

Plant Formations in the Bornean BioProvince

Peter Martin Rhind

Bornean Dipterocarp Forest

The Dipterocarpaceae with some 267 species, 155 of which are endemic, dominates the lowland forests of Borneo (Kalimantan). In fact, Borneo is the world's epicenter for dipterocarp diversity producing some of the tallest forests on earth. One species, *Koompassia excelsa* (Fabaceae) regularly exceeds 60 m and some individuals have nearly reached 90 m (300 ft). In fact, this tree is regarded as the tallest broadleaf tree in the world. These luxuriant forests have a complex vertical structure with at least two tree layers and a shrub layer. The canopy normally reaches heights of about 36 m, but often towering above this are various emergents that can exceed 60 m. Most of these emergents are dipterocarps of the genera *Dipterocarpus*, *Dryobalanops* and *Shorea*, but may also include several other genera such as *Koompassia* (Laurelaceae). Among the larger endemic species are *Dryobalanops beccarii* and *Shorea ferruginea* (Dipterocarpaceae). The canopy also includes many dipterocarps of the genera *Hopea* and *Vatica*, but in addition, species of the Berseraceae and Sapotaceae are also well represented. Many of these canopy trees are endemic and include, for example, *Carallia borneensis* (Rhizophoraceae), *Chisochaeton setosus*, *Dysoxylum pachyrache*, *Sandoricum borneense* (Meliaceae), *Crypteronia borneensis* (Crypteroniaceae), *Dipterocarpus stellatus*, *Shorea quadrivervis*, *Upuna borneensis* (Dipterocarpaceae), *Gonystylus borneensis* (Thymeleaceae), *Gymnacranthera contracta*, *Myristica borneensis* (Myristicaceae), *Hydnocarpus borneensis*, *Ryparosa kostermansii* (Flacourtiaceae), *Lithocarpus ferrugineus* (Fagaceae), *Meliosma sarawakensis* (Sabiaceae), *Sarcotheca macrophylla* (Oxalidaceae), *Semecarpus rufo-velutinus* (Anacardiaceae), *Scaphium borneensis* (Sterculiaceae) and *Scorodocarpus borneensis* (Olacaceae). Below is a sub-canopy layer of smaller, shade tolerant trees, which includes a number of families, but species of the Euphorbiaceae are particularly well represented. This layer is also characterized by the presence of many species, such as *Durio testudinarum*, that bear their flowers and fruit on their trunks – a phenomenon known as caulifory. Among the many endemic smaller trees are *Gonocaryum minus* (Thymelaeaceae), *Horsfieldia tenuifolia*, *Knema minima* (Myristicaceae) and *Sandoricum caudatum* (Meliaceae).

The shrubs layer is again rich in endemic species such as *Magnolia persuaveolens* (Magnoliaceae), *Rinorea iliaspaiei* (Violaceae), *Thottea curvisemen* (Aristolochiaceae) and *Vaccinium bigibbum* (Ericaceae). Draping over many of the trees are various lianas and climbers such as the endemic *Phytocrene racemosa* (Icacinaceae) and *Bauhinia sylvani* (Anacardiaceae) and various semi-parasitic aerial shrubs of the family Loranthaceae including endemics like *Macrosolen brevitybis* and *Trithecanthera flava*. Epiphytes, including many bryophytes, ferns and orchids cling to virtually all-damp substrates at all levels of the forest. In addition, there are many epiphylls i.e. species that can colonize the surface of leaves such as various algae, bryophytes and lichens. On the forest floor, herbs such as the endemic *Tacca bibracteata* (Taccaceae), seedlings and shade-tolerant palms exploit the few places that receive light. A striking feature of many of the rainforest herbs is the red and silver colouring and variegation of their leaves, which is apparently an adaptation to exploit the meager, light levels in these dark forests. The forest floor is also the place to find the spectacular *Rafflesia* plants including *Rafflesia arnoldii*, which produces the largest flowers in the world. Its huge red-brown flowers can measure up to a 60 cm across. Another giant is *Dawsonia superba*, the largest moss in the world, which can grow up to a metre in length. Other species include the endemic *Rafflesia keithii* and *R. pricei* (Rafflesiaceae). Rafflesias are all parasitic plants with no leaves and derive their

sustenance from the ground vine *Tetrastigma leucostaphylum*. Their flowers smell like rotting meat, which attracts the attention of various insect pollinators.

