themselves as a "self-defense village", which included both active protection of the forest as well as the establishment of various committees supporting forest protection. In 1988 the villagers agreed to stop cutting trees in the forest for any purpose. In 1992, the communities proposed that the forest be registered as a community forest in the Community Forest Office of the Royal Forestry Department, which recognized this forest as a community forest under the management and jurisdiction of the local communities in 1998.

Forest Management Practices

Several village headmen in consultation with villagers along with the technical assistance from provincial forest officials formed the Khok Bung Preu Forest Management Committee, which consisted of 310 members headed by a president. Three villages, namely *Ban Lung* (*moo 1*), *Ban Non Boad* (*moo 7*), and *Ban Trai Tong* (*moo 12*) of Tambon Sra Charokhea (Sub-district), consist of a total of 310 households and were the main user groups of Khok Bung Preu forest. Anyone accessing and using Khok Bung Preu forest out of those 310 households was designated as an outside user. The head of each household from the villages was by default the member of the Management Committee. The head of the Tambon Sra Charokhea (Sub-district) was selected as the president of the Management Committee for life. Rules and regulations related to access, use, care, monitoring, and sanctions were formed by the Management Committee. Any member of the Management Committee can propose a change in the rules and regulations related to forest management, development, conservation, and utilization during the general meeting of the Management Committee, with a final decision made through a vote. A team of 6–8 persons voluntarily patrols the forest on a daily basis during the dry season, when there is a high risk of forest fire. During the remaining months, patrolling is not daily but at regular intervals. The persons designated for patrolling were given technical training in forest patrolling and on the use of firearms by the provincial forest office. Later each trained person was given a licensed firearm by the local government. Approximately 100 volunteers (locally called *losoatohpo*) among the main user groups also have been trained by the provincial forest office to assist the Management Committee in forest protection and conservation activities. Trained volunteers are supposed to provide similar training in forest protection and conservation to other community members in collaboration with the Royal Forest Department.

Operational rules govern the use of the Khok Bung Preu forest by both the main and outside user groups. As a standard rule, collection of a wide variety of non-timber forest products is allowed for both consumption and sale by members of the main user groups. Outside user groups are only allowed to harvest certain non-timber forest products for subsistence purposes, and are forbidden to carry tree cutting equipment into the forest. The operational rules prohibit encroaching on forest land, illicitly cutting forest trees, making charcoal, collecting timber for commercial purposes, setting fires, grazing or browsing cattle, and hunting wildlife. A monetary fine from 500 to 10,000 Baht upon the recommendation from the Management Committee is charged to any first-time offender who fells timber, makes charcoal, carries tree cutting equipment or hunts wildlife. A 2,000 to 10,000 Baht fine is charged to any first-time offender who encroaches forest lands for personal or commercial use, grazes cattle, or starts fires. Second-time offenders are to be taken to court for the additional punishment along with the fine issued by the Management Committee.

Forest Resources Use

A wide variety of non-timber forest products were harvested on a regular basis from Khok Bung Preu community forest by both main and outside user groups. Two varieties of mushrooms, locally called *het langoo* and *het khun*, were harvested primarily for sale by the main user groups. Tender leaves of *"phak wan"* (*Melientha suavis* Pierre ssp. *suavis* [Opiliaceae]), were mainly harvested for self-consumption with no restriction on the quantity harvested and consumption pattern. Ant eggs were harvested by the main user groups mainly for selling as food and as fishing bait. Wild fruits of *ton khop* (*Flacourtia indica* Merr.), *takhrao* (*Schleichera oleosa* (Lour.) Oken), *som kung* (*Ampelocissus martini* Pl.), *nom wua* (*Fissistigma latifolium* Merr.), *kuyetao* (*Pueraria thomsonii* Benth.), and *ting tang* (*Getonia floribunda* Roxb.) were collected by the main user groups mainly for selling, with no restriction on quantity harvested and sale. A local vegetable called *phak sam sip* (*Asparagus racemosus* Willd) was commonly harvested for consumption. *Makham poam* (*Phyllanthus emblica* L.), *noo taiyang* (*Clitoria hanceana* Hemsl.), *hatha khun* (*Micromelum minutum* (G. Forst.) Wight & Arn.), and *khat khao* (*Randia horrida* Roem. & Schult.) were the major herbs harvested by most people for medicinal use. Toads and frogs, lizards, rabbits, wild chickens, birds, squirrels, and bamboo shoots were harvested mainly for food. *Yana*, a climber, was used to make rope for roofing.

In addition to non-timber forest products, there were several other products that could be harvested under certain restrictions such as timber, firewood, and honey, for which outside user groups had no access. Harvest of timber without permission was also banned for the main user groups. With approval from the Management Committee, timber could be harvested during stressful periods due to natural disasters such as fire and storms or for building and/or renovating public buildings such as the school, temple or community center. Fuelwood could be collected only for household use. Honey could only be harvested without causing any damage to the vegetation of the forest. The only non-consumptive use of the forest was utilization of a place in the forest called the 'house of spirits', locally "*san chao*", which villagers would occasionally visit to pray.

