WWF-Canon / Gerald S. CUBITT

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Biodiscoveries

Borneo's Botanical Secret

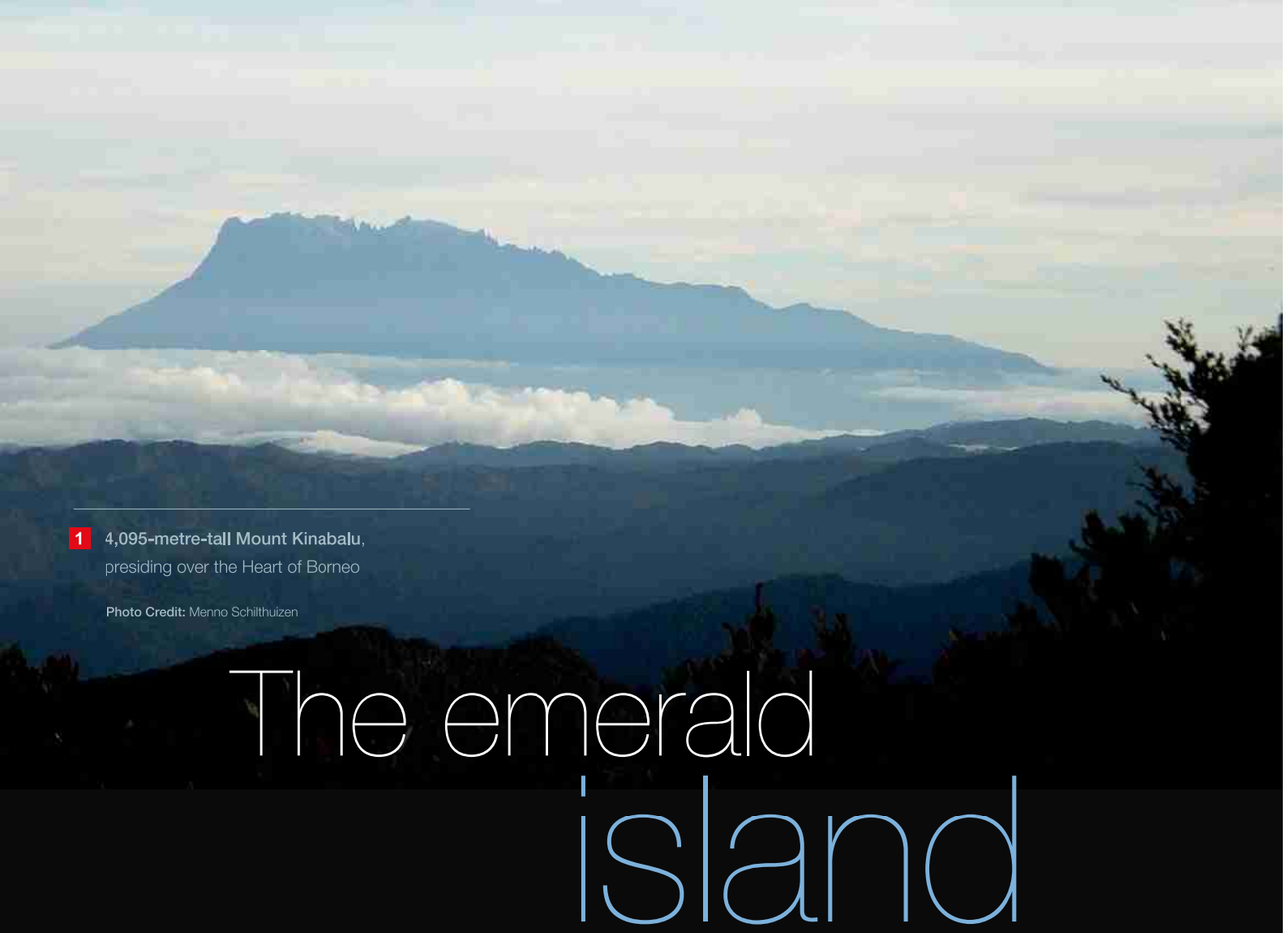
WWF-Canon / Edward PARKER

Biodiscoveries

Borneo's Botanical Secret







1 **4,095-metre-tall Mount Kinabalu**, presiding over the Heart of Borneo

Photo Credit: Menno Schilthuizen

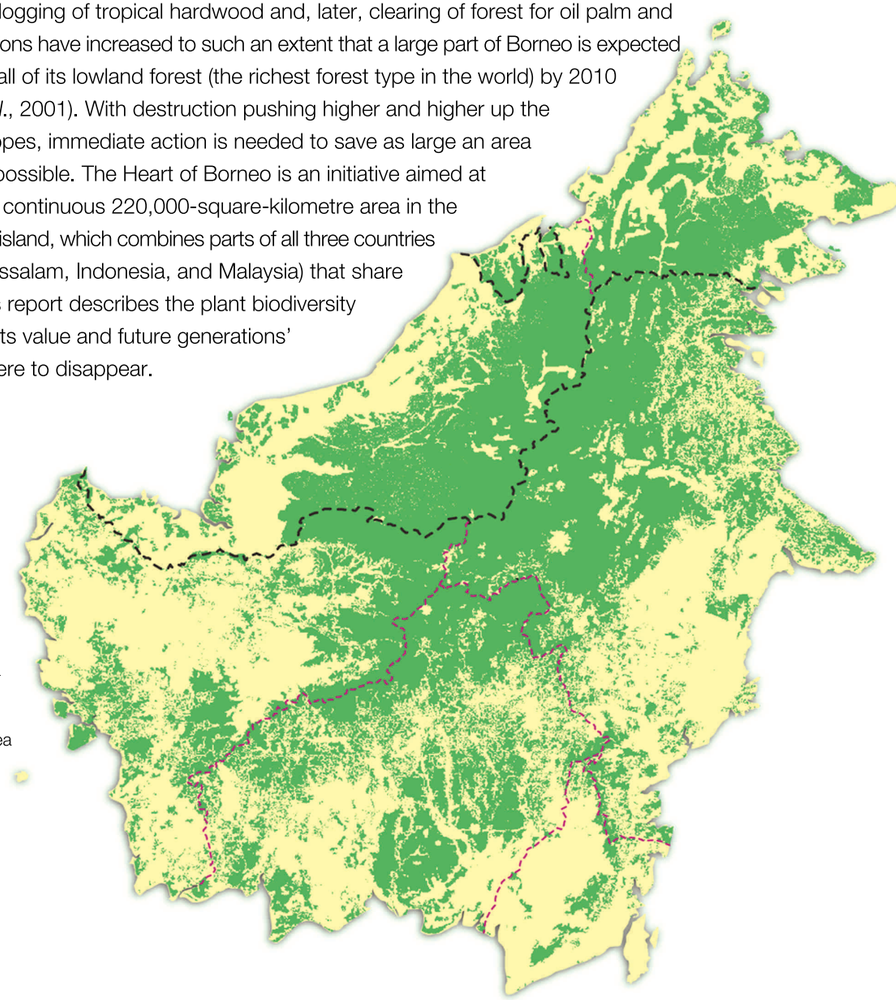
The emerald island

Borneo has always been the crown of the 25,000 islands that make up what 19th-century naturalist Alfred Russel Wallace called 'the Malay Archipelago'. Its 746,000 square kilometres make it the second largest after New Guinea. The 4,095-metre-tall Mount Kinabalu is the highest peak in a 3,000-kilometre radius. And where surrounding areas like Java, the Philippines, and the Malay Peninsula have been cultivated and densely populated for centuries, Borneo has always resisted much human interference and has remained a bastion of impenetrable forest and untameable highlands until just one or two generations ago.

Even today, the island's population of less than 20 million on an area twice the size of Germany is meagre compared with all neighbouring regions. Moreover, most people live along the coast, leaving large parts of the mountainous, forested interior almost uninhabited. Besides the rugged character of the land, this low human population can be blamed on Borneo's infertile soils, which made that farming was traditionally only possible in the coastal plains and by shifting cultivation in the hills (MacKinnon *et al.*, 1996).

Although Borneo's soils are poor in nutrients, they have, over millions of years, spawned a rich biodiversity. The island enjoys a humid tropical climate with temperatures ranging between 25°C and 35°C at sea level and a yearly rainfall of between 2,000 and 4,000 millimetres (MacKinnon *et al.*, 1996). More importantly, it has maintained its tropical position uninterruptedly over almost 100 million years. Whereas continental drift has pushed Borneo's neighbours like the Philippines, Sulawesi, and New Guinea to and from different climate zones, Borneo has stayed put at its balmy equatorial location and evolution has been able to develop an immensely varied flora and fauna (Hall & Holloway, 1998; Hall, 2006).

Sadly, the past decades have put an end to Borneo as a pristine tropical paradise. Large-scale logging of tropical hardwood and, later, clearing of forest for oil palm and other plantations have increased to such an extent that a large part of Borneo is expected to have lost all of its lowland forest (the richest forest type in the world) by 2010 (Jepson *et al.*, 2001). With destruction pushing higher and higher up the mountain slopes, immediate action is needed to save as large an area of forest as possible. The Heart of Borneo is an initiative aimed at preserving a continuous 220,000-square-kilometre area in the centre of the island, which combines parts of all three countries (Brunei Darussalam, Indonesia, and Malaysia) that share Borneo. This report describes the plant biodiversity in this area, its value and future generations' losses if it were to disappear.



2 **Forest cover on Borneo in 2005.** The heart of the island is the only area where contiguous forest survives.

Image Credit : 2 WWF Germany

A thousand shades of green

