The Red List of **Bornean Endemic** Dipterocarps

David Bartholomew, Megan Barstow, Agusti Randi, Vilma Bodos, Daniele Cicuzza, Pui Kiat Hoo, Suzika Juiling, Eyen Khoo, Yulita Kusumadewi, Richard Majapun, Andi Maryani A.M., Colin R. Maycock, Reuben Nilus, Joan T. Pereira, Julia Sang, Iyan Robiansyah, John B. Sugau, Sasikumar Tanggaraju, Sandy Tsen and Ling Chea Yiing















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Front cover: Shorea pinanga (Vilma Bodos) Back cover: Dipterocarpus confertus (Ling CY)

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BOTANIC GARDENS CONSERVATION INTERNATIONAL (BGCI) is the world's largest plant conservation network, comprising more than 500 botanic gardens in over 100 countries, and provides the secretariat to the IUCN/SSC Global Tree Specialist Group. BGCI was established in 1987 and is a registered charity with offices in the UK, US, China and Kenya.



IUCN/SSC GLOBAL TREE SPECIALIST GROUP (GTSG) forms part of the Species Survival Commission's network of over 7,000 volunteers working to stop the loss of plants, animals and their habitats. SSC is the largest of the six Commissions of IUCN – The International Union for Conservation of Nature. It serves as the main source of advice to the Union and its members on the technical aspects of species conservation. The aims of the IUCN/SSC Global Tree Specialist Group are to promote and implement global red listing for trees through the Global Tree Assessment and to act in an advisory capacity to the Global Trees Campaign.



INSTITUTE FOR BIODIVERSITY AND ENVIRONMENTAL RESEARCH (IBER), UNIVERSITI BRUNEI DARUSSALAM is committed towards research and education activities in biodiversity particularly in the pristine tropical rainforest and marine ecosystems. The unique features of Brunei's tropical biodiversity demand ongoing research towards the understanding of the values of the rich biodiversity, its interaction with the environment and links to ecosystem services. Through the IBER plot network and in collaboration with our counterparts, these activities guide the conservation and management of these unique rainforest ecosystems.

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October 2021

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Shorea flemmichii (Vilma Bodos)

IUCN RED LIST CATEGORIES



Foreword

Baislands in species diversity. There are several reasons for this. Firstly, the occurrence of its northern lowlands on a continental fragment, the Laconia Plate, which, although periodically largely submerged over the last fifteen million years, it has served as a refuge for species that evolved there. Secondly, the persistence of a stable climate over the same time period; and finally its geological and topographic diversity which, perhaps has been the biggest driver for the exceptional habitat diversity that it hosts.

Dipterocarps are iconic canopy trees typically bearing winged fruit. They are exceptional among tropical tree species (with Fagaceae and Caesalpinoid legumes) in their symbiotic relationship with ectotrophic mycorrhizae, often allowing them to reach heights of over 20 m tall. Associations with mycorrhizae has led to remarkable soil specificity in the group, with the highest specificity for trees growing on low nutrient soils. Dipterocarps are abundant and relatively easy to identify, once practised from fallen leaves alone. Hence its species are well studied but it also means that these trees provide a unique tool to identify habitats and localities of exceptional richness and/or endemism, similar examples of which can be predicted in unexplored regions by means of surface geology maps.

The Red List of Bornean Endemic Dipterocarps provides the first ever insight into the conservation status of all 162 species of dipterocarp endemic to this mega-diverse island. It considers trees endemic to the two Malaysian states in Borneo (Sabah and Sarawak), the Indonesian state of Kalimantan and the Sultanate of Brunei. Species may be endemic to one state or occur in all four depending on habitat specificity and other



Hill mixed dipterocarp forest, Kapit, Sarawak (Julia Sang)

aspects of ecology. We list those species whose chosen habitats are isolated as ecological islands, often quite small in area and now mostly devastated by unmanaged logging and relogging. Although some species may be able to have refuge in high elevations and protected areas, especially in Brunei where over half of the Sultanate is under intact forestry cover, others are at risk given their habitat specificity. This is of particular concern for trees found in lowland mixed forests, or peat swamp forests with rich soils favourable for land clearance for agriculture. The largest area of this unique habitat remaining is in Lambir Hills National Park, Sarawak, but patches persist elsewhere whose survival is of the utmost importance for the future of both regional and global diversity. *The Red List of Bornean Endemic Dipterocarps* highlights the importance of such protected areas and provides an account of conservation needs for the most threatened species.

It is hoped this publication will raise awareness of the need to protect this threatened tree group, and mobilise investment in continued and expanded conservation efforts towards the most threatened trees. Within it you will also find accounts of the conservation and research activities already taking place across Borneo to protect these ecologically important and diverse trees.

Peter Ashton The Arnold Arboretum

EXECUTIVE SUMMARY

his Red List of Bornean Endemic Dipterocarps provides and analyses IUCN Red List assessments for all dipterocarp species restricted to the island of Borneo. Trees of Dipterocarpaceae dominate the forests of South-East Asia, meaning the conservation of this family is of vital importance for protecting the biodiversity of the region. Borneo represents the centre of dipterocarp diversity with 269 accepted species, including 162 endemics.

Of the 162 species assessed, 99 species are threatened with extinction (Vulnerable, Endangered or Critically Endangered).

If Data Deficient species are assumed to have equivalent probability of being threatened as all other assessed species, 62% of Bornean endemic dipterocarps are assessed as threatened. To date, 18 species (10%) are Critically Endangered and require urgent conservation action.

The majority of assessed species are declining due to a multitude of threats. The high quality timber and local abundance of dipterocarps across Borneo mean they are widely logged and traded internationally. Unsustainable logging practices have caused rapid population decline of many species.



Shorea rubra (Ling CY)



Dipterocarpus confertus (Ling CY)

The other primary threats to Bornean endemic dipterocarps are forest conversion for agro-industrial oil palm and wood pulp plantations, road infrastructure development and increased fire frequency.

Currently, 146 (90%) Bornean endemic dipterocarp species are protected *in situ*, of which 85% are threatened. Rates of *ex situ* conservation are low, with only 32 threatened species (32%) found in *ex situ* collections. Currently, eleven species, all of which are threatened, have no formal protection either *in situ* or *ex situ*.

This publication identifies Bornean endemic dipterocarps that are most at risk of extinction, including 18 Critically Endangered. A diverse set of conservation priorities that are needed to protect these species from the array of threats they face are outlined. These assessments should be used to inform policy makers and guide conservation actions in the region to protect and prevent the loss of Borneo's unique dipterocarp diversity.

PART 1

BACKGROUND

The forests of South-East Asia are dominated by trees of the dipterocarp family, Dipterocarpaceae. Named after the two-winged seeds of the genus Dipterocarpus (von Blume, 1825), dipterocarps are an iconic family of South-East Asian forests. On the island of Borneo, over 20% of all trees in lowland and upland forest are dipterocarps (Slik et al., 2003), which rises to over 50% when only considering canopy trees (Ashton, 2019). This level of dominance by a single family is unique to the tropical forests of South-East Asia, with no monodominant family found in other major tropical forests.

Dipterocarps can be subcanopy, canopy or emergent trees. Many species grow to a height of 50 m or more (Ghazoul, 2016), including the world's tallest tropical tree, a 100.8 m tall Shorea faguetiana growing in Danum Valley, Sabah, Malaysia (Shenkin et al., 2019). Dipterocarps typically have tall, straight trunks and a 'cauliflorous' crown, especially those that emerge above the canopy. Some species possess large buttresses, such as Anisoptera spp., whilst others have stilt roots, such as *Hopea* spp. Dipterocarp species regularly form associations with ectomycorrhizal fungi, which may allow them to maintain their local dominance (Liang et al., 2020).

Most Bornean dipterocarps are found in lowland regions, where the forest type *Lowland mixed dipterocarp forests* possess exceptionally high biodiversity (Corlett, 2014). In a single 52 ha plot in Lambir Hills National Park, Sarawak, Malaysia, over 1,100 tree species were identified, including 88 dipterocarp species (Davies *et al.*, 2021). These forests additionally support a wide range of animal species, including many birds and orangutans (Corlett, 2014). Bornean lowland dipterocarp forests possess many other special characteristics, including



Dipterocarpus geniculatus (Ling CY)

mast flowering and fruiting (Ashton, 1988; Brearley *et al.*, 2007), exceptionally high aboveground biomass (Slik *et al.*, 2013) and wood productivity (Banin *et al.*, 2014). Because dipterocarps are keystone species, an assessment of their conservation status is vital for the long-term conservation of these forests.

Dipterocarpaceae is a pantropical plant family, with more than 500 species found across the tropics. However, their diversity is highest in South-East Asia. Borneo represents the centre of dipterocarp diversity, with 269 species known to occur, including 162 endemic species. The rate of endemism of dipterocarps on Borneo (60%) greatly exceeds that of nearby Peninsular Malaysia (14%) and Sumatra (10%). This has largely been attributed to the high edaphic and topographic heterogeneity of Borneo (Ghazoul, 2016). The 162 dipterocarp species endemic to Borneo come from nine different genera: Anisoptera, Cotylelobium, Dipterocarpus, Dryobalanops, Hopea, Parashorea, Shorea, Upuna and Vatica. Shorea has the most endemic species (85), followed by Vatica (26) and Hopea (24). The only dipterocarp genus endemic to Borneo is the monotypic Upuna, which contains a single species, Upuna borneensis.

The island of Borneo is politically divided into three countries: Brunei-Darussalam, Indonesia (Kalimantan) and Malaysia (Sabah and Sarawak). However, floristically, the island is divided into four main regions, separated by the major rivers in Sarawak and the central Bornean highlands (Ashton, 2005). Consequently, species richness and endemism are highest in Sarawak, where 148 species are found, including 20 endemics (Figure 3).



Shorea praestans (Vilma Bodos)

Borneo is located in the Sundaland biodiversity hotspot not only because of the region's high biodiversity, and variety of habitats but also because of a high rate of habitat loss (Mittermeier et al., 1998). Widespread conversion of forest to agriculture has occurred across Borneo, with more than 10% of the land area dedicated to industrial palm oil production and timber plantations as of 2010 (Gaveau et al., 2014). Oil palm is the principal driver of forest loss on Borneo (Abood et al., 2015), but the conversion of land for Acacia spp. and Eucalyptus pellita pulp plantations is also increasing. Land clearance and degradation has meant only 38% of the remaining forest in Sabah and Sarawak is fully intact (Bryan et al., 2013), with similar levels of degradation in Kalimantan (Miettinen et al., 2011). Conservation of intact forest has been considerably higher in Brunei-Darussalam where 79% of forests remain (Bryan et al., 2013).

Dipterocarpaceae is an economically valuable family that is regularly traded on the international market. Though having valuable resins, nuts and camphor (Ghazoul, 2016), dipterocarps are highly valued for their timber. Borneo is a key source of tropical timber. Dipterocarps are the main target of logging, contributing >85% of Indonesia's timber exports (Ghazoul, 2016). Ninetyseven percent of large canopy dipterocarps are typically harvested during logging in Kalimantan, where 60% of the lowland forest has already been logged (Curran et al., 1999; Curran & Webb, 2000). Secondary threats, such as road development, droughts and forest fires (Slik, 2004; Langner & Siegert, 2009; Bryan et al., 2013) can also follow logging and agricultural expansion, potentially threatening dipterocarps. These threats also cause soil erosion, which in turn reduces the success of reforestation efforts.

The Red List of Bornean Endemic Dipterocarps is the first, global level comprehensive assessment of the conservation status of all Dipterocarpaceae species endemic to Borneo. In 1998, 106 assessments for Bornean endemic dipterocarps were published alongside many other assessments for dipterocarps in South-East Asia. These assessments were completed by Peter Ashton, in collaboration with United Nations Programme Environment World Conservation Monitoring Centre (UNEP WCMC) as part of 'The World's Threatened Trees' publication released in 1998. In 2001 the IUCN Categories and Criteria were updated. Because of this and in accordance with recommendations to assess species every five to ten years, these assessments were due to be updated. Therefore, all species assessed in 1998 were reassessed and those previously unassessed were assessed for the first time.

This work has contributed to the Global Tree Assessment, an initiative to assess the world's tree species and have all assessments available for trees on the IUCN Red List by 2025 (see box 1).

Box 1: Global Tree Assessment

The Global Tree Assessment (GTA) is assessing the conservation status of every known tree species.



Despite the importance of trees, many are threatened by over-exploitation and habitat destruction, as well as by pests, diseases, drought and their interaction with global climate change. In order to estimate the impact of such threats to trees there is an urgent need to conduct a complete assessment of the conservation status of the world's 60,000 tree species – the Global Tree Assessment.

The GTA is led by BGCI and the IUCN SSC Global Tree Specialist Group. This initiative prioritises the tree species at greatest risk of extinction. The GTA provides information to ensure that conservation efforts are directed at the right species so that no tree species becomes extinct. www.globaltreeassessment.org.

METHODS



Vatica sarawakensis (Vilma Bodos)

All accepted tree names were considered for this project. The list of trees for the report was created using BGCI's GlobalTreeSearch database (BGCI, 2021) and the Dipterocarpaceae chapter in Volume 5 of the Tree Flora of Sabah and Sarawak (Ashton, 2004). The validity of names was determined using the World Checklist of Vascular Plants (WCVP) (POWO 2021). Species published after or not accepted on WCVP before 2019 are not included in this report. All species without an IUCN Red List assessment, or those with an old assessment (pre-2010), were assessed.

Data were gathered on the distribution, habitat and ecology, population, use and trade, threats and conservation actions. Distribution maps were also produced using georeferenced herbarium records following the IUCN Red List mapping guidelines. Assessors then evaluated this information against the IUCN Categories and Criteria. If the data met certain thresholds, the species was assigned one of three threatened categories -Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) - or if the thresholds were almost met, the species was assessed as Near Threatened (NT). Any species not meeting the thresholds were classified as Least Concern (LC) and species with insufficient information to complete an assessment were assigned Data Deficient (DD). For full IUCN Red List methodology please see the IUCN guidelines (IUCN Standards and Petitions Subcommittee, 2019). In this report NT and LC are grouped as "Not threatened".