Species Composition and Diversity

A total of 97 species in 48 families were recorded: 39 species in 23 families were trees, 31 species in 21 families were saplings, 48 species in 30 families were seedlings, and 10 species in 8 families were vines and woody climbers (Table 1). Families with the most species were Leguminosae, Papilionoideae (8), Rubiaceae (7); Leguminosae, Caesalpinioideae (6), and Gramineae (5). Approximately 23% of the total number of families (11/48) had more than 3 species and the remaining 77% of families (37/48) had only 1 to 2 species each. Approximately 26% of tree species were represented by 1 individual ha^{-1} and 39% of the sapling species were represented 11 individuals ha^{-1} (Figure 4).

Sindora siamensis var. *siamensis*, *Xylia xylocarpa* var. *kerrii*, *Erythrophloeum succirubrum*, and *Bauhinia saccocalyx* were the 4 most common species in this forest, accounting for 92% of the stems 2.5 cm dbh. *Shorea siamensis* var. *siamensis* and *Dipterocarpus gracilis* represented the only 2 species of Dipterocarpaceae. The tree community was dominated by *X. xylocarpa* var. *kerrii* and *Sindora siamensis* var. *siamensis*. The sapling community was dominated by *Sindora siamensis* var. *siamensis*, *B. saccocalyx*, and *E. succirubrum* (Table 1).

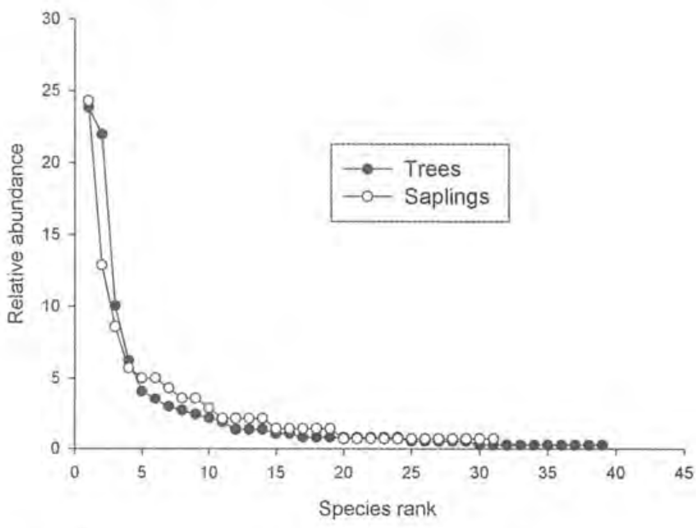

Figure 4. Species-rank plots of trees and saplings of Khok Bung Preu forest in Northeast Thailand. Total area sampled for trees 0.97 ha and for saplings 0.09 ha.

Table 1. List of species found in Khok Bung Preu Forest in Northeast Thailand. Herb (H), Shrub (S), Tree (T), Vine (V), Woody climber (WC). A, abundance (ha^{-1}); BA, basal area (m^2 ha^{-1}); IVI, importance value index; NP is the number of plot(s) in which the species was found; RF, relative frequency.

