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THE NEED TO PROTECT: A COMPARISON BETWEEN THREE PLANT DIVERSITY PLOTS IN NORTHEAST THAILAND

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ABSTRACT

The plant species communities of single 1-ha plots in each of three protected areas in Northeast Thailand, Phu Langka National Park, Phu Phan National Park and Phu Wua Wildlife Sanctuary, all of which supported mature forest on similar substrata and in a similar elevational zone, were studied. All trees were tagged and inventoried. The communities of the three sites differed widely. Of 168 species detected, most (147 spp.) were found on no more than one of the three plots. Only one species was common to all three plots. Biodiversity conservation under a scenario of changing climate will therefore be best served by conserving as large a number of protected areas as feasible, and ensuring connectivity among them so as to facilitate dispersal among sites.

Keywords: biodiversity, Northeast Thailand, plot study, protection, species conservation

INTRODUCTION

The distributions of plants in Thailand are mainly known as maps with a few dots based on the collecting localities noted on the labels of herbarium specimens. A technique that has become popular recently, Species Distribution Modelling (SDM), provides a model of where species might occur by calculating chances based on the abiotic climate and soil conditions present in the places where the species were collected. The abiotic climate variables are related to precipitation and temperature. As such, one can calculate their values likely in the future based on climate models (soil conditions will roughly remain the same). Such a study of the Thai flora (van Welzen *et al.*, 2011) showed that Northeast and East Thailand will show an increase in species in the models for 2050. SDMs are difficult to validate, because they make models for grid cells of c. 10 by 10 km, areas too large to inventory in detail and, moreover, predictions for the future can only be validated in the future. Therefore, three permanent 1 ha plots (100 by 100 m) were developed in Northeast Thailand for long term surveillance to monitor possible shifts in species composition. The plots are in two national parks, Phu Langka National Park (PL; 17°59'04"N, 104°07'56"E, c. 175 m altitude, Nakhon Phanom Province) and Phu Phan National Park (PP; 17°04'14"N, 103°58'07"E, c. 330 m altitude, Sakon Nakhon Province) and one wildlife sanctuary, Phu Wua Wildlife Sanctuary (PW; 18°41'31"N, 103°58'00"E, c. 210 m altitude, Buengkan Province) (Fig. 1).

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PARNELL *ET AL.* (2003) show that Northeast and East Thailand have very low forest cover (Fig. 1). Most of the area is cultivated; only a few small forest pockets are protected. The soil in Northeast and East Thailand is mainly nutrient-poor lying on sandstone with, in comparison to other areas in Thailand, a low plant biodiversity (VAN WELZEN *ET AL.*, 2011). Regions with low biodiversity are generally ignored or considered of less value when areas are considered for protection, because usually budgets are limited and other areas are much richer in species and take most attention. PARNELL *ET AL.* (2003) also show that the collecting density in Northeast and East Thailand is also low, which means that we are still largely ignorant of the flora in these areas.

In this paper we compare the results of three plots and use the comparison to make re-commendations for the protection of areas in Northeast and East Thailand, because both regions have large areas under cultivation, minimal forest cover, similar soil, and the same tectonic history.

MATERIAL AND METHODS

The three plots of 1 ha in Northeast Thailand (Fig. 1) are basically primary forest, but with human influence. All trees in the plots were inventoried, which means that the number of specimens is equal to their abundance in the plots. All trees received a tag with a number (originally plasticized, presently of metal) and at breast height a ring of white paint was made where the diameter (diameter at breast height [DBH]) was measured during every next survey. Several trees had more than one bole, splitting below the height of measuring, the DBH of all boles was measured and a note was made about their unity. These boles counted as a single specimen/individual.

Of all specimens, where possible, herbarium vouchers were made and leaf parts were dried on silica gel for DNA analysis. One set of vouchers, together with the silica samples, was sent to Naturalis Biodiversity Center in the Netherlands (L; formerly Leiden Herbarium), the other set was sent to the Forest Herbarium (BKF) in Bangkok. All collected data (DBH, height, description of plant, etc.) were entered in a BRAHMS (Botanical Research and Herbarium Management System, http://herbaria.plants.ox.ac.uk/bol/) Rapid Data Entry form, which the herbaria can add to their main databases once the vouchers are processed. All collections are labelled "Visser, Chumchamroon, Saengrit & Suphuntee" as collectors, followed by a prefix of the plot (PL, PP or PW) and a number. The database can be obtained from the first author and will eventually be added to the Naturalis specimen database and be online, either via Naturalis (http://bioportal.naturalis.nl/) or via GBIF (http://www.gbif.org/).

