

## THE VEGETATION OF JAE SAWN NATIONAL PARK, LAMPANG PROVINCE, THAILAND

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### ABSTRACT

Research on the botanical diversity, vegetation, and floristics of Jae Sawn National Park was started by Herbarium staff of the Department of Biology, Chiang Mai University in August 1995 and is continuing. The vegetation in the lowlands (300 to c. 800 m) includes bamboo + deciduous (teak) and deciduous dipterocarp–oak facies, while from c. 800–1,000 m the forest is mixed evergreen + deciduous hardwood. Above this is primary evergreen, seasonal, hardwood forest, mainly at 1,000–1,500 m and from 1,800 to 2,031 m (Doi Lahnggah), the highest peak in the national park. From c. 1,250 m and especially at 1,500–1,800 m, the forest is mostly primary evergreen hardwood + pine (*Pinus kesiya* Roy. ex Gord., Pinaceae). Most of the park has granite bedrock, while shale is found in scattered lowland areas up to c. 750 m and shale and phyllite in the Doi Lahnggah area. The northern part is limestone, where many calciphytes are found. Seven new records for the flora of Thailand have also been found.

A computer database, containing taxonomic, distributional and ecological information on all 1,353 species of vascular plants recorded as of 1 March 1997 has been prepared, including 344 tree species, 136 treelets, 106 woody climbers, 58 shrubs, 447 vines, and 562 herbs. The database clearly identified primary evergreen forest and mixed evergreen + deciduous forest equally as the two most important habitats in the park for the maintenance of overall botanical diversity and as the main repository of rare and threatened species. In combination they support 83% of the park's entire flora. The species most in danger of extirpation from the park and most in need of immediate conservation measures include *Podocarpus nerifolius* D. Don (Podocarpaceae), *Epirixanthes elongata* Bl. (Polygalaceae), and *Cycas pectinata* Griff. (Cycadaceae).

### INTRODUCTION

Established in 1988, Jae Sawn National Park is located in Lampang Province, northern Thailand, and has an area of 768 km<sup>2</sup>. Administratively it is included in three Districts, viz. Muang, Muang Bahn (Pan), and Wahng Nua, and is positioned between latitudes c. 18°30'–19°05' north and longitudes c. 99° 25'–30' east. The park is mostly mountainous with a northerly to southerly aspect. It is c. 63 km long and 12–14 km wide. It is contiguous with Doi Kuhnthan National Park to the south, Mae Dah Kry National Park to the west, Kuhn Jae National Park in the NW, and is adjacent to Doi Luang National Park in the north. Farm land and villages lie to the east in a low, mostly flat plain. The lowest elevation in the national park is on the eastern boundary, c. 300–350 m, and the highest point in the park is 2,031 m above sea level at the summit of Doi (Mt.) Lahnggah in the west-central part.

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## BEDROCK

Most of the exposed bedrock in Jae Sawn National Park is Triassic granite c. 200 million years old. There are scattered outcrops of shale below the granite belonging to the Kanchanaburi Formation of the Silurian to Carboniferous Geological Periods, i.e. 300–400 million years old. The Doi Lahnggah area has shale and phyllite belonging to the Kaeng Krachan Formation (Carboniferous to Silurian) on top of granite at elevations above c. 1,200 m. The northern part, in Wahng Nua District, has rugged limestone hills up to c. 950 m elevation of the Ratburi Formation, from the Carboniferous to Permian Periods, c. 250–300 million years old (JAVANAPET, 1969).

## CLIMATE

Typical of northern Thailand, the climate of the region is strongly seasonal. There is a hot, dry season from about mid-March to May, followed by the rainy season from June to October, with the cool, dry season from November to February. Details of the temperature and rainfall are presented in Figure 1. It should be noted that upland areas will have lower temperatures and higher rainfall than recorded at Lampang (241 m elevation).

## VEGETATION

As with most other remnant forested areas in northern Thailand, there are three basic forest types, viz. deciduous, mixed evergreen + deciduous, and evergreen. The vegetation in these habitats differs significantly because of moisture, elevation and, to a lesser extent, bedrock—specifically on limestone. The deciduous and evergreen forest types can be subdivided based on various floristic associations. The original lowland vegetation, now very degraded or destroyed, consisted of large, deciduous hardwood trees which have been severely exploited, e.g. *Tectona grandis* L. f. (Verbenaceae, teak) and other valuable timber trees, in the past 50 years. This zone extends from 300 m to about 800 m elevation and above this, c. 800–1,000 m, is a mixed association of deciduous + evergreen hardwood species. From c. 1,000 to 2,031 m the forest is mostly primary and evergreen with *Pinus kesiya* Roy. ex Gord. (Pinaceae, pine) in some places. The vegetation at Jae Sawn National Park is quite similar to that found in nearby places at all elevations and on the various bedrocks (MAXWELL, 1988, 1992, 1996; MAXWELL *ET AL.* 1995).

### Bamboo/Deciduous Forest

As noted above, much of the original vegetation throughout northern Thailand has been ravaged by unscrupulous and ecologically devastating logging operations for over 100 years. There is only one remaining lowland area with its original vegetation, Mae Yom National Park, Phrae Province, which is currently threatened with inundation by the proposed Kaeng Sua Ten Dam. It is c. 100 km SE of the middle of Jae Sawn National Park where the park headquarters is located. Since we have been able to study the vegetation and flora in Mae Yom National Park, we have a good idea of what the original

and degraded vegetation are like there and have applied this knowledge when studying places such as Jae Sawn National Park, where only vestiges of the original lowland forest remain (MAHIDOL UNIVERSITY, 1992).

Deciduous forest vegetation is found on the eastern side of the national park and formerly covered the now settled and cultivated area outside of the park boundary. Slightly over 50% of the original cover on all bedrocks consisted of *Tectona grandis*, while lesser percentages of *Azelia xylocarpa* (Kurz) Craib (Leguminosae, Caesalpinioideae), *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) Niels. (Leguminosae, Mimosoideae), *Dalbergia cana* Bth. var. *cana* and *Pterocarpus macrocarpus* Kurz (both Leguminosae, Papilionoideae), *Terminalia bellirica* (Gaertn.) Roxb. (Combretaceae), *Lagerstroemia cochinchinensis* Gagnep. var. *ovalifolia* Furt. & Mont. (Lythraceae) *Chukrasia tabularis* A. Juss. (Meliaceae), *Dillenia parviflora* Griff. var. *kerrii* (Craib) Hoogl. (Dilleniaceae), and other canopy species were found. Presently there are very few mature *Tectona grandis* or *Azelia xylocarpa* trees, while the numbers of other commercially valuable trees have been drastically reduced. Because of logging selection, many less valuable trees have been able to grow and reproduce, thus increasing their original amounts. These include *Lagerstroemia tomentosa* Presl (Lythraceae), *Terminalia mucronata* Craib & Hutch. (Combretaceae), *Schleichera oleosa* (Lour.) Oken (Sapindaceae), *Spondias pinnata* (L.f.) Kurz (Anacardiaceae) and *Alstonia scholaris* (L.) R. Br. var. *scholaris* (Apocynaceae). *Tetrameles nudiflora* R. Br. ex Benn. (Datisceae), certainly the tallest (40–50 m) tree in the lowlands, is readily distinguished by its spectacular plank buttresses and is found in seasonally dry stream valleys, but is uncommon. *Duabanga grandiflora* (Roxb. ex DC.) Walp. (Sonneratiaceae), which is mostly found in stream valleys, and *Irvingia malayana* Oliv. ex Benn. (Irvingiaceae) are the only two large evergreen tree species found in lowland deciduous forests. Evidence for massive forest destruction can be seen with large cut and rotting logs, numerous coppicing *Tectona grandis* stumps, some of which are 80–90 cm diameter, and abnormally high densities of several species of bamboo (Gramineae, Bambusoideae) which are naturally found in intact deciduous forests and become more abundant as a result of deforestation. These bamboos include *Dendrocalamus membranaceus* Munro, *D. nudus* Pilg., *Bambusa tulda* Roxb., and to a lesser extent *Cephalostachyum pergracile* Munro. It is because the original deciduous hardwood forest has been so severely degraded and now includes so much bamboo that we have called this kind of vegetation bamboo/deciduous forest.

All of these bamboos have been further exploited and subsequently damaged by widespread cutting of mature culms and removal of edible young “shoots”. Fire damage is prevalent and occurs during the dry, hot season (March–May) when fires are started to clear the ground for a putative increased yield in edible mushrooms during the rainy season, as well as to make hunting the last remaining animals easier. Removal of all the biomass (i.e. logs) along with annual vaporization of residual organics in the soil and subsequent erosion of the remainder by rain, have had a disastrous degrading effect on the quality of the soil.

Deciduous understory trees include: *Colona winitii* Craib and *Microcos paniculata* L. (both Tiliaceae), *Vitex canescens* Kurz, *V. glabrata* R. Br. and *V. limoniifolia* Wall. ex Kurz (all Verbenaceae), *Cassia fistula* L. (Leguminosae, Caesalpinioideae), *Dalbergia fusca* Pierre (Leguminosae, Papilionoideae), *Stereospermum neuranthum* Kurz and *Oroxylum*

*indicum* (L.) Kurz (both Bignoniaceae), *Holarrhena pubescens* (Bth.) Wall. ex D. Don (Apocynaceae), and *Artocarpus lakoocha* Roxb. (Moraceae). Deciduous woody climbers (lianas), some of them with basal diameters of over 20 cm, are evident and include *Entada rheedii* Spreng. (Leguminosae, Mimosoideae), *Millettia cinerea* Bth. and *M. extensa* (Bth.) Bth. ex Bak. (Leguminosae, Papilionoideae), *Caesalpinia digyna* Rottl. (Leguminosae, Caesalpinioideae), *Combretum latifolium* Bl. (Combretaceae), and *Congea tomentosa* Roxb. var. *tomentosa* (Verbenaceae). Deciduous shrubs and treelets are common. Some of the more common species are: *Leea indica* (Burm. f.) Merr. (Leeaceae), *Bauhinia viridescens* Desv. var. *viridescens* (Leguminosae, Caesalpinioideae), *Millettia caerulea* Grah. ex Bak. (Leguminosae, Papilionoideae), and *Antidesma acidum* Retz. (Euphorbiaceae). *Mussaenda parva* Wall. ex G. Don (Rubiaceae) is a deciduous, scandent species which has large, conspicuous, white sepals scattered in its inflorescences which are produced throughout much of the year.