Species	Family	Habit	Trees			Saplings			Seedlings		Vine/Woody climber			
			A	BA	IVI	A	BA	IVI	NP	RF	A	RF	NP	RF
Acacia csesia (L.) Willd. var. *subnuda* (Craib) Niels.	Leguminosae, Mimosoideae	WC									2.06	3.4	1	5.3
Aganosma marginata G. Don	Apocynaceae	V									1.03	1.7	1	5.3
Alangium salviifolium (L.f.) Wang. ssp. *hexapetalum* (Lmk.) Wang.	Alangiaceae	T	1.03	0.02	1.3									
Albizia odoratassima (L.f.) Bth.	Leguminosae, Mimosoideae	T	1.03	0.01	1.1	33.33	0.11	6.2						
Ampelocissus martini Pl.	Vitaceae	H							1	0.7				
Antidesma ghaesembilla Gaertn.	Euphorbiaceae	T				22.22	0.04	5.1						
Aporusa octandra (Ham. *ex* D. Don) Vick. var. *octandra*	Euphorbiaceae	T	1.03	0.01	1.1									
Azadirachta indica A. Juss.	Meliaceae	T	4.12	0.18	6.2									
Bauhinia saccocalyx Pierre	Leguminosae, Caesalpinioideae	T	10.31	0.11	7.9	200.00	0.59	37.5						
Bombax anceps Pierre var. *anceps*	Bombacaceae	T	2.06	0.09	3.4									
Caesalpinia digyna Rottl.	Leguminosae, Caesalpinioideae	H							1	0.7				
Cajanus scarabaeoides (L.) Thou. var. *scarabaeoides*	Leguminosae, Papilionoideae	H							1	0.7				
Canarium subulatum Guill.	Burseraceae	T	7.22	0.14	6.9				1	0.7				
Careya arborea Roxb.	Lecythidaceae	T	1.03	0.01	1.1	11.11	0.03	2.9						
Cassia fistula L.	Leguminosae, Caesalpinioideae	T	3.09	0.04	2.8									
Catunaregam tomentosa (Bl. *ex* DC.) Tirv.	Rubiaceae	T	13.40	0.16	12.4	55.56	0.18	11.8						
Cissus repens Lmk.	Vitaceae	H							1	0.7				
Cratoxylum thorelii Pierre *ex* Gagnep.	Guttiferae	T	3.09	0.05	3.0	44.44	0.18	11.2						
Crotalaria goreensis Guill. & Perr.	Leguminosae, Papilionoideae	H							3	2.0				
Cyanotis cristata (L.) D. Don	Commelinaceae	H							8	5.2				
Dalbergia merican Graham *ex* Bth.	Leguminosae, Papilionoideae	T	3.09	0.16	4.1									
Digitaria setigera Roth *ex* Roem. & Schult.	Gramineae	H							2	1.3				
Diospyros bejaudii Lec.	Ebenaceae	T				11.11	0.05	3.3						
Diospyros mollis Griff.	Ebenaceae	T				11.11	0.02	2.5						
Diospyros merica Roxb.	Ebenaceae	T	1.03	0.01	1.1									
Dipteracanthus repens (L.) Hassk.	Acanthaceae	H							1	0.7				
Dipterocarpus gracilis Bl.	Dipterocarpaceae	T	4.12	0.06	2.7	55.56	0.25	10.7	1	0.7				
Elephantopus scaber L. ssp. *scaber* var. *scaber*	Compositae	H							1	0.7				
Ellipanthus tomentosus Kurz var. *tomentosus*	Connaraceae	T	9.28	0.12	7.9									
Erythrophloeum succirubrum Gagnep.	Leguminosae, Caesalpinioideae	T	38.14	0.47	28.2	133.33	0.37	25.4						
Eupatorium odoratum L.	Compositae	H							6	4.0				

Species	Family	Habit	Trees			Saplings			Seedlings		Vine/Woody climber			
			A	BA	IVI	A	BA	IVI	NP	RF	A	RF	NP	RF
Evolvulus alsinoides (L.) var. *decumbens* (R. Br.) Oost.	Convolvulaceae	H							1	0.7				
Fimbristylis smitinandii T. Koy.	Cyperaceae	H							2	1.3				
Gardenia sootepensis Hutch.	Rubiaceae	T	1.03	0.01	1.1									
Gmelina arborea Roxb.	Verbenaceae	T	1.03	0.04	1.6									
Grewia eriocarpa A. Juss.	Tiliaceae	T							1	0.7				
Grewia merica Vahl	Tiliaceae	S							1	0.7				
Hapaline bentahmiana Schott	Araceae	H							1	0.7				
Harrisonia mericana (Blanco) Merr.	Simaroubaceae	WC									1.03	1.7	1	5.3
Helicteres lanata (Teijsm. & Binn.) Kurz	Sterculiaceae	S							9	5.8				
Heteropogon contortus (L.) P. Beauv. *ex* Roem. & Schult.	Gramineae	H							3	2.0				
Hymenodictyon orixense (Roxb.) Mabb.	Rubiaceae	T				88.89	0.13	14.1						
Hypserpa nitida Miers	Menispermaceae	H							4	2.6				
Kaempferia siamensis Siri.	Zingiberaceae	H							5	3.3				
Lagerstroemia cochinchinensis Pierre *ex* Gagnep.	Lythraceae	T	3.09	0.03	3.5	77.78	0.25	15.0						
Lagerstroemia floribunda Jack. var. *brevifolia* Craib	Lythraceae	T	3.09	0.03	2.7									
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	T	15.46	0.23	14.1	33.33	0.12	9.1	1	0.7				
Leea aequata L.	Leeaceae	S							2	1.3				
Limonia acidissima L.	Rutaceae	T				22.22	0.09	4.9						
Lindernia mericana (L.) F. Muell. var. *mericana*	Scrophulariaceae	H							5	3.3				
Litsea glutinosa (Lour.) C.B. Rob. var. *glutinosa*	Lauraceae	T							1	0.7				
Markhamia mericana Seem. *ex* K. Schum. var. *stipulata*	Bignoniaceae	T				11.11	0.01	2.3						
Memecylon scutellatum (Lour.) Naud.	Melastomataceae	T				77.78	0.11	13.0	3	2.0				
Merremia mericana (L.) Hall. F. ssp. *orientalis* (Hall. F.) Oost.	Convolvulaceae	H							7	4.6				
Microcos paniculata L.	Tiliaceae	T	2.06	0.03	1.8	22.22	0.05	3.9	1	0.7				
Micromelum minutum (Forst. f.) Wight & Arn.	Rutaceae	T							4	2.6				
Miliusa velutina (Dun.) Hk. F. & Th.	Annonaceae	T	1.03	0.01	1.1				1	0.7				
Millettia xylocarpa Miq.	Leguminosae, Papilionoideae	T	8.25	0.12	5.6									
Mitragyna rotundifolia (Roxb.) O. K.	Rubiaceae	T				11.11	0.05	3.3						
Morinda coreia Ham.	Rubiaceae	T	5.15	0.10	5.1	11.11	0.01	2.2						
Murdannia nudiflora (L.) Bren.	Commelinaceae	H							5	3.3				
Murdannia spectabilis (Kurz) Fad.	Commelinaceae	H							9	5.8				
Ochna integerrima (Lour.) Merr.	Ochnaceae	T	2.06	0.02	1.6	22.22	0.03	4.8	1	0.7				
Pachygone dasycarpa Kurz	Menispermaceae	V									1.03	1.7	1	5.3
Pavetta tomentosa Roxb. *ex* Sm. var. *tomentosa*	Rubiaceae	T				11.11	0.01	2.2						