Almost all specimens were sterile when collected. They were identified by staff of the Forest Herbarium (BKF) in the field and in the herbarium in Bangkok and by staff of Naturalis. Part of the silica-dried samples were used for DNA barcoding, based on two chloroplast sequences (*matK* and *trnL–F*). Primers are described in GRAVENDEEL *ET AL.* (2001) for *matK*, and for *trnL–F* in TABERLET *ET AL.* (1991), and SCHÜTZ *ET AL.* (2016). The laboratory protocol is described in MERCKX *ET AL.* (2015). The sequences found were blasted against the GenBank database (https://www.ncbi.nlm.nih.gov/genbank/) and the Barcode Of Life Database (BOLD; http://www.boldsystems.org/) to confirm identifications or to direct the process of identification. Finally, all specimens were checked for homogeneity per identified name.

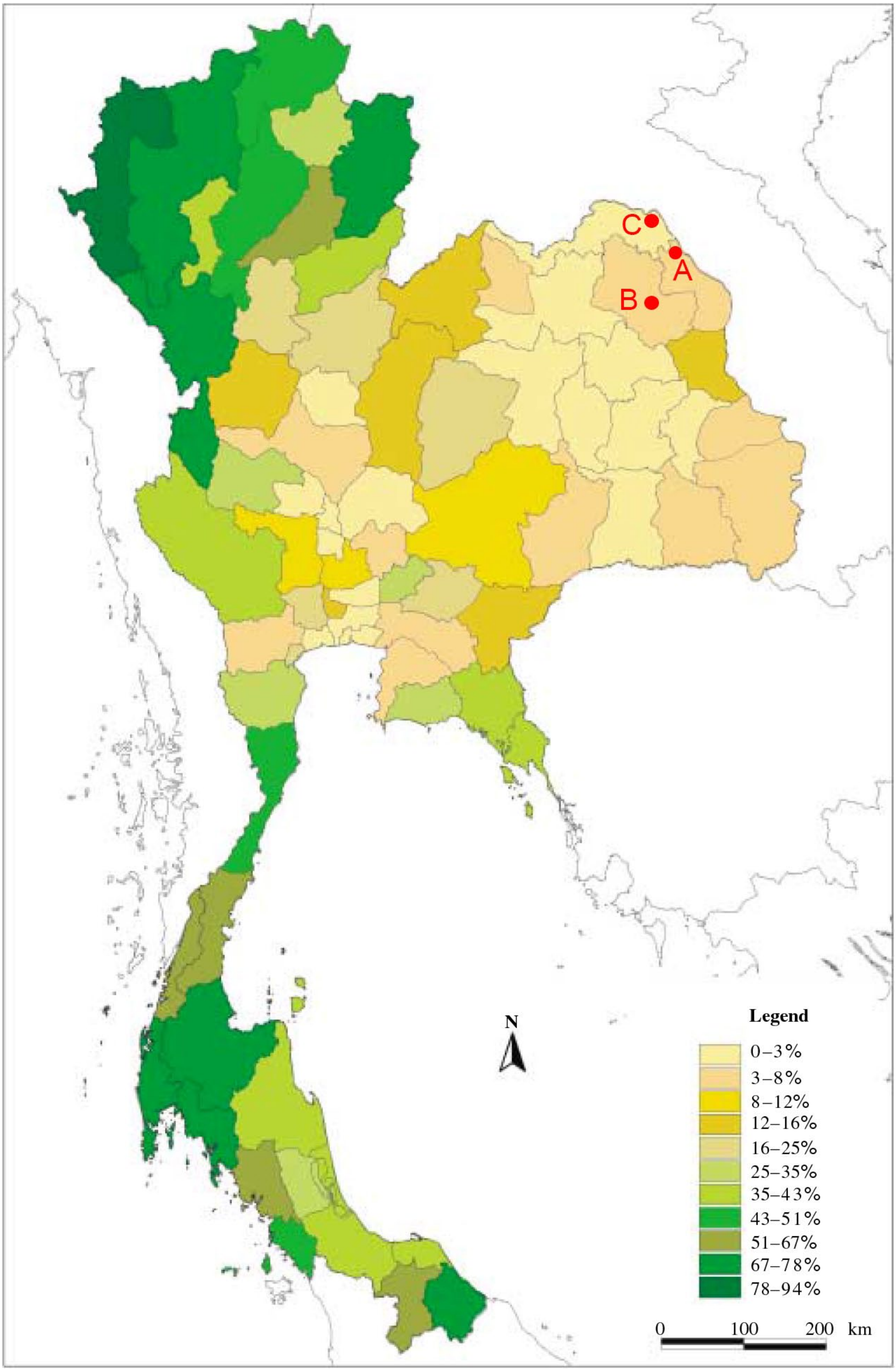

Figure 1. Forest cover per province of Thailand. A = Phu Langka National Park, B = Phu Phan National Park; C = Phu Wua Wildlife Sanctuary. After Figure 5 in PARNELL *ET AL*. (2003), published with permission of the authors.