Bornean Heath Forest

On the nutrient poor, acidic soils of Borneo a type of forest known as heath forest occurs (also known as Kerangas in Indonesia). The term 'heath forest' is slightly misleading since they are not particularly rich in heathland species, but are regarded as edaphic climax forest of poor soils where you would expect to find heathlands in other parts of the world. They have a low uniform single-layered canopy reaching no more than about 20 m in height, and are less species-rich than dipterocarp forests, but can extend well into the highlands where the trees become stunted and contorted. The tree species are dominated by members of the Casuarinaceae and Myrtaceae families together with conifers such as *Agathis*, *Dacrydium* and *Podocarpus*, but dipterocarps may also be present especially in some of the less nutrient poor areas. Other, less favourable areas are dominated by species of *Tristania* (Myrtaceae). Some characteristic species, such as *Casuarina nobilis*, are able to fix nitrogen. Among the many endemic trees are *Agathis borneensis* (Araucariaceae), *Castanopsis borneensis*, *Lithocarpus sericobalanus*, *Quercus kerangasensis* (Fagaceae), *Dactylocladus stenostachys* (Crypteroniaceae), *Hopea micrantha*, *Shorea coriacea*, *Vatica compressa* (Dipterocarpaceae) and *Horsfieldia carnosia* (Myristicaceae). Shrubs such as the endemic *Arthropodium crassum* (Aristolochiaceae) and *Diplycosia kalmiiifolia* (Ericaceae) may be present. The lack of available nutrients has fostered the development of a rich assemblage of carnivorous plants including pitcher plants (*Nepenthes*), sundews (*Drosera*) and bladderworts (*Utricularia*), and these represent a characteristic feature of these forests. Some of the *Nepenthes* species are spectacular such *N. veitchii* with its red-streaked rims and *N. reinwardtiana* with its sensuous curvy shapes. The rich epiphytic flora is largely dominated by orchids, such as the endemic *Bulbophyllum beccarii* (Orchidaceae), and ferns like the endemic *Selliguea setacea* (Polypodiaceae). There are also many epiphytic shrubs, particularly of the Ericaceae such as the endemic *Rhododendron nieuwenhuisii* and *Vaccinium monanthum*, while among the endemic lianas and climbers are *Bauhinia foraminifer* (Caesalpiniaceae) and *Costera cyclophylla* (Ericaceae). The forest floor is typically dominated by bryophytes but may also include a number of herbaceous species such as the endemic ground orchid *Entomophobia kinabaluensis* (Orchidaceae) and the endemic sedge *Tetraria borneensis* (Cyperaceae). In other places, presumably because of low light levels and poor soil quality, the ground layer maybe completely devoid of species.

Bornean Limestone Forest

In the lowlands these forests are often dominated by large emergent tree reaching heights of 40 m or so. Dipterocarps, such as the endemic *Hopea andersonii*, *H. dasyrachis* and *Shorea patoensis* (Dipterocarpaceae) are common together with nondipterocarps like *Brownlowia glabrata* and *Palaquium sericeum*. Many of these large trees are heavily buttressed. Other trees include various endemics such as *Aglaia ramotricha* (Meliaceae), *Chisocheton ruber* (Meliaceae), *Daphniphyllum dichotomum* (Daphniphyllaceae), *Osmoxylon kostermansii* (Araliaceae), *Tristiropsis ferruginea* (Sapindaceae) together with the two endemic palms *Livistona exigua* and *Pinanya yassinii* (Arecaceae). The shrub layer is sparse but several epiphytic shrubs may be present like the endemic *Vaccinium lobbii* (Ericaceae). Large woody climbers are also less common than in the dipterocarp forests but may, for example, include species of *Derris* and *Phanera*. Surprisingly, the epiphytic flora is also comparatively poor especially in the more shady areas, but may include the endemic fern *Pyrrosia platiphylla* (Polypodiaceae). Moving into the montane zones, dipterocarps decrease in number although *Hopea argentea* often persists well into the uplands. More typical here are species such as *Casuarina nobilis* while in the upper

zones above 1200 m the conifers *Dacrydium beccarii* and *Phyllocladus hypophyllus* come to dominate. *Knema sericea* (Myristicaceae) is one of many endemic trees, and there are many shrubby species including a number of endemic rhododendrons, and several endemic ferns such as *Ctenitis muluensis* (Tectariaceae). In fact, these limestone forests have extremely high levels of endemism.

