The Red List of Dipterocarpaceae

E. Khoo, M. Barstow, C. Maycock, V. Bodos, K.Y. Chong, L.S.L. Chua, D. Cicuzza, S. Deepu, A. Dhyani, A.N. Divina, G.T. Eduarte, V.M. Evangelista, S.K. Ganesan, R.C. Gibe, N. Gunatilleke, S. Gunatillke , Z. Haji Berudin, A. Hamidi, P.K Hoo, T. Jimbo, S. Juiling, Y.W.C. Kusuma, Y. Kusumadewi, C.Y. Ling, R.C.J. Lim, H.K. Lua, J.M.P. Magbuo, P.L. Malabrigo Jr., R. Majapun, A. Maryani, X.Y. Ng, R. Nilus, J.T. Pereira, J. Sang, H.H. Rachmat, S. Ranasinghe, A. Randi, I. Robiansyah, J.S. Solatre, J.S. Strijk, J.B. Sugau, JW. Tang, S. Tanggaraju, M.M.B. Tating, A.B. Tobias, S. Tsen, A.G.A. Umali, E. Velautham, Y.X. Xiao, W. Yong and W.B. Yu.

BOTANIC GARDENS CONSERVATION INTERNATIONAL
IUCN SSC
GTSG
GTA Global Tree Assessment
BINHI
energy DEVELOPMENT CORPORATION
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FRIM

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, Singapore and Kenya.

THE IUCN/SSC GLOBAL TREE SPECIALIST GROUP (GTSG) forms part of the Species Survival Commission's network of over 10,500 volunteers working to stop the loss of plants, animals and their habitats. SSC is the largest of the seven 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 and to act in an advisory capacity to the Global Trees Campaign.

Shorea symingtonii seedings (E. Khoo)

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COVER PHOTOS

Front cover: Mixed dipterocarp forest, Sabah (Cede Prudente)
Back cover: *Shorea ladiana* (Ling CY)

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December 2022

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Acknowledgements

For some, the attempt to complete conservation assessments for the entire family of Dipterocarpaceae would have been deemed an ambitious undertaking but through the effort to understand these tropical rainforest giants, total strangers have been brought together across various cultures and parts of the world and friendships have been forged. The production of this publication is a huge collaborative effort and would not have been possible without the support and contributions from our friends from various countries. Those who have contributed to this report are recognised as authors and a full list of the authors and their associated institutions are listed in Appendix 3.

We would like to express our sincere thanks and appreciation to the authors who have contributed the country profile reports and case studies. These reports have provided an overview of the conservation work that is carried out in-country, and the importance of these species across their range. Therefore, providing a greater understanding of the family and the roles of Dipterocarpaceae in each country. The case studies have been inspiring and proved to be an interesting addition to this report. Our humble appreciation to those who have provided many amazing photos. All of whom are recognised in individual photo credits.

Without the contribution of assessments we would not have been able to produce this report and give a global view of the current scenario and threats faced by this family. Our sincere gratitude to all the assessors who took the time in compiling and performing the assessments. Not to forget the regional reviewers, Global Tree Assessment partners, IUCN Species Survival Commission Global Tree Specialist Group members and others who have commented and reviewed IUCN Red List assessments for this family. The involvement of multiple parties has not just provided a better overview of species survival at the global level, but also a holistic view of the next steps to be taken to ensure their continued persistence.

Last and not least, our sincere thanks and appreciation to the organizations who have provided financial support to the assessment of Dipterocarpaceae species. This includes governmental agencies, research institutions, universities, private companies and others. Not to forget, The IUCN - Toyota Red List Partnership for funding 'The Barometer of Life: Global Timbers Species' project, Franklinia Foundation for Supporting the Global Tree Assessment and the IUCN Species Survival Commission Grants for their funding of the production of this publication.