Assessments have been produced and submitted by individual institutions (e.g Sabah endemic species were assessed by Sabah Forestry Department and Sarawak endemic species were assessed by Sarawak Forestry Corporation). In recognition of the fact that most endemic dipterocarps are present in multiple regions of Borneo, the majority of assessments were completed in collaboration among institutions across Borneo. The greatest effort towards this was the review of 123 endemic species at the Global Tree Assessment Red List Review Workshop for Bornean Endemic Dipterocarps, hosted by Universiti Brunei Darussalam in June 2019 as part of a pre-symposium event at the Flora Malesiana 11 Symposium.

In preparation for the workshop, data was gathered as described above, and a draft IUCN Red List assessment and map for each priority species was produced. At the workshop, these draft assessments were then reviewed by authors of this report from institutions across Borneo. Reviews were completed by three groups of five to six specialists, with each Bornean region represented in each group. The workshop ran for three days and during this period, 123 assessments were finalised.

Many assessments for Bornean endemic dipterocarps were completed using the Reduction Analysis tool of the Geospatial Conservation Assessment Tool (GeoCAT - www.geocat.kew.org). Reduction Analysis allows a map of occurrence points to be edited, in particular the removal of occurrence points where the species is no longer present (Bachmann et al., 2011). The removal of these points enables the calculation of decline in extent of occurrence (EOO) or area of occupancy (AOO) for a species. The value of decline calculated was used as an indicator of extent of decline over the last three generations for a species and therefore enabling the use of IUCN Criterion A. Also, in applying this Criterion, a standard generation length of 80 years was used for all species unless otherwise stated and justified. Maps for the species assessed using Reduction Analysis were coded accordingly, showing points still 'present' and those which are considered 'extinct' or 'presence uncertain'.

All 162 assessments for Bornean Endemic Dipterocarps are published on the IUCN Red List of Threatened Species (www.iucnredlist.org)

CASE STUDY 1: ESTABLISHMENT OF PERMANENT SAMPLE PLOT NETWORK PROJECT IN SARAWAK

By Ling Chea Yiing

In 2016, an initiative to establish permanent sample plots (PSP) in production forests in Sarawak was proposed and implemented. This project was funded by the Sarawak Government under the 11th Malaysian Plan. During this 5-year project, a total of 25 plots were established across Sarawak. each square plot measuring 1-ha in size. This includes two control plots established in areas with no logging history within logging concession areas. Each plot was established in a different period of time following logging; from immediately after logging to more than 20 years after logging. Only data from 23 plots is discussed for this case study.

A total of 2,751 individual trees were documented that exceeded 10 cm diameter were from the Dipterocarpaceae family, representing 102 species. Of these, 56.9% (58 species) are endemic to Borneo, 23 of which are assessed as threatened on the IUCN Red List (two species listed as Critically Endangered (CR), seven species as Endangered (EN) and 14 species as Vulnerable VU). The two species assessed globally as CR are *Hopeas micrantha* (Bodos *et al.*, 2019) and *Shorea iliasii* (Randi *et al.*, 2019) are both assessed nationally as Near Threatened (Julia *et al.*, 2014, Julia *et al.*, 2016). Two individual trees of *H. micrantha* were documented from one plot in Tatau District; the trees were 10.8 cm and 58.3 cm respectively in diameter. *Shorea iliasii* was recorded from six plots, with diameter of 10.5–53.8 cm.

Ten species of Bornean endemic dipterocarps were only recorded once across the plots including *Shorea woodii* (dbh 19.1 cm). This species is categorised as Endangered globally and nationally (Julia and Bodos, 2019; Julia *et al.*, 2014), and is endemic to central Sarawak (Ashton, 2004). This individual tree was found in a plot established in virgin jungle forest alongside one small tree with dbh over 9 cm, and two young saplings, 2-5 m tall. *Shorea domatiosa* was also represented as a single tree in one plot. This species is also listed as Endangered globally (Julia *et al.*, 2019),

but Vulnerable in Sarawak (Julia *et al.*, 2014). This tree was found in forest that was logged nine years ago, with a diameter of 21.4 cm, and no younger trees or wildings were observed. Counter to this, the most abundantly found dipterocarp was *Parashorea smythiesii*, recorded 64 times across nine plots distributed from northern to central Sarawak. This species is listed as DD (Data Deficient). The data from this project will be useful for the

In conclusion, the PSP Network Project helps develop a greater understanding of the changes to forest over time and forest recovery in logging concession areas. Yearly assessment for all plots is still ongoing in order to collect more data and establish a clearer picture of forest change and recovery in Sarawak. It also allows monitoring of threatened species and provides additional information on species' population and ecological niches for dipterocarp and other forest species.

assessment of this species in the future.

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Shorea woodii (Ling CY)

RESULTS

THREAT STATUS

All 162 Dipterocarpaceae species endemic to Borneo were assessed. An estimated 62% are threatened (considering Data Deficient; lower bound: 61%, midpoint: 62%, upper bound: 63%). Only 28 of 162 species (17%) are classified as Least Concern. While, 99 species are threatened with extinction including 18 species assessed as Critically Endangered (Figure 1, Table 1). The IUCN Red List category with the greatest number of species is Vulnerable, with 47 species.



Shorea praestans (Vilma Bodos)



Figure 1: The percentage of Bornean endemic dipterocarps species in each IUCN Red List Category.



Figure 2: The IUCN Red List Criteria used to assess threatened Bornean Endemic dipterocarp species.



Vatica oblongifolia (Ling CY)

IUCN Red List category	Number of species
Critically Endangered	18
Endangered	34
Vulnerable	47
Near Threatened	32
Least Concern	28
Data Deficient	3

Table 1: The number of Dipterocarpaceae species in each IUCN Red List category

Taxon name

Critically Endangered

Dipterocarpus cuspidatus
Dipterocarpus lamellatus
Dryobalanops fusca
Hopea depressinerva
Hopea micrantha
Hopea obscurinerva
Hopea rudiformis
Shorea dispar
Shorea foraminifera
Shorea iliasii
Shorea induplicata
Shorea praestans
Shorea revoluta
Shorea rotundifolia
Vatica adenanii
Vatica cauliflora
Vatica patentinervia
Vatica pentandra (PE)

Table 2a. Critically Endangered species of Bornean endemic Dipterocarpaceae



Shorea rotundifolia (Vilma Bodos)

Taxon name

Endangered

Anisoptera reticulata Cotylelobium burckii Dipterocarpus fusiformis Dipterocarpus geniculatus Dipterocarpus glabrigemmatus Dipterocarpus ochraceus Dipterocarpus tempehes Dryobalanops rappa Hopea aequalis Hopea altocollina Hopea centipeda Hopea enicosanthoides Hopea longirostrata Hopea megacarpa Hopea vacciniifolia Shorea alutacea Shorea biawak Shorea brunnescens Shorea calcicola Shorea cordata Shorea domatiosa Shorea elliptica Shorea inaequilateralis Shorea pachyphylla Shorea pallidifolia Shorea splendida Shorea tenuiramulosa Shorea woodii Vatica chartacea Vatica congesta Vatica endertii Vatica globosa Vatica rotata Vatica rynchocarpa

Table 2b. Endangered species of Bornean endemic Dipterocarpaceae

POPULATION TRENDS

The majority of Bornean endemic dipterocarps (94%) have a decreasing population trend, with only 4 species known to have stable populations.



Hopea altocollina (Vilma Bodos)

CRITERIA USED

Of the 99 species assessed as threatened with extinction, 82 species were assessed using Criterion A (population size reduction), including 13 Critically Endangered species that are experiencing ≥80% population declines within three generations (Figure 2). Twenty-three species were assessed under Criterion B because of their restricted geographic range, including the Critically Endangered Hopea depressinerva, H. obscurinerva, Vatica adenanii and V. pentandra that have an EOO of 8-12 km² and an AOO of 8 km², respectively. Shorea induplicata (CR) was the only species assessed under Criterion C (small and declining population). Dipterocarpus lamellatus (CR), Shorea bakoensis (VU) and Vatica patentinervia (CR) were assessed as threatened under criterion D (very small or restricted population). No species were assessed under Criterion E (Figure 2).

For the full list of species assessed as Critically Endangered and Endangered see Part 2, for species assessed as Vulnerable see Part 3, for Near Threatened species see Part 4, for Data Deficient species see Part 5 and for Least Concern species Part 6. A complete species list, including Category and distribution can be found in Appendix 1. CASE STUDY 2: BRIDGING THE GAP BETWEEN CONSERVATION ECOLOGY AND GENETICS IN THE CONSERVATION OF FRAGMENTED POPULATIONS OF SABAH'S RARE AND ENDEMIC DIPTEROCARP -DIPTEROCARPUS LAMELLATUS AND D. OCHRACEOUS

Richard Majapun, Eyen Khoo, Colin R. Maycock and Joan T. Pereira

DIPTEROCARPUS OCHRACEUS

Dipterocarpus ochraceus is one of the six dipterocarp species that is endemic to Sabah. Due to its rarity, very little is known about the species since it was first discovered. The species only has five specimens at the Sandakan Herbarium which were collected from various areas within Sabah's Ranau district (Meijer, 1963) in the 1960s. Many of these specimens were encountered outside Totally Protected Areas (TPAs) and consequently have experienced much land use change since the time of collection. From the Ecological Niche Model (ENM) generated, it was predicted that the species had lost 68% of its original habitat, due to human activities, such as land development and encroachment (Maycock, et al., 2012). In 2009, while ground truthing potential habitats, remnant fragmented populations of the species were discovered, in which approximately 100 adult trees were found. Genetic studies were conducted and it was observed that the species was affected by stochastic pressures and experienced genetic deterioration. This was not only the result of habitat fragmentation, but also due to the species' restricted niche habitat. It was also revealed that the degree of inbreeding was extremely high among the progenies, whereby contemporary pollenmediated gene immigration was low due to the localized pollinator movement. These fragmented populations are like



Seedlings of Dipterocarpus ochraceus grown to be planted at ex situ collection sites in Sabah

'terrestrial islands' where pollinator movement is restricted within the range of the island. Alongside the effects of inbreeding, pre- and post dispersal predation by boring beetles, squirrels, rodents and wild boars further lowers the recruitment success rate. There is now continuous monitoring of the remnant trees and efforts have been made in establishing *ex situ* collections of this species from Totally Protected Areas in Sabah.

DIPTEROCARPUS LAMELLATUS

Similar to *D. ochraceus*, much remains to be known about *Dipterocarpus lamellatus*. It is a rare Borneo endemic with only three confirmed collection localities in Borneo, of which two are in Sabah and the other from Brunei. Since the last collection from Sabah in 1955, the recorded collection sites have undergone massive land use



A newspaper clipping reporting on the rediscovery of Dipterocarpus lamellatus in Sabah

changes and no new collections have been made in over 50 years. Consequently, the species was considered to be locally extinct (Ashton, 2004). In 2011, ENM was generated for this species and five surveys were conducted in the west coast of Sabah on three areas of different soil associations with altitude ranging from 10 to 350 m. These surveys led to the rediscovery of the species within a Totally Protected Area in Sabah, the Siangau Forest Reserve (see Fig. 2). The joy of discovery was also met with the daunting fact that the remaining population only consists of 12 mature trees and 22 juveniles. In the last 10 years of monitoring, the team noticed that flowering events were rare and have only encountered one good fruiting event in 2015. Although seeds were harvested at this 2015 fruiting event, the germination rate was only 4%. When dissection on a sub sample of seeds was carried out, it showed that the chances of obtaining viable seeds was only 5%. Results from the genotyping work showed that the successfully raised seedlings were predominantly self fertilized. This lack of out crossing has undermined the species' reproduction and recruitment success as at the latter stage, less than 1% of the mentioned seedlings made it to the sapling stage. As for the adults and juveniles, they have the same genetic diversity and the adults were most likely to have established when the population was relatively big, leading to the vigour of the individuals. As of now, ongoing population monitoring is carried out on an annual basis.

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TAXONOMIC ANALYSIS

The 162 dipterocarp species endemic to Borneo are found across nine genera. Only one species of *Cotylelobium* and *Upuna* are endemic to Borneo. Both are assessed as threatened. *Dryobalanops, Dipterocarpus* and *Vatica* have the greatest proportion of threatened endemics with 75%, 73% and 62% threatened respectively. *Parashorea* is the only genus with no threatened Bornean endemics, although *Parashorea macrophylla* is assessed as Near Threatened.

GEOGRAPHIC ANALYSIS

The island of Borneo is divided into three countries: Brunei-Darussalam, Malaysia (Sabah and Sarawak) and Indonesia (Kalimantan). Sarawak has the greatest number of Bornean endemic dipterocarp species (148), including 91 threatened species. Sabah has 95 species (52 threatened), Kalimantan has 100 species (61 threatened) and Brunei-Darussalam has 91 species (45 threatened; Figure 3). As survey and field work continues across



Hill mixed dipterocarp forest, Kapit, Sarawak (Julia Sang)

Forest Type	Number of species
Moist Lowland	159
Moist Montane	10
Swamp	>2

Table 3: The habitat type for Bornean endemic dipterocarp species.



Figure 3: Heat map showing the number of endemic Bornean dipterocarps per state (left) and percentage of threatened species present in each state (right)

Borneo, species distributions are subject to change as more information is gathered; these counts are based on analysis of currently available literature and herbarium records at the time of publication.

HABITATS

All of the dipterocarp species endemic to the island of Borneo are found in various

forest types, with 98% (159 species) found in moist lowland forests such as mixed dipterocarp or heath forests (Table 3). Ten species are found above 1,500 m asl in moist montane forest. And at least two endemics are found in mixed swamp forest (*Shorea inaequilateralis* and *S. longiflora*) including peat swamp and freshwater swamp forests.



Danum Valley - Lowland Mixed Dipterocarp Forest (David Bartholomew)

USES

Bornean endemic dipterocarps are widely used by humans, with 138 of 162 species (85%) having a known recorded use (Figure 4). Dipterocarps have significant economic value meaning they are widely traded both domestically and on the international market. Of the dipterocarp species endemic to Borneo, 34 have international commercial value, whilst 109 have national commercial value. Dipterocarps additionally have a range of subsistence uses, with 115 Bornean endemics identified to have local livelihood value.

