

Plant diversity and their importance for conservation in Don Pa Puei Sacred Forest, Si Chiang Mai District, Nong Khai, Thailand

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Abstract. Maneewong N, Pochayavanich R, Phonkerd N, Saensouk S, Piwpuan N. 2025. Plant diversity and their importance for conservation in Don Pa Puei Sacred Forest, Si Chiang Mai District, Nong Khai, Thailand. *Biodiversitas* 26: 1343-1354. The plant's diversity, traditional utilizations, and the importance of their conservation status in Don Pa Puei Sacred Forest in Ban Mo Village, Si Chiang Mai District, Nong Khai Province, Thailand, were studied from February 2023 to March 2024. Species richness data were surveyed along the nature trails and walkways around the forest. Plant specimens were collected, and their photos were recorded. Quantitative data of tree species were gathered in five randomly placed plots (20×20 m²). Diversity indices, including Shannon-Weiner's diversity index (H'), evenness index (J'), Important Value Index (IVI), Relative Density (RD), Relative Frequency (RF), and Relative Dominance (RDo) were calculated. A total of 36 families, 62 genera, and 65 species were identified. Tree species represented the highest proportion (49.23%) among all habit types. The Arecaceae, Cucurbitaceae, and Leguminosae families each had the highest number of species (4). The H' and J' indices for tree species were 1.93 and 0.73, respectively. *Lagerstroemia calyculata* had the highest IVI value (78.65%). Four species, *Azelia xylocarpa*, *Dipterocarpus alatus*, *Hopea odorata*, and *Shorea roxburghii* are threatened according to IUCN Red List. *Capparis pyrifolia* is considered as a rare species according to the threatened plants in Thailand checklist. Fifteen species (23.07%) out of 65 had traditional uses by local people, and 19 species (29.23%) have the potential for medicinal uses. The eradication of invasive species, management of climbers, and protection of the area from land-use changes are urgently needed for the conservation of the forest's biodiversity; this treasure demands our utmost respect and protection.

Keywords: Crape myrtle tree, dry evergreen forest patch, forest conservation, medicinal herbs, sacred site

INTRODUCTION

Sacred forests are natural areas of special spiritual or cultural significance to the communities surrounding them and have been protected by these communities (Ray et al. 2014). Sacred natural sites are often rich in species, sometimes more diverse than even protected areas or forest reserves. Their importance as refuges for biodiversity and the conservation of threatened tree species is widely known (Sullivan et al. 2023). This is not restricted to the sacred forest itself but also extends to other types of forests that contain sacred sites. Sacred forests have the highest tree cover, species number, density, and basal area compared to forests without sacred sites (Lynch et al. 2018; Suchiang et al. 2020). Reports on biodiversity in sacred forests in Thailand align with these general trends. For example, sacred forests in Northern Thailand were found to be inhabited by more tree species than the fallows surrounding them (Junsongduang et al. 2014).

Sacred forests are mostly located outside protected areas and often lack legal protection. Some sacred forests are remnants of the former ancient forests (Manna et al. 2017). As a result, several factors threaten the preservation

of sacred forests, their biodiversity, and the benefits they provide to people. For example, land-use change and increasing edge density have been identified as significant vulnerabilities to sacred forests in The Gamo Highlands, Ethiopia (Daye and Healey 2015). In India, land-use changes, planned and accidental changes in species composition, developmental activities, and changes in social norms and cultural and religious practices are major anthropogenic disturbances over biodiversity (Ray et al. 2014). In Thailand, some national development programs pose risks of losing sacred sites and their biodiversity (Phatthanaphraiwan et al. 2022).

Nong Khai is a province located in the northeastern region of Thailand. The province's geographical area stretches along the Mekong River and includes plains, slopes, mountains, and distributed creeks within its boundaries (Office of Provincial Commercial Affairs Nongkhai 2021). The province has a wide range of ecological diversity, encompassing various types of forests such as deciduous dipterocarp, mixed deciduous, and dry evergreen forests. It also includes freshwater swamp forests, wetlands, and agricultural areas, such as rice fields, rubber plantations, and plantations of tobacco, tomatoes,

and chilies, as well as vegetation along the riverside. Several researchers have published reports on the plant diversity in Nong Khai Province. For example, Saensouk et al. (2017) studied the diversity of Zingiberaceae, and Kachina et al. (2019) investigated the structure of the plant community along the Mekong River, including Nong Khai. Nevertheless, there is still a dearth of data regarding the diversity of plants in particular regions within the province.

Don Pa Puei, located in Ban Mo Village, Si Chiang Mai District, Nong Khai Province, Thailand, is a sacred forest maintained by the local community for its cultural and spiritual significance. Historically, it served as a holy burial ground for the Thai Puan tribe. Nowadays, it holds religious significance as an accommodation for itinerant Buddhist monks and as a site for cremation ceremonies. Moreover, this forest is fascinating as it hosts more than 90 giant crape myrtle (*Lagerstroemia calyculata*) trees within a small, remnant, dry, evergreen forest surrounded by agricultural areas. Hence, the forest has been respected and protected by the community. Nowadays, in addition to its religious significance, the forest has become a popular destination for both tourists and pilgrims.

This study aims to provide baseline data on plant diversity, traditional utilizations, and the conservation status of species in Don Pa Puei Sacred Forest since such data is still lacking and needed by the community. This information will be valuable for visitors and support the community's achievement of sustainable forest management. Furthermore, local organizations have made efforts to provide information regarding plant species in the forest. However, there are still inaccuracies in some of the materials due to misunderstandings.