For most of the past 30 million years, Borneo was part of a single land mass ('Sundaland') that also included Java, Sumatra, Peninsular Malaysia, and the seas in between. The last time this happened was during the last 'ice age' just 12,000 years ago, when sea levels were more than 100 metres lower than today (Voris, 2000). In those days, animals could roam between Borneo and mainland Asia without having to cross any seas. No wonder, then, that the Bornean fauna is very similar to the ones of other parts of Sundaland. For example, only 9% of Borneo's bird species are unique to the island (MacKinnon *et al.*, 1996).

In plants, the situation is different. Because the pollen or seeds of many plants do not travel far, and also because many have adapted to Borneo's high mountains and unusual rock types, Borneo's flora has developed in a unique way. From early on, botanists have realised that the island offers rich pickings, and many focused their attentions on the fascinating Mount Kinabalu (Wong & Phillipps, 1996). One of the first was Hugh Low, the colonial secretary for Labuan and, coming from a horticultural family, keenly interested in plants. He was the first European to climb the mountain in 1851 and then twice more in 1858, collecting many plant specimens as he went along.

Since then until the Second World War, important contributions were made by a long line of European botanists. In the second part of the 20th century, Bornean botany was more and more conducted during large expeditions by local and overseas' universities and research organisations. Yet although one may think that after so much work, not much new remains to be discovered, the rate of finding new species does not appear to be letting up. Over the past 25 years, at least 422 new species were added to the list (see Appendix), and dozens more still await study and formal naming.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3 ***Hoya waymaniae***, **4** ***H. nabawanensis***, and **5** ***H. kloppenburgii***, three stunningly beautiful species of milkweed that were recently discovered in Sabah.

Photo Credit : 3, 4, 5 Peter Koomen

A selection of Borneo's orchids:
6 *Phalaenopsis philippinense*, **7** *Ph. fuscata*, **8** *Ph. pantherina*, and **9** *Paphiopedilum rothschildianum*.

Photo Credit : 6, 7, 8, 9 Peter Koomen


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Today, we know that the island has the richest plant life among the areas that once formed Sundaland. It boasts a staggering 15,000 species of flowering plants, a diversity as great as all of Africa, more than three times that of Java (MacKinnon *et al.*, 1996), and more than ten times that of European countries like the Netherlands (van der Meijden *et al.*, 1995). This includes some 1,700 species of orchid, and 3,000 species of tree. In addition to flowering plants, Borneo has more than 1,000 species of ferns, many of which live on Mount Kinabalu, which has more fern species than all of Africa (for comparison: The Netherlands only have 50 species) and 1,344 species of bryophytes, the mosses and liverworts (see Table 1 for some more figures on species richness in different plant groups). The diversity of algae must be enormous, too, but this group has been much neglected by scientists so far.