The ground flora is deciduous, mostly perennial, very diverse, and quite seasonal in phenology. During the dry season (November–April), most of the ground and much above it is leafless. The first herbs to appear are *Gagnepainia godefreyi* (Baill.) K. Sch., *Globba nuda* K. Lar. and *Kaempferia rotunda* L. (all Zingiberaceae), *Geodorum siamensis* Rol. ex Dow., *Nervilia aragoana* Gaud., and *N. plicata* (Andr.) Schltr. (all Orchidaceae), *Hapaline benthamiana* Schott and *Amorphophallus macrorhizus* Craib (both Araceae), and the very rare *Proiphys amboinensis* (L.) Herb. (Amaryllidaceae), all of which produce flowers in April before their leaves appear. In May, after the first rains have fallen, more species appear and produce flowers either during or after leaf development. Some of these are *Curcuma parviflora* Wall. and *Globba reflexa* Craib (both Zingiberaceae), *Stemona burkillii* Prain (Stemonaceae, a vine), *Geodorum recurvum* (Roxb.) Alst., *Habenaria thailandica* Seid., and *Peristylus constrictus* (Lindl.) Lindl. (all Orchidaceae). Afterwards, most of the other ground flora species develop and by July–August, the ground is covered with herbaceous vegetation. Many of these herbs flower for several months, e.g. *Curcumorpha longiflora* (Wall.) Rao & Verma (Zingiberaceae, May–September) and *Halopogon brachystachys* Craib (Marantaceae, August–October). However, most ground flora species flower for only a month or two, e.g. *Biophytum sensitivum* (L.) DC. (Oxalidaceae) and *Ruellia siamensis* Im. (Acanthaceae).

Some other common ground flora herbs include: *Munronia humilis* (Blanco) Harms (Meliaceae), *Andrographis laxiflora* (Bl.) Lindau, *Barleria cristata* L., *B. strigosa* Willd., *Justicia procumbens* L., *Lepidagathis incurva* Ham. ex D. Don, and *Rungia parviflora* (Retz.) Nees var. *ciliata* Brem. (all Acanthaceae); *Sonerila nisbetiana* Craib (Melastomataceae, an annual herb); *Hedyotis auricularia* L., *H. ovatifolia* Cav., *Knoxia corymbosa* Willd. (all Rubiaceae), *Oryza meyeriana* (Zoll. & Mor.) Baill. var. *granulata* (Watt) Duist. (Gramineae), and *Curculigo latifolia* Dry. ex W.T. Ait. var. *latifolia* (Amaranthaceae, Hypoxidoideae). *Aeginetia indica* Roxb. (Orobanchaceae), a deciduous, perennial, leafless, saprophyte/parasite, is also commonly found throughout the bamboo/deciduous forest from August–October. *Epirixanthes elongata* Bl. (Polygalaceae) is a very rare, leafless saprophyte/parasite on bamboo roots which is known to flower in August and fruit in September. *Microstegium vagans* (Nees ex Steud.) A. Camus (Gramineae) is very common in disturbed, fire-damage areas. It is a serious problem for forest regeneration since it is not only widespread and dense, but also very combustible.

### *Limestone flora*

A note concerning the vegetation in limestone areas is important here. As with the lowland vegetation found on granite and shale bedrocks, the same basic deciduous forest is found in limestone areas which have also been logged for *Tectona grandis* and other species. There are some geophytes restricted to limestone areas, the most conspicuous being the very common *Streblus ilicifolius* (Vidal) Corn. (Moraceae), a dense-growing, evergreen, understorey, treelet—tree species; *Spondias lakonensis* Pierre and *S. laxiflora* (Kurz) A.S. & For. (Anacardiaceae), both deciduous trees; *Euphorbia antiquorum* L. (Euphorbiaceae), a deciduous herb—treelet; and *Dracaena lourieri* Gagnep. (Agavaceae), an evergreen treelet—the latter two common and conspicuous species often being epilithic. Some of the higher and more shaded areas on limestone have a mixed evergreen + deciduous facies which does not differ, except for the epilithic flora, from that in the granite and shale zones. *Dracontomelon dao* (Blanco) Merr. & Rol. (Anacardiaceae), an evergreen canopy tree with prominent buttresses, is found in these mixed areas.

Some herbs commonly found on limestone hills, often in exposed rubble areas where a clear distinction between their being an epilith or geophyte is sometimes difficult to determine, include: *Crotalaria verrucosa* L. (Leguminosae, Papilionoideae), *Kalanchoe integra* (Med.) O.K. (Crassulaceae), *Plectranthus* (*Isodon nigropunctatus* Mur., Labiatae), and *Vernonia curtisii* Craib & Hutch. var. *curtisii* (Compositae).

The actual limestone peaks, at c. 700–900 m elevation, are very rugged, exposed, and include both deciduous and evergreen, often scrub-like, woody species as well as herbaceous epiliths. Deciduous trees include *Ficus pisocarpa* Bl. (Moraceae), a “strangling” epilith, *Spondias laxiflora* (Kurz) A.S. & For. (Anacardiaceae), *Firmiana kerrii* (Craib) Kosterm. (Sterculiaceae), and *Terminalia franchetii* Gagnep. var. *tomentosa* Nana. (Combretaceae)—all of which flower during the hot-dry season while leafless. Evergreen treelets or small trees are: *Memecylon scutellatum* (Lour.) Naud. (Melastomataceae), *Drypetes hainanensis* Merr. (Euphorbiaceae), *Streblus ilicifolius* (Vidal) Corn. (Moraceae), and *Buxus sempervirens* L. (Buxaceae). *Jasminum calcicolum* Kerr (Oleaceae) and *Derris tonkinensis* Gagnep. (Leguminosae, Papilionoideae) are evergreen woody climbers while *Ventilago denticulata* Willd. (Rhamnaceae), *Argyreia aggregata* Roxb. var. *aggregata*, and *Porana spectabilis* Kurz (both Convolvulaceae) are deciduous representatives. *Hoya kerrii* Craib (Asclepiadaceae), a succulent, evergreen, epiphytic vine, is found in partly shaded places.

These peaks notably lack species found in dipterocarp—oak and bamboo/deciduous forests as well as mixed evergreen + deciduous hardwood forest found on other bedrocks.

### *Epilithic species*

A basic distinction can be made between vascular plants growing on granite and shale rocks and those on limestone (calciphytes). This distinction is far more profound than the overall flora in these two zones. The reason for this distinction is due to acidic pH values for granite and shale and alkaline ones on limestone. Due to its scarcity and friability, there are very few shale epiliths. The few that we have seen have been along streams have not differed from those on granite. The differences between granite and limestone epiliths will, therefore, be discussed. In general, most lowland epiliths are deciduous and perennial; many are also succulent. Those growing, apparently exclusively, on granite are: *Begonia*

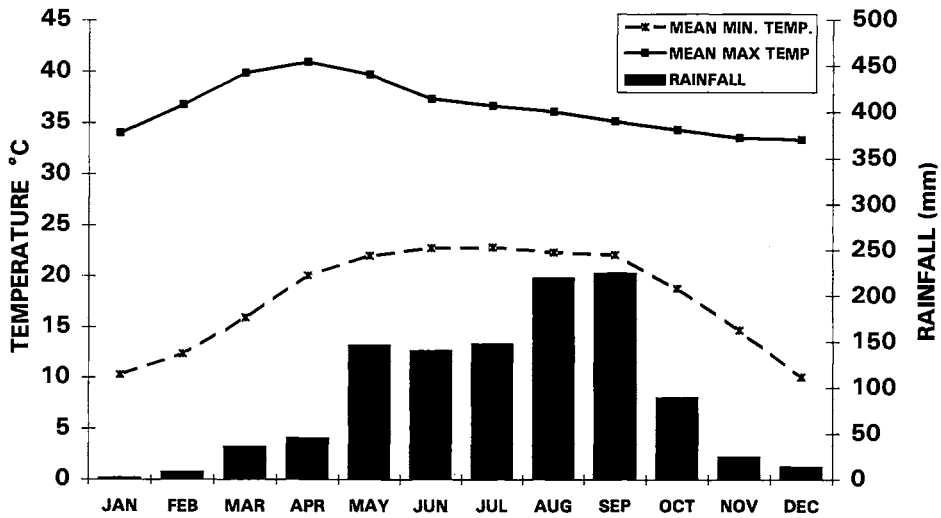


Figure 1. Temperature and rainfall recorded at Lampang, 1989–1996. Source: Meteorological Department, Lampang (241 m elevation).