The most common use for dipterocarps endemic to Borneo is as construction or structural materials (136 species, including 84 threatened species; Figure 4). Most dipterocarps are large tree species that have long, straight boles and produce a variety of different wood types including the dense wood of the Selangan Batu group and the softer wood of the light red meranti and serayu groups. This means dipterocarps are harvested for a variety of purposes and have high value on the international timber market. Other major uses of Bornean endemic dipterocarps include household goods (51 species), handicrafts and jewellery (26 species) and



Shorea macrophylla (cooked illipe nut) (Vilma Bodos)



Dipterocarpus geniculatus (Ling CY)

human food (12 species). Some species have been recorded to have medicinal values and several others are used for their oil, known as Tengkawang or Kawang (Case study 3). Trees providing oil and medicine are often protected due to the community benefits of the non-timber forest product provided by these trees.



Figure 4: Known uses of Bornean endemic dipterocarps, with bars coloured according to their threat status.

CASE STUDY 3: THE BORNEAN ILLIPE NUT - SHOREA SECTION PACHYCARPAE: A VALUABLE NON-TIMBER FOREST PRODUCT THAT HAS BEEN NEGLECTED

By Yulita Kusumadewi

The Bornean Illipe Nut, or Tengkawang in local dialect, refers to a group of 16 species of Shorea which produce illipe butter from their kernels. The fatty acid extract from tenakawana seed has similar characteristics to those of cocoa seeds, hence tengkawang fat can be used as a substitute of cocoa fat in food, cosmetic and medicinal industries. On the international market, fat extracted from tengkawang is known as Borneo tallow or green butter (Winarni et al., 2004). This is used as an alternative raw ingredient of cocoa fat and termed cocoa butter equivalent (CBE), cocoa butter substitutes (CBS) and cocoa butter replacers (CBR) (Blicher-Mathiesen, 1994). However, the use of illipe nut butter in Indonesia is not popular.

Nine of the 16 species that produce this oil are endemic to Borneo (Ashton, 1982), of which only two species are considered to be threatened (S. rotundifolia CR and S. splendida EN). However, some of the species in this group may not be globally threatened but are of national concern for Indonesia (Yulita et al., 2021) because the natural population of tengkawang forests in Indonesia is decreasing. Recent phylogenetic studies based on molecular markers and morphology considered Section Pachycarpae tend to form a monophyletic group, thus a natural group, and therefore are of evolutionary importance to conserve and a unique group in need of protection.

Amongst tengkawang species, *Shorea stenoptera* is the most utilised as it has the largest fruit size. Other species that



A community (customary) forest of Shorea stenoptera, West Kalimantan (Aseanty Pahlevi, Mongabay Indonesia)

are harvested widely are *S. pinanga* and *S. macrophylla* as they are the most widely distributed and are readily cultivated in Kalimantan and Java. *Shorea pinanga* is the most popular species for planting and grows even in degraded land. It is present in almost all arboreta and botanic gardens in Java. In West Kalimantan, the tengkawang - mainly *S. stenoptera*- is protected in community forests and has been kept for generations by the Dayak people.

Currently there is a wild trade-based company that empowers the Dayak community by processing several types of



Butter processed traditionally from Tengkawang (S. stenoptera) (Aseanty Pahlevi, Mongabay Indonesia)

non-timber forest product, including tengkawang to ensure the sustainability of the tengkawang tread. This ensures that it can empower the local community's economy. *Shorea stenoptera* has also been planted in several arboreta in West Java and Kalimantan with the aim to carry out research and development, education and training as well as for local religious and cultural interests.

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Assessing the Scope and Severity of Threats

Not all threats have the same impact on a population of a species; rather, they vary in scope and severity. As part of the IUCN Red List assessment procedure, assessors have the option to assign the scope (the proportion of the population impacted) and severity (the rate of population decline) for each threat. As part of the *Red List of Bornean Endemic Dipterocarps*, a total of 631 threats were identified for the 162 assessed species. Of these, 99% were assigned a scope and severity score, allowing the impact of each threat to be revealed.

Most of the threats identified impact the majority of a species' population and cause rapid declines (Figure B2). Only four threats were identified to impact the whole (>90%) of a species' population, affecting *Dipterocarpus lamellatus* (Increase in fire), *Hopea micrantha* (Agro-industry plantations and farming) and *Vatica parvifolia* (Unintentional large-scale logging).

The four main threats to Bornean endemic dipterocarps were agroindustry farming (122 species), large-scale intentional logging (106 species), agro-industry plantations (90 species) and roads and railroads (54 species). A detailed breakdown of the scope and severity of these threats reveals that agro-industry farming, large-scale intentional logging and agro-industry plantations cause rapid population declines that impact the majority (50-90%) of a species' population. In contrast, despite threatening many species, roads and railroads typically have a smaller impact, causing slow, significant population declines over the minority (<50%) of the species' population (Figure B2).





Figure B2: The scope and severity of threats for Bornean endemic dipterocarp species.

THREATS

Based on the assessments performed, a number of threats were identified and listed. This report finds that the major threats to Bornean endemic dipterocarps are agriculture and biological resource use (Figure 5). Agriculture impacts 148 species, including 92 threatened species. Agroindustrial farming of non-timber crops threatens the most species (122) followed by agro-industrial wood and pulp plantations (90). Many of these threats caused rapid population declines across the majority of a species (Box 2).

Ninety percent of Bornean endemic dipterocarps (145 species) are threatened by logging and timber harvesting. One hundred and nineteen (119) species, including 76 threatened species, are intentionally harvested for their timber, whilst an additional 14 are threatened by the unintentional impact of logging. Logging practices can threaten non-target species from direct mortality and damage caused by falling trees, soil compaction from skid trails and reduced seedling recruitment. In general logging practices cause habitat degredation and a decline in habitat quality.

Road construction presents another significant threat, impacting 55 species. Other considerable threats include natural system modifications (43 species) from changes in fire frequency and dams, residential and commercial development (27 species) and energy production and mining (12 species). Climate change is predicted to impact at least four species: Hopea tenuivervula, Shorea acuminatissima, S. micans and Vatica coriacea. Human intrusions and disturbance were identified to impact Shorea pachyphylla, whilst Dipterocarpus lamellatus is impacted by the invasive plantation species of Acacia mangium and Imperata cylindrica which increases the susceptibility of the species and habitat to fire.



Shorea myrionerva (Ling CY)



Figure 5: The number of Bornean endemic dipterocarp species threatened by each threat category.

IN SITU AND EX SITU CONSERVATION

The protected area network across Borneo incorporates the distribution range of most of the island's endemic dipterocarps. Of the 162 species, 146 (90%) are found within at least one protected area. However, all 16 species that are not known to be in a protected area are threatened with extinction, including 12 Critically Endangered species.

Rates of ex situ conservation are much lower than in situ conservation for Borneo's endemic dipterocarp trees. Only 47 species (29.7%) are conserved ex situ. It is likely that more species are found in ex situ collections, but records are not widely available. Also, as species cannot be traditionally seed banked, other methods of ex situ (as well as in situ conservation) are of greater priority for dipterocarp species. A greater proportion of threatened species are protected ex situ (32.3%) than Least Concern (28.6%) and Near Threatened (25%) species. Four species that are only conserved ex situ; Hopea enicosanthoides, Shorea induplicata, S. praestans and S. revoluta. (Figure 7). However, this still leaves 12 species with no in situ or ex situ



Figure 7: An alluvial flow plot showing the number of species protected in situ and ex situ for Bornean endemic dipterocarps. The width of connecting bars represent the number of species for each combination of conservation action.

conservation (Table 4). *Vatica palungensis* (DD) is also not found in *ex situ* conservation and its status in *in situ* conservation remains unknown.



Shorea praestans seedlings (Vilma Bodos)



Shorea rubra (Ling CY)

Species

Dipterocarpus cuspidatus	
Dipterocarpus glabrigemmatus	
Hopea depressinerva	
Hopea obscurinerva	
Shorea dispar	
Shorea foraminifera	
Vatica adenanii	
Vatica endertii	
Vatica glabrata	
Vatica palungensis	
Vatica patentinervia	
Vatica pentandra	

Table 4: Bornean endemic dipterocarps with no known in situ or ex situ conservation

CASE STUDY 4: EX SITU CONSERVATION OF NATIVE DIPTEROCARPS OF BORNEO AT THE BOTANICAL RESEARCH CENTRE, BRUNEI DARUSSALAM.

By Daniele Cicuzza

In the small country of Brunei Darussalam, there are 180 species of Dipterocarpaceae (Coode *et al.*, 1996) including seven Critically Endangered (CR) species. To secure the protection of the seven CR species in Brunei, the Botanical Research Centre (IBER/BRC), Universiti of Brunei Darussalam, began an *ex situ* conservation project for the species in 2018. This work was funded by the National Geographic Society and included collaboration with theSoutheast Asia Botanic Garden Network (SEABG) and other botanical gardens across Borneo.

The project goal was to collect seeds and seedlings of the seven CR species and transplant them to the BRC nursery. Extensive collections were conducted in the primary and secondary forest of Brunei. After the identification of mature mother trees, the ground was perlustrated to collect seeds and available seedlings, when available. Of the seven target species, six have been secured in the BRC nursery. The remaining species, Vatica maritima has only been recorded from the Tutong district and with few herbarium records in the Brunei National Herbarium and none in the UBD Herbarium (Zamri and Slik 2018). Further research is needed to secure seedlings of this species due to its specific ecology and low frequency of individuals in the wild. However the other six species are now secured here. The major challenge to our conservation efforts has been the transplantation process. Although this was conducted carefully and consideration of all



UBD nurseries for reforestation project, inc. Dipterocarp species

important aspects were taken to reduce the physiological trauma, nearly 90% of the seedlings did not survive transplanting. This has reduced the total available number of living plants in the BRC collection of rare species but luckily small numbers of six Critically Endangered species are present in the collection.

This case study illustrates some important factors in the ex situ conservation of dipterocarps in Brunei. First, the need for studies on the physiology of seedling or tropical trees species and particularly for the species in danger of extinction. Second, the necessity to have a faster response for the mass flowerina events of dipterocarps to increase the number of seeds available for botanic garden nurseries and other ex situ sites. There is also a need to develop propagation techniques for trees and herb species, as well as more accurate distribution maps for rare individuals within protected areas or in forest which is not protected by any form of legislation.

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Saplings of Critically Endangered dipterocarp at BRC Garden.

CASE STUDY 5: EX SITU CONSERVATION EFFORTS AT ARBORETUM SYLVA UNTAN IN PONTIANAK WEST KALIMANTAN

By Agusti Randi

Arboretum Sylva Untan was established in 1988. It is located in the middle of Pontianak town, the capital city of West Kalimantan province. This arboretum is at the early stages of development and has already come up against obstacles, originating as an area of 7 hectares but decreasing to 2.3 hectares due to pressure from the development of the city. The arboretum was established with the aim of becoming a small replica of Kalimantan forests with native and endemic trees collected from many forests throughout Kalimantan, with the goal to resemble a typical rainforest of Borneo.

Despite declining in area, *ex situ* conservation efforts have continued. Currently, the collection of live plants reaches 848 species planted on an area of only 2.3 hectares, almost 400 species of which are trees with a particular focus on dipterocarp tree species. Originally, 68 species of dipterocarp trees were planted in the area but some could not survive in the lowland city. Fortunately, 52 native species have succeeded in thriving, 28 of

which are endemic to Borneo and 33 species which are globally threatened on the IUCN Red List.

This artificial tropical rainforest ecosystem has now been growing and developing for more than 30 years, consequently some dipterocarp trees have reached a diameter of more than 80 cm and many of them produce fruit regularly such as *Shorea stenoptera, S. balangeran, S. macrophylla, S. leprosula, S. seminis* and *S. parvistipulata*. The process of pollination and seed dispersal occurs naturally in the area with the help of the animals that come and seek refuge in this small forest in a big city.



Forest structure in Arboretum Sylva Untan that's dominated by dipterocarps (Agusti Randi)

RESEARCH AND CONSERVATION PRIORITIES

A wide range of research needs are identified for Bornean endemic dipterocarp species (Table 5). Research into population size, distribution and trends is identified as being needed for 44 species. Research into habitat trends is needed for 38 species and population trends for 37 species.

The conservation action required for the greatest number of Bornean endemic dipterocarp species (70% of species) is development of a genome resource bank and 80 species (49%) require artificial propagation. Both these conservation actions require developing *ex situ* nursery collections for threatened species, which are diverse and held in multiple localities, where possible. Habitat protection and management were also identified as important conservation action priorities (Table 6). Changes to national legislation

and policy were identified as important conservation activities for four species: *Dryobalanops keithii, Hopea centipeda, Shorea flaviflora* and *S. pachyphylla*. Meanwhile, *Dipterocarpus lamellatus, S. pachyphylla* and *S. rotundifolia* are identified as in need of a species reintroduction programme. In fact since *S. rotundifolia* was assessed in 2019, *ex situ* collection of the species has been initiated by Forest Sarawak Department alongside enrichment planting *in situ* for the species in Anap Muput Forest Management Unit in Sarawak.

Category	Number of Species
Research	91
Conservation Planning	20
Monitoring	114

Table 5: Research priorities for Bornean Endemic Dipterocarps.



Shorea cuspidata (Ling CY)



Shorea faguetioides (Ling CY)



Shorea flaviflora (Vilma Bodos)

Conservation Action	Number of Species
Land Protection	40
Land Management	15
Species Management	117
Education & Awareness	17
Law & Policy	4

Table 6: Conservation actions identified as required for Bornean endemic dipterocarp species.

CONCLUSIONS AND OPPORTUNITIES FOR THE FUTURE

The Red List of Bornean Endemic Dipterocarps is the first comprehensive analysis of the conservation status of all 162 dipterocarp species that are endemic to Borneo. Overall, much research has been done for dipterocarps by either national or international agencies. This research ranges from taxonomical inquiries to that of logging impacts and forest management etc. It is hoped that this publication will raise a greater awareness in regards to the current status and information gaps for Bornean endemic dipterocarps. With the purpose to spur further conservation actions for the group and especially those species assessed as threatened. With the initiation of the Heart of Borneo Initiative by the governments of Brunei Darussalam, Indonesia and Malaysia in 2007, which aims to conserve the biodiversity in the Heart of Borneo (HoB), this report should be used as a reference to further the countries' conservation causes, may it be within or outside the scope of HoB or already designated protected areas.