IUCN Red List Categories

- EX Extinct
- EW Extinct in the Wild
- CR Critically Endangered
- EN Endangered
- VU Vulnerable
- NT Near Threatened
- LC Least Concern
- DD Data Deficient
- NE Not Evaluated

Innoprise Corporation Sdn. Bhd. (Sabah) and IKEA's restoration project site (E.Khoo)

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Shorea faguetioides (Ling CY)

Neobalanocarpus heimii (Rafidah. A. R.)

Executive Summary

The Red List of Dipterocarpaceae is published following the efforts of over 50 individuals, from at least 15 organizations, from across the global range of dipterocarps. For the first time, this report contains analysis of all 535 species of Dipterocarpaceae, their global conservation status and builds on national and regional red list publications.

Dipterocarpaceae, commonly known as dipterocarps, is an abundant tree family. The centre of diversity is in Southeast Asia, where they make up a significant proportion of the forest biomass. Aside from the ecological role the family plays it is highly valued for its timber and other products such as oleoresins and oils. As a result, of the socioeconomic value of Dipterocarpaceae and land use change within the region, the family has been put at significant risk in the wild.

The report finds that 357 (67%) species of Dipterocarpaceae are Threatened. This includes 70 species assessed as Critically Endangered. Unfortunately, one species, *Hopea shingkeng*, is already assessed as Extinct. A further 22 species are Data Deficient, indicating more information is needed.

Dipterocarpaceae is a taxonomically diverse family with 17 genera, including five monotypic genera. The genus *Shorea* is largest and contains 186 species (121 Threatened). While, the Sri Lankan endemic genus *Stemenoporus* has 26 species all of which are assessed as Threatened.

Indonesia and Malaysia are home to the greatest number of dipterocarp species. Consequently, these two countries also contain the highest number of Threatened species. Sri Lanka and India have comparitively fewer species, however due to the high number of single country endemics, a higher proportion of threat is observed there. Outside of Asia, 10 Threatened species are found in the continent of Africa. Analyses also found 201 single country endemics, of which 84% are Threatened in the wild.

It was reported that 400 species are impacted by land use change and land conversion for agricultural use especially for industrial plantations. As this is a major threat, *in situ* conservation efforts are a particular conservation priority. Fortunately, 71% of dipterocarps are found in protected areas. In combination with management of these sites and production forest, monitoring, habitat restoration and rehabilitation are also recommended conservation actions.

Due to the family's timber value, logging and timber harvesting are recorded as the second major threat. To mitigate this, there is a need to promote and expand Sustainable Forest Management practices across the board, alongside greater enforcement and research in this field. Finally, fire and climate change are identified as interlinked and emerging threats.

With 67% of dipterocarps Threatened, and even more species experiencing a population decline (including not threatened species), prioritising conservation action for this family needs thoughtful consideration. There are numerous successful conservation measures in place and a plethora of skills available. It would be timely for the wider conservation community to take note of these opportunities and promote knowledge sharing; thus ensuring the expansion and continuation of these important activities and objectives.

The production of *The Red List of Dipterocarpaceae* was a huge collaborative effort. It is essential that this collaboration continues to be fostered, with efforts now directed towards practical conservation actions. It is hoped this report highlights the plight of dipterocarps in the wild, and shows that long term sustainable action is required to reduce the extinction risk to this iconic tree family. There is still much to understand about the conservation of dipterocarps, but this report provides a road map to expand our knowledge, continue our exploration and inspire future efforts.

Background

"We should preserve every scrap of biodiversity as priceless while we learn to use it and come to understand what it means to humanity." E. O. Wilson

As the light of dawn shines upon the rainforest, it would be hard to not notice the towering Dipterocarpaceae trees that dominate this tropical habitat. Their overwhelming presence in the tropics has amazed and gained the interests of many. This family is particularly iconic in Southeast Asian forests where they can be dominant at all levels of the canopy (understory to emergent) and form much of the lowland forest habitat (Slik et *al*. 2023, Ghazoul 2016, Ashton 1998).