MATERIALS AND METHODS

Study area

The Don Pa Puei Sacred Forest is located at coordinates 17°57'35.77" N latitude and 102°31'51.39" E longitude, with an altitude of approximately 169 m above sea level. It

lies within the boundaries of Ban Mo Village, Si Chiang Mai District, Nong Khai Province, in Northeastern Thailand (Figure 1). The forest, which can be recognized as dry evergreen forest, covers an area of approximately 0.04 km². The name "Don Pa Puei" was given because it is home to at least 90 crape myrtle trees, locally known as "Ton Puei", and scientifically identified as *L. calyculata*, Lythraceae family. The forest serves as both a foraging area and a holy burial ground for the Thai Puan tribe, who immigrated and established their village here. It hosted a scenic location for the production of the film "Mekhong Full Moon Party" in 2001. Currently, the forest, which is entirely surrounded by agricultural areas, is managed and cared for by the local community. It has also been designated as a nature tourism destination, attracting visitors. As part of this, a trail has been constructed, including both ground-level and elevated walkways connecting the crape myrtle trees. Currently, some sections of the pathway are still under construction, with the aim of reaching a total distance of 2 km.

Procedures

Data collection

Monthly surveys of plant species along trailside and walkways around the forest were conducted from February 2023 to February 2024. Plants with flowers or fruits were photographed. The identification of plant specimens was based on the Flora of Thailand publications, also known as e-Flora of Thailand (Forest Herbarium 2024), as well as other relevant literature, such as key to species of *Gymnema* in Thailand (Kidyoo 2021) and key to species of the Genus *Vitex* (Lamiaceae) in Thailand (Chantaranothai 2011).

Then, to evaluate tree diversity, five 20x20 m² plots were randomly placed. All trees with Diameter at Breast Height (DBH) greater than 4.5 cm were counted, and the Circumference (perimeter) at Breast Height (CBH) of each individual was measured. The diameters at breast height and the radius of each tree were later calculated.

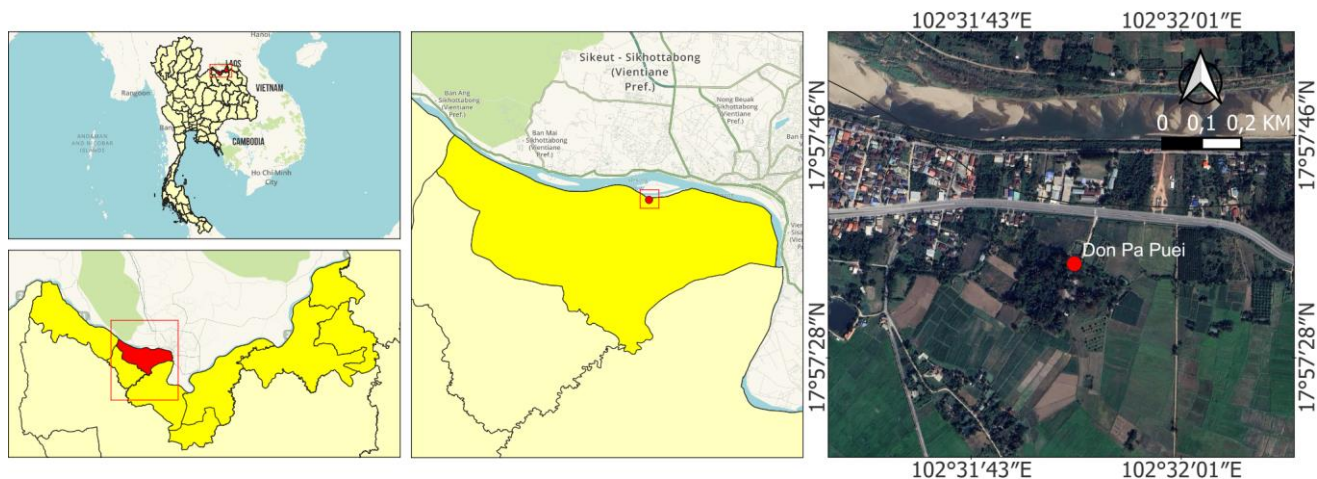


Figure 1. Map of the study area within Si Chiang Mai District, Nong Khai Province, Thailand, and a satellite image of Don Pa Puei Sacred Forest (Google earth.com)

Data on conservation status

The distribution of species in Thailand- whether native, endemic, or introduced- was determined based on distribution data available from the Plants of the World Online database (Kew Science 2024). The threat and conservation status of each species in Thailand were assessed based on the Threatened Plants in Thailand report (Department of National Parks, Wildlife and Plant Conservation 2017). The conservation status classified as common or rare species in the study area was evaluated based on fieldwork data collected during plant surveys in the plots. The status "rare species" was assigned when only a few individuals were found in the study area. Status for introduced species was assigned as common. Global conservation status and population trends were indicated based on IUCN criteria (IUCN 2024).

Use of plant resources by the community

To obtain data on local people's use of plants in Don Pa Puei Sacred Forest, we conducted a group discussion with four key informants (all over 30 years old) from the village. The data obtained from the discussion were later grouped as plant parts (root, stem/twig, leaf, flower, fruit) and their uses (food, medicine, fuel, wood, dye, cosmetics, ornamentals, ritual plants).

Potential for future uses of plant resources in the area

To provide more comprehensive data on the importance of local plant resources for the community, we gathered information on the potential of each species for use as medicinal plants from academic published data, mainly from the Phargarden.com website provided by the Faculty of Pharmaceutical Sciences at Ubon Ratchathani University, Thailand.

Data analysis

Information on the plant taxonomic groups (family, genus, and species), their conservation status, utilization, and potential for use as medicinal plants was classified. Quantitative data including Shannon Weiner's diversity index (H'), Pielou's evenness index (J') (Wheater et al. 2011), Important Value Index (IVI), Relative Density (RD), Relative Frequency (RF) and Relative Dominance (RDo) (Saensouk et al. 2024) were analyzed using the following formulas:

Shannon Weiner's diversity index (H')

$$H' = -\sum P_i \ln P_i$$

Pielou's evenness index (J')

$$J' = \frac{H'}{\ln N}$$

Important Value Index (IVI)

$$IVI = RD + RF + RDo$$

Relative Density (RD, %)

$$RD = \frac{\text{number of individuals of species}}{\text{number of all individuals of all species}} \times 100$$

Relative Frequency (RF, %)

$$RF = \frac{\text{frequency of individual species}}{\text{total frequency of all species}} \times 100$$

Relative Dominance (RDo, %)

$$RDo = \frac{\text{basal area of individual species}}{\text{total basal area of all species}} \times 100$$

Where, P_i is the proportion of the number of individuals of species i to the number of individuals of all species and N is number of species.