Many specimens could be identified down to species. When only identified to genus, then the species were generally divided into morphospecies.

The distributions in Thailand, as presented in Table 1, are taken from the Flora of Thailand series, and when not published yet in this series then they were taken from the specimen data as stored in the database of Naturalis Biodiversity Center, Leiden, The Netherlands.

RESULTS

Table 1 shows all species found with the numbers of specimens (= trees) per plot. At the end of Table 1 the total numbers per plot are provided. Phu Wua has by far the highest number of specimens (1,367) and the highest number of species (96). Phu Phan shows the lowest numbers with 304 specimens and 28 species. In total 168 species were found in all plots together.

Table 1. Families and species present in Phu Langka National Park (PL), Phu Phan National Park (PP), Phu Wua Wildlife Sanctuary (PW). The numbers in the three protected areas show the numbers of specimens/trees in the plots. The column distribution shows the presence in Thailand as taken from Flora of Thailand and/or the specimen database in Naturalis Biodiversity Center, Leiden, The Netherlands (N = North, NE = Northeast, E = East, SW = Southwest, C = Central, SE = Southeast, P = Peninsula, * = new record for the region); if empty then taxa still have to be revised and no reliable identifications exist. Family names according to The Plant List (www.theplantlist.org); species names between brackets show the presently accepted name. Sp. indicates that only the family or genus is known. The column DNA barcode shows how many specimens were barcoded (*matK* and *trnL–F* regions sequenced).

Family	Species	PL	PP	PW	Distribution	DNA barcode
Anacardiaceae	*Buchanania lanzan* Spreng. (= *Buchanania cochinchinensis* (Lour.) M.R.Almeida)		10		N, NE, SW	2
Anacardiaceae	*Buchanania* cf. *siamensis* Miq.	1			*NE, SW, SE	1
Anacardiaceae	*Gluta usitata* (Wall.) Ding Hou		3		N, NE, SE	1
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.		15		N, NE, SW, SE, P	2
Anacardiaceae	*Mangifera* sp.	1				
Anacardiaceae	*Spondias pinnata* (L.f.) Kurz	1			N, NE, SW, P	
Annonaceae	*Alphonsea* sp.			23		3
Annonaceae	*Xylopia vielana* Pierre			48	*NE	2
Annonaceae	Sp.	2				1
Apocynaceae	*Alstonia rostrata* C.E.C.Fisch.			8	N, NE, P	1
Apocynaceae	*Wrightia* sp.			1		1
Asparagaceae	*Dracaena conferta* Ridl.			3	*NE, SE, P	1
Bignoniaceae	*Radermachera hainanensis* Merr.	14			*NE, SE, P	2
Bignoniaceae	Sp.	1				
Boraginaceae	*Ehretia longiflora* Champ. ex Benth.			4		2
Burseraceae	*Canarium album* (Lour.) DC.			1		1
Burseraceae	*Canarium subulatum* Guillaumin	5	10		*NE, SW, SE, P	3
Burseraceae	*Canarium* sp.			1		
Calophyllaceae	*Mammea* sp.	2				
Cardiopteridaceae	*Gonocaryum lobbianum* (Miers) Kurz			8	N, NE, E, SE, P	1
Celastraceae	*Euonymus* sp.	1				1

Table 1 (continued).