In total, 146 Bornean endemic dipterocarp species are known to occur in protected areas, while 47 species can also be found in ex situ collections. To monitor these species, regular field surveys are carried out to provide and update data such as: occurrence; population health; habitat preference and niche: response to direct or indirect manmade stress or natural disasters etc. Apart from gaining a greater understanding of the taxon's conservation needs, at times field surveys yield new records of species occurrence that might have been overlooked in previous surveys. Resources and training should be expanded to enable these activities.

In case studies 2, 4 and 5, it is shown that seed collection is a regular practice across Borneo during mast and non-mast fruiting events. The purpose of this is for



Hopea fluvialis (Ling CY)

propagation and conservation practices. It is important to recognize that at times, the seedlings raised from the collections are not solely held for botanic gardens and arboreta but are used for restoration and other purposes as well. The overall goal for some may not be conservation, but they do offer important research data in relation to plantation establishment and planting efforts of dipterocarps.

There is growing interest shown in establishing dipterocarp plantations due to the high value of dipterocarp timber. In the past, conventional logging practices were used to harvest dipterocarp timber from the forest, however this practice has caused extensive damage, some which is irreversible. Learning from past mistakes, parts of Borneo have started to turn their focus towards the use of Reduced Impact Logging (RIL) practices in timber harvesting. This technique involves a number of practical measures such as pre harvest inventory and site planning to minimize site damage; establish buffer areas along streams and waterways; setting of minimal and maximal harvesting limits in order to retain mother trees and consideration of many other factors. Case study 7, provides an introduction on how the adoption of Sustainable Forest Management Policy has led to the practice of RIL and brought about a change in forest management.

Moving forward there is a need for continued effort from the different sectors across Borneo to share their knowledge, experiences, lessons learnt and best practices. In turn, this will reduce duplication of effort and ensure resources are aligned to species or habitats which are most in need of conservation efforts. Additionally, given the reassessment of some and first assessment of others, prioritization and readjustment of conservation actions plans is needed in existing forest management and research plans.

Some of the major restrictions to amplified conservation of dipterocarps is the lack of funding and resources available. Therefore, there is a dire need to raise awareness and spread the message of the importance of dipterocarp forest and the actions that are needed to ensure they have a future. This message needs to be conveyed widely across all sectors of society not just in Borneo, but also at a global level. In the recent assessment, of the 162 species assessed, 99 species are assessed as threatened with 18 species listed in the Critically Endangered category, with that in mind the following considerations should be made:

- Identify and investigate the feasibility to include the areas where the 15 threatened species not currently found in protected areas, into protected landscape and if not consider the option of including them in *ex situ* collections.
- Continue to promote the Sustainable Forest Management policy and RIL technique across Borneo, particularly through access to additional funds to support and expand these practices on the island.
- Foster greater awareness among different stakeholders regarding species

that are threatened and the conservation actions in place, through various channels (e.g., environmental education, roadshows, pamphlets, posters, talks, social media etc.) at the local, national, regional and global level.

- Establish a framework to further monitor habitat quality in protected areas,
 - Monitor established sites for their provision of ecosystem services and ensure they are resilient to threats and challenges such as fire and climate change
 - Identify and monitor potential areas that can be demarcated as buffer zones.
 - Secure additional resources to support enforcement on sites that are being encroached or over utilised
- Improve and enhance current or potential landscape corridors in terms of habitat quality to increase genetic flow across a wide landscape, especially for dipterocarps that have low dispersal ability.



Danum Valley - Dipterocarp seedlings following masting event (David Bartholomew)

- Encourage regeneration and seedling recruitment percentage through targeted silviculture practice, such as climber cutting in degraded areas that have a good populations of mature trees
- Disseminate information and explore new tools to enhance activities such as field surveys, restoration and reintroduction of dipterocarp trees;
 - Application on Ecological Niche Modelling (ENM) to predict potential sites for field survey and species site restoration projects (Case study 2).
 - Increase the practice of species site matching in restoration efforts; including suitable dipterocarp species but also considering other plant groups and threatened taxa in order to maximise site biodiversity.
 - Develop ways to mitigate the impact of soil erosion in reforestation and develop methods for soil amelioration during restoration
- Together with the Global Conservation Consortium for Dipterocarps (GCCD – See Box 3)
 - Establish networks of expertise between different sectors and different research streams related to dipterocarps
 - Enhance linkages, information and technology exchange at the national, international and transboundary level.
 - Explore the capacity to maintain information on current *ex situ* dipterocarp collections and potential collections in a centralised database e.g. BGCI's PlantSearch Database or by establishing a regional method.
- Ensure legislation and policy is reflective of the up-to-date regional, national or global conservation status of species, so that HCV areas can be correctly identified and other practices can be applied correctly.



Shorea rotundifolia (Ling CY)



Shorea pinanga (Vilma Bodos)

Box 2 – A Global Conservation Consortium for Dipterocarps



To accelerate effective conservation of global plant diversity, BGCl is coordinating a suite of

Global Conservation Consortia, which catalyse groups of institutions and experts to collaboratively develop and implement comprehensive strategies to prevent the extinction of priority threatened plant groups.

Building on previous and existing work, and to further address the conservation needs of dipterocarps, the Global Conservation Consortium for Dipterocarps coordinates collaborative work on all aspects of conservation and applied research in areas including phylogenomics, ecology, conservation genetics, tissue culture and cryopreservation. The consortium also encourages the exchange of both material and data which are vital for the advancement of knowledge informing conservation strategies. The consortium is led by Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences and works in a coordinated and collaborative way to achieve the following objectives:

- Foster new and existing networks of dipterocarp experts
- Identify dipterocarp species of greatest conservation concern and prioritize conservation action
- Ensure effective in situ dipterocarp species conservation
- Establish and manage coordinated *ex situ* dipterocarp collections of high conservation value
- Foster applied research (e.g. conservation biology, ecology, horticulture, population genetics, taxonomy) to support dipterocarp species conservation
- Build capacity to empower and mobilize in-country partners in diversity centres and across dipterocarp species' ranges
- Increase public awareness and engagement with dipterocarp species conservation issues
- Collaboratively fundraise to scale-up dipterocarp conservation action

For more information on BGCI's Global Conservation Consortia initiative please visit: www.globalconservationconsortia.org

CASE STUDY 6: VATICA PENTANDRA CONSERVATION PROJECT

By Iyan Robiansyah

Vatica pentandra is an endemic tree known only from its type locality along Belayan River in Kutai Kartanegara Regency, East Kalimantan Province, Indonesia (Ashton, 1978). Although the species was assessed as Critically Endangered (Ashton, 1998), it is currently not included in the list of Indonesian protected flora (Ministerial Decree of Environment and Forestry 2019). Since first collected in 1955, there has been no further record of this species. Furthermore, the species is not represented in any ex situ conservation collections. With this in mind, Bogor Botanic Gardens (BBG) and Botanic Gardens Conservation International (BGCI) initiated the V. pentandra Conservation Project to determine its current population status and to collect plant materials for ex situ conservation.

In February 2020, a population survey was conducted, taking in 14 possible sites the species could occur along Belayan River. The locations stretched from Long Beleh Village in Kembang Janggut District north to the upstream villages of Sungai Lunuk, Umaq Dian and Gunung Sari in Tabang District. Despite searching so many localities, it was not possible to relocate individuals of *V. pentandra*.

Based on our published survey results (Linsky et al., 2020), forest conversion into oil palm plantations and coal mining are the major threats that have caused V. pentandra to be assessed as Critically Endangered Possibly Extinct. In addition, many forestry companies extract timber from forests along the Belayan River and is likely contributing to the unsuccessful relocation of the species. Due to all these threats, the remaining forests along the river are degraded and heavily fragmented. Further surveys in upstream areas of Belayan River are recommended. The forests in these

areas are still in relatively good condition due to mountainous topography making them difficult to access.

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Survey to find Vatica cauliflora in the field (Iyan Robiansyah)



Vatica cauliflora (Iyan Robiansyah)

CASE STUDY 7: FORESTRY AND SUSTAINABLE USE OF DIPTEROCARPS IN SARAWAK

Vilma Bodos

In the past, conventional logging for timber in Dipterocarp forests of Sarawak took place using tractors. This method of extraction and conventional logging practices in general have caused substantial disturbance and damage to soils and primary forest condition (Maimer and Grip, 1990; Nussbaum, 1995). Consequently, many ecosystem functions and biological diversity have been affected. Following this. sustainable forest management and certified timber has become the global demand and Sarawak timber trading has had to adapt accordingly. For this reason, the state government of Sarawak has imposed all long term timber licenses to undergo Forest Management Certification (FMC) and develop a sustainable harvesting operation. To better implement this new policy of sustainable management of forest resources, a series of workshops were organised by Forest Department Sarawak to review the harvesting system. Guidelines were also produced in 2017 to address the requirements of the FMC standard. Ten forest timber licensed areas have been certified covering a total area of 955,676 hectares as of 1st May 2020 (Forest Department Sarawak, 2021). The state government has announced that failure to obtain FMC by 2022 will result in suspension and termination of the forest timber license (Ricky, 2020).

Since the new policy direction, a Reduced Impact Logging (RIL) system is now used for timber harvesting operation and has become mandatory for all timber license holders in Sarawak. RIL is based on the intensively planned and controlled

implementation of timber harvesting to minimise impacts on forest stands and soils. The system encourages responsible harvesting operation and selection of trees for harvesting with 100% tree tagging following three definitions (1) harvesting tree, (2) potential harvest tree and (3) protected tree. As dipterocarps are the major timber group in Sarawak, harvestable size for dipterocarp trees is restricted at 50 cm and above (Forest Department Sarawak, 2019). This is selected to ensure a continuous timber stocking of dipterocarps and gives allowance for time for regeneration. The length of cutting cycle and annual allowable cut is strictly dependent on survey of the actual timber stocking condition in the whole licensed area and calculated based on a continuous census of permanent sample plots. Six Bornean dipterocarp species are listed in the Sarawak WildLife Protection Ordinance (1998) - Shorea macrophylla, Shorea splendida, Shorea hemsleyana ssp. grandiflora, Shorea stenoptera, Shorea pinanga and Shorea ochracea. These six species are prohibited from harvesting in all forests.

The identification and management of High Conservation Value Area (HCVA) forest is used in combination with the FMC and is an obligatory conservation initiative for timber licenses (MTCC, 2020). This requires record and protection of endemic and threatened trees classified as HCV 1 (a species or area that represents high unique biological diversity including endemic species, rare and threatened or endangered species, that are important at global, regional or national levels (HCV Malaysia Toolkit Steering Committee, 2018)) within timber licenses. For example. Anap Muput Forest Management Unit. located in central Sarawak has demarcated two forest areas of 220 hectares and 58 hectares as HCVA for species protection. During the field assessment conducted in 2019, 21 Bornean dipterocarps were recorded in these HCVAs. The endemics *Shorea rotundifolia* and *Shorea woodii* are amongst the species recorded.

Sustainable forest management practices in Sarawak still need much improvement, nevertheless compliance to all requirements under FMC could strengthen best management practices and help to achieved the balance of economic gain, sustainable use of dipterocarps and maintenance of environmental functions.

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PART 2 CRITICALLY ENDANGERED AND ENDANGERED SPECIES

Dipterocarpus cuspidatus P.S.Ashton CR A4acd

Sarawak

Dipterocarpus cuspidatus is a large tree species endemic to Sarawak, Malaysia. The population of the species is decreasing due to its uses as an important source of timber and the impact of large scale oil palm and forest plantations expansion. The forest loss between 2001 to 2017 is estimated at 37% at canopy density of 50% (Global Forest Watch, 2018); therefore, it is projected that more than 80% of population reduction for 3 generations length within the species habitat range because all the subpopulations are located outside the Totally Protected Area. The species is globally assessed as Critically Endangered.

Dipterocarpus lamellatus Hook.f. CR A2c; D

Brunei Darussalam, Sabah

Dipterocarpus lamellatus is now known from a single locality in Sabah and in Brunei Darussalam. The estimated area of occupancy (AOO) is 8 km² and extent of occurrence (EOO) is likely to be less than 100 km² and an estimated 98% AOO and 95% EOO have been lost. While the Siaungau Virgin Jungle Reserve is a TPA, the reserve has previously been logged and burnt during the El Nino related droughts of 1982/83, 1997/98 and 2010. Surrounding areas of the reserve are undergoing rapid land and infrastructure development that potentially might damage the integrity of the reserve. The known population consists of of fewer than 15 mature trees and twenty juveniles. No information is available for the subpopulation in Brunei Darussalam. Based on the current understanding of the species it is globally assessed as Critically Endangered.

Dryobalanops fusca Slooten CB A4cd

Kalimantan. Sarawak

This species is native to Sarawak and Kalimantan. This tree has a restricted geographic range, with an extent of occurrence of less than 10,000 km². This species is threatened by illegal logging, forest fires, and roundwood production by some companies, which contributes to the decline of the species. Due to the threats to the species, over a 160 year window (1959 to 2119 - two generations) the population is suspected to have declined by 80%. It is recommended that there be *ex situ* collections made for the species. The species is assessed as Critically Endangered.

Hopea depressinerva P.S.Ashton CR B1ab(i,ii,iii)+2ab(i,ii,iii) Sarawak

Hopea depressinervia is a large tree endemic to Sarawak. This species has narrow distribution, known only from two localities in western Sarawak (Gunung Pueh and Bukit Jebong in Bau). This species is rare and has small population size. The last collection of this species was in 1961. The two known localities of this species are located outside the network of Totally Protected Areas, thus the habitat is threatened and fragmented owing to forest conversion and agricultural activities. The subpopulation in Gunung Pueh Forest Reserve is susceptible to forest conversion due to on-going oil palm plantation. The population at Bukit Jebong is at risk from small-scale farming by the local community. The tree is reported producing good durability of wood and possibly being cut down by the local people for general construction purposes. The species is globally assessed as Critically Endangered.