For these reasons, Borneo is listed among the six areas in the world with the highest plant diversity (Bartlott *et al.*, 1996). It applies to a small scale as well: the island holds the world record for tree species richness, with a mind-boggling 1,186 species in a 0.5 square kilometre-chunk of Sarawak forest (Condit *et al.*, 2000; Wills *et al.*, 2006). Forests in Peninsular Malaysia are at most only two-thirds as rich (Harrison & Ashton, 2003).


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10, **11** Two of Borneo's more than 1,000 fern species: the epiphytic staghorn fern, *Platycerium coronarium* and the bracken fern, *Dicronopteris sp.*

12 Borneo is home to 721 species of mosses and 623 species of liverworts.

Photo Credit : 10, Menno Schilthuizen **11,12** Peter Koomen

Not only is Borneo rich in species, many of the species are unique to the island as well. Over 5,000 species or 34% of the flowering plants are endemic: they are found nowhere else on earth (Wilson, 1994). Compare this with, say, Sumatra (with only 12% endemic plant species) and the botanical value of Borneo becomes clear. Among some groups, the percentage of endemicity is even higher: 58% of the highly-valued timber tree family Dipterocarpaceae, for example, are unique to the island. One family of small trees, the *Scyphostegiaceae*, is even entirely confined to Borneo.

	Borneo (% endemic)	Mt. Kinabalu	Netherlands
Flowering plants			
Total	ca. 15,000 (34%)	ca. 5,000	ca. 1,400
Orchids	ca. 1,700	840	30
Aroids	160	40	10
Trees	3,000		59
Dipterocarps	265-270 (58%)		0
Palms	280		0
Rattans	146		0
Figs	135		0
Non-flowering plants			
Ferns	>1,000	608	50
Bryophytes	1,344	234	507

Table 1: Figures on species richness and endemism for selected plant groups in Borneo and Mt. Kinabalu. Based on Akiyama *et al.* (2001); Andersen *et al.* (2003); Beaman (2001); Beaman & Beaman (1998); Dransfield & Johnson (1989); Lamb (pers. comm.); MacKinnon *et al.* (1996); Payne *et al.* (2000); Phillipps & Liew (2000); Rautner & Alfred (2005); Said (2005); Suleiman (pers. comm.); Suleiman & Akiyama (2005); Suleiman & Edwards (2002); van der Meijden *et al.* (1995); van der Meijden (2005); Wong & Phillipps (1996).

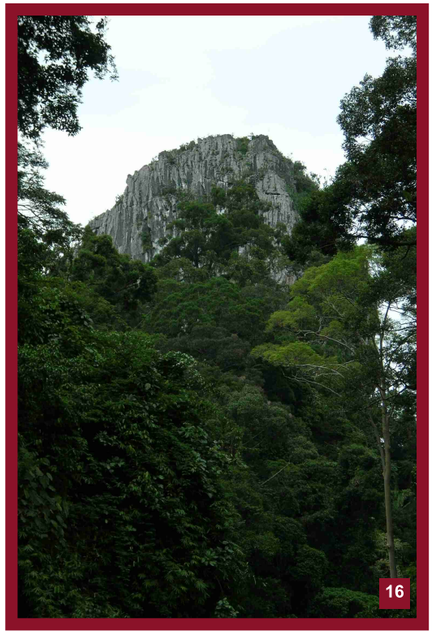
13 **The aroid *Alocasia robusta***, showing off its gigantic leaves.

14 ***Rafflesia keithii***, one of the world's largest flowers, parasitises on a vine and does not have any chlorophyll of its own.

Photo Credit: 13 Peter Koomen, **14** Barbera Veldhuisen

Besides the large numbers of species, the Bornean flora is one of other kinds of superlatives as well. It has two contenders (an aroid and a *Macaranga* tree) that vie for the honour of having the world's largest undivided leaf (Yorath & Teo, 1994). It also hosts the world's largest moss (a *Dawsonia* species), the world's largest pitcher plant (of four litre capacity), and eight species of the world's largest flower, *Rafflesia* (up to one metre across), a parasite that does not have any chlorophyll of its own (Nais, 2001). Another oddity is the fig *Ficus albipila*, one of the world's rarest trees: besides 1or 2 individuals growing along the banks of Kinabatangan river in Sabah and the upper Tabalong River in South Kalimantan, it only occurs as a handful of scattered trees in Australia and Peninsular Malaysia (Azmi, 2003).

Truly special assemblages of plants occur on those patches of Borneo that have unusual physical propeties, such as the extremely cold and wet summit of Mount Kinabalu, the nutrient-poor 'kerangas' soils, and ultramafic rocks (very acidic and rich in toxic heavy metals). Another example is limestone. Limestone outcrops are scattered in their hundreds over Borneo's lowlands. The flora of such 'karst' hills is unusual, because not all plants can tolerate the alkaline, dry, steep, and calcium-rich substrate. Some limestone plants are so specialised that they cannot live anywhere else, and many species of herbs, rattans, screw-pines, and other plants are only found here (Kiew, 2001). In fact, among all lowland forest types, limestone forest has the fewest tree species in common with the other types (Procter *et al.*, 1982). Not only that, but many species of *Begonia*, aroids, and orchids are endemic to just a single limestone outcrop. Batu Punggul in Sabah, for instance, is home to three recently discovered species, the orchids *Ania ponggolensis* and *Trichoglottis tinekeae*, and *Begonia amphioxus* all of which occur nowhere else on earth (Kiew, 2001).

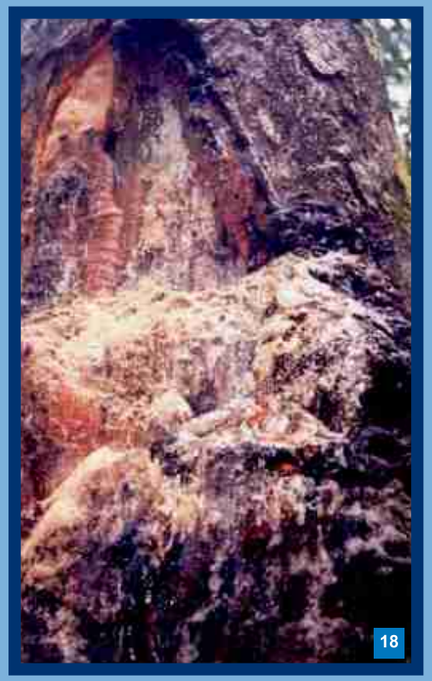


15 **Borneo's lowland rainforest** can contain over 1,000 species of tree in half a square kilometre.