Family	Species	PL	PP	PW	Distribution	DNA barcode
Celastraceae	Sp.	1				1
Clusiaceae	*Calophyllum polyanthum* Wall. ex Planch. & Triana			11	*NE, N	
Clusiaceae	*Garcinia merguensis* Wight			18	*NE, N, SW, SE, P	
Combretaceae	*Terminalia alata* B.Heyne ex Roth		8	1	*NE, N, SW	1
Combretaceae	*Terminalia chebula* Retz.	1	5		N, NE, SW, C	1
Combretaceae	*Terminalia* sp.	22				
Cornaceae	*Mastixia euonymoides* Prain			8	*NE, N, SE	3
Dilleniaceae	*Dillenia aurea* Sm.		1	13	N, NE, E	2
Dipterocarpaceae	*Anisoptera costata* Korth.			30	*NE, N, SW, SE, P	
Dipterocarpaceae	*Dipterocarpus costatus* C.F.Gaertn.			19	N, NE, SE, P	
Dipterocarpaceae	*Dipterocarpus obtusifolius* Teijsm. ex Miq.		4		Thailand	1
Dipterocarpaceae	*Dipterocarpus* sp.			4		
Dipterocarpaceae	*Hopea ferrea* Laness.	26			N, NE, E, C, P	
Dipterocarpaceae	*Hopea sublanceolata* Symington			2		1
Dipterocarpaceae	*Shorea obtusa* Wall. ex Blume		26		N, NE, E, SW	
Dipterocarpaceae	*Shorea siamensis* Miq. (= *Pentacme siamensis* (Miq.) Kurz)			472	Thailand	1
Dipterocarpaceae	*Vatica harmandiana* Pierre			2	*NE, P	1
Dipterocarpaceae	*Vatica* sp.			4		
Ebenaceae	*Diospyros ehretioides* Wall. ex G.Don		3		N, NE, E, SW	1
Ebenaceae	*Diospyros mollis* Griff.	2				1
Ebenaceae	*Diospyros undulata* Wall. ex G.Don			15	*NE, N, SE, P	2
Ebenaceae	*Diospyros venosa* Wall. ex A.DC.	28			*NE, SW, C, SE, P	5
Ebenaceae	*Diospyros* sp. A		5			3
Ebenaceae	*Diospyros* sp.		4			2
Elaeocarpaceae	*Elaeocarpus petiolatus* (Jack) Wall.			16	*NE, N, SE, P	1
Elaeocarpaceae	*Elaeocarpus* sp. A			23		1
Elaeocarpaceae	*Elaeocarpus* sp. B			5		
Elaeocarpaceae	*Elaeocarpus* sp. C			4		
Elaeocarpaceae	*Elaeocarpus* sp. D			3		
Elaeocarpaceae	*Elaeocarpus* sp.			1		
Escalloniaceae	*Polyosma* sp.			1		1
Euphorbiaceae	*Croton poomae* Esser			18	NE	
Euphorbiaceae	*Croton stellatopilosus* Ohba	15			*NE, C, SE	2
Euphorbiaceae	*Croton thorelii* Gagnep.	1				
Euphorbiaceae	*Lasiococca comberi* Haines	104			N, NE	
Euphorbiaceae	*Suregada multiflora* (A.Juss.) Baill.			2	Thailand	1
Euphorbiaceae	*Triadica cochinchinensis* Lour.			1	N, NE, E, P	1
Fabaceae	*Archidendron clypearia* (Jack) I.C.Nielsen			34	N, NE, E, C, SW, P	1
Fabaceae	*Archidendron* sp.			1		
Fabaceae	*Callerya atropurpurea* (Wall.) Schot			1	*NE, N, SW, P	1
Fabaceae	*Dalbergia cochinchinensis* Pierre	2		3		2
Fabaceae	*Dalbergia* sp.	1		4		3
Fabaceae	*Millettia leucantha* Kurz	10		5	NE, E, SW, C, SE, P	3

Table 1 (continued).