RESULTS AND DISCUSSION

Plant diversity

In Don Pa Puei's sacred forest, there are trees, shrubs, herbs, climbers, and lianas that bloom. Between February 2023 and March 2024, the survey found 36 families, 62 genera and 65 species. A list of all species found, along with their flowering or fruiting periods, is presented in Table 1. The families Arecaceae, Cucurbitaceae, and Leguminosae had the most species (4), followed by Apocynaceae, Dipterocarpaceae, Moraceae, and Sapindaceae (3 species each). The other 29 families each had 1-2 species (Figure 2). These species included 32 trees (49.23%), 6 shrubs (9.23%), 10 herbs (15.38%), 15 climbers (23.08%), and 2 lianas (3.08%). Photographs of some species are shown in Figure 3.

Considering the diversity of tree species in the forest, Shannon-Wiener's diversity index value was 1.93, and the evenness index was 0.73. *Lagerstroemia calyculata* is the species having the highest IVI value (78.65%), followed by *Caryota mitis* (61.80%) and *Broussonetia papyrifera* (26.56%) (Table 2).

Conservation status

Based on distribution data provided on the Plants of the World Online database, most of the species found in Don Pa Puei Sacred Forest are native to Thailand. Five out of 65 species, *Bidens pilosa*, *Muntingia calabura*, *Passiflora foetida*, *Physalis angulata* and *Sandoricum koetjape* are introduced species, with *B. pilosa* also being an invasive alien species. Based on the checklist in Threatened Plants in Thailand, *Capparis pyrifolia* is the only species assigned as rare plant species.

Table 1. Plant species found along the trail, forest edge, and sampling plots

Family and Species	Habits	Flowering and fruiting periods*	IUCN Red List Categories**	Habitat in the forest area		Collector no.
				Inside	Edge	
Acanthaceae						
<i>Eranthemum tetragonum</i>	Herb	Feb. (F, Fr)		●		Narumol 01
<i>Thunbergia grandiflora</i>	Climber	Feb. (F, Fr)		●	●	Narumol 02
Apocynaceae						
<i>Gymnema acuminatum</i>	Climber	Nov. (F)		●	●	Narumol 03
<i>Tabernaemontana bufalina</i>	Shrub	Feb.- Jul. (F, Fr)		●		Narumol 04
<i>Wrightia pubescens</i>	Tree	Apr. (F)	LC, ↔		●	Narumol 05
Araceae						
<i>Alocasia odora</i>	Herb	Feb. (F, Fr)	LC, ?	●		Narumol 06
<i>Amorphophallus paeoniifolius</i>	Herb	Nov. (Fr)		●		Narumol 07
Areaceae						
<i>Arenga caudata</i>	Shrub	Feb.- Mar. (F, Fr)		●		Narumol 08
<i>Calamus viminalis</i>	Climber	Feb. (F, Fr)		●		Narumol 09
<i>Caryota mitis</i>	Tree	Feb. (F, Fr)	LC, ↔	●		Narumol 10
<i>Livistona jenkinsiana</i>	Tree			●		Narumol 11
Bignoniaceae						
<i>Markhamia stipulata</i>	Tree	Nov. (F) - Feb. (Fr)	LC, ↔	●		Narumol 12
<i>Oroxylum indicum</i>	Tree			●	●	Narumol 13
Capparaceae						
<i>Capparis pyrifolia</i>	Shrub	Mar. (F)		●		Narumol 14
Chrysobalanaceae						
<i>Parinari anamensis</i>	Tree	Mar. (Fr)	LC, ↔	●		Narumol 15
Compositae						
<i>Bidens pilosa</i>	Herb	Dec. (F, Fr)			●	Narumol 16
<i>Mikania cordata</i>	Climber	Nov. (F, Fr)			●	Narumol 17
Convolvulaceae						
<i>Jacquemontia paniculata</i>	Climber	Dec. (F, Fr)			●	Narumol 18
<i>Operculina riedeliana</i>	Climber	Feb. (F, Fr)			●	Narumol 19
Cornaceae						
<i>Alangium indochinense</i>	Tree	Feb.- Mar. (F, Fr)			●	Narumol 20
Cucurbitaceae						
<i>Coccoloba grandis</i>	Climber				●	Narumol 21
<i>Gynostemma pentaphyllum</i>	Climber	Nov. (F, Fr)			●	Narumol 22
<i>Momordica cochinchinensis</i>	Climber	Jul.- Nov. (F, Fr)			●	Narumol 23
<i>Momordica subangulata</i>	Climber	Nov.-Dec. (F, Fr)			●	Narumol 24
Dipterocarpaceae						
<i>Dipterocarpus alatus</i>	Tree		VU, ↓	●		Narumol 25
<i>Hopea odorata</i>	Tree	Feb. (F)	VU, ↓		●	Narumol 26
<i>Shorea roxburghii</i>	Tree		VU, ↓		●	Narumol 27
Ebenaceae						
<i>Diospyros hasseltii</i>	Tree	Feb. (F) -Apr. (Fr)		●		Narumol 28
Euphorbiaceae						
<i>Baliospermum solanifolium</i>	Shrub	Feb. (F, Fr)	LC, ↔	●		Narumol 29
<i>Mallotus philippensis</i>	Tree	Dec. (F) -Mar. (Fr)	LC, ↔	●		Narumol 30
Icacinales						
<i>Pyrenacantha volubilis</i>	Climber	May (F, Fr)		●		Narumol 31
Irvingiaceae						
<i>Irvingia malayana</i>	Tree		LC, ↓	●		Narumol 32
Lamiaceae						
<i>Clerodendrum paniculatum</i>	Herb	Aug. (F, Fr)			●	Narumol 33
<i>Vitex canescens</i>	Tree	May (F)	LC		●	Narumol 34
Leeaceae						
<i>Leea indica</i>	Herb	Jul. (F, Fr)	LC, ↔	●		Narumol 35
Leguminosae-Caesalpinioideae						
<i>Afzelia xylocarpa</i>	Tree	Feb.- Mar. (F, Fr)	EN	●		Narumol 36
<i>Pterolobium macropterum</i>	Climber	May (Fr)			●	Narumol 37
Leguminosae-Mimosoideae						
<i>Adenantha pavonina</i>	Tree		LC, ↔	●		Narumol 38
<i>Senegalia megaladena</i>	Liana	Feb. (F)		●		Narumol 39
Lythraceae						
<i>Lagerstroemia calyculata</i>	Tree	Feb. (F) – Dec. (Fr)		●		Narumol 40
<i>Lagerstroemia floribunda</i>	Tree	Dec. (Fr)			●	Narumol 41