16 **Limestone outcrops**, like Batu Punggul in Sabah, are home to unique vegetation, often with species endemic to just a single outcrop.

Photo Credit: 15 Peter Koomen, **16** Menno Schilthuizen

Botanical treasure trove



For ages, the forests of Borneo have been a source of valued plant-derived materials, although the importing countries, the popularity of the commodities, and their uses have varied much over the centuries. Already two millennia ago, the Chinese traded on Borneo's shores to obtain coveted goods like tree resins, rattan, nuts, bananas, and fragrant 'gaharu' wood (Dunn, 1975; Whitmore, 1998). Since then, Borneo has provided the outside world with anything from charcoal and latex to fibres and fruits. Today, timber and rattan are the only remaining multimillion-dollar export products derived from Borneo's natural vegetation. However, a very large range of forest products continue to be gathered by the local communities for food, medicine, construction, and many other uses. A lot of those could also be commercialised in the future--provided the forest that harbours them survives.

One of the most important export products in the early days was the tree resin 'damar', which was (and still is) tapped from *Shorea* trees and the tall conifers *Agathis borneensis*, *A. dammara*, and A. *lenticula*. *A. borneensis* grows in lowlands, the other two in highlands. Originally, damar was used as fuel for lighting fires and to repair boats, but later it mostly found use in the preparation of paints, varnish, and linoleum (MacKinnon *et al.*, 1996; Payne *et al.*, 2000; Whitmore, 1998). Even today, Indonesia and Malaysia still export yearly some 2,000 tonnes (worth about two million US$) of damar for the production of specialised paints and varnishes, and much of it comes from Borneo (FAO, 1995).

17 18 **An Agathis tree** oozing the valued 'damar', and the dried resin.

Photo Credit: 17, 18 Aida Lapis

Another historically important export product is the nut of various species of Shorea trees. These 'illipe nuts' or 'tengkawang' are harvested from the forest and exported as nuts or as illipe oil for use as cocoa butter substitute, as well as in soap, candles, medicines and 'rainforest cosmetics'. Like most dipterocarps, *Shorea* trees fruit irregularly, once every seven years or so (MacKinnon *et al.*, 1996). In a fruiting year, a hectare of forest floor may yield over one tonne of dried nuts, and total export can be worth up to ten million US$ (Iqbal, 1993).

However, these figures are dwarfed by those for the spiny, climbing palms that we know as rattan (the palm subfamily *Lepidocaryoidae*). Borneo is home to almost 150 species, which snake through the vegetation in abundance. Many of them are coveted for their long, regular, and hard stems that, after de-spining and boiling, can be turned into light-weight but strong and durable furniture. *Calamus* species such as *C. caesius* and *C. optimus* produce thin (less than 17 mm in diameter) but very long (more than 50 m) stems, whereas *C. scipionum, C. ornatus*, and *C. subinermis* yield the thicker, but equally long, variety (Pearce, 1989; Chan, 2000). Throughout the 1990s, Indonesia and Malaysia exported an average of 125,000 tonnes of rattan and rattan products (valued about 125 million US$) per year (Vantomme *et al.*, 2002), and much of the raw material came from Bornean forests.

19 **Rattan after boiling in oil**

Photo Credit: 19 WWF-Malaysia / LYS

20 **A young ‘belian’ tree** (*Eusideroxylon zwageri*), which produces one of Borneo’s most durable types of timber.

21 ***Intsia palembanica***, an important timber tree.

22 ***Phalaenopsis amabilis***, one of the most popular orchids in Borneo gardens.

Photo Credit:
20 Menno Schilthuizen
21 Menno Schilthuizen
22 Peter Koomen

Although rattan exports are important, most revenue comes, of course, from timber. Among the 3,000 tree species that grow in Borneo’s forests are many with ideal properties for use as wood in construction and — to a lesser extent — for furniture and floors. The most popular timber family is the Dipterocarpaceae, but the most highly-valued species is actually a member of the laurel family: Borneo ironwood or ‘belian’ (*Eusideroxylon zwageri*). Untreated, its timber can last for up to a century. Hence, it was (and is) the wood of choice for the main beams of Borneo longhouses. Other much sought-after trees are the Agathis and Shorea species, ‘merbau’ (*Intsia palembanica*), and ‘ramin’ (*Gonystylus bancanus*). Borneo timber constitutes a multibillion-dollar market. Over the past two decades, more cubic metres of wood were exported from Borneo than from Africa and tropical America combined (Curran *et al.*, 2004). For Malaysian Borneo alone, the total value of wood (legally) exported in 2004 amounted to 2.5 billion US$ (MTC, 2006).

Wild Supermarket

Besides for international trade, many of Borneo’s plants are vital for the daily life of local communities. Even city folk could not live without some of its forest produce, like ‘durian’ (*Durio zibethinus*) and ‘tarap’ (*Artocarpus odoratissimus*) fruits, the ‘tuhau’ ginger (*Etlingera punicea*; Phillipps & Liew, 2000), and the ornamental orchids, palms, and aroids that adorn many a city garden.

Communities in villages, especially those far away from major towns are even more dependent on what can be obtained from the forest, such as edible ferns and other vegetables (for example, the recently discovered *Begonia lazat*, which is eaten by Sabah’s ‘Orang Sungai’ people [Azmi, 1999]), fruits like various local mango species,

23 **Selakau man using rattan** to make a fish trap.

24 **A Bornean Vanilla orchid**, *V. pilifera* (not flowering).

Photo Credit:
23 WWF-Malaysia / R.Rajanathan
24 Menno Schilthuizen

rattans for turning into mats, baskets, fish traps, hats, and ropes (Pearce, 1989), timber for building houses, the versatile bamboo, the football-sized fruits of *Pangium edule*, which have antimicrobial properties and are used for preserving meats, the poisonous ‘tuba’ (*Derris elliptica*) for catching fish, and an entire pharmacopoeia of herbal cures and medicines.