Family	Species	PL	PP	PW	Distribution	DNA barcode
Fabaceae	*Millettia* sp.	2		3		3
Fabaceae	*Peltophorum dasyrrhachis* (Miq.) Kurz	1		1	Thailand	1
Fabaceae	*Pterocarpus macrocarpus* Kurz	1	34		N, NE, E, SW, C, SE	2
Fabaceae	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen		70		Thailand	1
Fabaceae	Sp.	3		1		2
Fagaceae	*Castanopsis argyrophylla* King ex Hook.f.			21	N, NE, E, SW, P	1
Fagaceae	*Castanopsis* sp.			2		
Fagaceae	*Lithocarpus fenestratus* (Roxb.) Rehder			9	N, NE, SW, SE	1
Fagaceae	Sp.			4		
Hypericaceae	*Cratoxylum cochinchinense* (Lour.) Blume	1		31	Thailand	
Hypericaceae	*Cratoxylum formosum* (Jack) Benth. & Hook.f. ex Dyer		5		Thailand	
Hypericaceae	*Cratoxylum* sp.			5		
Irvingiaceae	*Irvingia malayana* Oliv. ex A.W.Benn.	1	1	16	Thailand	4
Ixonanthaceae	*Ixonanthes reticulata* Jack			68	*NE, P	
Lamiaceae	*Callicarpa* sp.			2		1
Lamiaceae	*Gmelina racemosa* (Lour.) Merr.			18	NE	1
Lamiaceae	*Vitex limonifolia* Wall. ex C.B.Clarke		1		*NE, N, SW, SE	
Lamiaceae	*Vitex pinnata* L.		26		N, NE, E, SW, SE, P	
Lamiaceae	*Vitex quinata* (Lour.) F.N.Williams	16			*NE, N, E, SW, C, P	
Lauraceae	*Cinnamomum* sp.			3		1
Lauraceae	*Dehaasia* sp.	1				1
Lauraceae	*Litsea* sp. A			40		
Lauraceae	*Litsea* sp. B			8		
Lauraceae	*Litsea* sp. C			4		
Lauraceae	*Litsea* sp. D			2		1
Lauraceae	*Litsea* sp. E			2		1
Lauraceae	*Machilus kurzii* King ex Hook.f.	1				1
Lauraceae	*Phoebe* sp.			5		1
Lauraceae	Sp.	1				1
Lecythidaceae	*Barringtonia* sp.			15		1
Lythraceae	*Lagerstroemia calyculata* Kurz	3			N, NE, E, SW, SE, P	
Lythraceae	*Lagerstroemia* sp.	5				
Magnoliaceae	*Magnolia* sp.			2		1
Malvaceae	*Bombax anceps* Pierre	1			*NE, N, SW, SE	1
Malvaceae	*Microcos tomentosa* Sm.	1		1	Thailand	2
Malvaceae	*Pterospermum* sp.	18				2
Malvaceae	*Sterculia* sp.	11				6
Malvaceae	Sp.	1				1
Melastomataceae	*Memecylon* sp.		28			4
Meliaceae	*Aglaia* sp.	2				2
Meliaceae	*Walsura* sp.	17		3		10

Table 1 (continued).

Family	Species	PL	PP	PW	Distribution	DNA barcode
Moraceae	*Ficus vasculosa* Wall. ex Miq.			3	*NE, N, SW, C, SE, P	1
Moraceae	*Ficus* sp.	2		3		2
Moraceae	*Streblus ilicifolius* (S.Vidal) Corner	64			*NE, N, E, SW, SE, P	3
Moraceae	*Streblus taxoides* (Heyne ex Roth) Kurz	29			Thailand	2
Myristicaceae	*Horsfieldia amygdalina* (Wall.) Warb. var. *amygdalina*			2	*NE, N, SW, P	
Myristicaceae	*Horsfieldia amygdalina* (Wall.) Warb. var. *lanata* W.J.de Wilde			3	NE	
Myrtaceae	*Syzygium helferi* (Duthie) Chantaran. & J.Parn.			2		1
Myrtaceae	*Syzygium* sp. A			1		
Myrtaceae	*Syzygium* sp. B			10		
Myrtaceae	*Syzygium* sp. C			2		
Myrtaceae	*Syzygium* sp. D			1		
Myrtaceae	*Syzygium* sp. E			2		
Myrtaceae	*Syzygium* sp. F			7		
Myrtaceae	*Syzygium* sp.			1		
Ochnaceae	*Ochna integerrima* (Lour.) Merr.		17		Thailand	
Oleaceae	*Chionanthus ramiflorus* Roxb.	6		3	N, NE, E, SW, SE, P	4
Oleaceae	Sp.	1				1
Opiliaceae	*Champereia manillana* (Blume) Merr.	2			*NE, E, SE, P	1
Penaeaceae	*Crypteronia paniculata* Blume			4	Thailand	1
Peraceae	*Chaetocarpus castanocarpus* (Roxb.) Thwaites			23	Thailand	1
Phyllanthaceae	*Aporosa octandra* (Buch.-Ham. ex D.Don) Vickery var. *octandra*	2		26	Thailand	5
Phyllanthaceae	*Aporosa serrata* Gagnep.			5	N, NE	1
Phyllanthaceae	*Aporosa villosa* (Wall. ex Lindl.) Baill.		13		N, NE, E, SW, SE	1
Phyllanthaceae	*Bridelia affinis* Craib	1			N, NE, E.	1
Phyllanthaceae	*Bridelia retusa* (L.) A.Juss.	1	1		Thailand	
Phyllanthaceae	*Cleistanthus* sp.	1				1
Phyllanthaceae	*Glochidion lanceolarium* (Roxb.) Voigt			3	NE, E, SW, C, SE, P	1
Polygalaceae	*Xanthophyllum* sp. A			4		3
Polygalaceae	*Xanthophyllum* sp. B			3		1
Primulaceae	*Myrsine* sp.			1		
Putranjivaceae	*Drypetes* sp. A	21				2
Putranjivaceae	*Drypetes* sp. B	1				
Rubiaceae	*Catunaregam* sp.		1			
Rubiaceae	*Catunaregam spathulifolia* Tirveng. (not in IPNI)	11			*NE, N, SW	6
Rubiaceae	*Gardenia obtusifolia* Roxb. ex Hook.f.		1		N, NE, E, SW, SE, P	1
Rubiaceae	*Gardenia* sp.	1		8		3
Rubiaceae	*Gynochthodes* sp.			1		1
Rubiaceae	*Ixora* sp.	1				1