Hopea micrantha Hook.f. CR A4cd

Brunei Darussalam, Sabah, Sarawak This species is native to Kalimantan, Brunei, Sabah and Sarawak. The range of the species is rather restricted and is experiencing a continuing decline. Within the last three generations, the species' extent of occurrence has declined by 75% and now measures 52.787 km² There has also been a decline in area of occupancy and population size. Declines are driven by threats to the species' habitat, often from agricultural expansion and logging activities. The rate of decline of the species varies between states. The remaining site in Sabah requires confirmation as it occurs in degraded forest. The decline is suspected to continue into the future at an equivalently high rate as the species is found in lowland forest, that is frequently exposed to threats. Considering a period of 160 years (1959 to 2119 or two generations), the species is likely to experience a decline of more than 80%. The species is assessed as Critically Endangered.

Hopea obscurinerva P.S.Ashton CR B2ab(i,ii,iii,v)

Sarawak

Hopea obscurinerva is a medium-sized tree endemic to Sarawak. It is known only from the two collections from Tubau. The known localities occur outside the Totally Protected Area. This species is exceptionally rare and has a small population and the last collection was recorded in 1986. The recent survey to the area failed to rediscover the species. Its habitat, the lowland mixed dipterocarp forest, is one of the highly threatened habitats in Sarawak for large-scale plantation (i.e., oil palm and tree plantation) and timber harvesting activities. The threats to habitat is on-going, thus population decline is suspected to continue. The species is globally assessed as Critically Endangered.

Hopea rudiformis P.S.Ashton CR A2cd

Kalimantan, Sabah

This species is native to Kalimantan and Sabah. There is limited information on this species. The population is in decline due to habitat threats, logging and fire. This has led to a loss in extent of occurrence (EOO) of 82%. Decline in the population size is suspected to be equivalent. Therefore the species is assessed as Critically Endangered.

Shorea dispar P.S.Ashton CR A3cd Sarawak

Shorea dispar is a large emergent tree species endemic to Sarawak, Malaysia. The species has a small geographic range. It is only known from central Sarawak where all the subpopulations occur outside the Totally Protected Area. The species habitat and population are highly at risk from forest conversion to oil palm and forest plantations and logging activities. Across Sarawak there has been at least a 37% decline in forest cover since the 1970s. It is anticipated that the species habitat and population decline will exceed 80% over a three generation window. Therefore, the species is globally assessed as Critically Endangered.

Shorea foraminifera P.S.Ashton CR A4c

Brunei Darussalam, Sabah (possibly extinct), Sarawak

This species is native to Borneo. It is still present in Sarawak and Brunei, however the one remaining locality in Sabah has been burnt and the species is considered extinct from this state. The species is severely threatened by land use change as particular sites of trees are threatened by agricultural or human settlement expansion. In Brunei the species is secure and occurs in protected areas, but all remaining individuals in Sarawak are outside of protected areas. Globally the species is experiencing population decline. Therefore, considering a period of 160 years (1959 to 2119 or two generations), the species will likely experience a decline of at least 80%. The species is assessed as Critically Endangered. There is a conservation need to develop a network of in situ and ex situ sites of protection for the species.

Shorea iliasii P.S.Ashton CR A4cd

Kalimantan, Sarawak

This species is native to Kalimantan and Sarawak. The species is rare in its range and there has been a decline in extent of occurrence of 79% (mostly loss from Kalimantan). The population is localised and restricted. The population of the species is decreasing across its range, due to habitat loss and conversion. Therefore in the future decline is suspected to exceed 80%. The species is assessed as Critically Endangered. Population and habitat decline is focused in sites outside of protected areas, and decline in Sarawak is less than the global value. Both in situ and ex situ conservation is needed for the species to be saved in the wild.

Shorea induplicata Slooten CR A4cd; C2a(i)

Kalimantan, Sarawak

This species is native to Kalimantan and Sarawak. The range of the species is restricted in each country and the population is small. Fewer than 250 individuals are thought to remain. The species is experiencing population decline as it grows in peat swamp and kerangas forests, both highly threatened habitats. In Kalimantan, the decline in the species and habitat is suspected to be over 80% but is lower in Sarawak. However, in Sarawak the species is found outside Totally Protected Areas and the decline is therefore continuing. Hence across a 160 year window (1959 to 2119 - two generations) the decline in the species is still suspected to be over 80% in both countries. The species is Severely Fragmented and there is decline in extent of occurrence, area of occupancy, mature individuals and subpopulations. The species is assessed as Critically Endangered. In situ conservation efforts are required for this species.

Shorea praestans P.S.Ashton CR A3cd+4cd Sarawak

Shorea praestans is a tree species native and endemic to Sarawak, Malaysia. The species is only known from central western Sarawak where most of the individuals occur outside Totally Protected Areas and are highly at risk from forest conversion to oil palm plantation and human settlement. In Bukit Tiban National Park, the species habitat is threatened by encroachment. Based on reduction analysis, decline in the species extent of occurrence is estimated at 37% between 2001 to 2017. Here it is projected that habitat and population decline exceeds 80% for 100 years into the future because most of the subpopulations occur outside the Totally Protected Area. The population is Severely Fragmented and in degraded forest, thus, the species is globally assessed as Critically Endangered.



Shorea rotundifolia (Vilma Bodos)



Shorea praestans (Vilma Bodos)

Shorea revoluta P.S.Ashton CR A2cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak.

This species is native to Kalimantan, Brunei, Sabah and Sarawak. The species is found in very few localities in each of its native states and requires confirmation from Sarawak as it has not been collected here since the 1950's. With current records, the extent of occurrence is just over 25,000 km² and area of occupancy is only 32 km². The species' present day, restricted geographic range is suspected to have occurred due to a reduction in population size of 80% caused by threats of logging and habitat loss over the last three generations. The species is assessed as Critically Endangered.

Shorea rotundifolia P.S.Ashton CR A3cd+4cd Sarawak

Shorea rotundifolia is low emergent tree species to 40 m tall native to the lowland mixed dipterocarp forests of Sarawak, Malaysia. We do not know the size of the population. All known subpopulations and habitats occur outside the Totally Protected Area in Sarawak except one subpopulation protected within High Value Conservation Forest. Population reduction within its extent of occurrence calculated using reduction analysis in GeoCat is estimated at 29%. Due to the occurrence of most subpopulations outside the Totally Protected Area and the observed threats to its habitats, it is suspected that population loss in the next 100 years will be 80%. Therefore the species is globally assessed as Critically Endangered.

Vatica adenanii Meekiong, Nizam, Latiff, Tawan & Yahud

CR B1ab(i,ii,iii)+2ab(i,ii,iii)

Sarawak

Vatica adenanii is a tree species endemic to Sarawak, Malaysia. The size of the population is unknown. The species is very rare and only known from the type locality in Samapadi Forest Reserve. The habitat is located outside the Totally Protected Area and thus it is highly threatened by habitat loss and forest degradation caused by logging and plantation activities. This is likely to lead to population decline and decline in area of occupancy, extent of occurrence and number of locations at an unknown rate. The species is globally assessed as Critically Endangered.

Vatica cauliflora P.S.Ashton CR A4cd

Kalimantan

This species is endemic to Kalimantan. Currently information on the population size is lacking, however considering a period of 160 years (1959 to 2119 or two generations), the species is likely to experience a decline of at least 80%. This is due to the widespread destruction of lowland forest in this region of Kalimantan and the persistence of the species in only two localities. There is continuing decline in the habitat quality in the species range, even within the protected area in which the species is found. Therefore, the species will be threatened in the future. The species is assessed as Critically Endangered.

Vatica patentinervia P.S.Ashton CR D

Brunei Darussalam, Sarawak

This species is native to Sarawak and Brunei. However, the species has not been recently recorded in either country. The species has a small population size, estimated to be below 50 mature individuals. The range of the species is restricted with extent of occurrence and area of occupancy both below 10 km². The recorded site of the species in Sarawak is found outside of protected areas and in Sarawak the species is threatened by habitat loss. It is globally assessed as Critically Endangered.

Vatica pentandra P.S.Ashton CR (PE) B1ab(i,ii,iii)+2ab(i,ii,iii) Kalimantan

The species is endemic to Indonesia. It is only known from one location, therefore extent of occurrence (EOO) and area of occupancy (AOO) are less than 4 km². Most of the areas along Belayan River have been converted into oil palm plantation and coal mining. In addition, there are several logging concessions that have been extracting wood in the remaining forested areas. Therefore, the species is experiencing a continuing decline in EOO and AOO. Recent surveys in the type locality of the species in the wild failed to locate any remaining individuals. Therefore, the species is considered as Critically Endangered, Possibly Extinct in the Wild.

Anisoptera reticulata P.S.Ashton EN A3cd+4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak

This species is native to Sabah, Sarawak, Kalimantan and Brunei. The species has an extent of occurrence of over 150,000 km² but within this the species is localised. The decline in area of occupancy (AOO) in the past is measured as 38% and known AOO has declined to 68 km². The species is known from only a single record in Kalimantan. Across the range the species is threatened by habitat loss and conversion driven by agricultural encroachment and logging operations. The species is also a target for timber harvest. Therefore population decline in the future (100 years) is suspected to continue and exceed 50%. The species is assessed as Endangered.

Cotylelobium burckii (F.Heim) F.Heim EN A4cd

Brunei Darusaalam, Kalimantan, Sabah, Sarawak,

This species is native to Brunei Darussalam, Kalimantan and Sarawak. There is one locality in Sabah and the species is considered native here but more information on this subpopulation is needed. In its range this species is at risk in the wild from logging and land conversion of native lowland, forest habitat. The species is also found on kerangas, a highly threatened habitat in Borneo. The population is suspected to be in decline. In Kalimantan decline may have historically been up to 80% and in the future will still exceed 50%. In Sarawak outside of protected areas historical decline is 40% but in the future could be 70%. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline that is between 50 and 80%. The species is assessed as Endangered.

Dipterocarpus fusiformis P.S.Ashton EN A2cd; B2ab(i,ii,iii,iv) Kalimantan, Sabah

This species is native to Sabah and Kalimantan. The species has a wide geographic range of over 100,000 km², however, the area of occupancy (AOO) of the species is now only 20 km². The species was originally collected from nine localities but due to habitat loss and other threats only five sites of the species are considered to remain. This has led to a decline in AOO of 55%. The population of the species is in decline and over the last three generations the species is suspected to have experienced a decline of at least 50%. The species is globally assessed as Endangered.

Dipterocarpus geniculatus Vesque EN A4cd

Kalimantan, Sabah, Sarawak This species is endemic to Borneo. The species does not appear common in its native range. Across Borneo there has been a decline in forest cover of 34% since 1974. The species is found at low elevations making it particularly threatened by deforestation and also by timber harvest. Across the range of the species, historical and future declines for the species varies, from up to 80% historically in Kalimantan and 50% in Sarawak. In Sabah the population has historically declined by at least 30% but it is found in protected areas. The species is also found in Brunei and protected areas where the population of the species will be more stable. Therefore, across the range of the species it is suspected that it will experience a decline of at least 50% due to threats from logging and habitat loss. The species is assessed as Endangered.



Dipterocarpus geniculatus (Ling CY)

Dipterocarpus glabrigemmatus P.S.Ashton EN B2ab(iii,v)

Sarawak

This species is endemic to Sarawak, Malaysia. It was once considered native to Kalimantan, but this record is no longer considered valid. The species has a restricted geographic range with an extent of occurrence of 6,327 km² and area of occupancy of 52 km². The species is threatened by habitat loss and degradation caused by logging operations and also the loss of mature individuals, as the species is harvested for timber. It is only known from five locations. The species is assessed as Endangered and requires both in situ and ex situ conservation measures to be put in place.

Dipterocarpus ochraceus Meijer EN B1ab(i,ii,v)+2ab(i,ii,v) Sabah

Dipterocarpus ochraceus is known to occur in at least three Totally Protected Area in Sabah. The estimated area of occupancy (AOO) and extent of occurrence (EOO) are 40 km² and 2,850.260 km² respectively. The species is known from four locations. The potential threat for this species is natural disaster such as forest fire and encroachment which causes the decline in 35% of AOO and 13% of EOO. Hence, it is assessed as Endangered.

Dipterocarpus tempehes Slooten EN A4cd

Kalimantan, Sabah, Sarawak

This species is native to Sabah, Sarawak and Kalimantan. The species has a local distribution. It is found in some protected areas but outside of these sites the population is in decline. At the state level population decline estimates vary, but based on these figures it is suspected that the decline over a 160 year window (1959 to 2119 - two generations) could be at least 50%. Threats to the species include targeting for timber and habitat loss due to logging and habitat conversion these are particularly major threats in Kalimantan. The species is assessed as Endangered.

Dryobalanops rappa Becc. EN A4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak

The species is native to Borneo, where it is common in coastal peat swamp forest and heath forest. These habitats have experienced massive degradation and fragmentation due to human activities such as land conversion and forest encroachment. Several subpopulations are also severely damaged by fires in Kalimantan. This habitat loss has caused a decline in extent of occurrence of the species and also led to population declines. Due to continuing threats to the species, the decline will continue to the future at a high rate across the range of the species. Declines in the species varies from country to country and the highest rate of decline is in Sabah. Overall the decline is suspected to be over 50% across a 160 year window (1959-2119 two generations). The species is assessed as Endangered.

Hopea aequalis P.S.Ashton EN A4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak,

The species is native to Brunei Darussalam, Kalimantan, Sabah and Sarawak. The species is uncommon in its geographic range due to the decline in lowland, mixed dipterocarp forest. The species has increased in rarity in each state it is found and across Borneo lowland forest decline is at least 30%. Therefore across the range of the species over a 160 year window (1959-2119 - two generations) the population decline is suspected to be at least 50%. The species is assessed as Endangered.

Hopea altocollina P.S.Ashton EN A4cd; B2ab(i,ii,iii) Sabah, Sarawak

This species is native to Sarawak and Sabah. However in Sabah the presence of the species requires confirmation due to a poor herbarium record, and known localities now being in deforested areas. The species is not locally abundant. In Sarawak it is suspected that the species has historically declined by 20% but including future declines it could be over 60% based on habitat loss. There has also been a probable decline in Sabah. although confirmation is needed. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of over 50%. The species has a restricted range, at high altitude in north and central Sarawak. As it is found in few discrete locations the area of occupancy of the species is 60 km² and the population is Severely Fragmented. It is assessed as Endangered.