*yunnanensis* Levl. (Begoniaceae), *Argostemma verticillatum* Wall. (Rubiaceae), *Boea herbacea* Cl. (Gesneriaceae), and *Asplenium crinicaule* Hance (Aspleniaceae). Many are only known to grow on limestone, e.g. dicots: *Impatiens calcicola* Craib and *I. salaengensis* T. Shim. (Balsaminaceae); *Argostemma condensum* Craib, *A. saxicolum*, Craib and *A. aff. unifolium* Benn. (Rubiaceae), *Ornithoboea archnoidea* (Diels) Craib, *O. wildeana* Craib (Gesneriaceae); and *Elatostema salvinoides* W.T. Wang (Utricaceae). Some monocots are *Arisaema balansae* Engl. (Araceae), *Pommereschea lackneri* Witt. (Zingiberaceae), *Spatholirion ornatum* Ridl. (Commelinaceae), and *Calanthe rosea* (Lindl.) Bth. (Orchidaceae). Some common pteridophytes are: *Doryopteris ludens* (Wall. ex Hk.) J. Sm. (Parkeriaceae) and *Asplenium simonsianum* Hk. (Aspleniaceae). *Garrettia siamensis* Flet. (Verbenaceae) is a deciduous treelet confined to lowland limestone areas.

Some species common on all three bedrocks are: *Impatiens violaeiflora* Hk. f. (Balsaminaceae); *Chirita hamosa* Wall. ex R. Br., *Epithema carnosum* (D. Don) Bth., *Petrocosmea kerrii* Craib and *Rhynchoglossum obliquum* Bl. (all Gesneriaceae), and *Elatostema monandrum* (Ham. ex D. Don) Hara (Urticaceae).

### Stream flora

There are many streams, many of the smaller ones being seasonal, in Jae Sawn National Park which flow through the lowland bamboo/deciduous forest. Due to permanent wetness or moister soil during the dry season, lowland riverine areas have a more evergreen vegetation. Many species are confined to this habitat, while others are either amphibious or rheophytic. *Eugenia formosa* Wall., *E. megacarpa* Craib (Myrtaceae) (Figure 2), and *Meliosma simplicifolia* (Roxb.) Walp. spp. *fordii* (Hemsl. ex Forb. & Hemsl.) Beus. (Sabiaceae), are all common, very conspicuous, small evergreen trees. *Ficus racemosa* L.



Figure 2. *Eugenia megacarpa* Craib (Myrtaceae), a common, small, evergreen tree grows along streams, on granite, limestone, and shale in a wide range of habitats (lowland deciduous; mixed evergreen + deciduous; and primary, evergreen, seasonal, hardwood forests) from 450–1,200 m. It flowers in March–April and produces baccate berries in May–June. Photo: V. Anusarnsunthorn, 27 May 1996 (Maxwell 96–718, 500 m).

Figure 3. *Ficus squamosa* Roxb. (Moraceae) in Mae Mawn Stream at 475 m. It is a common evergreen rheophytic shrub which produces figs (synconia) from May to December. It is found at elevations of 450–1,300 m on granite, limestone, and shale. Photo: V. Anusarnsunthorn, 27 May 1996.







Figure 4. *Elaeocarpus floribundus* Bl. (Elaeocarpaceae) is found in the lower parts of the primary, evergreen, seasonal, hardwood forest, at 1,150–1,400 m elevation on granite bedrock. It is an evergreen, understory tree, which flowers in May–June and bears drupes in October. Photo: V. Anusarnsunthorn, 28 May 1996 (Maxwell 96–729, 1,175 m).



Figure 5. *Apodytes dimidiata* E. Meyer ex Arn. (Icacinaeae), an evergreen understory tree, is found in the lower parts of the primary, evergreen, seasonal, hardwood forest, 1,025–1,400 m elevation. It flowers in May–June and bears drupes in October. Photo: V. Anusarnsunthorn, 28 May 1996 (Maxwell 96–742, 1,025 m).





Figure 6. *Clerodendrum serratum* (L.) Moon var. *wallichii* Cl. (Verbenaceae) is found in disturbed, often open, areas in primary, evergreen, seasonal, hardwood forested areas at 1,100–1,600 m elevation on granite bedrock. This variety is an evergreen treelet or shrub which flowers during May–September and has ripe drupes in September–November. Photo: V. Anusarnsunthorn, 27 May 1996, 1,125 m.

Figure 7. *Connarus semidecandrus* Jack (Connaraceae) is an evergreen woody climber found mostly in “mixed” and lower parts of the primary, evergreen, seasonal, hardwood forest on shale and granite bedrocks. It is known from elevations of 400–1,050 m, flowers in March–April, and produces follicles in April–May. Photo: V. Anusarnsunthorn, 28 May 1996 (Maxwell 96-744, 1,025 m).



Figure 8. *Malaxis latifolia* J.E. Sm. (Orchidaceae), an uncommon, deciduous, ground orchid, grows in slightly disturbed stream areas in primary, evergreen, seasonal, hardwood forest on granite bedrock at 1,000–1,150 m. It flowers in May–June, produces capsules in August–September, which remain on the plant for several months after dehiscence and has leaves from May to December. Photo: V. Anusarnsunthorn, 28 May 1996 (Maxwell 96–738, 1,100 m).



Figure 9. *Rhaphidophora peepla* (Roxb.) Schott (Araceae), a common evergreen vine which creeps on tree trunks or rocks, is found along streams in lowland deciduous forests and throughout the “mixed” and primary evergreen, seasonal, hardwood forests from 475–c. 2,000 m elevation. Inflorescences are produced from May to December, while infructescences of baccate berries are found from December to March. It is found on all three kinds of bedrock in the national park. Photo: V. Anusarnsunthorn, 27 May 1996 (Maxwell 96–721, 475 m).



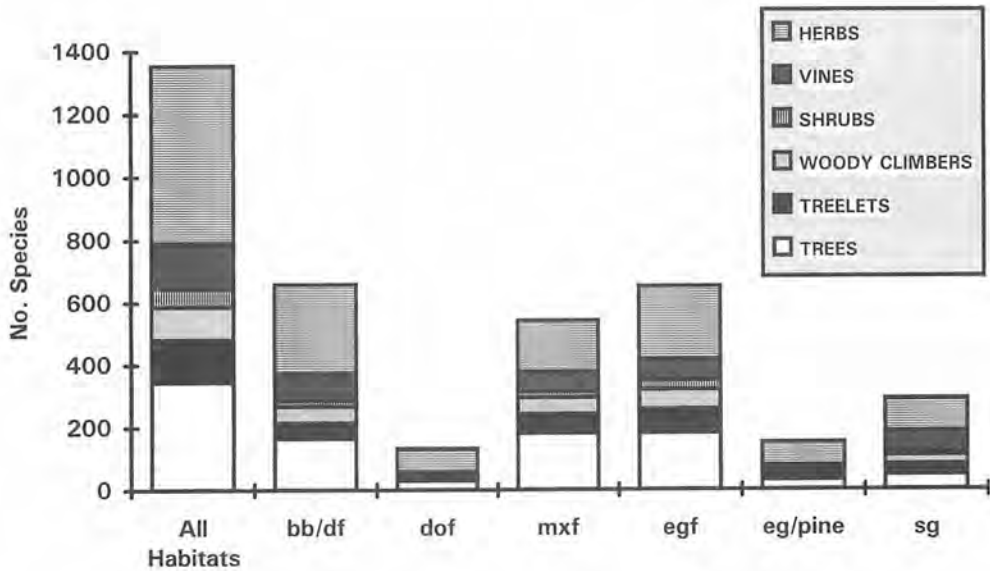


Figure 10. Species richness of vascular plants in different forest types in Jae Sawn National Park: bb/df = bamboo/deciduous forest; dof = deciduous dipterocarp-oak forest; mxf = mixed evergreen + deciduous hardwood; egf = primary evergreen forest; eg/pine = evergreen hardwood + pine forest and sg = secondary growth.

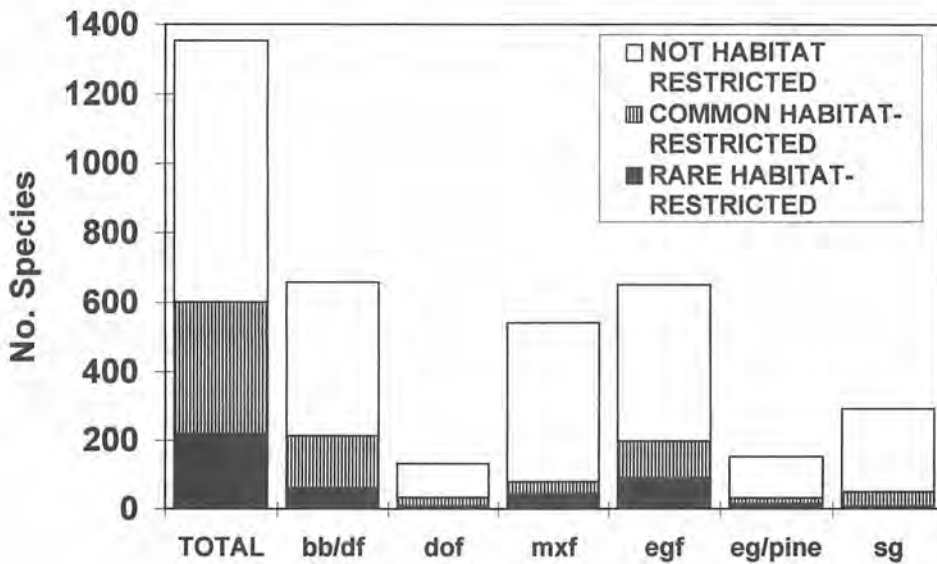


Figure 11. Habitat-restricted and rare species in the various forest types of Jae Sawn National Park.

var. *racemosa* (Moraceae) is a deciduous, cauliflorous (fig) tree. *Ficus squamosa* Roxb. (Moraceae) (Figure 3) grows as an evergreen, rheophytic shrub. All of these species are found on all three kinds of bedrock. Common evergreen herbs found in this habitat are: *Donax cannaeformis* (G. Forst.) K. Sch. and *Phrynium capitatum* Willd. (both Marantaceae), *Forrestia glabratus* (Hassk.) Hassk. (Commelinaceae, a vine), *Thelypteris nudata* (Roxb.) Mort. (Thelypteridaceae), and *Angiopteris evecta* (Forst.) Hoffm. (Marattiaceae). *Microsorium pteropus* (Bl.) Copel. (Polypodiaceae) is an uncommon, epilithic, rheophytic/aquatic herb which only grows on granite and shale bedrocks.