Table 1 (continued).

Family	Species	PL	PP	PW	Distribution	DNA barcode
Rubiaceae	*Mitragyna rotundifolia* (Roxb.) Kuntze		2		*NE, N, SW	1
Rubiaceae	*Morinda coreia* Buch.-Ham.	1	8		N, NE, SW, C, SE	1
Rubiaceae	*Pavetta tomentosa* Roxb. ex Sm.		1		N, NE, C	
Rubiaceae	*Psydrax* sp. A	1				
Rubiaceae	*Psydrax* sp. B	4				1
Rubiaceae	*Rothmannia eucodon* (K.Schum.) Bremek.	4			*NE, SE	1
Rubiaceae	*Rothmannia* sp.	1				1
Rubiaceae	*Tarenna* sp.	1				1
Rubiaceae	Sp.	2				1
Rutaceae	*Murraya paniculata* (L.) Jack	11			*NE, N, SW, C, SE, P	3
Salicaceae	*Casearia* sp.		1			1
Sapindaceae	*Acer laurinum* Hassk.			1	N, NE, SW	1
Sapindaceae	*Guioa diplopetala* (Hassk.) Radlk.			9	*NE, SE	2
Sapindaceae	*Lepisanthes tetraphylla* (Vahl) Radlk.	15			Thailand	5
Stemonuraceae	*Gomphandra* sp.	3				
Symplocaceae	*Symplocos cochinchinensis* (Lour.) S.Moore			6	Thailand	2
Symplocaceae	*Symplocos* sp. B			2		
Symplocaceae	*Symplocos* sp. C			2		
Symplocaceae	*Symplocos* sp. D			1		
Symplocaceae	*Symplocos* sp.			1		
Tetramelaceae	*Tetrameles nudiflora* R.Br.	2			Thailand	1
Theaceae	*Pyrenaria camelliiflora* Kurz (= *P. diospyricarpa* Kurz var. *camelliiflora* (Kurz) S.X.Yang)			1	*NE, N, P	1
Theaceae	*Schima wallichii* (DC.) Korth.			151	Thailand	1
Thymelaeaceae	*Linostoma decandrum* (Roxb.) Wall. ex Meisn.			1	N, NE, E, SE, P	1
Violaceae	*Rinorea scorpioidea* (H.Boissieu) Gagnep.	51			*NE, E, SW, P	5
	Total number of specimens per plot	569	304	1,367	2,240 in all plots	
	Total number of species per plot	67	28	96	168 in all plots	

It is obvious from Table 1 that most species, genera and even families mainly occur in a single plot. This is summarized in Table 2. Only one species occurs in all three plots, *Irvingia malayana* Oliv. ex A.W.Benn., but then only with a single specimen in Phu Langka and Phu Phan and most specimens in Phu Wua. Phu Langka and Phu Phan share 5 species (*Canarium subulatum* Guillaumin [Burseraceae], *Terminalia chebula* Retz. [Combretaceae], *Bridelia retusa* (L.) A.Juss. [Phyllanthaceae], *Pterocarpus macrocarpus* Kurz [Fabaceae], and *Morinda coreia* Buch.-Ham. [Rubiaceae]), all of them with the majority of the specimens in Phu Phan. The picture is a bit more mixed for Phu Phan and Phu Wua (2 species: *Terminalia alata* B.Heyne ex Roth [Combretaceae], *Dillenia aurea* Sm. [Dilleniaceae]) with the *Terminalia* species with most specimens in Phu Phan and *Dillenia* mainly in Phu Wua. Most species (13) are shared between Phu Langka and Phu Wua, but roughly half of them have more specimens in Phu Langka and the other half in Phu Wua.