Bornean Ultrabasic Forest

Ultrabasic rocks only account for about 1% of the land area of Borneo being mostly confined to Sabah and South Kalimantan. It is rich in nickel and chromium, which is toxic to many plants and so often supports an assemblage of specially adapted species. However, unlike New Caledonia where the forest on ultrabasic rock is very distinctive, here there is less demarcation between the 'untrabasic' forests and those of the surrounding areas. Nevertheless, several dipterocarps including the endemic *Dipterocarpus geniculatus*, *Shorea andulensis* and *S. laxa* together with a few other endemic trees such as *Borneodendron anaegmaticum* (Euphorbiaceae) and *Buchaninia arborescens* (Anacardiaceae) are more or less confined to ultrabasic soils. In the uplands shrubs such as *Leptospermum recurvum* and the endemic *Dacrydium gibbsiae* (Podocarpaceae) become the main species, while other shrubs may include the endemic *Rhododendron ericoides* (Ericaceae). Here the ground layer can be almost barren in places with just a few tufts of *Machaerina micrantha*, *Schoenus curvulus* and the endemic *Euphrasia borneensis* (Scrophulariaceae). However, endemism in general on ultrabasics is far less pronounced in Borneo than it is compared with, for example, New Caledonia, where some 79% of the species on these soils are found no where else. The few species endemic to Borneo that seem to be mainly found on ultrabasics including several trees like *Atuna cordata* (Chrysobalanaceae), *Dipterocarpus ochraceus* (Dipterocarpaceae), *Podocarpus confertus* (Podocarpaceae) and *Quercus kinabaluensis* (Fagaceae).

Bornean Swamp Forest

These can be divided into rain-fed peat swamp forests and river-fed swamp forests. The ones fed by rainwater are less nutrient rich and generally less species rich than adjacent river water swamps. Peat swamp forests are widespread occurring in the lowlands of Kalimantan and on the coastal plains of Brunei and Sarawak - the largest being on the Maludam Peninsula. Some of these are thought to have been established for many thousands of years and in places have developed a peat layer up to 20 m thick. The dominant trees vary from place to place, but in a number of peat swamps including those of the Maludam Peninsula, the endemic *Shorea albida* (Dipterocarpaceae) is dominant. Other trees may include *Dyera costulata*, *Gonystylus bancanus* and several endemic taxa such as *Adenantha malagana* subsp. *andersonii*, *Albizia dolichadena* (Fabaceae), *Lophopetalum sessilifolium* (Celastraceae), *Prunus turfosa* (Rosaceae), *Xanthophyllum ramiflorum* (Polygalaceae), and on the edges of peat swamps the endemic *Shorea balangeran* (Dipterocarpaceae). Several of these trees have prominent aerial roots (pneumatophores) for obtaining oxygen in waterlogged conditions. Another feature of these low nutrient forests is the presence of many plants with supplementary means of nutrition such as the ant plants *Hydnophyton* and *Myrmecodia* and pitcher plants. River swamp forests are mostly associated with huge low-lying river basins and there are extensive examples occurring in the southwest of Borneo. They are typically more species rich and taller than peat swamp forests reaching heights of 35 m. Their species composition is very mixed but some of the more important trees include *Cerbera manghas*, *Dracontomelon puberulum*, *Heritiera littoralis*, *Initsia palembanica*, *Lagerstromia speciosa*, the endemic dipterocarps *Shorea macrophylla* and *S. splendida* (Dipterocarpaceae) and the Bornean ironwood *Eusideroxylon zwageri* (Lauraceae). Other endemic trees include *Archidendron fagifolium* var. *borneense* (Fabaceae), *Chisocheton lansiifolius* (Meliaceae),

Copaifera palustris (Caesalpiniaceae), *Dacrycarpus steupii* (Podocarpaceae), *Dactylocladus stenostachys* (Crypteroniaceae), *Dipterocarpus tempehes* and *Hopea pentanervia* (Dipterocarpaceae), *Dryobalanops rappa* (Dipterocarpaceae), *Horsfieldia carnosa* (Myristicaceae), *Knema uliginosa* (Myristicaceae), *Lepisanthes divaricata* (Sapindaceae), *Lithocarpus andersonii* (Fagaceae), *Lophopetalum sessilifolium* (Celastraceae), *Magnolia lasia* (Magnoliaceae), *Prunus turfosa* (Rosaceae) and *Semecarpus glaucus* (Anacardiaceae). Among the endemic shrubs are *Arthrophyllum crassum* (Araliaceae), *Diplycosia lavandulifera*, *Rhododendron commutatum* and *Vaccinium costerifolium* (Ericaceae). There are also a number of epiphytic shrubs such as the endemic *Diplycosia carrii* (Ericaceae) and a few lianas and climbers like to endemic *Gnetum neglectum* (Gnetaceae). Included among the many epiphytes is the endemic fern *Drynaria involuta* (Polypodiaceae). Not surprisingly, the permanently saturated or flooded ground layer includes many hydrophytes and hygrophytes such as the endemic sedge *Mapania maschalina* (Cyperaceae).