Unding Jami climbing up *Shorea faguetiana*, 100.8 m tall in Danum Valley, Sabah (Unding Jami)

Genus	Common timber names for species within genus
Anisoptera	Mersawa
Cotylelobium	Resak
Dipterocarpus	Keruing
Dryobalanops	Kapur
Hopea	Merawan, Giam
Parashorea	Gerutu
Shorea	Balau, Meranti (Dark red, red, white or yellow)
Vateria	Copal
Vatica	Resak/rassak

Table 1: Genera of Dipterocarpaceae and trade names associated with species within each genus

Globally there are a total of 535 species of Dipterocarpaceae in 17 genera distributed across four continents (Africa, Asia, Oceania and South America) with Southeast Asia being the center of diversity for the family. In particular, the island of Borneo is home to at least 260 dipterocarp species (Bartholomew et *al*. 2021).

Dipterocarpaceae are prized for their timber which is traded internationally. Dipterocarpaceae are traded under several trade names (Table 1). The hardwood traded as Meranti is particularly desirable given the varieties of colors, workability and strength available. In general, dipterocarp timber can be used to make veneer, furniture, packing materials, for decorative purposes and much more. Dipterocarps alone provided >85% of Indonesia's timber exports (Ghazoul 2016).

Alongside timber production several species are utilized for resins, nuts and camphor. These products are utilized by rural communities, and products are also sold at local markets. Aside from local interest, dipterocarps are recognized internationally as the family containing the world's tallest tropical tree, *Shorea faguetiana*, found in Danum valley Sabah, measuring 100.8 m tall (Shenkin et *al*. 2019).

Ecologically, Dipterocarpaceae are of great importance providing habitat to a wide range of flora and fauna. Dipterocarps provide vital ecosystem services in many of the regions they are found, including regulation of climate, water and soil cycles; as well as protection against extreme weather events (fire, flooding, etc). The mast fruiting and flowering exhibited by dipterocarps is of particular biological interest and there is a growing knowledge base of the ectomycorrhizal associations dipterocarps form in forests in Asia and Colombia (Case study 1).

Despite all these points of interest and intrigue, dipterocarps and their forests are ravaged by threats. Logging and land use change has reduced the extent covered by dipterocarp forest in lowland areas in much of Southeast Asia and the rest of the world. Major land use change for agricultural plantations such as oil palm, *Acacia* and others causes permanent loss of trees and habitat. While other threats such as fire and shifting agriculture have led to temporary land use change.

Appanah (1998), previously identified that the timber potential of Dipterocarpaceae was limited by the lack of compilation of comprehensive information available due to factors such as: (1) Differing interests due to species diversity and presence; (2) Dissimilar emphasis on forest management and variable institutional strength in research and development; (3) Lack of coalition and cross country institutional links; and (4) Information availability and degree of accessibility on topics related to this family. Ironically, these same factors influence the conservation of this family as well.

With the increasing demand for both natural and land resources, it is anticipated that conservation efforts will be even more challenging for dipterocarps in the future. Over the last few decades research and interest in dipterocarps has changed from their use as an economic resource to preservation of the species in the wild. This includes developing sustainable management plans for logging concessions and other forested land, maintaining protected areas, developing conservation and production nurseries and other *ex situ* and *in situ* conservation activities. There is national, regional and international support in place to conserve dipterocarps in the wild. However all these efforts can and should be expanded to protect the most threatened species. *The Red List of Dipterocarpaceae* aims to identify which species are threatened at the global level and provide information towards enhanced conservation action.

Raising seedlings for KOPEL, Sabah's restoration project (S. Juhari)

The report

Before the start of the Global Tree Assessment (GTA) in 2015, roughly 130 dipterocarp species had an assessment on the IUCN Red List of Threatened Species, with the majority being assessed in 1998. Since this time, two decades have passed and the IUCN Red List of Categories and Criteria have been updated. Consequently, there was a need to assess the conservation status of all assessed and unassessed Dipterocarpaceae to provide an updated understanding of the conservation need for the family. In recognition of this, the Global Tree Assessment began working towards assessing all species of Dipterocarpaceae in 2017. The assessment process has been a global effort, comprising the efforts of over 50 individuals from at least 15 organizations from across the globe (Appendix 3).