Species	Family	Habit	Trees			Saplings			Seedlings		Vine/Woody climber			
			A	BA	IVI	A	BA	IVI	NP	RF	A	RF	NP	RF
Perotis indica (L.) O. K.	Gramineae	H							3	2.0				
Phyllanthus emblica L.	Euphorbiaceae	T	1.03	0.01	1.1									
Polyalthia cerasoides (Roxb.) Bth. *ex* Bedd.	Annonaceae	T	11.34	0.15	7.6	66.67	0.16	13.5	2	1.3				
Polyalthia evecta (Pierre) Fin. & Gagnep.	Annonaceae	T							1	0.7				
Portulaca pilosa L.	Portulacaceae	H							6	3.9				
Pterocarpus macrocarpus Kurz.	Leguminosae, Papilionoideae	T	3.09	0.08	3.5	11.11	0.01	2.2						
Rhapidophora peepla (Roxb.) Schott	Araceae	V									1.03	1.7	1	5.3
Rothmannia wittii (Craib.) Brem.	Rubiaceae	T	5.15	0.06	3.8									
Schleichera oleosa (Lour.) Oken	Sapindaceae	T	2.06	0.02	2.3	11.11	0.02	2.6						
Senna garrettiana (Craib)	Leguminosae, Caesalpinioideae	T	3.09	0.03	3.4									
Setaria parviflora (Poir.) Kerg.	Gramineae	H							8	5.2				
Shorea siamensis Miq. var. siamensis	Dipterocarpaceae	T	23.71	0.44	17.7	22.22	0.12	7.0						
Sida cordifolia L.	Malvaceae	S							6	3.9				
Sindora siamensis Teysm. *ex* Miq. var. siamensis	Leguminosae, Caesalpinioideae	T	90.72	1.31	58.0	377.78	1.15	63.4						
Spondias pinnata (L. f.) Kurz	Anacardiaceae	T	5.15	0.14	5.0									
Stemona merican Lour. var. *tuberosa*	Stemonaceae	V									1.03	1.7	1	5.3
Streptocaulon juventas (Lour.) Merr.	Asclepiadaceae	H							3	2.0				
Strychnos nuxvomica L.	Loganiaceae	T				11.11	0.01	2.4						
Suregada multiflora (A. Juss.) Baill. var. *multiflora*	Euphorbiaceae	T	1.03	0.01	1.1	11.11	0.03	2.7						
Tephrosia kerrii Drum. & Craib	Leguminosae, Papilionoideae	H							4	2.6				
Terminalia mucronata Craib & Hutch.	Combretaceae	T	2.06	0.04	2.6	33.33	0.04	4.5						
Uraria campanulata (Wall. *ex* Bth.) Gagnep.	Leguminosae, Papilionoideae	H							2	1.3				
Urochloa panicoides P. Beauv. var. *panicoides*	Gramineae	H							5	3.3				
Uvaria rufa Bl.	Annonaceae	WC									8.25	13.6	3	15.9
Vietnamosasa ciliata (A. Camus) T. Q. Nguyen	Gramineae, Bambusoideae	H							13	8.4				
Waltheria mericana L.	Sterculiaceae	S							4	2.6				
Wrightia arborea (Denn.) Mabb.	Apocynaceae	T	3.09	0.06	3.9	11.11	0.01	2.4	1	0.7				
Xylia xylocarpa (Roxb.) Taub. var. *kerrii* (Craib & Hutch) Niels.	Leguminosae, Mimosoideae	T	83.51	1.44	60.4	33.33	0.06	7.6	1	0.7				
Zizyphus cambodiana Pierre	Rhamnaceae	WC									41.24	67.8	8	42.3
Zizyphus nummularia (Burm. F.) Wight & Arn.	Rhamnaceae	WC									1.03	1.7	1	5.3
Zizyphus oenoplia Mill. var. *oenoplia*	Rhamnaceae	WC									3.09	5.1	1	5.3
Zornia gibbosa Span.	Leguminosae, Papilionoideae	H							1	0.7				
Total: 97	**48**		**380.35**	**6.05**		**1555.56**	**4.29**				**60.82**			