Malvaceae					
<i>Melochia umbellata</i>	Tree	Nov. (F) - Dec. (Fr)		●	Narumol 42
Meliaceae					
<i>Aphanamixis polystachya</i>	Tree	Nov. (F)	LC, ?	●	Narumol 43
<i>Sandoricum koetjape</i>	Tree	Mar. (F)	LC, ?		● Narumol 44
Menispermaceae					
<i>Anamirta cocculus</i>	Liana	Feb. - Mar. (Fr)		●	Narumol 45
<i>Tinospora crispa</i>	Climber				● Narumol 46
Moraceae					
<i>Broussonetia papyrifera</i>	Tree	Jul. (F, Fr)	LC, ↔	●	Narumol 47
<i>Ficus hispida</i>	Tree	Dec. (Fr)	LC, ↔	●	Narumol 48
<i>Streblus asper</i>	Tree		LC, ↔	●	Narumol 49
Muntingiaceae					
<i>Muntingia calabura</i>	Tree	May (F, Fr)	LC, ↔		● Narumol 50
Musaceae					
<i>Musa acuminata</i>	Herb	Apr. – Jul. (F, Fr)	LC, ?	●	Narumol 51
Myrtaceae					
<i>Syzygium cumini</i>	Tree	Feb. (F), May (Fr)	LC, ↔		● Narumol 52
Passifloraceae					
<i>Passiflora foetida</i>	Climber	May (F, Fr)			● Narumol 53
Phyllanthaceae					
<i>Antidesma sootepense</i>	Tree	Nov. (Fr)		●	Narumol 54
<i>Baccaurea racemosa</i>	Tree	Feb. - Mar. (F, Fr)		●	Narumol 55
Primulaceae					
<i>Ardisia polycephala</i>	Shrub	Feb. - Mar. (F, Fr)		●	Narumol 56
Sapindaceae					
<i>Lepisanthes rubiginosa</i>	Tree	Feb. – Mar. (F, Fr)	LC, ↔	●	Narumol 57
<i>Lepisanthes senegalensis</i>	Shrub	Mar. - Apr. (F, Fr)	LC, ↔	●	Narumol 58
<i>Schleichera oleosa</i>	Tree	Jul. (F)	LC, ↔	●	Narumol 59
Sapotaceae					
<i>Xantolis burmanica</i>	Tree	May (F)			● Narumol 60
Solanaceae					
<i>Physalis angulata</i>	Herb	Aug. (F, Fr)	LC, ↔		● Narumol 61
Tiliaceae					
<i>Microcos tomentosa</i>	Tree	May (F)	LC, ↔		● Narumol 62
Vitaceae					
<i>Ampelocissus martini</i>	Climber	Jul. (F, Fr)		●	Narumol 63
Zingiberaceae					
<i>Alpinia latilabris</i>	Herb	Apr. (F, Fr)	LC, ↓	●	Narumol 64
<i>Globba marantina</i>	Herb	Jul. (F, Fr)	LC, ↔	●	Narumol 65

Note: *: The species without information means there were no flower or fruit specimens found under this survey study; F: Flower; Fr: Fruit; LC: Least Concern; VU: Vulnerable; EN: Endangered; Population trend: ↔: Stable; ↓: Decreasing; ?: Unknown