### Deciduous Dipterocarp–Oak Association

As discussed in a recent paper on the vegetation of Doi Kuhn Tan National Park, which is directly south of Jae Sawn National Park, the deciduous dipterocarp–oak association is a secondary and probably climax growth, derived from destroyed bamboo/deciduous forest (MAXWELL ET AL., 1995). There are few similarities in the woody flora to bamboo/deciduous facies, but the herbaceous components are complementary. In general, the deciduous dipterocarp–oak forest, named because of the dominance of Dipterocarpaceae and *Quercus* (Fagaceae, oaks), is more open, drier, and diminutive than bamboo/deciduous forest, with little or no bamboo. The soil has obviously been more eroded, since there is an even thinner organic layer and more coarse texture to what is often merely subsoil. There is no definite boundary between these two forest facies and in most instances they merge. Both kinds of vegetation are on all three bedrocks throughout the lowlands of the national park. Due to varying amounts of initial and subsequent damage to the original deciduous forest, there are many transitional areas where the forest is a mixture of bamboo/deciduous and dipterocarp–oak facies. In our opinion bamboo/deciduous forested areas, if left alone, can recover, perhaps in hundreds of years, to a more original state. The normal situation is that uncontrolled abuse, i.e. chopping and fire, prevent recovery and encourage the development of a dipterocarp–oak facies. There must be a parameter, probably in the soil, where there is a minimum level of recovery whereby tree seeds from the bamboo/deciduous forest cannot either germinate or survive after germination. At present there is no information available to support this view except for our own observations, but it is certainly a fact that a deciduous dipterocarp–oak forest either maintains itself as a secondary community or when cut develops into secondary scrub or barren wasteland. The herbaceous ground flora in both forest types is often very similar, except when the deciduous dipterocarp–oak forest has been severely degraded.

Several tree species of the Dipterocarpaceae are very common and tend to dominate this kind of forest. *Dipterocarpus obtusifolius* Teijsm. ex Miq. var. *obtusifolius*, *D. tuberculatus* Roxb. var. *tuberculatus*, *Shorea obtusa* Wall. ex Bl., and *S. siamensis* Miq. var. *siamensis* are more abundant than all other tree species in this forest. *Quercus kerrii* Craib var. *kerrii* and *Q. kingiana* Craib are very common. Other common, but never dominant, trees are *Careya arborea* Roxb. (Lecythidaceae), *Tristaniaopsis burmanica* (Griff.) Wils. & Wat. var. *rufescens* (Hance) Parn. & Lug. (Myrtaceae), *Anneslea fragrans* Wall. (Theaceae), *Aporosa villosa* (Lindl.) Baill. and *A. wallichii* Hk. f. (Euphobiaceae), *Craibiodendron stellatum* (Pierre) W.W. Sm. (Ericaceae), *Buchanania lanzan* Spreng. (Anacardiaceae), *Dalbergia fusca* Pierre (Leguminosae, Papilionoideae), and *Strychnos*



*nux-vomica* L. (Loganiaceae).

*Spatholobus parviflorus* (Roxb.) O.K. (Leguminosae, Papilionoideae) and *Celastrus paniculatus* Willd. (Celastraceae), both deciduous woody climbers, are also present. In general, vines are scarce, in contrast to vascular epiphytes and epiliths, which are common. Evergreen, always succulent, epiphytes and epiliths include *Dischidia nummularia* R. Br. and *D. major* (Vahl) Merr. (Asclepiadaceae) and numerous Orchidaceae, e.g. *Cymbidium bicolor* Lindl. and *Coelogyne trinervis* Lindl.; and *Pyrrosia adnascens* (Sw.) Ching (Polypodiaceae). Some deciduous counterparts are: *Dendrobium gratiosissimum* Rehb. f. (Orchidaceae), *Drynaria rigidula* (Sw.) Bedd., and *Placycerium wallichii* Hk. (both Polypodiaceae).

The ground flora is mostly perennial, deciduous, and is quite similar to that found in bamboo/deciduous forested areas. In well developed deciduous dipterocarp-oak forest areas there is no bamboo. However, in transitional areas those bamboo species found in bamboo/deciduous forest are common. During the latter part of the rainy season, i.e. July–October, the ground is densely covered with mostly monocot herbs in most areas. Members of the Zingiberaceae are quite common, e.g. *Curcumorpha longiflora* (Wall.) Rao & Verma, *Curcuma petiolata* Roxb., *Boesenbergia longipes* (King & Prain) Schltr., and *Globba villosula* Gagnep. Gramineae (grasses) frequently dominate many places with *Apluda mutica* L., *Themeda triandra* Forssk., and *Arundinella setosa* Trin. var. *setosa*. These are also mixed with Cyperaceae (sedges) e.g. *Carex stramentita* Boott ex Boeck, *Fimbristylis dichotoma* (L.) Vahl ssp. *dichotoma*, *Scleria levis* Retz., and *S. lithosperma* (L.) Sw. var. *lithosperma*.

More exposed, rocky, and fire-damaged places have many species of annual dicot herbs, especially *Crotalaria alata* D. Don, *C. neriifolia* Wall. ex Bth., and *C. sessiliflora* L. (all Leguminosae, Papilionoideae); and the deciduous, perennial pteridophyte *Selaginella ostenfeldii* Hier. (Selaginellaceae). *Pueraria stricta* Kurz (Leguminosae, Papilionoideae), a deciduous vine, which is sometimes somewhat scandent, is also common. The granite boulders, which are abundant in this kind of forest, are covered from July to November with various pteridophytes, e.g. *Adiantum philippense* L. and *A. zollingeri* Mett. ex Kuhn (Parkeriaceae), and a few dicots, e.g. *Lindenbergia indica* (L.) Vat. (Scrophulariaceae) and *Peperomia pellucida* (L.) H.B.K. (Piperaceae), a naturalized herb native to tropical America.

As in the bamboo/deciduous forest, there are numerous seedlings and saplings of woody plants, especially trees, found as mature individuals in these two associations, as well as edible, inedible, and poisonous fungi which are most apparent during the rainy season.

### Mixed Evergreen + Deciduous Hardwood Forest

From about 800 m, or even as low as 550 m in stream valleys, to 1,000 m, there is a mixture of deciduous and evergreen hardwood species. The boundaries of this mixed evergreen + deciduous hardwood forest are not always definite; i.e. there are transitional zones present mainly due to the amount and extent of disturbance. *Tectona grandis* L.f. (Verbenaceae, teak) is not found in this mixed zone mainly because it is not naturally found above c. 850 m and also perhaps because of various unsuitable soil/moisture conditions. Some common deciduous canopy trees are: *Polyalthia simiarum* (Ham. ex Hk.



f. & Th.) Bth. ex Hk. f. & Th. (Annonaceae), *Lagerstroemia tomentosa* Presl (Lythraceae), *Terminalia mucronata* Craib & Hutch. (Combretaceae), *Engelhardia serrata* Bl. (Juglandaceae), and *Vitex quinata* (Lour.) Will. (Verbenaceae). In the limestone area *Pterocymbium laoticum* Tard. (Sterculiaceae) is also found. Evergreen canopy counterparts are *Dipterocarpus costatus* Gaertn. f., the tallest and most distinct species which is also restricted to the mixed forest, *D. turbinatus* Gaertn. f. (Dipterocarpaceae), *Mangifera caloneura* Kurz (Anacardiaceae), *Eugenia albiflora* Duth. ex Kurz (Myrtaceae), *Sapium baccatum* Roxb. (Euphorbiaceae) and *Castanopsis calathiformis* (Skan) Rehd. & Wils. (Fagaceae). *Lithocarpus elegans* (Bl.) Hatus. ex Soep. (Fagaceae), *Turpinia pomifera* (Roxb.) Wall. ex DC. (Staphyleaceae), *Knema laurina* (Bl.) Warb. (Myristicaceae), *Cinnamomum iners* Reinw. ex Bl. (Lauraceae), and *Baccaurea ramiflora* Lour. (Euphorbiaceae) are some common understorey trees. Woody climbers are common and include *Combretum trifoliatum* Vent. (Combretaceae) and *Ventilago denticulata* Willd. (Rhamnaceae), both of which are deciduous; while *Combretum sundaicum* Miq. (Combretaceae), *Rhamnus nipalensis* (Wall.) Laws. (Rhamnaceae), and *Tetrastigma laoticum* Gagnep. (Vitaceae, especially along streams) are some frequently seen evergreen representatives.

The ground flora is diverse and includes both deciduous and evergreen species. Common deciduous herbs are *Goldfussia anfractuosa* (Cl.) Brem., and *Ruellia siamensis* Im. (both Acanthaceae), *Begonia integrifolia* Dalz. (Begoniaceae), and *Globba villosula* Gagnep. (Zingiberaceae). Evergreen herb species are more common and include: *Tacca chantrieri* Andr. (Taccaceae), *Amomum uliginosum* Koen., and *Etlingera littoralis* (Kon.) Gise., the latter along streams (both Zingiberaceae), *Thelypteris arida* (D. Don) Mort. (Thelypteridaceae), and *Cibotium barometz* (L.) J. Sm. (Dicksoniaceae). Treelets and shrubs frequently seen are *Millettia caerulea* Grah. ex Bak. (Leguminosae, Papilionoideae), which is deciduous, with *Ixora cibdela* Craib var. *puberula* Craib, and *Psychotria opioxyloides* Wall. (both Rubiaceae), which are evergreen. Seedlings, saplings, and immature herbs are also common, especially in areas that are shaded and less disturbed.