Table 2. Diversity indices for trees and saplings of Khok Bung Preu forest in northeast Thailand. Trees dbh 10 cm and saplings dbh 2.5 to 9.9 cm. N_0 is absolute richness. R_1 (MARGALEF, 1958) and R_2 (MENHINICK, 1964) are the two species richness indices. Simpson's λ (SIMPSON, 1949) and Shannon's H' (SHANNON & WEAVER, 1949) are the two species diversity indices. N_1 and N_2 represent the number of dominant and very dominant species (HILL, 1973) in the forest. Pielou's J or E_1 (PIELOU, 1975; 1977) and E_5 (HILL, 1973) are species evenness indices.

Life forms	Area sampled (ha)	Richness				Diversity			Evenness	
		N_0	R_1	R_2	λ	H'	N_1	N_2	E_1	E_5
Tree	0.97	39	6.43	2.03	0.12	2.81	14.37	8.06	0.73	0.53
Sapling	0.09	31	6.07	2.62	0.09	2.67	16.05	10.72	0.82	0.62

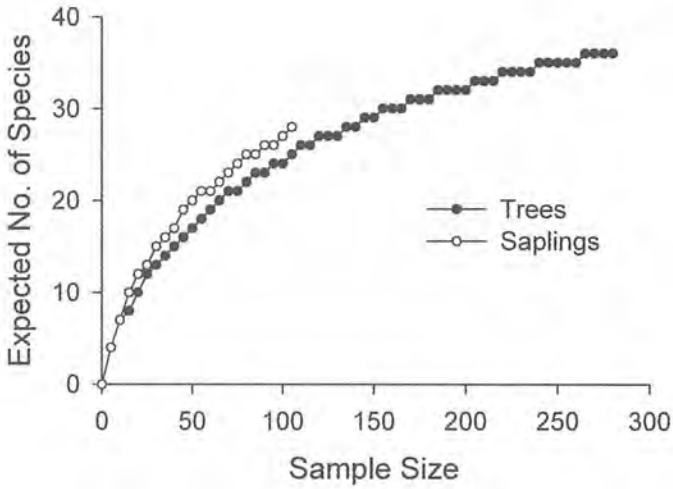

Figure 5. Rarefaction curves of trees and saplings of Khok Bung Preu forest in Northeast Thailand showing the expected number of species from a certain number of randomly selected individuals.

Trees and saplings in Khok Bung Preu forest were similar in species diversity (Simpson λ = 0.12 for trees and 0.09 for saplings, Shannon H' = 2.81 for trees and 2.67 for saplings), evenness (Pielou J' or E_1 = 0.73 for trees and 0.82 for saplings, Hill's E_5 = 0.53 for trees and 0.62 for saplings (Table 2), and in rarefraction (Fig. 5).

Abundance, Dominance, and Size Classes

The mean plot abundance and basal area values for all stems 2.5 cm dbh were 1936 stem ha^{-1} and 10.34 m^2 ha^{-1}, respectively. The mean plot tree abundance was 380 stems ha^{-1} and basal area of 6.05 m^2 ha^{-1}. For saplings, abundance was 1556 stems ha^{-1} and basal area 4.29 m^2 ha^{-1} (Table 1). Approximately 75% of the trees were less than 15 cm dbh with only 1% of trees > 30 cm dbh. Similarly, 64% of all trees were < 10 m height, with only 1% of the trees > 15 m height and the rest (35%) between 10 and 15 m height (Table 3).

Vietnamosasa ciliata was the most common herbaceous species in the forest followed by *Helicteres lanata* and *Murdannia spectabilis*. The mean abundance for vines and woody climbers was 61 individuals ha^{-1}. *Zizyphus cambodiana* was the most common species among vines and woody climbers followed by *Uvaria rufa* (Table 1).