Bornean Montane Forest

Being derived from both Asian and Australian elements, the montane forest of Borneo is one of the most diverse montane habitats in the world, and nowhere are these forests better developed than on Borneo's highest mountain, Mount Kinabalu. Above about 1300 m Fagaceae becomes the main tree family with the lowland domination of the Dipterocarpaceae being replaced by oaks (*Quercus* and *Lithocarpus*) and chestnuts (*Castanopsis*). Among these are many endemic species like *Lithocarpus luteus*, *Castanopsis clemensii* and *Quercus valdinervosa*. These forests can be likened to montane islands in a sea of lowland dipterocarps. They experience high rainfall levels and are often bathed in clouds. Other important families include Araucariaceae, Clethraceae, Ericaceae, Lauraceae, Myrtaceae, Podocarpaceae, Symplocaceae and Theaceae. The canopy typically reaches heights of between 10 and 20 m, but larger emergent trees are absent, and there are very few trees with large buttresses. Other endemic trees include *Archidendron kinabaluense* (Fabaceae), *Horsfieldia androphora* (Myristicaceae), *Illicium kinabaluense* (Illiciaceae), *Knema hirtella* (Myristicaceae), *Polyscias borneensis* (Araliaceae) and *Xanthophyllum tenue* (Xanthophyllaceae). Two particularly interesting trees are the curious celery pine *Phyllocladus hypophyllum* and the so-called trig-oak *Trigonobalanus verticillata* - both have been described as living fossils. The celery pine is thought to be the most primitive living conifer, while the trig-oak, which was only discovered in 1961, appears to be the missing link between beeches, southern beeches and oaks. It has the nuts of northern, temperate beeches (*Fagus*), but these are borne in acorn cups, and it has the timber and leaves of tropical oaks. Below the canopy various shrubs are usually present including many endemic species like *Daphniphyllum borneense* (Daphniphyllaceae), *Diplycosia fimbriata* (Ericaceae) and *Symplocos tricoccata* (Symplocaceae), while *Vaccinium andersonii* (Ericaceae) is one of several epiphytic endemic shrubs. Rhododendrons start to become more conspicuous with increasing altitude and are a major feature of the mossy forests of the upper montane zones. Lianas, climbers and vines are also plentiful. *Adenia kinabaluensis* (Passifloraceae), *Bauhinia excelsa* (Caesalpiniaceae) and *Kudsuria acsmithii* (Schisandraceae) are a few of the endemic species. The forest floor, as you would expect, provides habitat for many bryophytes, ferns and flowering plants. The small mountain pitcher plant *Nepenthes tentaculata* found nestled in mounds of wet moss is one of the more interesting ground layer denizens with its distinctive tentacular bristles.

Bornean Mossy Forest

Above about 1800 m and extending to about 3200 m is the so-called mossy forest. At this height the mountain is frequently enveloped in mist, and mosses and other epiphytes cling