This work has built on national initiatives which have been producing national assessments for native and endemic dipterocarps for the last ten years or more. For example in Malaysia, efforts have been undertaken to perform national and regional assessments for Sabah (Khoo *et al*. 2022), Sarawak (Sang *et al*. 2014, Sang and Bodos 2016) and Peninsular Malaysia (Chua *et al*. 2010, Yong *et al*. 2021). Dipterocarps have also been assessed as part of regional floras, species monographs and red data books in The Philippines, China, Singapore, Sri Lanka, Malaysia, Vietnam, Cameroon, Lao PDR, Burkina Faso and Indonesia (BGCI 2022a). To date, there are at least 250 dipterocarp species that have national/regional assessments (BGCI 2022a). National assessments are of great importance for conservation prioritisation and informing policy and decision making, particularly around the trade and harvest management of dipterocarps at the national level.

To complete IUCN Red List assessments for dipterocarps at the global level, The Global Tree Assessment hosted one regional workshop in Brunei Darussalam and one online workshop to bring partners together and finalize global assessments. The results of the first workshop have been published in *The Red List of Bornean Endemic Dipterocarps* (Bartholomew *et al*. 2021). Alongside completing assessments in workshops, assessments have also been shared and reviewed via email and there have also been organizational level review meetings coordinated by national Global Tree Assessment partners to complete assessments for endemic species. These efforts have led to consistent publication of IUCN Red List assessments for dipterocarps since 2017. Already 368 assessments have been published and the remainder will be published in 2023.

In the compilation of *The Red List of Dipterocarpaceae,* initiatives have been taken to involve researchers not only in production of the assessments but also in the production of this report. This has led to the inclusion of country reports (Section III) which provide an overview of dipterocarps in eight countries where they are native. This intends to give readers an introduction to the forest management regime, institutional strength, conservation measures and cross institutional links that are currently in place. This report therefore provides both a global and national perspective on the conservation of dipterocarps.

Webinars and e-learning modules on taxonomy, horticultural conservation, red list updates and plant identification have also been organized to disseminate knowledge. In addition, cross country joint collaboration towards conserving dipterocarps in the field, such as the "Securing the Threatened Tree Giants in Borneo" have been carried out to improve and develop a living collection network for threatened dipterocarps. This project also focused on building technical skills of local researchers.

To build upon the foundation established through existing work, the Global Conservation Consortium for Dipterocarps (GCCD) was established in 2020 with the aim to build a support network among the Dipterocarpaceae research community. At the same time coordinating and working with the greater community in developing and implementing strategies in the conservation of Dipterocarpaceae. Recommendations and conservation actions needed are identified in this report and should guide the work of the GCCD.

Mixed dipterocarp forest (S.K.Ganesan)

Material and Methods

Species list preparation

In preparation for this report, the species list was generated from the following references: BGCI's GlobalTreeSearch database (BGCI 2022b), Tree Flora of Sabah and Sarawak, Volume 5 (Ashton 2004) and the Malaysia Plant Red List: Peninsular Malaysian Dipterocarpaceae (Chua *et al.* 2010). Individual states and countries also shared their native species lists to ensure all names were compiled. During this process, all accepted species names were considered and name validity was checked against the World Checklist of Vascular Plants (WCVP) (POWO 2022). The species list was compiled at the end of 2021, therefore names published post 2021, or accepted on the WCVP after 2021, have not been included. The names that are used in the report are based on the accepted names during the time of assessment. A complete species list is provided in Appendix 1.

While compiling the species list, species that had not been previously evaluated using the IUCN Red List Categories and Criteria and those that were assessed before 2013 were selected for assessment or reassessment.

Data gathering

Pre-assessment, a list of native species was provided to each country and their respective agencies, institutions, researchers and local experts to assist in the data gathering process. Distribution data, information on habitat preference, ecology, population, conservation measures, use and trade were all gathered. From the information provided, assessments were written and distribution maps were generated. The points used to generate the maps are generally from georeferenced herbarium records and when available, recent data points from field surveys, expeditions and research plots were used as well. Therefore, the distribution dataset provided for each species varies.