Comparable quantitative vegetation studies of deciduous forests in Thailand include community-managed forests (KIJTEWACHAKUL *ET AL.*, 2004) and protected forests (BUNYAVEJCHEWIN, 1999; MAROD *ET AL.*, 1999; BUNYAVEJCHEWIN *ET AL.*, 2001; VAN DE BULT & GREIJMANS, 2006; WEBB, STEINMETZ, VAN DE BULT, SEUATURIEN, & CHUTIPONG, unpublished data). Khok Beung Preu exhibited species richness for all stems similar to community-managed forests (both of which had historical disturbances) and a disturbed watershed plot (YARWUDHI *ET AL.*, 1996), but lower richness values for trees 5 cm dbh than protected forests with little or no recent history of major disturbance other than fire. In contrast, stem abundance values for Khok Bung Preu were at the high end of the spectrum, being much higher than the other community-managed forest and some protected forests. Basal area values for Khok Bung Preu, on the other hand, showed the same pattern as species richness: similar to community-managed forests and well below protected forest values. Particularly notable is the basal area of trees 10 cm dbh, which was about one-third that of typical protected deciduous forest of Thailand (Table 4). Taken together, the biophysical parameters of Khok Bung Preu indicate that the prolonged history of human-induced disturbance has resulted in a degraded forest with reduced species diversity and virtually no large trees. However the forest appears to contain substantial levels of regeneration indicating a potential for structural recovery.

Table 3. Height and dbh class for trees of Khok Bung Preu forest in Northeast Thailand. A total of 369 individuals of trees (10 cm dbh) recorded from 0.97 ha area sampled. Percent of the total number of individuals of trees is in parenthesis.

	Height (m)			
dbh (cm)	0 < 10	10 < 15	15 < 25	Total
	Frequency	Frequency	Frequency	Frequency
0 < 15	201	74	0	275 (75)
15 < 30	34	52	5	91 (24)
30 < 45	1	2	0	3 (1)
45	0	0	0	0 (0)
Total	236 (64)	128 (35)	5 (1)	369

Table 4. Compositional and structural comparison of Khok Bung Preu community forest with other similar forests in Thailand.

Study	Forest type	Management	Area sampled (ha)	Absolute diversity			Abundance (stems ha^{-1})			Basal area (m2 ha^{-1})		
				all spp.	5 cm	10 cm	2.5 cm	5 cm	10 cm	2.5 cm	5 cm	10 cm
This study	Deciduous	Community	0.97 (10 cm) 0.09 (2.5–9.9 cm) 0.01 (2.5 cm)	97	47	39	1936	1290	380	10.34	9.60	6.05
van de Bult & Greijmans, 2006	Deciduous Dipterocarp	Protected area	0.2	33					364			22.28
van de Bult & Greijmans, 2006	Deciduous hardwood with bamboo	Protected area	0.2	64					534			16.77
Kijtewachakul *et al.*, 2004	Mixed Dry Deciduous	Community Conservation		103			339		144	9.27[1]		
		Community Conservation		50			333		171	7.52[1]		
		Community Utilization		71			566		159	9.08[1]		
		Community Utilization		158			436		227	14.55[1]		
Bunyavejchewin *et al.*, 2001	Dry Evergreen	Protected area	50.0	248[2]			1613[2]			30.45[2]		
Bunyavejchewin, 1999	Seasonal Dry Evergreen	Protected environmental research station[4]	1.0		76[3]			1168[3]			29.1[3]	
			1.0		100[3]			1356[3]			29.8[3]	
			1.0		65[3]			1115[3]			29.4[3]	
			1.0		111[3]			1499[3]			28.9[3]	
Gillison and Liswanti, 1999	Deciduous		0.02	94								
Marod *et al.*, 1999	Mixed Deciduous	Protected watershed research station	4.0		93			171			17.2	
Yarwudhi *et al.*, 1996	Deciduous	Protected forest watershed research station	4.0		76			204			17.17	
		Disturbed forest watershed research station	4.0		36			254			1.76	
Webb, Steinmetz, van de Bult, Seuaturien & Chutipong unpublished data	Mixed deciduous and grassland	Protected area, annual fires	4.0		86	73		601	343		21.6	20.6
	Mixed evergreen plus deciduous	Protected area, occasional fires	1.0		78	53		440	220		18.5	17.9

[1] includes bamboo; [2] 1.0 cm dbh; [3] > 4.5 cm dbh; [4] Results are repeated measures from the same plot over several years.

DISCUSSION

Khok Bung Preu Forest has a long history of logging, fire, and grazing. Selective logging and repeated fires in the deciduous forest has resulted in reduced diversity, lower density, and altered structure characterized by lower average tree heights and diameters. Similar results have been seen in other studies (STOTT *ET AL.*, 1990; UHL & KAUFFMAN, 1990; MAXWELL, 1996; MILLER & KAUFFMAN, 1998; BUNYAVEJCHEWIN *ET AL.*, 2001; RAMIREZ-MARCIAL *ET AL.*, 2001). Although we cannot confidently state what the 'original' species composition of the forest was, we are confident that logging has heavily impacted the populations of *Shorea siamensis*, which in deciduous forest often co-occurs with *Quercus* species (MAXWELL & ELLIOTT, 2001; Webb, Steinmetz, van de Bult, Seuaturien, & Chutipong, unpublished data; J. F. Maxwell, personal communication).