to virtually every available tree trunk and branch. The trees are rich in endemic species such as *Agathis kinabaluensis* (Araucariaceae), *Arthropodium ashtonii* (Araliaceae), *Dacrydium ericoides* (Podocarpaceae), *Diplycosia punctata* (Ericaceae), *Horsfieldia endertii* (Myristicaceae), *Knema muscosa* (Myristicaceae), *Lithocarpus turbinatus* (Fagaceae), *Podocarpus laubenfelsii* (Podocarpaceae), *Prunus oocarpa* (Rosaceae), *Quercus chrysotricha* (Fagaceae) and include many endemic members of the Ericaceae like *Rhododendron lowii*, *R. polyanthemum*, *Vaccinium claoxylon*, *V. moultonii*, *V. pachydermum*, *V. retivenium*, *V. stapfianum* and *V. stenanthum*. Many of the tree are stunted allowing more light to reach the forest floor which results in a profusion of plant growth including a great variety of colourful rhododendron shrubs many of which, like *Rhododendron acuminatum*, *R. durionifolium*, *R. ericoides*, *R. fallacinum*, *R. fortunans*, *R. maxwellii*, *R. moultonii* and *R. salicifolium* (Ericaceae) are endemic. Other endemic shrubs include *Diplycosia acuminata*, *D. ciliolata*, *D. cinnamomifolia*, *D. kostermansii*, *D. orophila*, *D. sphenophylla* (Ericaceae), *Rhus borneensis* (Anacardiaceae), *Vaccinium cercidifolium*, *V. kemulense*, and *V. tenerellum* (Ericaceae). Members of the Ericaceae often dominate the shrub flora and some of these upland forests are sometimes referred to as ericaceous forests. There is also a wealth of ericaceous epiphytic and climbing shrubs - *Diplycosia caudatifolia*, *Rhododendron crassifolium* and *Costera tetramera* (Ericaceae) are just a few of the many endemic ones. Ferns, including spectacular tree ferns like the endemic *Cyathea megalosora* (Cyatheaceae) are plentiful, and there are literally hundreds of endemic orchids. Pitcher plants, like the endemic *Nepenthes edwardsiana*, *N. lowii* and *N. villosa* (Nepenthaceae), are also well represented. Above about 2,600 m the gnarled and stunted trees of the endemic conifer *Dacrydium gibbaiae* (Podocarpaceae) and *Leptospermum recurvum* form the curious elfin forest. At altitudes above about 3,400 m a treeless zone occurs where herbs and stunted shrubs predominate. Borneo's only buttercup, the endemic *Ranunculus lowii* (Ranunculaceae), is found here together with shrubs of *Gentiana*, *Potentilla* and *Rubus*.

Further information required.

References

- Aiba, S. & Kitayama, K. 1999. Structure, composition and species diversity in an altitude-substrate matrix of rain forest tree communities on Mount Kinabalu, Borneo. *Plant Ecology*, 140: 139-157.
- Beaman, T. E., Wood, J. J., Repin, R. & Beaman, J. H. 1999. An enumeration of the orchid collections from the Kelabit Highlands. *ASEAN Review of Biodiversity and Environmental Conservation (ARBEC)*.
- Bruenig, E. F. 1990. Oligotrophic forested wetlands in Borneo. In: *Ecosystems of the World 15. Forested Wetlands*. Eds. A. Lugo, M. Brinson and S. Brown. Elsevier.
- Chapman, V. J. 1977. Wet coastal formations of Indio-Malesia and Papua New Guinea. In: *Ecosystems of the World 1 - Wet Coastal Ecosystems*. Ed. V. J. Chapman. Elsevier Scientific Publishing Company.
- Kitayama, K. 1992. An altitudinal transect study of the vegetation on Mount Kinabalu, Borneo. *Vegetatio*, 102: 149-171.
- Leith, H. & Werger, M. J. A. 1989. *Ecosystems of the World 14B - Tropical Rain Forests*. Elsevier Scientific Publishing Company.

MacKinnon, K., Hatta, G., Halim, H. & Mangalik, A. 1997. *The Ecology of Kalimantan*. Oxford University Press.

Phillips, V. D. 1998. Peatswamp ecology and sustainable development in Borneo. *Biodiversity and Conservation*, 7: 651-671.

Proctor, J. 1983. Ecological studies in four contrasting lowland rain forests in Gunung Mulu National Park, Sarawak. *Journal of Ecology*, 71: 237-260.

Proctor, J. 2003. Vegetation and soil and plant chemistry on ultramafic rocks in the tropical Far East. *Perspective in Plant Ecology, Evolution and Systematics*, 6: 105-124.

Small, A., Martin, T. G., Kitching, R. L. & Wong, K. M. 2004. Contribution of tree species to the biodiversity of a 1 ha Old World rainforest in Brunei, Borneo. *Biodiversity and Conservation*, 13: 2067-2088.

Specht, R. L. & Womersley, J. S. 1979. Heathlands and related shrublands of Malesia (with particular reference to Borneo and New Guinea). In: *Ecosystems of the World (9A) – heathlands and related shrublands: descriptive studies*. Ed. R. L. Specht. Elsevier Science.

Steenis, C. G. G. J. van. 1957. Outline of the vegetation types in Indonesia and some adjacent regions. *Proceedings of the Pacific Scientific Congress*, 8: 61-97.

Watanabe, N. M. & Suzuki, E. 2008. Species diversity, abundance, and vertical size structure of rattans in Borneo and Java. *Biodiversity and Conservation*, 17: 523-538.

Wilkie, P., Argent, G., Cambell, E. & Saridan, A. 2004. The diversity of 15 ha of lowland mixed dipterocarp forest, Central Kalimantan. *Biodiversity and Conservation*, 13: 695-708.