### Primary Evergreen Forest

The upper part of the mixed evergreen + deciduous forest merges with the lower part of the evergreen forest at c. 900–950 m. The limestone zone in the northern part of the national park does not have an evergreen facies, since the highest peaks, which are very exposed, rise to 850–900 m. The evergreen forest also includes *Pinus kesiya* Roy. ex Gord. (Pinaceae, pine) on ridges from c. 1,200 m to c. 1,800 m, i.e. below the summit of Doi Lahnggah, which is 2,031 m in elevation. This kind of forest will be discussed later. The evergreen forest is well developed from c. 1,000–2,031 m and includes vascular plant species which are not generally found in the bamboo/deciduous forest and only some in the mixed evergreen + deciduous zone. The canopy in the evergreen forest is higher and denser than in the forests at lower elevations. A few of the larger canopy trees are deciduous, e.g. *Michelia champaca* L. and *Paramichelia baillonii* (Pierre) Hu (both Magnoliaceae), *Acrocarpus fraxinifolius* Wight & Arn. (Leguminosae, Caesalpinioideae), *Homalium ceylanicum* (Gardn.) Bth. (Flacourtiaceae), *Melia toosendan* Sieb. & Zucc., and *Toona microcarpa* (C. DC.) Harms (both Meliaceae), *Ficus callosa* Willd., and *Artocarpus*

*gomezianus* Wall. ex Trec. (both Moraceae and also found at lower elevations), *Morus macroura* Miq. (Moraceae), and *Hovenia dulcis* Thunb. (Rhamnaceae), which is a rare species found in stream valleys at c. 1,050 m.

Common evergreen canopy trees, 20–30 m tall, are *Sapium baccatum* Roxb. (Euphorbiaceae), *Artocarpus lanceolata* Trec. (Moraceae), *Phoebe cathia* (D. Don) Kosterm. (Lauraceae), *Schima wallichii* (DC.) Korth. (Theaceae), and several species of Fagaceae, e.g. *Castanopsis acuminatissima* (Bl.) A. DC., *C. diversifolia* (Kurz) King ex Hk. f., *C. tribuloides* (Sm.) A. DC., and *Lithocarpus elegans* (Bl.) Hatus. ex Soep. Gigantic “strangling” figs (Moraceae) are common with *Ficus altissima* Bl. and *F. benjamina* L. var. *benjamina* as good examples.

Some understory species of trees which don’t grow more than 15 m tall are *Elaeocarpus floribundus* Bl. (Figure 4), *E. prunifolius* Wall. ex C. Muell. (Elaeocarpaceae), *Semecarpus cochinchinensis* Engl. (Anacardiaceae), *Apodytes dimidia* E. Meyer ex Arn. (Icacinaeae) (Figure 5), *Eugenia fruticosa* (DC.) Roxb. (Myrtaceae), *Actinodaphne henryi* Gamb. (Lauraceae), and *Helicia nilagirica* Bedd. (Proteaceae)—all of which are evergreen. *Bauhinia variegata* L. (Leguminosae, Caesalpinioideae), *Spondias axillaris* Roxb. (Anacardiaceae), and *Engelhardia spicata* Lechen. ex Bl. var. *spicata* (Juglandaceae) are deciduous representatives.

Loranthaceae, a family of evergreen, hemiparasitic, epiphytic shrubs, is well represented, the most common being *Helixanthera pulchra* (DC.) Dans., *Macrosolen cochinchinensis* (Lour.) Tiegh., and *Viscum ovalifolium* Wall. ex DC.

Many areas of the evergreen forest have been disturbed or completely destroyed. *Camellia sinensis* (L.) O.K. var. *assamica* (Mast.) Kita. (Theaceae, tea), a native evergreen treelet, is grown in extensive plantations from c. 800 m to c. 1,350 m. This species produces optimum yields with about 50% of the forest canopy intact. Farmers growing this crop are aware of forest abuse, conservation, and the condition of their plants; thus the tree diversity in these areas is good, albeit diminished. Most of the original understory and ground flora, however, have been destroyed while regrowth is maintained, without fire, by frequent cutting. Hill tribe farmers, many of whom have been resettled at lower elevations or outside of the national park, have caused far more damage to the evergreen forest leaving vast areas denuded—most of which have yet to recover.

The understory is denser than that of forests at lower elevations and is especially diverse in stream valleys. Understorey trees include *Phoebe lanceolata* (Nees) Nees (Lauraceae), *Acronychia pedunculata* (L.) Miq. (Rutaceae), *Garcinia speciosa* Wall. (Guttiferae), *Sarcosperma arboreum* Bth. (Sapotaceae), and *Diospyros glandulosa* Lace (Ebenaceae). *Styrax benzoides* Craib (Styracaceae) and *Maesa ramentacea* Wall. ex Roxb. (Myrsinaceae) are also common, but grow in disturbed places. Treelets and shrubs are numerous and include more species than found at lower elevations. *Milliusa cuneata* Craib (Annonaceae), *Vernonia volkameriifolia* DC. var. *volkameriifolia* (Compositae), *Clerodendrum serratum* (L.) Moon var. *wallichii* Cl. (Verbenaceae) (Figure 6), *Ardisia villosa* Roxb. (Myrsinaceae), *Euodia viticina* Wall. ex Kurz (Rutaceae), *Antidesma sootepense* Craib (Euphorbiaceae), and *Pseuderanthemum latifolium* (Bl.) B. Han. (Acanthaceae) are common. *Pandanus penetrans* St. John (Pandanaeae), another evergreen species, is most common in shaded, undisturbed stream valleys. Deciduous counterparts are found usually in disturbed, often burned, places and include *Desmodium multiflorum*

DC., *D. oblongum* Wall. ex Bth., *Flemingia sootepensis* Craib (Leguminosae, Papilionoideae), and *Wendlandia scabra* Kurz (Rubiaceae). *Pueraria stricta* Kurz and *P. wallichii* DC. (Leguminosae, Papilionoideae), which are scandent, are also found in this habitat.

Woody climbers are common, some evergreen examples being: *Toddalia asiatica* (L.) Link (Rutaceae), *Melodorum oblongum* Craib (Annonaceae), *Connarus semidecandrus* Jack (Connaraceae) (Figure 7), *Ficus parietalis* Bl., and *F. pubigera* (Wall. ex Miq.) Miq. var. *pubigera* (Moraceae). *Dalbergia stipulacea* Roxb. (Leguminosae, Papilionoideae) is a deciduous representative which is found in open places. The herbaceous ground flora is very diverse and includes numerous species of dicots, monocots, and pteridophytes. Some common dicots are: *Impatiens violaeiflora* Hk. f. (Balsaminaceae), *Hydrocotyle siamica* Craib (Umbelliferae), *Ophiorrhiza hispidula* Wall. ex G. Don var. *hispidula*, and *Geophila repens* (L.) I.M. John. (both Rubiaceae), *Wedelia montana* (Bl.) Boerl. var. *wallichii* (Less.) H. Koy. (Compositae), and *Pilea trinervia* Wight (Urticaceae). Frequently encountered herbaceous monocots are: *Aneilema sinicum* Lindl., *Commelina diffusa* Burm. f., and *Murdannia gigantea* (Vahl) Bruck (all Commelinaceae); *Globba kerrii* Craib, *G. villosula* Gagnep., and *Zingiber smilesianum* Craib (all Zingiberaceae), *Acorus gramineus* Sol. ex W. Ait., an epilithic rheophyte; and *Amorphophallus corrugatus* N.E. Br. (both Araceae), *Vanilla siamensis* Rol. ex Dow. (Orchidaceae, a vine), and *Carex baccans* Nees (Cyperaceae). *Malaxis latifolia* J.E. Sm. (Orchidaceae) is a relatively rare, deciduous, ground orchid which is found in slightly disturbed stream areas at 1,000–1,150 m (Figure 8).

Many geophytic pteridophytes are common with *Cibotium barometz* (L.) J. Sm. (Dicksoniaceae), *Bolbitis virens* (Wall. ex Hk. & Grev.) Schott var. *virens* (Lomariopsidaceae, along streams), and *Thelypteris subelata* (Bak.) K. Iw. (Thelypteridaceae). Epiphytic and epilithic pteridophytes are also common with *Davallia trichomanoides* Bl. var. *lorrainii* (Hance) Holtt., and *Leucostegia immersa* Presl (both Davalliaceae), *Asplenium nidus* L. var. *nidus* (Aspleniaceae), *Aglaomorpha coronans* (Wall. ex Mett.) Copel., and *Pyrrosia mollis* (O.K.) Ching (both Polypodiaceae).

### Evergreen Hardwood + Pine Association

*Pinus kesiya* Roy. ex Gord. (Pinaceae, pine) has been exploited extensively in the national park, especially from c. 1,200–1,500 m, but is abundant in undisturbed areas from 1,500–1,800 m. *P. kesiya* is found on ridges and in other well drained places, with an approximately equal association of primary evergreen forest species. There are some species which are more commonly found with *Pinus kesiya* than elsewhere, mostly due to the lower pH of the soil. Some of the woody species are *Craibiodendron stellatum* (Pierre) W.W. Sm., *Lyonia ovalifolia* (Wall.) Druce, and *Vaccinium sprengelii* (D. Don) Sleum. (all Ericaceae), *Viburnum inopinatum* Craib (Caprifoliaceae), *Myrica esculenta* B.-H. ex D. Don (Myricaceae); *Castanopsis argyrophylla* King ex Hk. f., *C. tribuloides* (Sm.) A. DC., *Quercus brandisiana* Kurz, which is deciduous, and *Q. leticellata* Barn. (all Fagaceae).