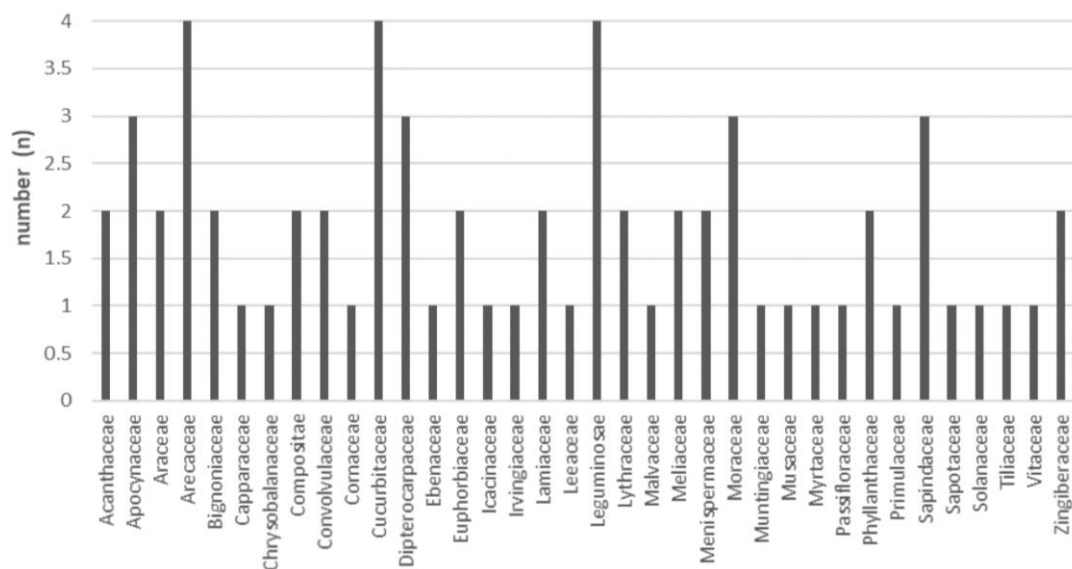


Figure 2. Number of species found in each plant family

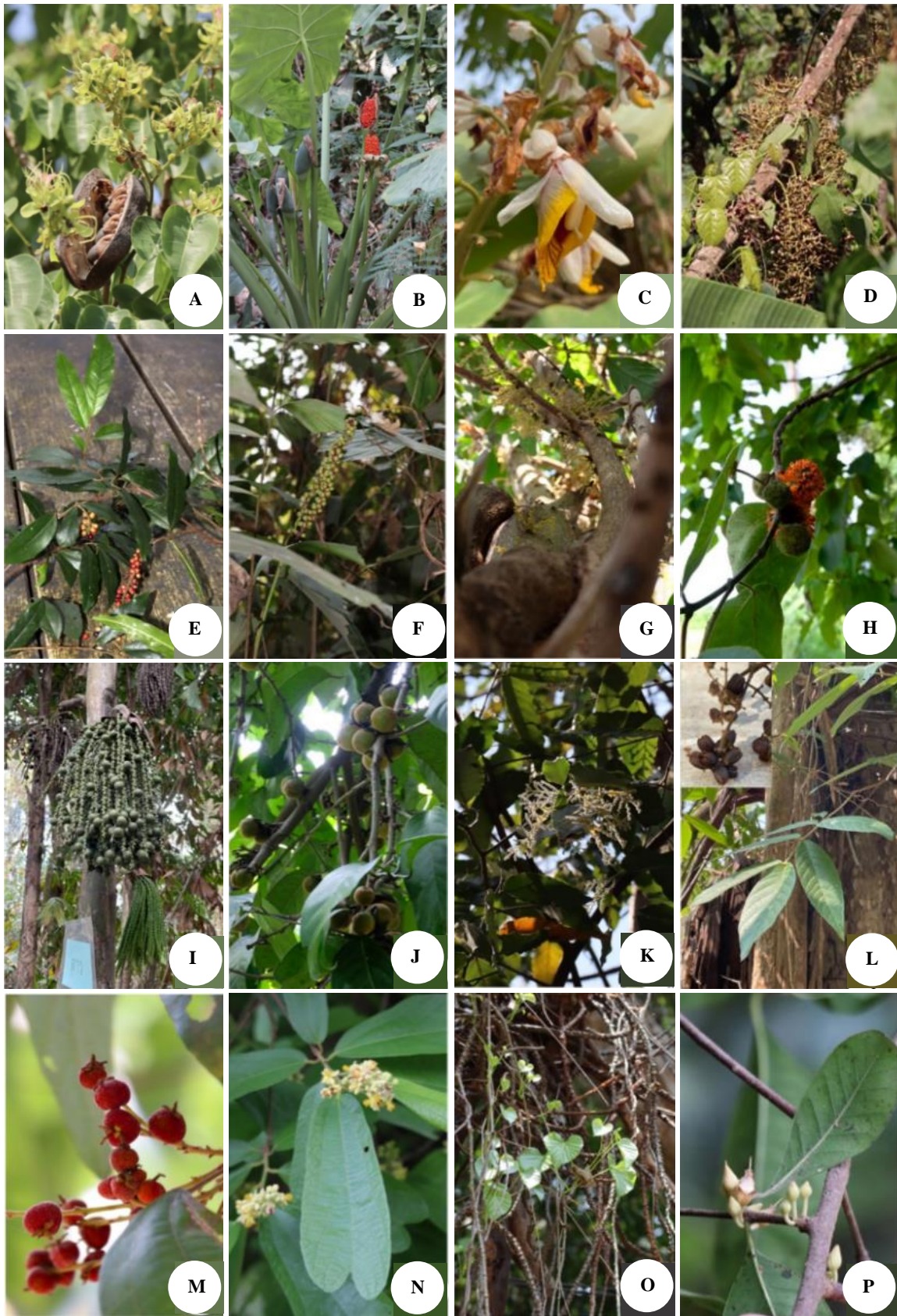


Figure 3. Some plant species found in Don Pa Puei Sacred Forest, Si Chiang Mai District, Nong Khai Province, Thailand. A. *Afzelia xylocarpa*; B. *Alocasia odora*; C. *Alpinia latilabris*; D. *Anamirta cocculus*; E. *Antidesma sootepense*; F. *Arenga caudata*; G. *Baccaurea racemosa*; H. *Broussonetia papyrifera*; I. *Caryota mitis*; J. *Diospyros hasseltii*; K. *Hopea odorata*; L. *Lagerstroemia calyculata*; M. *Mallotus philippensis*; N. *Microcos tomentosa*; O. *Tinospora crispa*; and P. *Xantolis burmanica*

Table 2. Relative Density (RD), Relative Frequency (RF), Relative Dominance (RDo), and Important Value Index (IVI) of tree species in five sampling plots

Species	RD (%)	RF (%)	RDo (%)	IVI
<i>Lagerstroemia calyculata</i>	5.52	12.12	61.01	78.65
<i>Caryota mitis</i>	44.14	12.12	5.54	61.80
<i>Broussonetia papyrifera</i>	13.79	6.06	6.71	26.56
<i>Diospyros hasseltii</i>	7.59	12.12	1.61	21.32
<i>Afzelia xylocarpa</i>	1.38	3.03	15.36	19.77
<i>Baccaurea racemosa</i>	4.83	12.12	1.17	18.12
<i>Mallotus philippensis</i>	6.21	9.09	2.25	17.54
<i>Ficus hispida</i>	3.45	6.06	0.72	10.23
<i>Adenantha pavonina</i>	1.38	3.03	0.81	5.22
<i>Aphanamixis polystachya</i>	0.69	3.03	0.42	4.14
Others	11.04	21.24	4.39	36.65
Sum	100	100	100	300

According to this field study in the study area, we evaluated the conservation status of plant species. Twenty-three species were found to be rare species, which were *Adenantha pavonina*, *Afzelia xylocarpa*, *Alangium indochinense*, *Antidesma sootepense*, *Baccaurea racemosa*, *C. pyriformis*, *Clerodendrum paniculatum*, *Dipterocarpus alatus*, *Jacquemontia paniculata*, *Hopea odorata*, *Lagerstroemia floribunda*, *Livistona jenkinsiana*, *Markhamia stipulata*, *Microcos tomentosa*, *Parinari anamensis*, *Wrightia pubescens*, *Senegalia megaladena*, *Shorea roxburghii*, *Streblus asper*, *Syzygium cumini*, *Tinospora crispa*, *Vitex canescens* and *Xantolis burmanica*. The remaining 42 species are common (Table 1).