The sheer diversity of plants used by rural communities highlights the degree of underutilisation of Borneo’s flora. The legendary durian fruit *Durio zibethinus*, hugely popular throughout Southeast Asia (the trade is estimated to be worth 1.5 billion US$ yearly; Ross, 1997), is originally a species from Borneo (Baja-Lapis *et al.*, 2004; Tate, 1999). Eighteen more species of durian are found on the island, each with a different taste, and many are enjoyed by local people, though none are commercially grown on any scale. The same applies to the 24 wild mango species, and the 25 wild breadfruit species (Payne *et al.*, 2000). Another possibility are the many *Vanilla* orchids that occur in Borneo, of which some might be as useful as a spice as the globally used South American *V. planifolia*. At Tenom Agricultural Park in Sabah, some experiments have been started to assess the potential of the five *Vanilla* species of Sabah (Lamb, personal

25 **Wild durian fruits**, an underexploited Borneo forest product

26 **A native durian**, *Durio grandiflora*, flowering

27 **A red durian tree**, with steps installed by local durian collectors

Photo Credit:
25 WWF-Malaysia / Junaidi Payne
26 Peter Koomen
27 WWF-Malaysia / Reza Azmi

Photo Credit:
28, 30 Menno Schilthuizen
29, 31 Peter Koomen

28 29 30 31 **Aroids**, like *Alocasia cuprea* (28) and *begonias* from Borneo are popular as ornamental plants.

communication). Even more revenue may be obtained from commercialising the many ornamental plants, like orchids, hoyas, begonias, palms, gingers, rhododendrons, and aroids, which might join a huge international market.

Hidden Cures

But perhaps most promising is tapping into local people's traditional herbal medicine. Scientists have only just started exploring this vast, and rapidly vanishing knowledge base. Interviews with elders of local comunities such as the Dusun and the Orang Sungai of Sabah have yielded long lists of plants that are used for a wide variety of ailments (Ahmad & Ismail, 2000; Phillipps & Liew, 2000; Yusoff *et al.*, 2003). Pharmacological investigation is beginning to show that some of these plants can be sources for new, powerful drugs of global importance.

Already, a Sarawak shrub (the identity of which is kept secret) has yielded a promising substance (code-named CBL316) that kills human cancer cells (Rouhi, 2003). The chemical was found by an Australian company, Cerylid Biosciences, which claims it is effective against 57 of 60 kinds of human cancer cells kept in the laboratory, including those that cause brain and breast cancer and melanoma. It is now being tested on laboratory mice and according to the US National Cancer Institute, appears to be a completely novel kind of anticancer agent, at least as effective as a leading anticancer drug, paclitaxel (Cerylid Biosciences, 2006).

The latex of bintangor trees (*Calophyllum lanigerum* and *C. teysmannii*, relatives of the mangosteen), also from Sarawak, was found to contain two compounds (calanolides A and B, respectively), effective against a wide range of strains of the Human Immunodeficiency Virus HIV. The chemicals appear to block the replication of the virus. Moreover, calanolide A does not have the nasty side-effects that many other anti-AIDS drugs have, and it also acts against the tuberculosis bacterium, which many AIDS patients also suffer from. Clinical trials and development of this possible medicine is done by the company Sarawak MediChem

32 33 **The bark of the langsat** (*Lansium domesticum*) contains a powerful drug against malaria.

Pharmaceuticals, a joint venture between the Sarawak government and the US-based company Advanced Life Sciences (Sarawak MediChem, 2006).

Finally, the bark of the 'langsat' tree (*Lansium domesticum*), used by the Kenyah of Kalimantan to treat malaria, was indeed discovered to contain a powerful and previously unknown antimalarial substance (Omar *et al.*, 2003). Researchers found that the compound, a 'triterpenoid', killed the malaria parasite, *Plasmodim falciparum*, in the test tube. It also cured mice that were ill with the mouse version of the disease. More such drugs could be discovered in projects such as the one started by Universiti Malaysia Sarawak in collaboration with the Japanese Yamanouchi Pharmaceutical company. This project tries to do rapid chemical screenings of extracts from hundreds of Borneo plants used in traditional medicine, and come up with potential drugs (Ahmad & Ismail, 2000).

So, the forests of Borneo are an unexplored botanical treasure trove, which, if kept intact, could be sustainably used to generate potentially billions of dollars' worth of additional revenue for the island. But even more valuable than the possible commercialisation of individual species are the 'ecosystem services' that the vegetation can provide. Regenerating rainforest stores more than one kilogramme of carbon dioxide per square metre per year in its wood, thus mopping up the greenhouse gas from the atmosphere. Mature forest also stabilises the climate, controls soil erosion, maintains soil quality and fertility, and is essential for a steady supply of clean drinking water. These priceless services are literally a matter of life or death for Borneo's 20 million people.

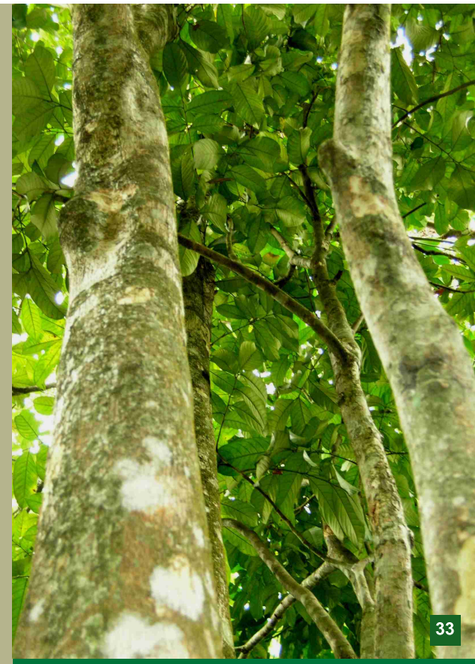


Photo Credit: 32-33 Menno Schilthuizen

Plants in peril

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34 The unique vegetation of limestone outcrops are vulnerable to fire when the surrounding forest is cleared, as this scorched hill in the interior of Sabah shows.

Photo Credit:
34 Menno Schilthuizen

Sadly, Borneo's treasure trove is currently being chopped, burned and emptied fast. Since the 1950s, when mechanised logging became available, Borneo's forests have been overexploited and severely degraded. During El-Niño droughts, as in 1982-1983 and 1997-1998, much of this degraded forest and other flammable types, like heath forest and those on peat and on limestone was destroyed in great island-wide fires. It is estimated that in the 1982-1983 fires, 4.3 million hectares of forest were lost in Sabah and Kalimantan (MacKinnon *et al.*, 1996), and in the 1997-1998 fires, some 6.5 million hectares were affected. As a result of logging and fire, the percentage of land in Borneo under forest cover dwindled from 74% in 1985 to just 50% in 2005, and this precipitous trend is likely to continue over the next 15 years (Rautner & Alfred, 2005).