Annual herbs include *Blumeopsis flava* (DC.) Gagnep. and *Anaphalis margaritacea* (L.) Bth. & Hk. f. (both Compositae), *Lobeia nicotianaefolia* Roth ex Roem. & Schult. (Campanulaceae), and *Exactum pteranthum* Wall. ex Colebr. (Genitanaceae). Some

deciduous, perennial counterparts are *Inula cappa* (Ham. ex D. Don) forma *cappa* (Compositae), *Pratia begoniifolia* (Wall. ex Roxb.) Lindl. (Campanulaceae), a creeper, and *Anthogonium gracile* Wall. ex Lindl. (Orchidaceae). *Sonerila kerrii* Craib & Stapf (Melastomataceae) and the pteridophyte *Onychinum contiguum* Hope (Parkeriaceae), both deciduous ground herbs, are also occasionally found. *Shuteria involucrata* (Wall.) Wight & Arn. (Leguminosae, Papilionoideae), a vine, is common. Two uncommon species of Pteridophytes, viz. *Brainea insignis* (Hk.) J. Sm. and *Woodwardia cochinchinensis* Ching (both Blechnaceae), are also occasionally seen. Fires, all caused by man, are common in pine areas and, in places where fire frequently occurs, many evergreen forest associates have been replaced by deciduous dipterocarpaceae ones, e.g. *Anneslea fragrans* Wall. (Theaceae) and *Aporosa villosa* (Lindl.) Baill. (Euphorbiaceae).

### Upper Water Catchment Valleys

Primary evergreen seasonal forested areas above c. 1,500 m, especially in shaded, moist water catchment valleys, are the most botanically pristine places in the national park. In contrast to settled areas in the lowlands, middle elevations where tea plantations are common, and destroyed ridges and summit areas, the upper water catchment valleys are mostly undisturbed.

The tree species are similar to those found in lower evergreen areas and in most instances *Pinus kesiya* Roy. ex Gord. (Pinaceae) is absent, especially on the west side of the park, bordering Sahngahmpang District, Chiang Mai Province, i.e. Doi Lohn/Doi Mawn Lahn, which rises to 1,725–1,800 m. The highest source of water is at c. 1,850 m elevation, just below the summit of Doi Lahnggah. Prominent canopy trees include *Lithocarpus xylocarpus* (Kurz) Mgf. and *Castanopsis acuminatissima* (Bl.) A. DC. (both Fagaceae). *Aidia yunnanensis* (Hutch.) Yaha. (Rubiaceae), *Symplocos cochinchinensis* (Lour.) S. Moore ssp. *cochinchinensis* (Symplocaceae), *Rapanea yunnanensis* Mez (Myrsinaceae), *Elaeocarpus bracteanus* Watt ex Cl. (Elaeocarpaceae), and *Euonymus colonoides* Craib (Celastraceae) are some of the smaller trees which are commonly found in these more moist upland areas. *Dinorchloa maclellandii* (Munro) Kurz (Gramineae, Bambusoideae) is the most common and sometimes dominant understorey species in many of these areas.

The understory and ground vegetation is quite diverse and more dense than at lower elevations. Some typical treelets and shrubs, not found below c. 1,500 m, are: *Pseudodissochaeta septentrionalis* (W.W.Sm.) Nayar (Melastomataceae), *Ixora stricta* Roxb. (Rubiaceae), and to a lesser extent *Symplocos hookeri* Cl. (Symplocaceae). *Justicia decurrens* Im. (Acanthaceae), mostly confined to shaded stream valleys, is also common. The ground flora is quite distinct and includes many pteridophytes which are either more common or restricted to this habitat. Included here are several ground ferns, e.g. *Diacalpe aspidoides* Bl., *Didymochlaena truncatula* (Sw.) J. Sm., and *Polystichum semifertile* (Cl.) Ching (all Dryopteridaceae), *Cornopteris opaca* (D. Don) Tag. (Athyraceae), and *Cyathea gigantea* (Wall. ex Hk.) Holtt. (Cyatheaceae), which is confined to wet streams and grows up to 6 m tall. *Neocheiropteris normalis* (D. Don) Tag. (Polypodiaceae), which creeps up tree trunks, is also confined to shaded, moist places.

### Summit Flora

From between 1,800–1,900 m, *Pinus kesiya* Roy. ex Gord. (Pinaceae), the only pine in the national park, becomes much less common than it is at elevations of c. 1,200–1,800 m and only a few scattered trees are found above 1,900 m to summit at 2,031 m. Much of the summit area has been destroyed by the primitive agricultural practices of various hilltribe people who formerly occupied the area. Even after 10–15 years since their resettlement, much of summit still remains as grassland. There are, however, some pristine areas remaining where we have been able to get a good idea of what the vegetation is and have also found some of the species that must have been more common than they presently are. Many of these species are also found at lower elevations, while many others are only found above c. 1800 m.

Common trees in the summit area from c. 1,900–2,031 m are *Anneslea fragrans* Wall., *Pyrenaria garrettiana* Craib, *Schima wallichii* (DC.) Korth., and *Ternstroemia gymnanthera* (Wight & Arn.) Bedd. (all Theaceae); *Myrica esculenta* B.-H. ex D. Don (Myricaceae), *Engelhardia spicata* Lechen. ex Bl. var. *spicata* (Junglandaceae), which is deciduous; *Castanopsis calathiformis* (Skan) Rehd. & Wils., *C. tribuloides* (Sm.) A. DC. (Fagaceae), and *Symplocos macrophylla* Wall. ex DC. ssp. *sulcata* (Kurz) Noot. var. *sulcata* (Symplocaceae). The understorey and ground flora are mostly evergreen, especially in shaded, upper water catchment valleys where *Lithocarpus xylocarpus* (Kurz) Mgf. (Fagaceae) is a common canopy tree species. Some common treelets are *Euodia triphylla* DC. (Rutaceae), *Psychotria monticola* Kurz var. *monticola*, and *Mycetia rivicola* Craib (both Rutaceae), *Baliospermum micranthum* M.-A. (Euphorbiaceae), and *Polygala crillata* B.-H. ex D. Don (Polygalaceae). Some shrubs are *Gaultheria notabilis* Anth. and *Vaccinium sprengelii* (D. Don) Sleum. (both Ericaceae and found in open places), and *Dichroa febrifuga* Lour. (Saxifragaceae), which grows both as a shrub or treelet in shaded, often moist, places. *Embelia pulchra* Mez (Myrsinaceae), a shrub which is often somewhat scandent, is also common.

*Brainea insignis* (Hk.) J. Sm. (Blechnaceae), a robust, cycad-like ground fern, is frequently seen. Burned areas have *Polygonum chinense* L. (Polygonaceae), *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dryopteridaceae), *Inula wissmanniana* Hand.-Maz. forma *wissmanniana* (Compositae), *Carex baccans* Nees (Cyperaceae), and *Smilax perfoliata* Lour. (Smilacaceae). Annual herbs found on exposed, disturbed ridges include *Swertia angustifolia* Ham. ex D. Don (Gentianaceae), *Alectra avensis* (Bth.) Merr. (Scrophulariaceae), *Burmanna nepalensis* (Miers) Hk. f. (Burmanniaceae), and *Arthraxon microphyllus* (Trin.) Hochst. (Gramineae). Perennial evergreen and deciduous counterparts are *Gentiana crassa* Kurz and *G. napulifera* Fran. (Gentianaceae), and *Eulalia trispicata* (Schult.) Henr. (Gramineae). *Dumasia leiocarpa* Bth. (Leguminosae, Papilionoideae), a vine, is found in both shaded and open places, while *Rhaphidophora peepla* (Roxb.) Schott (Araceae) (Figure 9) is a common creeper on shaded tree trunks. Herbs such as *Hydrocotyle siamica* Craib (Umbelliferae), *Impatiens claviger* Hk. f., and *I. violaeiflora* Hk. f. (Balsaminaceae), *Ainsliaea latifolia* (D. Don) Sch.-Bip. ssp. *henryi* (Diels) H. Koy. (Compositae), *Zingiber smilesianum* Craib (Zingiberaceae), and *Athyrium setiferum* C. Chr. (Athyriaceae), a ground fern, grow in shaded places.

Epiphytes are common, especially in shaded places. Some dicot representatives



which are common and conspicuous are *Agapetes hosseana* Diels (Ericaceae), *Aeschynanthus hildebrandii* Hemsl. and *A. lineatus* Craib (a creeping or hanging vine) (Gesneriaceae), and the relatively rare *Hoya multiflora* Bl. (Asclepiadaceae). The family Orchidaceae is very common and some evergreen examples are *Bulbophyllum retusiusculum* Rchb. f., *Eria truncata* Lindl., *Oberonia acaulis* Griff., *Pholidota articulata* Lindl., and *P. convallariae* (Rchb. f.) Hk. f. Some deciduous counterparts include *Bulbophyllum sauvissimum* Rol., *Dendrobium heterocarpum* Lindl., and *Porpax ustulata* (Par. & Rchb. f.) Krzl. Pteridophytes are also common with *Asplenium ensiforme* Wall. ex Hk. & Grev. (Aspleniaceae) and *Crypsinus rhynchophyllus* (Hk.) Copel. (Polypodiaceae), both of which have evergreen fronds which dehydrate and shrivel during the dry months of January to May. Epiphytic algae, bryophytes, and lichens are also abundant.