Repeated disturbances such as fire may favor regeneration by species that grow best in degraded conditions, such as legumes (BRAKENHIELM & LIU, 1998). Indeed, both the tree and sapling communities were dominated by several species of legumes. Our results of relatively high sapling abundance, small tree height and dbh class distribution (Table 3), low basal area, and domination by legumes, suggests that Khok Bung Preu forest is heavily degraded from its original state after continued logging, firing, and grazing.

Despite the relatively poor physical condition of the forest and its isolation, it is still an important repository of biodiversity and contributes to species conservation and livelihood supplementation for local villagers. Forest fragments often contain rare species subject to local extirpation (THEBAUD & STRASBERG, 1997) as we found in the case of Khok Bung Preu forest. Of particular interest is *Vietnamosasa ciliata*, a bamboo species becoming uncommon in forests of Thailand because it is generally only found on soil that has not been tilled (J. F. Maxwell, personal communication). Livelihood of the local community was supplemented through the sustainable harvest of non-timber products, particularly mushroom, *phak wan*, wild fruits, and ant eggs from the forest.

Khok Bung Preu faces several challenges to long-term regeneration. Logging of large trees in the past had severely reduced the abundance of seed-bearing mother trees, which may deteriorate the genetic quality of the propagules (CORLETT & TURNER, 1997). Repeated fires reduce accumulated litter on the forest floor which leads to dry and nutrient-poor soil (ZHUANG, 1997; RAMIREZ-MARCIAL *ET AL.*, 2001). Fires, grazing, and trampling by livestock kills seedlings, depresses seed germination, and changes soil moisture and temperature, potentially altering long-term species composition and structure (GUINDON, 1996). In addition, the forest is a highly isolated fragment so there is very little scope for seed dispersal from larger forest areas (GUINDON, 1996; THEBAUD & STRASBERG, 1997; VIANA *ET AL.*, 1997; LEMENIH & TEKETAY, 2005). Thus, poor management of Khok Bung Preu could lead to local extirpation or genetic deterioration of rare species, and spatial isolation allows little chance of genetic out-crossing through pollination or dispersal.

It is important to consider the role of the local village community in forest protection, management, and conservation. The villages surrounding Khok Bung Preu forest took the initiative to protect the forest from further encroachment, establish management rules, and enforce them. It is now widely acknowledged by social scientists that collective action and locally-initiated forest conservation can lead to successful forest conservation outcomes (OSTROM, 1990; BALAND & PLATTEAU, 1996; AGRAWAL, 1999; BANANA & GOMBYA-SSEMBAJJWE, 2000; JOHNSON & FORSYTH, 2002; KIJTEWACHAKUL *ET AL.*, 2004; WEBB & SHIVAKOTI, 2007), and both the existence of the forest and the species diversity of Khok

Bung Preu demonstrate this. Well-defined protection and management rules appeared to be successful in protecting the forest from complete degradation and loss. In addition, provision and implementation of graduated sanctions upon the violation of existing rules in use also appeared to be effective tools for forest conservation. Self-initiated protection, given rights to use, and strong community leadership contributed to the safeguarding of Khok Bung Preu forest.

Although protected forests are usually more effective repositories of plant diversity than forests under management for extractive use (BRUNER *ET AL.*, 2001; SALAFSKY *ET AL.*, 2001), community-managed forest is a vital repository of biodiversity values alongside the protected area system. Without the initiative of the community leaders, Khok Bung Preu forest would have been converted to agriculture in the 1970s. Resulting from the community effort is a forest that still contains a fairly diverse flora with an apparently regenerating community structure. This should be considered a near-term community-based conservation success, even though the level of diversity and dominance was estimated low compared to other forests in Thailand under more complete protection.

Care must be taken when interpreting our results. Although indeed in this case study the community management did result in the retention of forest cover, the future trajectory of biodiversity and structural variables is not known. Moreover, this single case study is not necessarily representative of all community forests in Thailand. Accumulation of longitudinal case studies will be required before we may generalize results like ours. Community forests may vary greatly in biodiversity, intensity of use, and trends over time. Significantly more research is required on the impacts of community management on forest condition in Thailand, and in Asia.

RECOMMENDED ACTIONS

Although the overall results suggest that Khok Bung Preu forest still retains enough structural complexity to give a good start to secondary succession, it is still difficult to estimate how long it will take to recover to 'mature' conditions. Given the challenges to long-term regeneration discussed above, action should be taken to assist in the restoration of Khon Bung Preu. We recommend two investments that should increase the probability of long-term forest restoration.