According to the IUCN Red List categories, *D. alatus*, *H. odorata*, and *S. roxburghii* are threatened species evaluated under the Vulnerable (VU) category, while *A. xylocarpa* is classified as Endangered (EN). Although 23 species are categorized as Least Concern (LC), the populations of the two species, namely *Irvingia malayana* and *Alpinia latilabris* are decreasing.

Use of plant resources by the community

To gather information on the traditional utilization of plants in Don Pa Puei, we conducted a group discussion with four informants aged 30 and above. According to the discussion, the forest has long been respected as a sacred area and conserved by the local community. Nowadays, people typically do not collect plants directly from the forest but instead cultivate some, such as medicinal plants, in their home gardens. However, the data from the informants revealed that some plant species have been used either recently or in the past. The uses include food, drink, medicine, cosmetics, and household tools. Eleven species are used as food, drink, and medicines. Three species, *Calamus viminalis*, *A. indochinense*, and *Ficus hispida*, are used for household tools. One species, *T. crispa*, is used as an ingredient in cosmetics. A summary of the plant parts used, their use categories, and their application in each category is shown in Table 3.

Potential for medicinal uses of plant resources in Don Pa Puei Sacred Forest

Based on data obtained from the herbal database, 19 species can be used as medicinal plants. We classified their medicinal categories following Niamngon et al. (2023) and added two more categories: dysentery and antimalarial. Data on the names of species and their medicinal categories are shown in Table 4. Each species has the potential for use in at least two medicinal categories. The species with the highest number of medicinal categories is *A. pavonina* (10 categories), followed by *F. hispida*, *Leea indica*, and *Lepisanthes rubiginosa* (8 categories). The species with potential for use in 5-7 medicinal categories are *C. paniculatum* and *T. crispa* (7 categories), *A. indochinense*, *Oroxylum indicum* and *W. pubescens* (6 categories), *I. malayana*, *Momordica cochinchinensis* and *S. roxburghii* (5 categories). The species with potential for use in 2-4 medicinal categories include *Baliospermum solanifolium* (4 categories), *Ampelocissus martini* and *Tabernaemontana bufalina* (3 categories), and *Amorphophallus paeoniifolius*, *C. viminalis*, *H. odorata* and *M. tomentosa* (2 categories). The highest number of species has the potential to be used for antitussive, cold, and mucolytic treatments. The medicinal categories with the lowest number of species are cancer, diuretic, heart disease, and potency.

Discussion

Although Don Pa Puei is a remnant forest with an area of approximately five hectares and surrounded by agricultural areas, it contains a diverse range of plant species in terms of taxonomic groups (36 families, 62 genera, 65 species). Considering tree species diversity in the studied area, there were 32 tree species found that make up 49.23% of all species found in this study. The tree diversity indices, H' and J' , were 1.93 and 0.73, respectively. This finding is consistent with other studies in Thailand, which revealed that dry evergreen forests usually have higher species richness than other forest types. For example, there was higher species richness in dry evergreen forests than in dry dipterocarp forests or mixed deciduous forests in Doi Suthep-Pui National Park, Chiang Mai Province (Khamyong et al. 2018). Some tree species found in Don Pa Puei Sacred Forest are similar to those in dry evergreen forest in Northeastern Thailand. For instance, the same species found in Don Pa Puei and at Wang Nam Khiao Forestry Research and Training Station are *A. pavonina*, *A. xylocarpa*, *A. sootepense*, *Aphanamixis polystachya*, *D. alatus*, *H. odorata*, *L. calyculata*, *Mallotus philippensis*, *M. stipulata*, and *S. asper* (Phumphueng et al. 2018). Among the 32 tree species found, *L. calyculata* was the most dominant tree species, indicated by the IVI as high as 78.65%, which is notably higher compared to the IVI of 7.11% for *L. calyculata* in the dry evergreen forests at Wang Nam Khiao Forestry Research and Training Station (Phumphueng et al. 2018). The highest IVI value for *L. calyculata* was also reported in Don Pu Ta Forest, the community conservation area accessed by Thai Yoi Ethnic Groups in Sakon Nakhon Province, Thailand (Saensouk et al. 2024). The dominance of this species is

unique and serves as a key feature, supporting well with the community's tourism promotion plans.

Sacred community forests have been considered very important areas since they serve as a treasure house of endemic and threatened plant species (Suchiang et al. 2020). It also acts as a node of resilience for threatened tree species when located within human-modified landscapes (Undaharta and Wee 2020). In this study, four plant species were classified as threatened species under the IUCN Red List categories: *A. xylocarpa* (EN), *D. alatus* (VU), *H. odorata* (VU), and *S. roxburghii* (VU). Results from this study are consistent with the findings of Junsongduang et al. (2014), who reported that two sacred forests in Thailand harbored five endemic and threatened plant species, including *Antidesma bunius* var. *bunius*, *Archidendron clypearia*, *Kopsia arborea*, *Ilex umbellata* and *Ostodes paniculata*. In addition, there is a rare species in Thailand found in the studied area. As suggested by Undaharta and Wee (2020), forests that contain rare, threatened, or endemic species fall within the medium to high priority for conservation, depending on the conservation status of the species. Tree species such as *A. xylocarpa* are late-successional species with a constant growth rate (Phumphuang et al. 2018), meaning it may take time to

replace those that are cut down. Hence, together with efforts to replant these species, preserving the existing ones is crucial for conserving these threatened tree species in the area.