Hopea altocollina (Vilma Bodos)



Hopea enicosanthoides (Ling CY)

Hopea centipeda P.S.Ashton EN A4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak,

This species is native to Brunei, Kalimantan, Sabah and Sarawak. The species has a wide range but is infrequent across this. There is a risk to the habitat of the species, and there is decline in the number of mature individuals due to timber harvest. The decline is suspected to become greater in the future as the habitat of the species becomes more threatened. In Sabah only one site of the species remains, if this locality is lost the extent of occurrence of the species will be reduced by 70%. In Kalimantan the species is found in a National Park, which is threatened as the habitat within is still utilised, and this will begin to have an impact on the species in the future. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 60%. It is assessed as Endangered.

Hopea enicosanthoides P.S.Ashton EN A4c; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v) Sarawak

Hopea enicosanthoides is a mediumsized tree endemic to Sarawak. The habitat is confined to riparian areas of lowland mixed dipterocarp forest at elevation below 100 m. This species is only known from four locations, where all locations are located outside the Totally Protected Area in Sarawak. The population is declining due to the threats to the species habitat caused by forest conversion to oil palm and forest plantations. The habitat is continuing to decline and the forest loss between 2001 to 2017 is estimated at 34%. It is projected that population decline over the next 100 years will be at least 50% because all the subpopulations are located outside the Totally Protected Area. The species is globally assessed as Endangered.

Hopea longirostrata P.S.Ashton EN B2ab(i,ii,iii,v)

Sarawak

Hopea longistrata is a medium-sized tree endemic to Sarawak. This species is recorded only from four localities where most localities occur outside the Totally Protected Area. One sub-population in Semengoh Nature Reserve (Totally Protected Area) recorded only one tree >10 cm diameter (at breast height) from 4hectare plot. The populations outside the Totally Protected Area are highly susceptible to habitat exploitation for logging activities and changes of land use for agriculture expansion. The forest loss between 2001 to 2017 is estimated at 32% . The species is globally assessed as Endangered with the threats still on-going and the population continuing to decline.

Hopea megacarpa P.S.Ashton EN B2ab(i,ii,iii)

Kalimantan, Sarawak

This species has a restricted range in Sarawak and in Kalimantan. The species is frequent in this range but is Severely Fragmented. The population of the species is in decline due to habitat loss in the range of the species, driven by logging activities. The area of occupancy of the species is between 88 km² (with the current herbarium record) and 500 km² (upper boundary on greater collection effort). It is assessed as Endangered. There is some *in situ* protection of the species in Kalimantan but there are no *ex situ* conservation efforts reported.

Hopea vacciniifolia Ridl. ex P.S.Ashton EN A4c

Brunei Darussalam, Sarawak

This species is native to Brunei, Sabah, Sarawak and Kalimantan. The species is not common and has a restricted area of occupancy. The species is found in very few localities. In Brunei and Sabah all localities are within protected areas and there is no population or habitat decline. However the species is only known from one locality in Sarawak and a single site in Kalimantan. Both of these localities are outside of protected areas and the species is at risk from land conversion and forest degredation and fragmentation. It is suspected that in Sarawak and Kalimantan there has been historical loss of habitat and the species which has led to the restriction of the species range. If the species is lost from Kalimantan and Sarawak this will cause extent of occurrence to decline by over 70%. As threats in these two areas are continuing it is therefore suspected that over 160 years (1959 to 2119 - two generations) the decline of the species will exceed 50%. The species is globally assessed as Endangered.

Shorea alutacea P.S.Ashton EN A3cd+4acd; B1ab(i,ii,iii)+2ab(i,ii,iii) Sarawak

Shorea alutacea is a medium-sized to large tree species to 36 m tall endemic to Sarawak, Malaysia. We do not know the size of the population. The species is confined to the south of Sarawak and has only recorded from four localities including two Totally Protected Areas (Gunung Gading National Park and Kubah National Park). In the Totally Protected Areas, the species was recorded once from Kubah National Park in 1994 and was last collected from Gunung Gading in 1958. More recent surveys to both areas failed to re-locate the species. the subpopulations outside the Totally Protected Areas network are threatened by forest conversion. The forest loss within the species extent of occurrence between 2001 to 2017 is estimated at 30% at the canopy density of 50%. It is suspected that a the species could experience population reduction of at least 50% in the next 100 years due to changes in species habitat range as two of the sub-populations are located outside the Totally Protected Area. Therefore the species is globally assessed as Endangered.

Shorea biawak P.S.Ashton EN B2ab(i,ii,iii)

Brunei Darussalam, Kalimantan, Sabah, Sarawak

This species is endemic to Borneo. It is not a common species and the population is in decline. Based on Global Forest Watch data, it is suspected that the population has declined by at least 30% over the last three generations. The species has an extent of occurrence of 181,589km² and area of occupancy is 48 km². The area of occupancy of the species has declined by 34% in at least three generations. The remaining population is Severely Fragmented and the species is only recorded from protected areas in Sarawak. The species is threatened by agricultural and human settlement expansion. It is assessed as Endangered.

Shorea brunnescens P.S.Ashton EN A4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak

This species is endemic to Borneo, it is recorded from Sabah, Sarawak, Brunei and Kalimantan. However, its presence in Sabah now requires confirmation as the last records of the species are from the 1960's. The population of the species is in decline in much of its native range, particularly outside of protected areas. The population of the species is in decline due to various threats to the habitat. In each country, measures of the species' decline in the last few decades vary from 20% in Sarawak (using Global Forest Watch data) up to 80% in Kalimantan and are suspected to be equivalently high in Sabah. Globally the species is assessed as Endangered, with global population decline over 160 years suspected to be over 50%. Regionally the conservation status of the species is variable.

Shorea calcicola P.S.Ashton EN B2ab(i,ii)

Sarawak

Shorea calcicola is a small to mediumsized tree species native and endemic Sarawak, Malaysia. We do not know the size of the population. The species is restricted to limestone forests including two Totally Protected Areas, namely Niah National Park and Dered Krian National Park. It is suspected that the species has experienced population decline within its habitat range due to habitat disturbance outside the Totally Protected Areas. As the species is restricted to limestone hills, it has disjunct distribution with an area of occupancy of 36 km². Therefore, the species is globally assessed as Endangered.

Shorea cordata P.S.Ashton EN B2ab(iii)

Kalimantan, Sarawak

This species is native to Kalimantan and Sarawak. The species is experiencing a population decline due to threats to its habitat, and it is currently known from only five locations. Population declines could be at least 30% over the last three generations. The species has a limited distribution with an area of occupancy, below 500 km². It is assessed as Endangered.

Shorea domatiosa P.S.Ashton EN A2cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak

This species is endemic to Borneo. The population and habitat of the species is in decline as land is converted for agricultural space and degraded by other anthropogenic activities. Due to land use change, in Sarawak using Global Forest Watch, the decline in the species' habitat is suspected be 27% in the last two decades. Losses are higher in Kalimantan and Sabah, where the historical decline is suspected to exceed 50%. As this makes up the majority of the range of the species it is suspected that across the range of the species over the last three generations decline is over 50%. The species is found in protected areas in Sabah and Sarawak only. It is globally assessed as Endangered.

Shorea elliptica Burck EN A2cd

Kalimantan, Sarawak

This species is native to Sarawak and Kalimantan. The species is experiencing a continuing population decline as mature individuals are lost for timber, and as the species is found in a threatened habitat. Due to habitat loss the species is suspected to have lost at least 30% forest cover over the last two decades in Sarawak, while in Kalimantan, population loss is historically estimated to to be between 50 and 80% and in the future could still be high - between 30 and 50%. Therefore, across the range of the species, over the last three generations, the population decline is suspected to be at least 50%. The species is assessed as Endangered.

Shorea inaequilateralis Symington EN A4cd

Brunei Darusaalam, Kalimantan, Sarawak This species is native to Brunei, Kalimantan and Sarawak. In Kalimantan the species is only known from one locality, but is widespread elsewhere. This tree is only found in peat swamp forest, which experiences a high rate of threat and decline. The threats to the species are from logging and encroachment of agriculture, but in Brunei the species is not in decline as individuals are in protected forest. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 50%, particularly if the species is lost from it's single locality in Kalimantan. The species is assessed as Endangered.

Shorea pachyphylla Ridl. ex Symington EN A4cd

Brunei Darussalam, Kalimantan, Sarawak Shorea pachyphylla is a large tree species native to Brunei Darussalam, Kalimantan and Sarawak. This gives the species a large extent of occurrence. However this area has declined by at least 30% within the last three generations. The species exists in a fragmented patchy habitat caused by forest fires and the establishment of industrial crop plantations in lowland forest. Shorea pachyphylla occurs in declining peat swamp forests, where in Sarawak only 10% of the original area of this habitat type remains. Alongside habitat loss the species is also threatened by the extraction of timber in the forest, a use for which the species itself is targeted. Considering the scale of these threats across a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 50%. There is some in situ and ex situ conservation of this species already in place which should be maintained. This species is globally assessed as Endangered.

Shorea pallidifolia P.S.Ashton EN A2cd

Kalimantan, Sarawak

This species is native to Sarawak and Kalimantan. The population of the species is localised, and overall the species is not considered common. The population of the species is declining. Using Global Forest Watch data, habitat loss in the range of the species in Sarawak is 41% since 2000. In Kalimantan, habitat loss and the population decline is higher and historically may have reached 80%, but in the future it may be between 30 and 50%. The major threats to the species are the expansion of plantations and urban settlements. The species is also logged for timber causing loss of mature individuals, and even saplings and polls are taken in Kalimantan. Overall, across the range of the species, the historical population decline is suspected to be be at least 50%. The species is assessed as Endangered.

Shorea splendida (de Vriese) P.S.Ashton EN A4cd

Kalimantan, Sarawak

This species is native to Sarawak and Kalimantan. The species is threatened by habitat conversion for oil palm and tree plantation expansion and also due to the expansion of other anthropogenic activities such as settlement and industry. As a result of this habitat loss the population of the species is in decline. In Sarawak, Global Forest Watch data gives a habitat decline of 39% since 2000. In Kalimantan, continuing population decline is suspected to be greater and fall between 30 and 50%. As decline is continuing, considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 50%. It is assessed as Endangered.

Shorea tenuiramulosa P.S.Ashton EN A4cd

Sabah, Sarawak

This species is native to Sabah and Sarawak. The species is not common and is at risk from habitat loss. In Sarawak, there has been 22% decline in the habitat of the species since 2000. Therefore, over a longer time period, the decline is suspected to be higher. As the majority of individuals of the species occur outside of protected areas, often in lowland coastal sites, threats and the population decline is considered to be continuing. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 50%. The species is assessed as Endangered.



Shorea woodii (Ling CY)

Shorea woodii P.S.Ashton EN B1ab(i,ii,iii)+2ab(i,ii,iii) Sarawak

Shorea woodii is a medium-sized tree species native and endemic to Sarawak, Malaysia. We do not know the size of the population. All known localities are located outside the Totally Protected Area but occurs in the protection forest within a timber concession area. This leads to a decline in area of occupancy and extent of occurrence as habitat is converted and trees are harvested. The species is restricted to Central Sarawak with an extent of occurrence of 2,557 km². Therefore the species is globally assessed as Endangered.

Vatica chartacea P.S.Ashton EN A4cd

Kalimantan, Sabah, Sarawak

This species is native to Sabah, Sarawak and Kalimantan. The species is uncommon in its range, particularly in Kalimantan where only 12 mature individuals are known. The species is found in protected areas but illegal activities still occur in them. The population of the species is in decline due to threats from land conversion and logging. Over the last few decades declines in Sarawak and Kalimantan are suspected to have fallen between 20 and 40%, while in the future it may be higher. In Sarawak it is suspected to decline by 50 to 60%. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 50%. The species is globally assessed as Endangered.

Vatica congesta P.S.Ashton EN B2ab(iii)

Kalimantan, Sarawak

The species is native to Kalimantan and Sarawak. This species has a restricted range, with an area of occupancy of 12 km2. The species is known from one collection site in Kalimantan that has not been resurveyed since the 1950's. Therefore, it is recommended that the species' presence here is confirmed. In Sarawak, the species is known from two localities including one in a protected area. Outside of these sites, the habitat and population are in decline due to anthropogenic activities in lowland forests of Borneo. Threats from habitat loss mostly lie in the future of the species. It is is assessed as Endangered.

Vatica endertii Slooten

EN A4cd; B2ab(i,ii,iii)

Kalimantan, Sarawak

This species is native to Sarawak and Kalimantan. The species is infrequent and known from few localities within a large geographic range. Due to threats to the species' habitat there has been a decline in both extent of occurrence and area of occupancy within the last three generations. Extent of occurrence is now only 118,724 km² and area of occupancy is 16 km². The population of the species is suspected to have declined by around 40%, but including future declines, this is likely to exceed 50% as threats from logging and habitat conversion continue. The species is assessed as Endangered.

Vatica globosa P.S.Ashton EN A4cd

Kalimantan, Sarawak

This species is native to Sarawak and Kalimantan. The species is localised within its range. Outside of protected areas, the species is threatened by lowland forest conversion to agricultural expansion of different scales. It is also logged for timber in Kalimantan. These activities cause both the habitat and the population of the species to decline. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of 50%. Declines in each country are variable with losses being greater in Kalimantan, estimated to be 50 to 80% in the future compared to 40 and 50% in Sarawak. The species is assessed as Endangered.

Vatica rotata P.S.Ashton EN A4cd

Kalimantan, Sabah, Sarawak

This species is native to Sabah, Sarawak and Kalimantan. The population of the species is in decline due to habitat loss caused by agricultural activities. In Sarawak, historical declines in the species are suspected to have been 57% and future declines (over the next 100 years) could be from 60 to 70%. This decline is suspected to be equivalent across the range of the species. Considering a period of 160 years (1959 to 2119 - two generations), the species is likely to experience a decline of at least 60%. The species is therefore assessed as Endangered.