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Currently, logging itself is no longer the greatest threat to Borneo's flora. Instead, the trend to convert logged-over forest to plantations has a much more severe impact on biodiversity. Whereas even moderately damaged natural forest can still contain fairly complete representations of the natural flora and fauna, tree plantations (for timber, rubber, gaharu, or palm oil, for example) do not (Payne, 2001).

Oil palm plantations in particular are currently enjoying a boom due to an anticipated replacement of fossil fuels by vegetable oils. Throughout Borneo, they have grown by almost ten percent per year between 1998 and 2003, and now cover about three million hectares, an area almost the size of the Netherlands (Rautner & Alfred, 2005). This trend seems to be only increasing, now that European laws call for the introduction of 'bio-diesel', mixtures of petroleum and vegetable oil (Pearce, 2005).

35 36 Going, going... In the last 20 years, Borneo has exported as much timber as Africa and tropical America together.

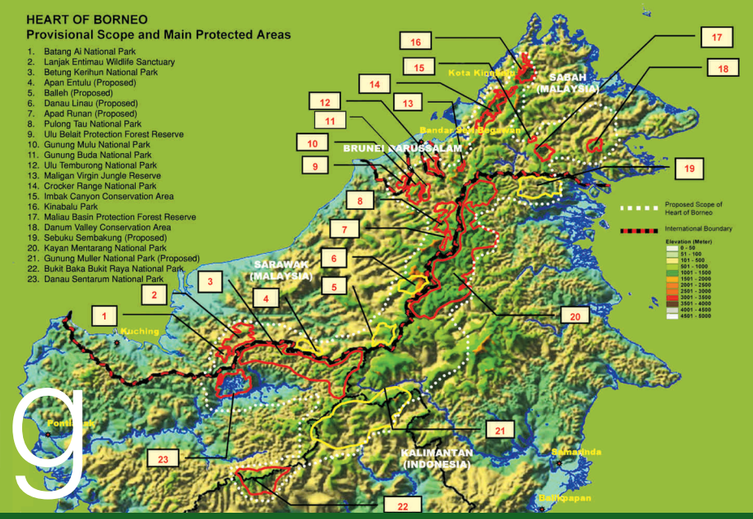
Photo Credit: 35 Annadel Cabanban, **36** Peter Koomen

In addition to wholesale disappearance of forest, even of supposedly ‘protected’ ones in Kalimantan (Curran *et al.*, 2004), individual plant species suffer as well. Borneo ironwood is now so rare in the wild that it has been placed on the IUCN Red List of Endangered Species (IUCN, 2004). Many rattans were overcollected in Sarawak and Kalimantan when demand rose in the late 1980s (Pearce, 1989) and almost half of them are now considered endangered. And in Maliau Basin, Sabah, ‘gaharu’ collectors often kill many of the *Aquilaria malaccensis* trees (now also on the Red List) in their search for suitably fragrant wood (Ali, 2001).

Some species endemic to limestone hills seem to have disappeared altogether: the slipper orchid *Paphiopedilum philippinense*, which used to grow on the limestone outcrops of Balambangan island off Borneo’s north coast, has been exterminated by commercial collectors (Kiew, 2001). And the fate of the many plant species that were only known from Kinabalu’s Pinusok Plateau also looks bleak, now that the area has been converted for vegetable farming and a golf course (Wong & Phillipps, 1996).

37 **38** **Throughout Borneo**, natural forest is giving way to oil palm plantations.

Photos Credit
37 Liew Thor Seng
38 Menno Schilthuizen



Saving the Heart of Borneo

With so many setbacks, Borneo’s flora is likely to be suffering devastating blows. More than 5,000 species are endemic to the island, and many occur in very small pockets. Habitat destruction, overcollecting and sometimes more subtle threats, such as the disappearance of pollinators (Harrison, 2000) will drive many plant species to extinction. Researchers from the National University of Singapore have estimated that up to 44% of the plant species of Southeast Asia are going to go extinct within the 21st century (Sodhi *et al.*, 2004), and unless active steps are taken soon, Borneo’s flora will not escape this onslaught.

The Heart of Borneo initiative involving Brunei Darussalam, Indonesia, and Malaysia, is a last-ditch attempt to conserve a large chunk of the island’s beleaguered biodiversity. The 220,000 square kilometres of lowland and highland rainforest in the heartland of Borneo could preserve much of its flora for posterity, and continue its function as a water catchment area and carbon sink. The area is large and pristine enough for the complex ecosystems to continue as before, providing opportunities for scientists to go on studying the myriad of subtle interactions between species. The Heart of Borneo will also serve as a refuge for the many threatened species of plants that are now on the brink of extinction.

With dozens of new plant species discovered in Borneo’s forests each year, it is likely that the Heart of Borneo will continue to be an important source for new biodiscoveries for the next centuries. And naming new species will only be the beginning. If sustainably managed, the area could be a source for valuable plant species that can be cultivated and commercialised for new foods and medicines for Borneo, Southeast Asia, and the rest of the world. But if we lose the Heart of Borneo, it will take its secrets to its grave.

39 **Botanists studying plant samples** in a previously unexplored area in Borneo.

Photo Credit:
39 Menno Schilthuizen

APPENDIX

List of plant species, newly discovered in Borneo between 1980 and 2005

This list of 422 species was compiled from references in the Flora Malesiana Bulletin, the Thomson ISI Web of Knowledge, and random literature searches. While attempts have been made to aim for completeness, it is unavoidable that many species (in particular those hidden in large revisions, and those published in minor journals) remain unlisted. The literature reference usually refers to the original description, although in some cases it refers to a secondary source.