From our literature review, there are at least 19 species, accounting for approximately 30% of all species reported in this study, that are already well-known for their medicinal properties. The proportion of medicinal plant species in Don Pa Puei Sacred Forest is comparable to the proportion of medicinal plants reported in other sacred forests (17-22%) and swidden fallow fields (34-48%) used by Karen and Lawa ethnic minorities in Northern Thailand (Junsongduang et al. 2013). Additionally, the traditional use of plants as herbal medicines by the local community (villagers, ethnic groups, and tribal people) was found to be one of the most important forms of plant utilization in other areas in Thailand (e.g. Pholhiamhan et al. 2018; Phumthum and Balslev 2018; Saisor et al. 2021; Niamngon et al. 2023, 2024). Although the surrounding communities do not use a large number of plant species from the forest for medicinal purposes, Don Pa Puei remains a great house of gene pools of medicinal plants. Conserving the forest, in consequence, conserves the source of these medicinal herbs *in situ*.

Table 3. List of plant species used by the local community

Family and species	Part used	Category	Application
Acanthaceae			
<i>Thunbergia grandiflora</i>	Leaf	Animal food	Boiled leaf for chicken feed
Arecaceae			
<i>Calamus viminalis</i>	Flagellum	Tool	Flagellum is used for making a fishing tool
<i>Livistona jenkinsiana</i>	Fruit	Food	Fruit is cooked for dessert
Bignoniaceae			
<i>Markhamia stipulata</i>	Flower, fruit	Food	Flower and fruit are used as vegetables
<i>Oroxylum indicum</i>	Fruit	Food	Fruit is used as vegetables
Cornaceae			
<i>Alangium indochinense</i>	Bark	Medicine	Bark is boiled to drink for antimalaria
	Stem, twig	Tool	Stem or twig is used for making a gun handle
Chrysobalanaceae			
<i>Parinari anamensis</i>	Fruit	Food	Fruit is eaten fresh
Ebenaceae			
<i>Diospyros hasseltii</i>	Leaf	Drink	Leaf boiled to drink as tea
Irvingiaceae			
<i>Irvingia malayana</i>	Seed	Food	Seed is eaten
Meliaceae			
<i>Sandoricum koetjape</i>	Fruit	Food	Fruit is eaten
Menispermaceae			
<i>Tinospora crispa</i>	Stem	Medicine	Mixed with other ingredients and eaten as medicine, medicine for animals
	Stem	Cosmetics	Stem is used for making shampoo (mixed with other ingredients such as butterfly peas and indian laurel)
Moraceae			
<i>Ficus hispida</i>	Fruit	Tool	Fruit is used as fish bait for fishing
Myrtaceae			
<i>Syzygium cumini</i>	Fruit	Food	Fruit is eaten fresh
Sapindaceae			
<i>Lepisanthes rubiginosa</i>	Fruit	Food	Fruit is eaten fresh
<i>Schleichera oleosa</i>	Fruit	Food	Fruit is eaten fresh

Table 4. Potential plant species for use as medicinal plants and their medical categories

Medicinal categories	Number of species	Family	Species
Antitussive, cold, mucolytic	16	Apocynaceae	<i>Tabernaemontana bufalina</i>
		Araceae	<i>Amorphophallus paeoniifolius</i>
		Arecaceae	<i>Calamus viminalis</i>
		Bignoniaceae	<i>Oroxylum indicum</i>
		Cornaceae	<i>Alangium indochinense</i>
		Cucurbitaceae	<i>Momordica cochinchinensis</i>
		Dipterocarpaceae	<i>Hopea odorata</i>
		Dipterocarpaceae	<i>Shorea roxburghii</i>
		Irvingiaceae	<i>Irvingia malayana</i>
		Lamiaceae	<i>Clerodendrum paniculatum</i>
		Leeaceae	<i>Leea indica</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
		Menispermaceae	<i>Tinospora crispa</i>
		Moraceae	<i>Ficus hispida</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
		Laxative	9
Apocynaceae	<i>Wrightia pubescens</i>		
Bignoniaceae	<i>Oroxylum indicum</i>		
Cornaceae	<i>Alangium indochinense</i>		
Euphorbiaceae	<i>Baliospermum solanifolium</i>		
Lamiaceae	<i>Clerodendrum paniculatum</i>		
Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>		
Moraceae	<i>Ficus hispida</i>		
Female, pregnancy, birth, and puerperium	8	Tiliaceae	<i>Microcos tomentosa</i>
		Vitaceae	<i>Ampelocissus martini</i>
		Apocynaceae	<i>Tabernaemontana bufalina</i>
		Apocynaceae	<i>Wrightia pubescens</i>
		Irvingiaceae	<i>Irvingia malayana</i>
		Lamiaceae	<i>Clerodendrum paniculatum</i>
		Leeaceae	<i>Leea indica</i>
		Moraceae	<i>Ficus hispida</i>
Skin disease	8	Tiliaceae	<i>Microcos tomentosa</i>
		Vitaceae	<i>Ampelocissus martini</i>
		Araceae	<i>Amorphophallus paeoniifolius</i>
		Dipterocarpaceae	<i>Shorea roxburghii</i>
		Irvingiaceae	<i>Irvingia malayana</i>
		Lamiaceae	<i>Clerodendrum paniculatum</i>
		Leeaceae	<i>Leea indica</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
Wounds and injuries	8	Menispermaceae	<i>Tinospora crispa</i>
		Moraceae	<i>Ficus hispida</i>
		Bignoniaceae	<i>Oroxylum indicum</i>
		Cucurbitaceae	<i>Momordica cochinchinensis</i>
		Dipterocarpaceae	<i>Hopea odorata</i>
		Dipterocarpaceae	<i>Shorea roxburghii</i>
		Leeaceae	<i>Leea indica</i>
		Menispermaceae	<i>Tinospora crispa</i>
Dysentery	7	Moraceae	<i>Ficus hispida</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
		Apocynaceae	<i>Wrightia pubescens</i>
		Bignoniaceae	<i>Oroxylum indicum</i>
		Leeaceae	<i>Leea indica</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
		Menispermaceae	<i>Tinospora crispa</i>
Flatulence and expel wind	7	Moraceae	<i>Ficus hispida</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
		Apocynaceae	<i>Tabernaemontana bufalina</i>
		Bignoniaceae	<i>Oroxylum indicum</i>
		Cornaceae	<i>Alangium indochinense</i>
		Dipterocarpaceae	<i>Shorea roxburghii</i>
		Euphorbiaceae	<i>Baliospermum solanifolium</i>
		Lamiaceae	<i>Clerodendrum paniculatum</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>