Vatica rynchocarpa P.S.Ashton EN A2cd+3cd+4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak

This species is endemic to Borneo. It is native to Brunei, Kalimantan, Sabah and Sarawak. The species is threatened by habitat loss, driven by agricultural expansion. The population of the species is in decline. This has caused the extent of occurrence (EOO) of the species has declined by at least 60% and this decline will continue into the future by at least 50%. The species is assessed as Endangered. *In situ* and *ex situ* conservation efforts are needed for this species.

Part 3

VULNERABLE SPECIES OF BORNEAN ENDEMIC DIPTEROCARP

Dipterocarpus applanatus Slooten **VU A4cd** Kalimantan, Sabah, Sarawak

Dipterocarpus mundus Slooten VU A3cd Kalimantan, Sarawak

Dipterocarpus pachyphyllus Meijer VU A2cd Brunei Darussalam, Sabah, Sarawak

Dipterocarpus stellatus Vesque VU A3cd+4cd Brunei Darussalam, Kalimantan, Sabah, Sarawak

Dryobalanops keithii Symington VU A3cd Kalimantan, Sabah

Hopea andersonii P.S.Ashton VU A4cd Kalimantan, Sabah, Sarawak

Hopea pentanervia Symington ex G.H.S. Wood VU A3cd+4cd

Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea acuminatissima Symington **VU A3cd** Brunei Darussalam, Kalimantan, Sabah,

Sarawak

Shorea albida Symington **VU A2cd+4cd** Brunei Darusaalam, Kalimantan, Sarawak

Shorea andulensis P.S.Ashton **VU A2cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea bakoensis P.S.Ashton **VU D1+2** Sarawak



Shorea albida (Ling CY)



Shorea cuspidata (Ling CY)

Shorea bullata P.S.Ashton **VU A2cd** Brunei Darussalam, Sarawak

Shorea chaiana P.S.Ashton VU A3cd Brunei Darussalam, Sarawak

Shorea collaris Slooten VU A2cd Kalimantan, Sabah, Sarawak Shorea confusa P.S.Ashton VU A2cd+4cd Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea cuspidata P.S.Ashton VU A2cd Kalimantan, Sarawak

Shorea ferruginea Dyer ex Brandis **VU A2c** Brunei Darussalam, Sabah, Sarawak



Shorea flaviflora (Vilma Bodos)

Shorea flaviflora G.H.S.Wood ex P.S.Ashton **VU A3cd** Brunei Darussalam, Sabah, Sarawak

Shorea flemmichii Symington **VU A4c; B2ab(iii,v)** Sarawak

Shorea geniculata Symington ex P.S.Ashton VU A2cd Brunei Darussalam, Sarawak

Shorea hypoleuca Meijer **VU A2cd** Sabah, Sarawak

Shorea isoptera P.S.Ashton **VU A2cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea ladiana P.S.Ashton **VU A2cd** Brunei Darussalam, Sarawak



Shorea flemmichii (Vilma Bodos)

Shorea longiflora (Brandis) Symington **VU A2cd** Brunei Darusaalam, Kalimantan, Sarawak

Shorea macrobalanos P.S.Ashton VU A3cd Kalimantan, Sarawak

Shorea mecistopteryx Ridl. VU A2cd+4cd Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea mujongensis P.S.Ashton VU A4cd Kalimantan, Sabah, Sarawak

Shorea obovoidea Slooten VU A4cd Kalimantan, Sarawak

Shorea obscura Meijer **VU A4cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak **Shorea ochracea** Symington **VU A4cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea polyandra P.S.Ashton VU A2cd+4cd Kalimantan, Sabah, Sarawak



Shorea ladiana (Ling CY)

Shorea quadrinervis Slooten **VU A2cd+4cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea retusa Meijer **VU A2cd+4cd** Kalimantan, Sabah, Sarawak

Shorea richetia Symington **VU B1ab(iii)** Sabah, Sarawak

Shorea rubella P.S.Ashton **VU A2cd** Brunei Darussalam, Sabah, Sarawak

Shorea slootenii P.S.Ashton **VU A2cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea smithiana Symington VU A2cd+4cd Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea subcylindrica Slooten VU A2cd Kalimantan, Sabah, Sarawak **Shorea superba** Symington **VU A2cd+4cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea symingtonii G.H.S.Wood **VU A2c** Sabah

Upuna borneensis Symington **VU A2cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak

Vatica badiifolia P.S.Ashton VU A2cd Brunei Darusaalam, Kalimantan, Sarawak

Vatica compressa P.S.Ashton VU A3cd+4cd; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v) Sarawak

Vatica glabrata P.S.Ashton VU B1ab(iii,v)+2ab(iii,v) Brunei Darussalam, Sarawak

Vatica parvifolia P.S.Ashton VU A3cd Brunei Darussalam, Sabah, Sarawak



Upuna borneensis (Ling CY)

Vatica pedicellata Brandis VU A2c; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v) Sarawak

Vatica sarawakensis F.Heim **VU A4cd** Brunei Darussalam, Kalimantan, Sabah, Sarawak



Shorea smithiana (David Bartholomew)



Vatica sarawakensis (Vilma Bodos)

Part 4 Near threatened species of Bornean Endemic Dipterocarp



Dipterocarpus confertus (Ling CY)

Dipterocarpus caudiferus Merr. Brunei Darussalam, Kalimantan, Sabah, Sarawak

Dipterocarpus confertus Slooten Brunei Darussalam, Kalimantan, Sabah, Sarawak

Hopea bullatifolia P.S.Ashton Kalimantan, Sarawak *Hopea fluvialis* P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Hopea sphaerocarpa (F.Heim) P.S.Ashton Sarawak

Hopea tenuivervula P.S.Ashton Kalimantan, Sabah, Sarawak

Hopea treubii F.Heim Brunei Darussalam, Sarawak

Hopea wyattsmithii G.H.S.Wood ex P.S.Ashton Brunei Darussalam, Sabah, Sarawak

Parashorea macrophylla Wyatt-Sm. ex P.S.Ashton Brunei Darusaalam, Kalimantan, Sarawak

Shorea agami P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak



Hopea fluvialis (Ling CY)



Parashorea macrophylla (Vilma Bodos)

Shorea amplexicaulis P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea angustifolia P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea asahi P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea carapae P.S.Ashton Brunei Darusaalam, Kalimantan, Sarawak

Shorea coriacea Burck Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea faguetioides P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea kudatensis G.H.S.Wood ex Meijer Sabah



Shorea faguetioides (Ling CY)

Shorea lunduensis P.S.Ashton Kalimantan, Sarawak

Shorea myrionerva Symington ex P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea sagittata P.S.Ashton Sarawak

Shorea scaberrima Burck Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea stenoptera Burck Kalimantan, Sarawak

Shorea patoiensis P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea pilosa P.S.Ashton Brunei Darussalam, Sabah, Sarawak

Shorea rubra P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak



Parashorea macrophylla (Vilma Bodos)

Shorea waltonii G.H.S.Wood ex Meijer Sabah

Shorea xanthophylla Symington Brunei Darussalam, Sabah, Sarawak

Vatica brevipes P.S.Ashton Kalimantan, Sarawak

Vatica borneensis Burck Brunei Darussalam, Sarawak

Vatica coriacea P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Vatica dulitensis Symington Brunei Darussalam, Kalimantan, Sabah, Sarawak Vatica vinosa P.S.Ashton Brunei Darussalam, Sabah, Sarawak



Shorea rubra (Ling CY)

PART 5 DATA DEFICIENT SPECIES OF BORNEAN ENDEMIC DIPTEROCARP

Parashorea smythiesii Wyatt-Sm. ex P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Hopea ovoidea P.S.Ashton Sabah

Vatica palungensis P.S.Ashton Kalimantan



Parashorea smythiesii (Vilma Bodos)

PART 6

LEAST CONCERN SPECIES OF BORNEAN ENDEMIC DIPTEROCARP

Shorea macrophylla (de Vriese) P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak



Shorea macrophylla (Ling CY)

Shorea havilandii Brandis Brunei Darussalam, Sabah, Sarawak

Dryobalanops lanceolata Burck Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea beccariana Burck Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea parvistipulata F.Heim Brunei Darussalam, Sabah, Sarawak

Shorea venulosa G.H.S.Wood ex Meijer Sabah, Sarawak

Vatica oblongifolia Hook.f. Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea fallax Meijer Brunei Darussalam, Kalimantan, Sabah, Sarawak



Vatica oblongifolia (Ling CY)

Hopea mesuoides P.S.Ashton Brunei Darussalam, Sarawak

Hopea pterygota P.S.Ashton Brunei Darusaalam, Kalimantan, Sarawak



Shorea pinanga (Vilma Bodos)

Shorea acuta P.S.Ashton Brunei Darussalam, Sarawak

Hopea rugifolia P.S.Ashton Brunei Darussalam, Sarawak

Shorea monticola P.S.Ashton Kalimantan, Sabah, Sarawak

Shorea pinanga Scheff. Brunei Darussalam, Kalimantan, Sabah, Sarawak

Anisoptera grossivenia Slooten Brunei Darussalam, Kalimantan, Sabah, Sarawak *Vatica micrantha* Slooten Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea Iaxa Slooten Brunei Darussalam, Sabah, Sarawak

Vatica albiramis Slooten Brunei Darussalam, Sabah, Sarawak

Vatica granulata Slooten Brunei Darussalam, Kalimantan, Sabah, Sarawak

Shorea argentifolia Symington Brunei Darussalam, Kalimantan, Sabah, Sarawak *Dipterocarpus globosus* Vesque Brunei Darussalam, Sarawak

Parashorea parvifolia Wyatt-Sm. ex P.S.Ashton Brunei Darussalam, Kalimantan, Sabah, Sarawak

Dipterocarpus nudus Vesque Brunei Darussalam, Sarawak

Hopea vesquei F.Heim Sarawak

Parashorea tomentella (Symington) Meijer Kalimantan, Sabah

Shorea crassa P.S.Ashton Brunei Darusaalam, Kalimantan, Sarawak

Shorea micans P.S.Ashton Sabah

Shorea pubistyla P.S.Ashton Sarawak

APPENDIX 1

LIST OF ALL BORNEAN ENDEMIC DIPTEROCARPS

Taxon name	Red List Category	Red List Criteria	Distribution
Anisoptera grossivenia Slooten	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Anisoptera reticulata P.S.Ashton	EN	A3cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Cotylelobium burckii (F.Heim) F.Heim	EN	A4cd	Brunei Darusaalam, Kalimantan, Sabah, Sarawak
Dipterocarpus applanatus Slooten	VU	A4cd	Kalimantan, Sabah, Sarawak
Dipterocarpus caudiferus Merr.	NT	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Dipterocarpus confertus Slooten	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Dipterocarpus cuspidatus P.S.Ashton	CR	A4acd	Sarawak
Dipterocarpus fusiformis P.S.Ashton	EN	A2cd; B2ab(i,ii,iii,iv)	Kalimantan, Sabah
Dipterocarpus geniculatus Vesque	EN	A4cd	Kalimantan, Sabah, Sarawak
Dipterocarpus glabrigemmatus P.S.Ashton	EN	B2ab(iii,v)	Sarawak
Dipterocarpus globosus Vesque	LC	N/A	Brunei Darussalam, Sarawak
Dipterocarpus lamellatus Hook.f.	CR	A2c; D	Brunei Darussalam, Sabah
Dipterocarpus mundus Slooten	VU	A3cd	Kalimantan, Sarawak
Dipterocarpus nudus Vesque	LC	N/A	Brunei Darussalam, Sarawak
Dipterocarpus ochraceus Meijer	EN	B1ab(i,ii,v)+2ab(i,ii,v)	Sabah
Dipterocarpus pachyphyllus Meijer	VU	A2cd	Brunei Darussalam, Sabah, Sarawak
Dipterocarpus stellatus Vesque	VU	A3cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Dipterocarpus tempehes Slooten	EN	A4cd	Kalimantan, Sabah, Sarawak
Dryobalanops fusca Slooten	CR	A4cd	Kalimantan, Sarawak
Dryobalanops keithii Symington	VU	A3cd	Kalimantan, Sabah
Dryobalanops lanceolata Burck	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Dryobalanops rappa Becc.	EN	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Hopea aequalis P.S.Ashton	EN	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Hopea altocollina P.S.Ashton	EN	A4cd; B2ab(i,ii,iii)	Sabah, Sarawak
Hopea andersonii P.S.Ashton	VU	A4cd	Kalimantan, Sabah, Sarawak
Hopea bullatifolia P.S.Ashton	NT	A4cd	Kalimantan, Sarawak
Hopea centipeda P.S.Ashton	EN	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Hopea depressinerva P.S.Ashton	CR	B1ab(i,ii,iii)+2ab(i,ii,iii)	Sarawak
Hopea enicosanthoides P.S.Ashton	EN	A4c; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	Sarawak
Hopea fluvialis P.S.Ashton	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Hopea longirostrata P.S.Ashton	EN	B2ab(i,ii,iii,v)	Sarawak
Hopea megacarpa P.S.Ashton	EN	B2ab(i,ii,iii)	Kalimantan, Sarawak
Hopea mesuoides P.S.Ashton	LC	N/A	Brunei Darussalam, Sarawak
Hopea micrantha Hook.f.	CR	A4cd	Brunei Darussalam, Sabah, Sarawak
Hopea obscurinerva P.S.Ashton	CR	B2ab(i,ii,iii,v)	Sarawak
Hopea ovoidea P.S.Ashton	DD	N/A	Sabah
Hopea pentanervia Symington ex G.H.S. Wood	VU	A3cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Hopea pterygota P.S.Ashton	LC	N/A	Brunei Darusaalam, Kalimantan, Sarawak
Hopea rudiformis P.S.Ashton	CR	A2cd	Kalimantan, Sabah
Hopea rugifolia P.S.Ashton	LC	N/A	Brunei Darussalam, Sarawak
Hopea sphaerocarpa P.S.Ashton	NT	A2c	Sarawak
Hopea tenuivervula (F.Heim) P.S.Ashton	NT	A2cd	Kalimantan, Sabah, Sarawak
Hopea treubii F.Heim	NT	A2cd	Brunei Darussalam, Sarawak
Hopea vacciniifolia Ridl. ex P.S.Ashton	EN	A4c	Brunei Darussalam, Kalimantan, Sabah, Sarawak