Table 2. Species present in more than one plot. In the top rows the identification and the plots (PL = Phu Langka National Park; PP = Phu Phan National Park; PW = Phu Wua Wildlife Sanctuary).

Number of families	In all plots	10	
	In 2 plots	9	
	(in PL-PP)		1
	(in PP-PW)		1
	(in PL-PW)		7
	In 1 plot	35	
	(in PL)		10
	(in PP)		3
	(in PW)		22
Total number of families		54	
Number of genera	In all plots	6	
	In 2 plots	19	
	(in PL-PP)		6
	(in PP-PW)		3
	(in PL-PW)		10
	In 1 plot	77	
	(in PL)		26
	(in PP)		9
	(in PW)		42
Total number of genera		102	
Number of species	In all plots	1	
	In 2 plots	20	
	(in PL-PP)		5
	(in PP-PW)		2
	(in PL-PW; identified to sp.)		7
	(in PL-PW; unidentified to sp.)		6
	In 1 plot	147	
	(in PL)		48
	(in PP)		20
	(in PW)		79
Total number of species		168	

All three areas have a few dominant species. *Lasiococca comberi* Haines (Euphorbiaceae) with 104 specimens, *Streblus ilicifolius* (S.Vidal) Corner (Moraceae) with 64 specimens, and *Rinorea scorpioidea* (H.Boissieu) Gagnep. (Violaceae) with 51 specimens (all three resemble each other morphologically and were generally confused) are the most common species in Phu Langka. In Phu Phan, *Xylia xylocarpa* (Roxb.) Taub. is most common with 70 specimens, followed by a group of four species with 26–34 specimens. The most common species in Phu Wua are *Shorea siamensis* Miq. (or *Pentacme siamensis* (Miq.) Kurz) (Dipterocarpaceae) with 472 specimens and *Schima wallichii* (DC.) Korth. (Theaceae) with 161 specimens. All these dominant species are only present in a single protected area.

DISCUSSION

The three plots are situated close together (Fig. 1), but all are very different in composition, which is normal for tropical rainforest and evergreen forest. The plots are not particularly rich, but still the presence of 31 species (asterisk in the last column of Table 1) in the Northeast is an addition to their distribution as published in the Flora of Thailand or to the specimens present in the Naturalis database. Three taxa are typical for only Northeast Thailand: *Croton poomae* Esser (Euphorbiaceae), *Gmelina racemosa* (Lour.) Merr. (Lamiaceae), and *Horsfieldia amygdalina* (Wall.) Warb. var. *lanata* W.J.de Wilde (Myristicaceae). The flora of this area is not very well known (though Prof. Pranom Chantaranothai and his students of Khon Kaen University are changing this rapidly) and it may be that many of the specimens not identified to species level contain represent new species.

Only a few specimens bore fruits; all the rest was sterile. Consequently, identification was difficult and the utmost care was taken to obtain accurate identifications (independent identification in the field, specialists in BKF and L, and blasting of DNA barcodes). Not all collections/trees could be identified to genus or species level. Only a limited number of silica-dried samples could be DNA barcoded. As the selection of samples was made after initial identifications, often incorrect, not all species are barcoded yet, while other species have up to ten barcodes (Table 1). The barcodes were generally very helpful to pointing to the correct family or genus. However, the blasts against the GenBank and Bold databases usually resulted in various species and often different genus names. Reasons for this result are a lack of Asian taxa in the databases, unreliable identifications, and insufficient barcode markers to separate the species (still too many species alike). Undoubtedly, several identifications are incorrect, but what is certain is that all individuals under the same name or morphospecies are homogeneous.

In all plots only trees were inventoried. One of the reviewers suggested that especially the herbaceous plants, including epiphytes, would be most sensitive to climate change, and as such constituted a more logical target group. The choice of trees was partly practical, partly methodological. As the canopy in the plots was high and the time for field work short, epiphytes were not sampled. Most experts in BKF and L are more familiar with trees than with herbs/shrubs. However, most important is that trees are easy to mark permanently and easier to follow through time.

The size of the three protected areas is not large, Phu Langka 12.48 km^2, Phu Phan 664 km^2 and Phu Wua 186.5 km^2 (Wikipedia). It is thus questionable if all species have population sizes large enough to survive. Some may disappear in the near future, but due to habitat limitation rather than climate change. These two influences will be difficult to separate from each other.