First, forest regeneration needs to be facilitated. Restoration of biodiversity improves with manual enrichment of native plant species (PARROTTA *ET AL.*, 1997; ZHUANG, 1997; BLAKESLEY *ET AL.*, 2002) and has been the focus of long-term efforts in Northern Thailand (FOREST RESTORATION RESEARCH UNIT, 2000). Well-planned enrichment planting of native species would reduce fire hazards, improve soil conditions, attract seed dispersal agents (particularly birds) and create microenvironments favorable for the natural establishment of native forest species (CORLETT & TURNER, 1997; JOSEPH & WUNDERLE, 1997; LAMB *ET AL.*, 1997; BRAKENHIELM & LIU, 1998; BATTAGLIA *ET AL.*, 2004). We recommend 23 native forest species suitable for enrichment planting in Khok Bung Preu forest, based on their presence in the forest, leafing phenology, and potential to contribute to the immediate and long-term mechanisms of forest restoration (Table 5). Enrichment planting would require a major human resource investment by the communities as well as generous technical backstopping and distribution of appropriate seedlings by the Royal Forest Department, but could potentially have significant and positive impact on forest conditions.

Table 5. Native species recommended for enrichment planting in Khok Bung Preu forest, with the justification of the selection.

Species	Family	Leafing Phenology	Current status in KBP	Notes
Albizia odoratissima (L. f.) Bth.	Leguminosae, Mimosoideae	Deciduous	Present	Canopy tree, fast growing, provides shade, leaves used as fodder
Azadarichta indica A. Juss.	Meliaceae	Deciduous	Present	Fodder, medicinal, edible fruits for animals.
Bombax anceps Pierre var. *anceps*	Bombacaceae	Deciduous	Present	Bird-attracting flowers, canopy
Butea monosperma (Lmk.) Taub.	Leguminosae, Papilionoideae	Deciduous	Not present	Bird attracting flowers, fire resilient
Canarium subulatum Guill.	Burseraceae	Deciduous	Present	Edible fruits for both human and animals
Dalbergia cochinchinensis Pierre *ex* Lanes	Leguminosae, Papilionoideae	Evergreen/Deciduous	Not present	Canopy tree, provides shade, common in disturbed areas
Dillenia ovata Wall.	Dilleniaceae	Evergreen/Deciduous	Not present	Provides shade, often in secondary growth
Diospyros mollis Griff.	Ebenaceae	Deciduous	Present	Canopy tree, provides shade, timber tree
Erythrina stricta Roxb.	Leguminosae, Papilionoideae	Deciduous	Not Present	Canopy tree, regenerates in open areas, bird-attracting flowers
Ficus hispida L. f. var. *hispida*	Moraceae	Evergreen	Not present	Under story tree, fruits edible
Gmelina arborea Roxb.	Verbenaceae	Deciduous	Present	Common in secondary growth, easy propagation
Hymenodictyon orixense (Roxb.) Mabb.	Rubiaceae	Deciduous	Present	Fast growing, canopy tree, provides shade
Irvingia malayana Oliv. *ex* Benn.	Irvingiaceae	Evergreen	Not present	Canopy tree, provides shade, edible fruits
Lagerstroemia floribunda Jack var. *floribunda*	Lythraceae	Deciduous	Not present	Often planted in drier and secondary forest
Litsea glutinosa (Lour.) C.B. Rob. var. *glutinosa*	Lauraceae	Deciduous	Present	Understory tree, edible fruits
Markhamia stipulata Seem. *ex* K. Schum. var. *stipulata*	Bignoniaceae	Deciduous	Present	Common in under story of disturbed forest, bat-pollinated,
Oroxylum indicum (L.) Kurz	Bignoniaceae	Deciduous	Not present	Common in secondary growth, bat pollinated, fruit edible
Pterocarpus macrocarpus Kurz	Leguminosae, Papilionoideae	Deciduous	Present	Canopy tree, provides shade, often planted, timber tree
Schleichera oleosa (Lour.) Oken	Sapindaceae	Deciduous	Present	Edible fruits, provides shade, medicinal
Senna siamea (Lmk.) Irwin & Barn.	Leguminosae, Caesalpiniodeae	Evergreen	Not present	Fast growing, often planted, understory tree, edible leaves
Spondias pinnata (L. f.) Kurz	Anacardiaceae	Deciduous	Present	Flower, fruits and leaves are edible for both animals and humans
Sterculia pexa Pierre	Sterculiaceae	Deciduous	Not present	Common in disturbed forest
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	Deciduous	Not present	Canopy tree, provides shade, medicinal

Second, there needs to be strict implementation of operational rules, a strengthening of institutions for regular monitoring, and increased authority to implement sanctions against violators. A strong core of concerned leaders and citizens in communities like those surrounding Khok Bung Preu benefits from increased authority and implementing power. Vested interest in the forest and its benefits, combined with the capacity and authority to protect the forest, should improve the outcomes of management and restoration by the communities. Many degraded forest fragments have been successfully restored in the tropical regions after given certain protection against disturbances (CORLETT & TURNER, 1997; ZHUANG, 1997). If both forest restoration and vigilant protection is initiated promptly, Khok Bung Preu could be on a trajectory towards significant improvement of forest conditions.

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