Adiantaceae--Maidenhair ferns
Adiantum, new species (Bidin *et al.*, 1988)

Anacardiaceae--Cashew family
Semecarpus calcicola (Kiew, 2001b)

Annonaceae--Custard Apple family
Mitrephora clemensiorum, M. vittata, M. woodii (Weerasooyia & Saunders, 2001)
Tetrapetalum 1 new species (Momose, 1998)
Goniothalamus, 10 new species (Mat-Salleh,1993)
Goniothalamus 1 new species (Beaman *et al.*, 2001a)
Polyalthia, 4 new species (Johnson & Murray, 1999)
Monocapia borneensis (Mols & Kessler, 2000)

Apocynaceae--Periwinkle family
Secamone badia (Klackenberg, 2004)
Willughbeia lunduensis (Middleton, 1996)

Araceae--Aroids
Schismatoglottis bulbifera (Okada *et al.*, 1999)
Amorphophallus julaihii, A. angulatus, A. brachyphyllus, A. eburneus, A. hottae, A. infundibuliformis, A. pendulus, A. lambii, A. rugosus, A. tinekeae, A. venustus, A. costatus, A. linguiformis
(Hetterscheid, 1994; P. Boyce, cited at: http://www.snowsexotics.com/firstdivexp.htm)
Nephthythis, 1 new species (Hay *et al.*, 1994)
Aridarum, Bucephalandra, and *Hottarum*, 1 new species each (Okada & Mori, 2000)
Alocasia reginula, A. pangerana, A. princeps, A. puteri (Kiew, 2001b)
Colocasia oresbia and *Hottarum kinabaluense* (Beaman & Beaman, 1998)

Araliaceae--Ivy family
Aralia, 1 new species (Wen, 1994)

Araucariaceae--Monkey Puzzle family
Agathis kinabaluensis and *A. lenticula* (Beaman & Beaman, 1998)

Asclepiadaceae--Milkweed family
Hoya telosmoides (Omlor, 1996)
Hoya nabawanensis (Kloppenburg & Wiberg, 2002)
Hoya, at least 2 new species (Kloppenburg & Wiberg, 2002)
Hoya callistophylla, H. clemensiorum, H. kloppenburgii, H. lambii, H. meredithii, H. spatiodes, H. waymaniae (Lamb, 2003)

Aytoniaceae
Asterella limbata (Long & Grolle, 1994)

Begoniaceae--Begonias
Begonia lazat (Azmi, 1999)
Begonia, 2 new species (Kiew, 1998a)
Begonia keithii (Kiew, 1998b)





Begonia, 7 new species (Beaman *et al.*, 2001a)
Begonia, 12 new species (Kiew, 2001a)
Begonia, 6 new species (Sands, 1990)

Bombacaceae--Durian family
Coelostegia montana (Sidiyasa, 2001)
Durio bukitrayaensis (Kostermans, 1990)

Burmanniaceae
Thismia lauriana (Jarvie, 1996)
Thismia goodii (Kiew, 1999)

Capparaceae--Caper family
Capparis buwaldae (Maschwitz *et al.*, 1996)

Chrysobalanaceae
Kostermanthus robustus (Prance, 2001)

Crypteroniaceae
Payena, 5 new species (Pereira, 1997)
Crypteronia, 3 new species (Pereira & Wong, 1995)

Dipteridaceae
Cheiropleuria parva (Kato *et al.*, 2001)

Elaeocarpaceae--Jamaican Cherry family
Elaeocarpus, 5 new species (Coode, 1998)

Ericaceae--Heather family
Rhododendron, 10 new species (Argent, 2003; Argent *et al.*, 2006).

Euphorbiaceae--Spurge family
Macaranga, at least 2 new species (Davies, 1999)

Fagaceae--Beeches, Oaks, Chestnuts
Lithocarpus palungensis (Cannon & Manos, 2000)

Gesneriaceae--African Violet family
Agalmyla macrocalyx (Hilliard & Burtt, 1999)

Monophyllaea, 1 new species (Kiew, 2002)
Epithema dolichopodum (Kiew, 2001b)
Paraboea madaiensis, P. sabahensis (Kiew, 2001b)

Hanguanaceae
Hanguana major (Beaman & Beaman, 1998)

Hookeriaceae
Chaetomitrium, 2 new species (Akiyama & Suleiman, 2001)
Distichophyllum scabrisetum (Akiyama & Yamaguchi, 1999)

Lauraceae--Laurel family
Beilschmiedia, 1 new species (Nishida, 2005)
Endiandra, 3 new species (Arifiani, 2000)

Leguminosae--Legumes
Millettia borneensis (Adema, 2000)
Kunstleria sarawakensis (Ridder-Numan & Kornet, 1994)
Bauhinia, 1 new species (Jarvie, 1998)
Bauhinia campanulata (Larsen, 1994)
Dalbergia, 4 new species (Sunarno & Ohashi, 1997)

Lejeuneaceae
Metalejeunea winkleri (Zhu & Grolle, 2002)

Loganiaceae--Buddleja and Strychnine family
Fagraea, 21 new species (Wong & Sugau, 1996)

Loranthaceae--Mistletoe family
Macrosolen brevitubus and Trithecanthera sparsa (Barlow, 1995)

Lowiaceae
Orchidantha, 4 new species (Pedersen, 2001)
Orchidantha inouei (Nagamasu & Sakai, 1999)
Orchidantha holttumii (Larsen, 1993)

Marattiaceae--Giant Fern family
Marattia pellucida (Maideen *et al.*, 2002)





Melastomataceae--Melastoma family
Sonerila verticillata (McDonald, 1995)
Sonerila, 1 new species (Cellinese, 1997)

Myrsinaceae--Myrsine family
Embelia, 1 new species, *Maesa*, 1 new species (Stone, 1989)

Musci (unknown family)--mosses
At least 2 new moss species (Tan *et al.*, 1997)

Myrtaceae--Myrtle family
Syzygium velutinum (Davis, 1997)

Nepenthaceae--Pitcher Plants
Nepenthes vogelii (Schuiteman & de Vogel, 2002)
Nepenthes faizaliana (Adam & Wilcock, 1991)
Nepenthes, 1 new species (Turnbull & Middleton, 1988)
Nepenthes platychila (Lee, 2002)
Nepenthes hurrelliana (Cheek *et al.*, 2003)