### Secondary Growth

Severely damaged or destroyed forest areas have a distinct vegetation facies, composed of primary invaders, i.e. weeds and later a transitional association of woody plants. Compared with the deciduous dipterocarp-oak forest, which is stable secondary growth, successional or ephemeral secondary growth is quite different. A clear distinction between very degraded bamboo/deciduous or damaged primary evergreen forest is often difficult to determine. However, there are several secondary growth species which can be considered as indicators of this kind of growth. *Trema orientalis* (L.) Bl. (Ulmaceae), a common deciduous or evergreen tree or treelet, is found in open disturbed, secondary growth areas from c. 300–1,500 m and flowers and fruits throughout the year. Deciduous species, e.g. *Harrisonia perforata* (Blanco) Merr. (Simaroubaceae), a scandent/woody climber and *Phyllanthus columnaris* M.-A. (Euphorbiaceae), a small tree, are found below 900 m, while *Buddleja asiatica* Lour. (Loganiaceae), a treelet, ranges from c. 650–1,700 m. Trees such as *Alangium kurzii* Craib (Alangiaceae), *Callicarpa arborea* Roxb. var. *arborea* and *Gmelina arborea* Roxb. (both Verbenaceae) are mostly found above 900 m in secondary growth areas. The ground flora is weedy with many Compositae, e.g. *Conyza leucantha* (D. Don) Lud. & Rav., *Crassocephalum crepidioides* (Bth.) S. Moore, *Eupatorium odoratum* L. (300–1,100 m), *E. adenophorum* Spreng. (mostly above 900 m); *Imperata cylindrica* (L.) P. Beauv. var. *major* (Ness) C.E. Hubb. ex Hubb. & Vaugh. (Gramineae), and *Pteridium aquilinum* (L.) Kunth ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dennstaedtiaceae)—the later two species forming dense, more persistent growth.

### NEW RECORDS

Seven new records for the flora of Thailand have been found during this research in Jae Sawn National Park, viz. (MAXWELL, 1996a):

1. *Schisandra verrucosa* Gagnep. (Schisandraceae), a vine in primary evergreen, seasonal, hardwood forest; 925 m, granite bedrock;
2. *Glycosmis pseudoracemosa* (Guill.) Swingle (Rutaceae), a deciduous, epilithic treelet found on limestone peaks, 600–650 m;

3. *Momordica laotica* Gagnep. (Cucurbitaceae), a vine found in disturbed lowland secondary growth at 525 m on granite bedrock;
4. *Helixanthera pierreii* Dans. (Loranthaceae), an evergreen, epiphytic, hemiparasitic shrub in mixed evergreen + deciduous, seasonal hardwood forest at 850 m on granite bedrock;
5. *Ficus nervosa* Hey. ex Roth var. *nervosa* (Moraceae), a tree collected along a stream in degraded deciduous, hardwood forest with much bamboo on shale bedrock at 550 m;
6. *Archidendron robinsonii* (Gagnep.) Niels. (Leguminosae, Mimosoideae), a small (8 m) tree found along streams at 450 m in mixed evergreen + deciduous, seasonal, hardwood forest with bamboo on shale bedrock; and
7. *Burmannia nepalensis* (Miers) Hk. f. (Burmanniaceae), an inconspicuous, annual, ground herb from the exposed summit area of Doi Lahnggah at 1,950–2,031 m on shale bedrock.

### AN ANALYSIS OF THE FLORA FOR CONSERVATION

A record for every species observed was entered into a computer database, using the FoxPro package, including botanical name, family, habit, abundance, habitat, altitude range, time of flowering, fruiting and leafing and other notes. The database can be used to generate statistics to determine the conservation value of different habitats or ranges of altitude and answer more specific questions to help plan management of the park. It now covers 1,353 vascular plant species, including 344 tree species, 136 treelets, 106 woody climbers, 58 shrubs, 447 vines and 562 herbs. For a taxonomic breakdown of the vascular flora see Table 1.

Table 1. Summary of collection as of 1 March 1997

	FAMILIES	SP., SSP., VAR.
ANGIOSPERMS		
Dicots	121	988
Monocots	21	246
GYMNOSPERMS	4	5
FERNS & ALLIES	24	114
TOTALS	170	1,353

Of the major habitat types, bamboo/deciduous forest had the highest species richness of vascular plants (658 or 49% of the park's flora), followed closely by primary evergreen forest (50), mixed evergreen + deciduous hardwood forest (541), secondary growth (290), evergreen hardwood + pine forest (151) and deciduous dipterocarp-oak forest (132) (Figure 10.).

Bamboo/deciduous forest had the most species restricted to a single habitat type (212) followed by primary evergreen forest (196) mixed evergreen + deciduous hardwood forest (79), secondary growth (48), deciduous dipterocarp-oak forest (33) and evergreen hardwood + pine forest (31). Of such species restricted to a single habitat, primary evergreen forest had the most which were ranked as rare or in immediate danger of becoming extirpated from the park (89), followed by bamboo/deciduous forest (60), mixed deciduous-evergreen hardwood forest (43), evergreen hardwood + pine forest (14), deciduous dipterocarp-oak forest (6) and secondary growth (6) (Figure 11.).

In every respect, the database clearly identified bamboo/deciduous forest and primary evergreen forest as almost equally the two most important habitats both for the overall maintenance of botanical diversity (in combination they supported 83 % of the park's vascular flora) and for preventing the extinction of habitat restricted or rare species. Clearly any further disturbance of these two forest types will result in a considerable reduction in the value of the park, since disturbed areas and secondary growth supported only 21.4% of the park's total flora.

The database was also analysed to identify individual species in need of special monitoring or conservation measures. A list of the most threatened plant species in the park is provided in the appendix. The conservation priority rating was calculated using the following scoring system:

CRITERIA:	SCORES:
Either reduced to a few individuals	2
or rare.	1
Sole species of a family present in the park .	1
Restricted to a single habitat.	0.5
Not found in any of the other sites currently listed in the CMU herbarium.	0.5

This rating system gives a maximum value of 4 for those species in most need of special conservation measures and a minimum value of zero for species in no danger. The appendix lists all species with a rating of 2 or higher. It is recommended that populations of these species should be monitored and, if it is found that they are continuing to decline, special protective measures should be implemented and propagation and replanting considered.

Most of the species in need of conservation are restricted to specialized niches such as rocks and streams in evergreen forest and bamboo/deciduous forest. Urgent increased protection of such habitats is recommended. The species most in need of conservation measures at Jae Sawn is the ancient gymnosperm tree *Podocarpus neriifolius* D. Don. It is the only representative of the family Podocarpaceae in northwestern Thailand. At Jae Sawn it is confined to a few upper catchment valleys in primary evergreen forest at c. 1,600–1,950 m elevation. Although it also occurs in Doi Suthep-Pui and Obluang National Parks, it warrants immediate conservation measures. Also represented by just a few individuals in the park is another gymnosperm, *Cycas pectinata* Griff. Although also recorded from Doi Chiang Dao Wildlife Sanctuary and Obluang National Park, at Jae Sawn this species is confined to a single area in evergreen hardwood + pine forest. The leafless saprophyte *Epirixanthes elongata* Bl. has been observed in only one place in the

park in bamboo/deciduous forest. It has not yet been found at other sites currently covered by the CMU herbarium database.

**The database is open to anyone who wishes to use it for research or conservation management. Those wishing to access the facility should contact the authors at Chiang Mai University, Biology Department, Herbarium.**

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**Appendix.** Species most in need of conservation measures. For calculation of the rating system see text.

Abundance:

- 1 = population reduced to a few individuals, in immediate danger of extirpation from the park
- 2 = rare
- 3 = medium abundance

Conservation Priority Ratings:

- 3.5 = immediate increased protection and monitoring required, should consider propagation and replanting
- 3.0 = urgent increased protection required plus intensive monitoring to determine cause of population decline
- 2.5 = increased protection and population monitoring required
- 2.0 = population monitoring required, to determine if special conservation measures may become necessary

Threats:

- DO = damage by domestic animals
- DR = drainage
- E = extirpation of animal dispersers of fruits/seeds, mainly by hunting
- F = fire
- L = logging (usually small scale tree felling)
- SA = clearing forest for shifting agriculture
- TP = establishment of tea plantations



SPECIES	FAMILY	ABUNDANCE	SINGLE SPECIES OF FAMILY	RESTRICTED HABITAT	RESTRICTED DISTRIBUTION	CONSERVATION PRIORITY RATING	THREAT
<i>Podocarpus neriifolius</i> D. Don	Podocarpaceae	1	X	streams in egf		3.5	L, SA, E
<i>Epirixanthes elongata</i> Bl.	Polygalaceae	1		bb/df	X	3	F, DO
<i>Cycas pectinata</i> Griff.	Cycadaceae	1		eg/pine		2.5	SA, DO, E
<i>Lysimachia peduncularis</i> Wall. ex Hk. f.	Primulaceae	2	X	bb/df		2.5	L, F, DO
<i>Rorippa heterophylla</i> (Bl.) Will.	Cruciferae	2	X	streams, wet areas in egf		2.5	DR
<i>Utricularia striatula</i> Sm.	Lentibulariaceae	2	X	streams, wet areas in bb/df		2.5	DR
<i>Xyris capensis</i> Thunb.	Xyridaceae	2	X	cliffs eg/pine		2.5	
<i>Aglaia</i> sp.	Meliaceae	2		rocks in bb/df	X	2	L, F, DO, E
<i>Aquilaria crassna</i> Pierre ex Lec.	Thymelaeaceae	2		egf	X	2	L, TP, DO, E
<i>Archidendron robinsonii</i> (Gagnep.) Niels.	Leguminosae (Mimosoideae)	2		streams in mxf	X	2	L, F, DO, E
<i>Aspidopterys hirsuta</i> (Wall.) Juss.	Malpighiaceae	2		bb/df	X	2	F, DO
<i>Asplenium cheilosorum</i> O.K. ex Mett.	Aspleniaceae	2		rocks, streams, wet areas in egf	X	2	SA, DR
<i>Athyrium setiferum</i> C. Chr.	Athyriaceae	2		egf	X	2	SA, DO
<i>Barringtonia augusta</i> Kurz	Lecythidaceae	2		mx	X	2	L, TP, DO
<i>Begonia socia</i> Craib	Begoniaceae	2		streams, cliffs in egf	X	2	F, DO
<i>Begonia</i> sp.	Begoniaceae	2		rocks, cliffs in eg/pine	X	2	SA, DO
<i>Boerhavia chinensis</i> (L.) Asch. & Schw.	Nyctaginaceae	3	X	sg in bb/df	X	2	F, DO
<i>Borreria</i> sp.	Rubiaceae	2		rocks, cliffs in bb/df	X	2	DO
<i>Brandisia discolor</i> Hk. f. & th.	Scrophulariaceae	2		egf	X	2	L, SA
<i>Bulbophyllum alaicorne</i> Par. & Rehb. f.	Orchidaceae	2		dof	X	2	L
<i>Burmannia nepalensis</i> (Miers) Hk. f.	Burmanniaceae	3	X	cliffs egf	X	2	SA