Parashorea macrophylla (Vilma Bodos)

Assessment process

Given the diversity of Dipterocarpaceae, the assessment of all species was broadly handled in two separate methods: single country endemics and widespread species. Details of these two methods are as follows:

Single Country Endemics

The assessment of single country endemic species was broadly led by Global Tree Assessment partners made up of in-country government agencies, institutions and researchers. These assessments were completed as part of country level tree assessment projects and, following assessment, BGCI provided the technical review of the prepared assessments. Therefore, the assessments for endemic species were completed by assessors at country based organisations using georeferenced herbarium records, coupled with field surveys and research plots data. Some of the collaborative partners are as listed in Table 2.

Country	Agencies/Institutions
India	Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI), Kerala Forest Research Institute
Indonesia	Fauna & Flora International (FFI) Indonesia Programme, National Research and Innovation Agency (BRIN), Arboretum Sylva Universitas Tanjungpura
Malaysia	Forest Department Sarawak (FDS), Forest Research Institute Malaysia (FRIM), Forever Sabah (FS), Sabah Forestry Department (SFD), Universiti Malaysia Sabah (UMS)
Philippines	Energy Development Corporation, Proseeds Development Assoiciation Inc., University of the Philiipines Los Banos

Table 2: List of in-country assessment partners for the assessment of endemic and widespread Dipterocarpaceae.

Widespread species

As for species that are recorded in more than one country or are widespread across a continent or region, BGCI staff members compiled data from online resources, publications and literature to produce draft assessments for each species. Additional data for draft assessments was also provided by in-country partners, institutions, researchers and local experts. These were then reviewed by local experts through a variety of methods.

Application of IUCN Categories and Criteria

To complete assessments, the Geospatial Conservation Assessment Tool (GeoCAT – www.geocat.kew.org) was used to perform geospatial analysis of each species. Distribution data compiled at the *data-gathering* stages was used to generate a map and give an estimate of a species' geographic range. Two measures were taken; the extent of occurrence (EOO) and the area of occupancy (AOO). Following this, for some species the decline in EOO and AOO was calculated using the Reduction Analysis (RA) tool in GeoCAT. Through the process, occurrence points were removed if the species no longer existed in the recorded area (Bachmann *et al.* 2011). This enabled the calculation of decline and provided an update on the geographic range size. Based on the results from RA, species were assessed against as many criteria as possible. Should Criterion A be used, a standard generation length of 80 years was used for species in this family, unless otherwise stated and justified. Following the IUCN Red List mapping guidelines (IUCN Standards and Petitions Subcommittee 2019), individual points from the RA process were coded accordingly, showing points that are still 'present', 'extinct' or with 'presence uncertain'.

Fruit of *Shorea macrophylla* (Agusti Randi)

In combination with the results from RA or if a species could not be assessed using RA, available information and risk factors (past/present/future) that will affect a species' survival were taken into account and used to assign a species to one of the nine IUCN Red List Categories (Figure 1). Should the data meet the thresholds, the species were assigned to one of three Threatened categories - Critically Endangered (CR), Endangered (EN) or Vulnerable (VU). In cases where the threat thresholds were almost met, the species was assessed as Near Threatened (NT). Any species that did not meet the threat thresholds were classified as Least Concern (LC), while species with insufficient information were assessed as Data Deficient (DD). Species that are assessed as NT and LC are grouped as "Not threatened". For the full IUCN Red List methodology please see the IUCN guidelines (IUCN Standards and Petitions Subcommittee 2019).