Taxon name	Red List Category	Red List Criteria	Distribution
<i>Hopea vesquei</i> F.Heim	LC	N/A	Sarawak
Hopea wyattsmithii G.H.S.Wood ex P.S.Ashton	NT	A4cd	Brunei Darussalam, Sabah, Sarawak
Parashorea macrophylla Wyatt-Sm. ex P.S.Ashton	NT	A4cd	Brunei Darusaalam, Kalimantan, Sarawak
Parashorea parvifolia Wyatt-Sm. ex P.S.Ashton	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Parashorea smythiesii Wyatt-Sm. ex P.S.Ashton	DD	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Parashorea tomentella (Symington) Meijer	LC	N/A	Kalimantan, Sabah
Shorea acuminatissima Symington	VU	A3cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea acuta P.S.Ashton	LC	N/A	Brunei Darussalam, Sarawak
Shorea agami P.S.Ashton	NT	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea albida Symington	VU	A2cd+4cd	Brunei Darusaalam, Kalimantan, Sarawak
Shorea alutacea P.S.Ashton	EN	A3cd+4acd; B1ab(i,ii,iii)+2ab(i,ii,iii)	Sarawak
Shorea amplexicaulis P.S.Ashton	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea andulensis P.S.Ashton	VU	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea angustifolia P.S.Ashton	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea argentifolia Symington	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea asahi P.S.Ashton	NT	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea bakoensis P.S.Ashton	VU	D1+2	Sarawak
Shorea beccariana Burck	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea biawak P.S.Ashton	EN	B2ab(i,ii,iii)	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea brunnescens P.S.Ashton	EN	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea bullata P.S.Ashton	VU	A2cd	Brunei Darussalam, Sarawak
Shorea calcicola P.S.Ashton	EN	B2ab(i,ii)	Sarawak
Shorea carapae P.S.Ashton	NT	A4cd	Brunei Darusaalam, Kalimantan, Sarawak
Shorea chaiana P.S.Ashton	VU	A3cd	Brunei Darussalam, Sarawak
Shorea collaris Slooten	VU	A2cd	Kalimantan, Sabah, Sarawak
Shorea confusa P.S.Ashton	VU	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea cordata P.S.Ashton	EN	B2ab(iii)	Kalimantan, Sarawak
Shorea coriacea Burck	NT	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea crassa P.S.Ashton	LC	N/A	Brunei Darusaalam, Kalimantan, Sarawak
Shorea cuspidata P.S.Ashton	VU	A2cd	Kalimantan, Sarawak
Shorea dispar P.S.Ashton	CR	A3cd	Sarawak
Shorea domatiosa P.S.Ashton	EN	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea elliptica Burck	EN	A2cd	Kalimantan, Sarawak
Shorea faguetioides P.S.Ashton	NT	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea fallax Meijer	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea ferruginea Dyer ex Brandis	VU	A2c	Brunei Darussalam, Sabah, Sarawak
Shorea flaviflora G.H.S.Wood ex P.S.Ashton	VU	A3cd	Brunei Darussalam, Sabah, Sarawak
Shorea flemmichii Symington	VU	A4c; B2ab(iii,v)	Sarawak
Shorea foraminifera P.S.Ashton	CR	A4c	Brunei Darussalam, Sarawak
Shorea geniculata Symington ex P.S.Ashton	VU	A2cd	Brunei Darussalam, Sarawak
Shorea havilandii Brandis	LC	N/A	Brunei Darussalam, Sabah, Sarawak
Shorea hypoleuca Meijer	VU	A2cd	Sabah, Sarawak
Shorea Iliasii P.S.Ashton	CR	A4cd	Kalimantan, Sarawak
Shorea inaequilateralis Symington	EN	A4cd	Brunei Darusaalam, Kalimantan, Sarawak

Taxon name	Red List Category	Red List Criteria	Distribution
Shorea induplicata Slooten	CR	A4cd; C2a(i)	Kalimantan, Sarawak
Shorea isoptera P.S.Ashton	VU	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea kudatensis G.H.S.Wood ex Meijer	NT	B2ab(i,ii,iii)	Sabah
Shorea ladiana P.S.Ashton	VU	A2cd	Brunei Darussalam, Sarawak
Shorea Iaxa Slooten	LC	N/A	Brunei Darussalam, Sabah, Sarawak
Shorea longiflora (Brandis) Symington	VU	A2cd	Brunei Darusaalam, Kalimantan, Sarawak
Shorea lunduensis P.S.Ashton	NT	B1ab(iii)+2ab(iii)	Kalimantan, Sarawak
Shorea macrobalanos P.S.Ashton	VU	A3cd	Kalimantan, Sarawak
Shorea macrophylla (de Vriese) P.S.Ashton	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea mecistopteryx Ridl.	VU	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea micans P.S.Ashton	LC	N/A	Sabah
Shorea monticola P.S.Ashton	LC	N/A	Kalimantan, Sabah, Sarawak
Shorea mujongensis P.S.Ashton	VU	A4cd	Kalimantan, Sabah, Sarawak
Shorea myrionerva Symington ex P.S.Ashton	NT	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea obovoidea Slooten	VU	A4cd	Kalimantan, Sarawak
Shorea obscura Meijer	VU	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea ochracea Symington	VU	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea pachyphylla Ridl. ex Symington	EN	A4cd	Brunei Darussalam, Kalimantan, Sarawak
Shorea pallidifolia P.S.Ashton	EN	A2cd	Kalimantan, Sarawak
Shorea parvistipulata F.Heim	LC	N/A	Brunei Darussalam, Sabah, Sarawak
Shorea patoiensis P.S.Ashton	NT	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea pilosa P.S.Ashton	NT	A2cd	Brunei Darussalam, Sabah, Sarawak
Shorea pinanga Scheff.	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea polyandra P.S.Ashton	VU	A2cd+4cd	Kalimantan, Sabah, Sarawak
Shorea praestans P.S.Ashton	CR	A3cd+4cd	Sarawak
Shorea pubistyla P.S.Ashton	LC	N/A	Sarawak
Shorea quadrinervis Slooten	VU	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea retusa Meijer	VU	A2cd+4cd	Kalimantan, Sabah, Sarawak
Shorea revoluta P.S.Ashton	CR	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea richetia Symington	VU	B1ab(iii)	Sabah, Sarawak
Shorea rotundifolia P.S.Ashton	CR	A3cd+4cd	Sarawak
Shorea rubella P.S.Ashton	VU	A2cd	Brunei Darussalam, Sabah, Sarawak
Shorea rubra P.S.Ashton	NT	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea sagittata P.S.Ashton	NT	A3cd	Sarawak
Shorea scaberrima Burck	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea slootenii P.S.Ashton	VU	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea smithiana Symington	VU	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea splendida (de Vriese) P.S.Ashton	EN	A4cd	Kalimantan, Sarawak
Shorea stenoptera Burck.	NT	A2cd	Kalimantan, Sarawak
Shorea subcylindrica Slooten	VU	A2cd	Kalimantan, Sabah, Sarawak
Shorea superba Symington	VU	A2cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Shorea symingtonii G.H.S.Wood	VU	A2c	Sabah
Shorea tenuiramulosa P.S.Ashton	EN	A4cd	Sabah, Sarawak
Shorea venulosa G.H.S.Wood ex Meijer	LC	N/A	Sabah, Sarawak

Taxon name	Red List Category	Red List Criteria	Distribution
Shorea waltonii G.H.S.Wood ex Meijer	NT	B2ab(i,ii,iii)	Sabah
Shorea woodii P.S.Ashton	EN	B1ab(i,ii,iii)+2ab(i,ii,iii)	Sarawak
Shorea xanthophylla Symington	NT	A4cd	Brunei Darussalam, Sabah, Sarawak
Upuna borneensis Symington	VU	A2cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica adenanii Meekiong, Nizam, Latiff, Tawan & Yahud	CR	B1ab(i,ii,iii)+2ab(i,ii,iii)	Sarawak
Vatica albiramis Slooten	LC	N/A	Brunei Darussalam, Sabah, Sarawak
Vatica badiifolia P.S.Ashton	VU	A2cd	Brunei Darusaalam, Kalimantan, Sarawak
Vatica borneensis Burck	NT	A4cd	Brunei Darussalam, Sarawak
Vatica brevipes P.S.Ashton	NT	A4cd	Kalimantan, Sarawak
Vatica cauliflora P.S.Ashton	CR	A4cd	Kalimantan
Vatica chartacea P.S.Ashton	EN	A4cd	Kalimantan, Sabah, Sarawak
Vatica compressa P.S.Ashton	VU	A3cd+4cd; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	Sarawak
Vatica congesta P.S.Ashton	EN	B2ab(iii)	Kalimantan, Sarawak
Vatica coriacea P.S.Ashton	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica dulitensis Symington	NT	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica endertii Slooten	EN	A4cd; B2ab(i,ii,iii)	Kalimantan, Sarawak
Vatica glabrata P.S.Ashton	VU	B1ab(iii,v)+2ab(iii,v)	Brunei Darussalam, Sarawak
Vatica globosa P.S.Ashton	EN	A4cd	Kalimantan, Sarawak
Vatica granulata Slooten	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica micrantha Slooten	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
<i>Vatica oblongifolia</i> Hook.f.	LC	N/A	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica palungensis P.S.Ashton	DD		Kalimantan
Vatica parvifolia P.S.Ashton	VU	A3cd	Brunei Darussalam, Sabah, Sarawak
Vatica patentinervia P.S.Ashton	CR	D	Brunei Darussalam, Sarawak
<i>Vatica pedicellata</i> Brandis	VU	A2c; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	Sarawak
Vatica pentandra P.S.Ashton	CR (PE)	B1ab(i,ii,iii)+2ab(i,ii,iii)	Kalimantan
Vatica rotata P.S.Ashton	EN	A4cd	Kalimantan, Sabah, Sarawak
Vatica rynchocarpa P.S.Ashton	EN	A2cd+3cd+4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica sarawakensis F.Heim	VU	A4cd	Brunei Darussalam, Kalimantan, Sabah, Sarawak
Vatica vinosa P.S.Ashton	NT	A2cd	Brunei Darussalam, Sabah, Sarawak



Shorea rotundifolia (Ling CY)



Shorea myrionerva (Ling CY)

Appendix 2 IUCN Red List Categories and Criteria

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time-frame appropriate to the taxon's life cycle and life form.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time-frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

NEAR THREATENED (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

THE CRITERIA FOR CRITICALLY ENDANGERED, ENDANGERED AND VULNERABLE

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk of extinction in the wild:

- A. Reduction in population size based on any of the following:
 - An observed, estimated, inferred or suspected population size reduction of ≥90% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
 - (a) direct observation
 - (b) an index of abundance appropriate to the taxon
 - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
 - (d) actual or potential levels of exploitation
 - (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
 - 2 An observed, estimated, inferred or suspected population size reduction of ≥80% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may

not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

- A population size reduction of ≥80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
- 4. An observed, estimated, inferred, projected or suspected population size reduction of ≥80% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
 - 1. Extent of occurrence estimated to be less than 100 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at only a single location.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 - 2. Area of occupancy estimated to be less than 10 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at only a single location.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.

- c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
- C. Population size estimated to number fewer than 250 mature individuals and either:
 - 1. An estimated continuing decline of at least 25% within three years or one generation, whichever is longer, (up to a maximum of 100 years in the future) OR
 - 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
 - (a) Population structure in the form of one of the following:
 - (i) no subpopulation estimated to contain more than 50 mature individuals, OR
 - (ii) at least 90% of mature individuals in one subpopulation.
 - (b) Extreme fluctuations in number of mature individuals.
- D. Population size estimated to number fewer than 50 mature individuals.
- E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:

- A. Reduction in population size based on any of the following:
 - An observed, estimated, inferred or suspected population size reduction of ≥70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
 - (a) direct observation
 - (b) an index of abundance appropriate to the taxon
 - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
 - (d) actual or potential levels of exploitation
 - (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

- An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- A population size reduction of ≥50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
- 4. An observed, estimated, inferred, projected or suspected population size reduction of ≥50% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
 - 1. Extent of occurrence estimated to be less than 5000 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than five locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 - 2. Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than five locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence

- (ii) area of occupancy
- (iii) area, extent and/or quality of habitat
- (iv) number of locations or subpopulations
- (v) number of mature individuals.
- c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
- C. Population size estimated to number fewer than 2500 mature individuals and either:
 - 1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR
 - 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
 - (a) Population structure in the form of one of the following:
 - (i) no subpopulation estimated to contain more than 250 mature individuals, OR
 - (ii) at least 95% of mature individuals in one subpopulation.
 - (b) Extreme fluctuations in number of mature individuals.
- D. Population size estimated to number fewer than 250 mature individuals.
- E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

- An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
 - (a) direct observation
 - (b) an index of abundance appropriate to the taxon
 - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

- (d) actual or potential levels of exploitation
- (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
- An observed, estimated, inferred or suspected population size reduction of ≥30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- A population size reduction of ≥30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
- 4. An observed, estimated, inferred, projected or suspected population size reduction of ≥30% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, AND where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
- B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:
 - 1. Extent of occurrence estimated to be less than 20,000 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than 10 locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
 - 2. Area of occupancy estimated to be less than 2000 km², and estimates indicating at least two of a-c:
 - a. Severely fragmented or known to exist at no more than 10 locations.

- b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
- c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
- C. Population size estimated to number fewer than 10,000 mature individuals and either:
 - 1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR
 - 2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
 - (a) Population structure in the form of one of the following:
 (i) no subpopulation estimated to contain more than
 - 1000 mature individuals, OR
 - (ii) all mature individuals are in one subpopulation.
 - (b) Extreme fluctuations in number of mature individuals.
- D. Population very small or restricted in the form of either of the following:
 - 1. Population size estimated to number fewer than 1000 mature individuals.
 - 2. Population with a very restricted area of occupancy (typically less than 20 km²) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.
- E. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

Source: IUCN (2012)



The Red List of Bornean Endemic Dipterocarps

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