SPECIES	FAMILY	ABUNDANCE	SINGLE SPECIES OF FAMILY	RESTRICTED HABITAT	RESTRICTED DISTRIBUTION	CONSERVATION PRIORITY RATING	THREAT
<i>Calanthe triplicata</i> (Will.) Ames	Orchidaceae	2		egf	X	2	L, TP
<i>Cheilanthes ? fragilis</i> Hk.	Parkeriaceae	2		rocks, cliffs in bb/df	X	2	L, DO
<i>Cinnamomum</i> sp.	Lauraceae	2		egf	X	2	L, TP, DO
<i>Cinnamomum</i> sp.	Lauraceae	2		streams in egf	X	2	L, TP, DO
<i>Cipadessa bacciformis</i> (Roth) Miq.	Meliaceae	2		da in egf	X	2	F, DO
<i>Crepidomanes megistostomum</i> (Copel.) Copel.	Hymenophyllaceae	2		egf	X	2	L, DR
<i>Crypteronia paniculata</i> Bl.	Crypteroniaceae	2	X			2	L, Do
<i>Cyrtandromoea grandiflora</i> Cl.	Scrophulariaceae	2		egf	X	2	L, SA
<i>Daphne composita</i> (L.f.) Gilg	Thymelaeaceae	2		streams in egf	X	2	TP, DR, E
<i>Dendrobium bilobulatum</i> Seid.	Orchidaceae	2		egf	X	2	L, SA
<i>Dendrobium dixonianum</i> Rol. ex Dow.	Orchidaceae	2		dof	X	2	L
<i>Dendrobium</i> sect. <i>Stachyobium</i> Lindl.	Orchidaceae	2		egf	X	2	L
<i>Densmos</i> aff. <i>praecox</i> Hk. f. & Th.	Annonaceae	2		egf	X	2	L, TP, DO
<i>Desmos chinensis</i> Lour.	Annonaceae	2		mx	X	2	TP, DO
<i>Didymoplexis pallens</i> Griff.	Orchidaceae	2		mx	X	2	DR, TP, DO
<i>Diplazium subfluvialis</i> (Haya.) M. Kato	Athyriaceae	2		egf	X	2	DR, TP, SA
<i>Doritis pulcherrima</i> Lindl.	Orchidaceae	2		cliffs eg/pine	X	2	F, DO
<i>Dracaena</i> sp.	Agavaceae	2		mx	X	2	TP, DO, E
<i>Elatostema</i> aff. <i>clarkei</i> Hk. f.	Urticaceae	2		rocks, streams, cliffs in egf	X	2	DR, L
<i>Elsholtzia pilosa</i> (Bth.) Bth.	Labiatae	2		streams in egf	X	2	DR, DO
<i>Epiprinus siletianus</i> (Baill.) Croiz	Euphorbiaceae	2		mx	X	2	L, F, DO
<i>Gluta</i> sp.	Anacardiaceae	2		mx	X	2	L, F, E

SPECIES	FAMILY	ABUNDANCE	SINGLE SPECIES OF FAMILY	RESTRICTED HABITAT	RESTRICTED DISTRIBUTION	CONSERVATION PRIORITY RATING	THREAT
<i>Gnetum leptostachyum</i> Bl.	Gnetaceae	2	X			2	TP, DO, E
<i>Helixanthera pierrei</i> Dans.	Loranthaceae	2		mx	X	2	L, TP
<i>Heterostemma</i> sp.	Asclepiadaceae	2		da sg in mx	X	2	TP, DO
<i>Ilex godajam</i> Colebr. ex Wall.	Aquifoliaceae	2		da sg in egf	X	2	L, E
<i>Impatiens claviger</i> Hk. f.	Balsaminaceae	2		egf	X	2	SA
<i>Impatiens salagengensis</i> T. Shim.	Balsaminaceae	2		streams in mx	X	2	DR, DO
<i>Jasminum calcicolum</i> Kerr	Oleaceae	2		cliffs mx	X	2	F, E
<i>Jasminum sempervirens</i> Kerr	Oleaceae	2		mx	X	2	TP, E
<i>Kadsura ananosma</i> Kerr	Schisandraceae	2		egf	X	2	TP, DO
<i>Kalanchoe integra</i> (Med.) O.K.	Crassulaceae	2	X			2	DO
<i>Kydia glabrescens</i> Mast.	Malvaceae	2		da sg in egf	X	2	L, F, DO, SA
<i>Leonurus sibiricus</i> L.	Labiatae	2		da sg in egf	X	2	F, DO
<i>Lepidagathis purpuricaulis</i> Nees	Acanthaceae	2		bb/df	X	2	DO
<i>Luisia platyglossa</i> Rchb. f.	Orchidaceae	2		egf	X	2	L, SA
<i>Maclura cochinchinensis</i> (Lour.) Corn. var. <i>cochinchinensis</i>	Moraceae	2		streams in bb/df	X	2	L, DO, E
<i>Malaxis</i> aff. <i>ovatisepala</i> (J.J. Sm.) Seid.	Orchidaceae	2		rocks cliffs bb/df	X	2	DO
<i>Melampodium divaricatum</i> (Pers.) DC.	Compositae	2		da, sg in egf	X	2	F, DO, TP
<i>Microlepia calvescens</i> (Wall. ex Hk.) Presl	Dennstaedtiaceae	2		da in egf	X	2	F, SA, DO
<i>Microtropis pallens</i> Pierre	Celastraceae	2		mx	X	2	TP, DO
<i>Murdania gigantea</i> (Vahl) Bruck.	Commelinaceae	2		mx	X	2	F, DO
<i>Musa glauca</i> Roxb.	Musaceae	2		bb/df	X	2	F, DR, DO, E
<i>Oleandra musifolia</i> (Bl.) Presl	Oleandraceae	2		rocks streams in egf	X	2	F, DR

SPECIES	FAMILY	ABUNDANCE	SINGLE SPECIES OF FAMILY	RESTRICTED HABITAT	RESTRICTED DISTRIBUTION	CONSERVATION PRIORITY RATING	THREAT
<i>Paramigyna scandens</i> (Griff.) Craib	Rutaceae	2		streams in egf	X	2	F, DO, E
<i>Pellionia bulbifera</i> (Kurz) Hk. f. var. <i>burmanicum</i> (Hk. f.) Yaha.	Urticaceae	2		streams in mxf	X	2	TP, DO
<i>Phaius mishmensis</i> (Lindl. & Paxt.) Rchb. f.	Orchidaceae	2		streams in egf	X	2	DR, DO
<i>Phlogacanthus racemosus</i> Brem.	Acanthaceae	2		streams in egf	X	2	DR, SA
<i>Pogostemon purpurascens</i> Dalz.	Labiatae	2		egf	X	2	DO, SA
<i>Pommereschea lackneri</i> Witt.	Zingiberaceae	2		bb/df	X	2	DO
<i>Proiphys amboinensis</i> (L.) Herb.	Amaryllidaceae	2		bb/df	X	2	DO
<i>Prunus zippeliana</i> Miq. var. <i>zippeliana</i>	Rosaceae	2		egf	X	2	L, DR, DO
<i>Rhododendron microphyton</i> Fran.	Ericaceae	2		eg/pine	X	2	SA, DO
<i>Schisandra verrucosa</i> Gagnep.	Schisandraceae	2		da in egf	X	2	L, TP, E
<i>Sladenia celastrifolia</i> Griff.	Theaceae	2		streams in egf	X	2	L, TP, E
<i>Streblus indicus</i> (Bur.) Corn.	Moraceae	2		egf	X	2	L, TP, E
<i>Strobilanthes</i> sp.	Acanthaceae	2		rocks cliffs mxf	X	2	F
<i>Sunipia rimannii</i> (Rchb. f.) Seid.	Orchidaceae	2		egf	X	2	L, SA
<i>Terminalia franchetii</i> Gagnep. var. <i>tomentosa</i> Nana.	Combretaceae	2		rocks cliffs mxf	X	2	L, F
<i>Thunbergia concinea</i> Wall.	Acanthaceae	2		da in egf	X	2	F, TP
<i>Trevesia</i> sp.	Araliaceae	2		rocks cliffs bb/df	X	2	F, E
<i>Typhonium flagelliforme</i> (Lodd.) Bl	Araceae	2		seasonally wet pond in bb/df	X	2	DR, DO, E
<i>Uncaria scandens</i> (Sm.) Hutch.	Rubiaceae	2		da sg in egf	X	2	L, DO
<i>Vernonia garrettiana</i> Craib	Compositae	2		bb/df	X	2	DO
<i>Woodwardia cochinchinensis</i> Ching	Blechnaceae	2		eg/pine	X	2	SA, DO
<i>Zingiber</i> aff. <i>laoticum</i> Gagnep.	Zingiberaceae	2		bb/df	X	2	DO, E