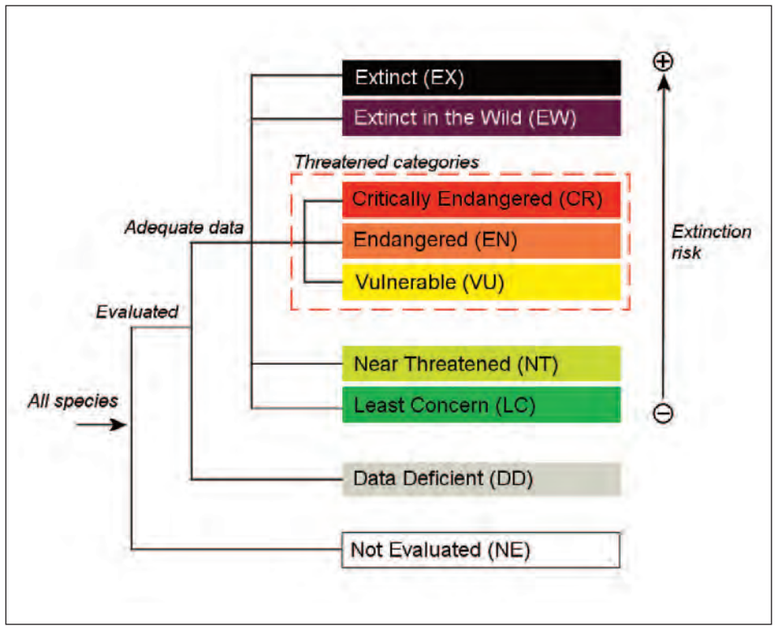


Figure 1: Structure of the IUCN Red List Categories (version 3.1) (Credit: IUCN)

Shorea cuspidata (Ling CY)

Assessment Review

In accordance with IUCN Red List regulations, those who carried out the species assessments are named as assessors, and those who contributed data for the assessments were listed as contributors. While those who reviewed the assessments are listed as reviewers. All assessments have undergone review by either relevant experts in regional institutions, members of the IUCN Global Tree Specialist Group or staff members at BGCI. A full list of assessors, contributors and reviewers involved in the assessments can be found in the Appendix 3, and in each individual species assessment.

In the reviewing process, the assessment reports are sent out to individual reviewers for comment and feedback. This was done for the single country endemics, some of the species assessed as Least Concern and assessments reviewed by BGCI. However, for widespread Dipterocarpaceae review workshops were hosted to finalise the assessments. A total of two workshops (in-person and online) were organised. They aimed to bring together regional experts to assess species shared among the region and to review draft assessments in the IUCN SIS database.

The first workshop was held at the Universiti Brunei Darussalam in 2019. This workshop focused on completing assessments for Bornean endemic dipterocarp species which, included reviewing both reassessments and the first assessments of several species. The results of this workshop are published in *The Red List of Bornean Endemic Dipterocarps* (Bartholomew et *al.* 2021). The second workshop was held online spanning over four days in 2022. The workshop was supported by the IUCN Species Survival Commission. The goal of these workshops was to review reassessments for species and to complete assessments for the remaining dipterocarp species that had no assessment; with the aim of producing this report - *The Red List of Dipterocarpaceae*.

Across these workshops, more than 200 dipterocarp assessments were reviewed. The review process involved representatives from each region, who work on different aspects of research of this family. The suggested Category and Criteria used in each draft assessment were discussed, and adjusted accordingly. Additional information and data points were incorporated, while reviewers' comments were taken into account in the refinement of the draft assessments prior to submission to the IUCN Red List Unit. The assessments can be found on the IUCN Red List of Threatened Species (www.iucnredlist.org).

Results

Summary

- 357 species of dipterocarp are assessed as Threatened on the IUCN Red List
- 270 species are assessed using Criterion A and overall the majority of species experience population decline.
- Dipterocarpaceae are found in 46 countries in four continents: Africa (27 species), Asia (500 species), Oceania (12 species) and South America (1 species)
- There are 201 single country endemic species, 84% of these species are assessed as Threatened.
- Malaysia has the most species of dipterocarp, followed by Indonesia and Brunei Darussalam, these three countries also have the highest numbers of threatened species
- The major threat is agricultural land use change, particularly industrial agricultural development. Large scale, intentional logging is the second major threat
- 71% of dipterocarp species are recorded in at least one *in situ* conservation site. Major conservation needs are habitat protection and management, and *in situ* conservation management. conservation needs for the family
- Over 60% of dipterocarp species are not known from *ex situ* collections, this is also identified as a conservation need for the group.