Nutritious	7	Apocynaceae	<i>Wrightia pubescens</i>
		Arecaceae	<i>Calamus viminalis</i>
		Bignoniaceae	<i>Oroxylum indicum</i>
		Cornaceae	<i>Alangium indochinense</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
		Menispermaceae	<i>Tinospora crispa</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
Anthelmintic	6	Cornaceae	<i>Alangium indochinense</i>
		Euphorbiaceae	<i>Baliospermum solanifolium</i>
		Irvingiaceae	<i>Irvingia malayana</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
		Menispermaceae	<i>Tinospora crispa</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
Hemorrhoid	5	Cornaceae	<i>Alangium indochinense</i>
		Cucurbitaceae	<i>Momordica cochinchinensis</i>
		Euphorbiaceae	<i>Baliospermum solanifolium</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
		Moraceae	<i>Ficus hispida</i>
Tuberculosis	4	Apocynaceae	<i>Wrightia pubescens</i>
		Cucurbitaceae	<i>Momordica cochinchinensis</i>
		Irvingiaceae	<i>Irvingia malayana</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
Antimalarial	3	Lamiaceae	<i>Clerodendrum paniculatum</i>
		Menispermaceae	<i>Tinospora crispa</i>
		Moraceae	<i>Ficus hispida</i>
Dizziness	3	Leeaceae	<i>Leea indica</i>
		Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
Body aches	2	Leeaceae	<i>Leea indica</i>
		Sapindaceae	<i>Lepisanthes rubiginosa</i>
Insect bites	2	Apocynaceae	<i>Wrightia pubescens</i>
		Lamiaceae	<i>Clerodendrum paniculatum</i>
Cancer	1	Leeaceae	<i>Leea indica</i>
Diuretic	1	Cucurbitaceae	<i>Momordica cochinchinensis</i>
Heart disease	1	Dipterocarpaceae	<i>Shorea roxburghii</i>
Potency	1	Leguminosae-Mimosoideae	<i>Adenanthera pavonina</i>

In this study, 17 out of 65 species (26.16%) found are climbers and lianas, accounting for nearly half of the tree species found in the forest. Lianas were primarily associated with large tree species inside the forest. According to Manna et al. (2017), the association with large major trees supports lianas to occupy the top canopy, while climbers were mostly found at the forest edges, creating dense bushes on small trees and shrubs. Climbers may impact tree diversity over time by competing with trees and understory plants for sunshine and nutrition. Thus, climber removal has been shown to enhance tree growth and biomass (Finlayson et al. 2022). Additionally, one species, *Mikania cordata*, is a species having a life form very similar to its relative, *M. micrantha*, a recognizable invasive species (Office of Natural Resources and Environmental Policy and Planning 2024). This resemblance suggests that *M. cordata* may pose a similar threat to tree diversity, as climbers can pose negative effects on the overall health and diversity of the forest.

The study conducted in Meghalaya, Northeast India, reported that various types of disturbance, including the encroachment of forest land for agriculture and road construction, have pushed community forests into a degraded state (Mir et al. 2022). This study is of utmost importance as it sheds light on the critical situation of the

community forests. Nowadays, the land surrounding Don Pa Puei Sacred Forest is being converted into agricultural areas, such as rice fields and cassava plantations. Remnant forest areas may remain unaffected if there is no further encroachment. However, the cleared areas have already welcomed some invasive species settlement. We found at least one invasive species, *B. pilosa* (Office of Natural Resources and Environmental Policy and Planning 2024), in agricultural and opened areas along the forest edges. Invasive species are well known for their potential to cause biodiversity loss (IPBES 2023). We suggest that this situation represents one of the most important priorities for conservation and urgently requires management strategy to prevent further degradation of the forest.

Community forest management is a management strategy that local people or groups take some roles in forest management and are therefore entitled to the benefits from the forest under their care. Community forest management approaches have been accepted as a successful strategy for forest conservation for decades (Hodgdon 2021). In Thailand, the Community Forest Act BE 2562 came into action in 2019. This act promotes community forests to be registered under legal process and managed under formal mechanisms. In consequence, the rights of local people to manage and use the forest in

sustainable ways, and the forest's biodiversity will be protected by law (Tantapong 2025). Agarwal et al. (2022) provided strong evidence that community-based forest management in Nan province, Thailand, resulted in effective forest conservation. Being assigned as a community forest managed under mechanisms that fit the local context could be an effective strategy for the conservation of biodiversity in this sacred forest in the future.

In conclusion, the results of our study highlight that Don Pa Puei Sacred Forest is a valuable area for conservation due to its unique characteristic of a dry evergreen forest with a high density of *L. calyculata*. The forest also contains significant plant diversity, including threatened plant species and significant numbers of medicinal plants. The findings from our study provide essential information to support the community's efforts to promote tourism activity and to emphasize awareness among local people about forest conservation. Nevertheless, further long-term studies are necessary to complete the baseline data on the plant diversity of the forest. We recommend that the eradication of invasive species and management of climbers, together with the protection of the area from land-use change, are urgently needed to ensure the conservation of the forest's biodiversity. Formally, management of the forest under the Community Forest Act BE 2562's procedures could be another effective strategy to conserve the forest's biodiversity.

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