Only a few areas in Northeast Thailand are protected; outside these areas there are mainly cultivated fields. This in combination with the fact that the forest composition changes rapidly over short distances means that many species in the Northeast Thailand have already disappeared. Most protected areas are isolated, thus if the flora composition starts to change due to global warming, then species cannot disperse or escape bad conditions and will become, at least locally, extinct.

CONCLUSIONS

The effort Thailand puts into the protection of as many natural areas as possible in Northeast Thailand is really worthwhile as it will protect the maximum number of species left in this area. The protected areas should not become smaller as this will lead to extra loss of biodiversity, because populations need sufficient space to remain viable. It is also important to try to connect the areas to enable species to disperse to more suitable climate conditions when necessary.

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REFERENCES

Gravendeel, B., M. W. Chase, E. F. de Vogel, M. C. Roos, T. H. M. Mes, and K. Bachmann. 2001. Molecular phylogeny of *Coelogyne* (Epidendroideae; Orchidaceae) based on plastid RFLPS, *matK*, and nuclear ribosomal ITS sequences: evidence for polyphyly. *Am. J. Bot.* 88: 1915–1927.

Merckx, V. S. F. T., K. P. Hendriks, K. K. Beentjes, C. B. Mennes, L. E. Becking, K. T. C. A. Peijnenburg, A. Afendy, N. Arumugam, H. de Boer, A. Biun, M. M. Buang, P.-P. Chen, A. Y. C. Chung, R. Dow, F. A. A. Feijen, H. Feijen, C. Feijen-van Soest, J. Geml, R. Geurts, B. Gravendeel, P. Hovenkamp, P. Imbun, I. Ipor., S. B. Janssens, M. Jocqué, H. Kappes, E. Khoo, P. Koomen, F. Lens, R. J. Majapun, L. N. Morgado, S. Neupane, N. Nieser, J.T. Pereira, H. Rahman, S. Sabran, A. Sawang, R. M. Schwallier, P.-S. Shim, H. Smit, N. Sol, M. Spait, M. Stech, F. Stokvis, J. B. Sugau, M. Suleiman, S. Sumail, D. C. Thomas, J. van Tol, F. Y. Y. Tuh, B. E. Yahya, J. Nais, R. Repin, M. Lakim, and M. Schilthuizen. 2015. Evolution of endemism on a young tropical mountain. *Nature* 524: 347–350.

Parnell, J. A. N., D. A. Simpson, J. Moat, D. W. Kirkup, P. Chantaranothai, P. C. Boyce, P. Bygrave, S. Dransfield, M. H. P. Jebb, J. Macklin, C. Meade, D. J. Middleton, A. M. Muasya, A. Prajaksood, C. A. Pendry, R. Pooma, S. Suddee, and P. Wilkin. 2003. Plant collecting spread and densities: their potential impact on biogeographical studies in Thailand. *J. Biogeogr.* 30: 193–209.

Schütz, N., D. Quandt, and M. Nebel. 2016. The position of the genus *Apopellia* stat. nov. within the Pelliales (Marchantiophytina: Jungermanniopsida). *Taxon* 65: 221–234.

Taberlet, P., L. Gielly, G. Pautou, and J. Bouvet. 1991. Universal primers for amplification of three non-coding regions of chloroplast DNA. *Pl. Mol. Biol.* 17: 1105–1109.

van Welzen, P. C., A. Madern, N. Raes, J. A. N. Parnell, D. A. Simpson, C. Byrne, T. Curtis, J. Macklin, A. Trias-Blasi, A. Prajaksood, P. Bygrave, S. Dransfield, D. W. Kirkup, J. Moat, P. Wilkin, C. Couch, P. C. Boyce, K. Chayamarit, P. Chantaranothai, H.-J. Esser, M. H. P. Jebb, K. Larsen, S. S. Larsen, I. Nielsen, C. Meade, D. J. Middleton, C. A. Pendry, A. M. Muasya, N. Pattharahirantricin, R. Pooma, S. Suddee, G. W. Staples, S. Sungkaew, and A. Teerawatananon. 2011. The Current and Future Status of Floristic Provinces in Thailand. Pages 219–247 *in* Y. Trisurat, R. P. Shrestrha, and R. Alkemade (eds.), *Land Use, Climate Change and Biodiversity Modeling: Perspectives and Applications*. Information Science Reference (IGI Global), Hershey (PA).