Orchidaceae--Orchids
Podochilus marsupialis (Schuiteman, 1998)
Trichoglottis tinekeae (Schuiteman, 1998)
Trichoglottis, 1 new species (Wood *et al.*, 1998b)
Crepidium mieczyslawii (Margonska & Szlachetko, 2001)
Crepidium, 1 new species (Margonska, 2002)
Bulbophyllum, 9 new species (Vermeulen & Lamb, 1994)
Bulbophyllum gemma-reginae (Vermeulen, 1996)
Bulbophyllum, 41 new species (Vermeulen, pers. comm.; in addition to the 10 mentioned above)
Trias, 1 new species (Vermeulen & Lamb, 1994)
Liparis anopheles (Wood, 1991)
Appendicula, 1 new species (Wood, 1997a)
Dendrochilum, 1 new species (Wood, 1997b)
Dendrochilum, 1 new species (Beaman *et al.*, 2001b)
Dendrochilum 5 new species (Wood, 2001)
Dendrobium lamrianum (Chan, 1994; cited in Chan 1999)
Dendrobium, 2 new species (Yukawa, 1998)
Coelogyne, 1 new species (Wood *et al.*, 1998a)
Coelogyne marthae, C. verrucosa (Sierra *et al.*, 2000)
Paphiopedilum platyphyllum (Gruß, 2001)
Paphiopedilum supardii (Braem & Loeb, 1985)
Paphiopedilum kolopakingii (Fowlie, 1984)
Ania ponggolensis (Kiew, 2001b)
Various genera, 14 new species (Chan *et al.*, 1994)

Palmae--Palms, Rattans
Calamus fimbriatus, C. nigricans, Daemonorops pumilus (van Valkenburg, 1995)
Daemonorops banggiensis (Dransfield, cited in Kiew 2001)
Daemonorops ingens (Beaman & Beaman, 1998)
28 palm species endemic to Sarawak described post-1980 by Dransfield and Kiew (Pearce, 1989)
Areca rheophytica, Calamus amplijugus, C. comptus, C. convallium, C. elopurensis, C. mesilauensis, C. praetermissus, Korthalsia furtadoana, K. jala, Plectocomiopsis mira, Salacca lophospatha (Beaman & Beaman, 1998)

Pandanaceae--Screw Pines
Pandanus calcinatus and *P. lepatophilus* (Stone, 1982)
Pandanus beccatus and *P. leuconotus* (Beaman & Beaman, 1998)

Pittosporaceae--Pittosporum family
Pittosporum, 2 new species (Sugau, 1994)

Poaceae--Grasses
Kinabaluchloa nebulosa, Racemobambos hepburnii, Sphaerobambos hirsuta (Beaman & Beaman, 1998)

Podocarpaceae--Podocarp family
Podocarpus laubenfelsii (Tiong, 1984)
Podocarpus confertus, P. globulus (Beaman & Beaman, 1998)
Dacrydium gracilis (Beaman & Beaman, 1998)





Protaceae
Helicia and Heliciopsis, each at least one new species (Chung, 1998)

Rafflesiaceae--Rafflesias
Rafflesia tengku-adlinii (Salleh & Latiff, 1989)
Rafflesia keithii, R. pricei (Meijer, 1984)

Rhizophoraceae--Mangroves
Anisophyllea ismailii (McDonald, 1995)

Rubiaceae--Bestraw family
Schradera grandiflora and *S. pseudonervulosa* (Puff *et al.*, 1998a)
*Lecananthus pedunculari*s (Puff *et al.*, 1998b)
Aleisanthiopsis multiflora (Tange, 1996)
Xanthophytum bullatum (Tange, 1995)
Neomussaenda kostermansiana (Tange, 1994)
Antirhea inaequalis (Kiew, 2001b)

Sapindaceae--Soapberry family
Zollingeria, 1 new species (Adema, 1992)

Schisandraceae
Kadsura acsmithii (Saunders, 1997)

Scrophulariaceae--Figwort family
Brookea, 1 new species (Yamazaki, 1994)

Sematophyllaceae
Trismegistia maliauensis (Akiyama & Suleiman, 2003)

Staphyleaceae--Bladder-nut family
Turpinia, 1 new species (Pereira, 1994)

Urticaceae--Nettle family
Elatostema, 8 new species (Beaman & Cellinese, 2004).
Poikilospermum, 1 new species (Church *et al.*, 1998)

Violaceae--Violets
Rinorea belalongii (Stevens, 2000)

Vitaceae
Tetrastigma steenisii and *T. megacarpum* (Latiff, 1991)

Zingiberaceae--Gingers
Zingiber, 6 new species (Theilade & Mood, 1999)
Zingiber, 5 new species (Theilade & Mood, 1997a)
Zingiber kelabitianum (Theilade & Christensen 1998)
Zingiber, 2 new species (Theilade & Mood, 1997b)
Zingiber pseudopungens (Beaman & Beaman, 1998)
Etlingera kenyalang (Poulsen & Christensen, 2004)
Etlingera, 3 new species (Poulsen *et al.* 1999)
Etlingera muluensis (Beaman & Beaman, 1998)
Boesenbergia, 2 new species (Poulsen, 1993)
Boesenberia armeniaca, B. hosensis (Cowley, 2000)
Boesenbergia, 2 new species (Cowley, 1998)
Boesenbergia grandis (Beaman & Beaman, 1998)
Amomum roseisquamosum (Nagamasu & Sakai, 1996)
Amomum botryoideum (Cowley, 2000)
Amomum, 2 new species (Smith, 1989a)
Amomum anomalum, A. longipedunculatum and A. flavoalbum (Beaman & Beaman, 1998)
Plagiostachys, 2 new species (Cowley, 1999)
Plagiostachys bracteolata, P. glandulosa (Julius, 2006)
Plagiostachys, 8 new species (Julius, 2006)
Zingiberaceae, 4 new species (Smith, 1990)
Zingiberaceae, 2 new species (Smith, 1987)
Alpinia beamani (Smith 1989b)
Hedychium muluense (Beaman & Beaman, 1998)
Hornstedtia incana (Beaman & Beaman, 1998)

Yet undescribed (not included in the total tally):
1 fern species (Parris in Kiew, 2001)
20 species of *Hoya* (Lamb, 2003)
1 species of *Pinanga* (Andersen, 2003)
3 species of *Plagiostachys* (Julius, 2006)
12 species of orchids (Lamb, personal communication)
5 species of *Orchidantha* (Lamb, personal communication)

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