Masting in the Upland Dipterocarp forests in Sabah (R.C. Ong)

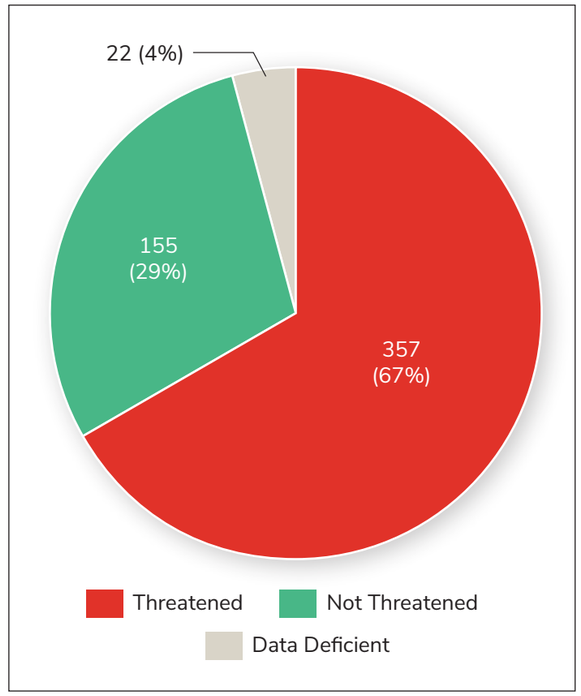


Figure 2: Summary of threat status for Dipterocarpaceae

Threat Status

There are 535 species assessed for *The Red List of Dipterocarpaceae*. Of these, 70 species are assessed as Critically Endangered, 143 are Endangered and 144 are Vulnerable. Therefore, 357 species are Threatened. There is one documented Extinct species, while 22 species are assessed as Data Deficient. The remaining 155 are Not Threatened, with 73 species assessed as Near Threatened and 82 species assessed as Least Concern (Table 3).

The single Extinct species is *Hopea shingkeng*, recorded to be native to China and India. The last record for *H. shingkeng* was in 1911, collected from the Outer Abor Hills, Eastern Himalaya by I. H. Burkill.

Category	Number of species
Extinct (EX)	1
Critically Endangered (CR)	70
Endangered (EN)	143
Vulnerable (VU)	144
Near Threatened (NT)	73
Least Concern (LC)	82
Data Deficient (DD)	22

Table 3: Number of Dipterocarpaceae assessed in each of the IUCN Red List Categories

Category	Number of species
A (Population size reduction)	270
B (Geographic range)	161
C (Small population size and decline)	24
D (Very small or restricted population)	18

Table 4: The IUCN Red List Criteria used to assess the 357 Threatened Dipterocarpaceae species
(note that some species are assessed using more than one criteria)

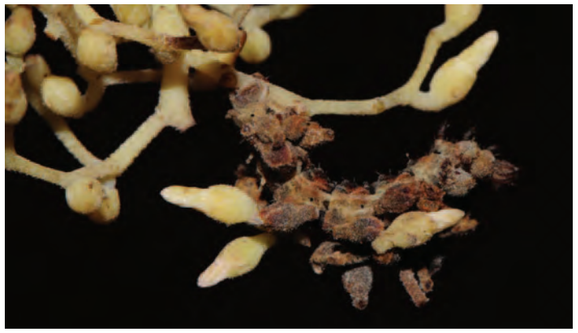
Criteria Used

Overall, of the five IUCN Red List Criteria, Criterion A (population size reduction) is used with greatest frequency during the assessment of Dipterocarpaceae (Table 4). This was followed by Criterion B, Criterion C then Criterion D. Criterion E was not used.

Criterion A

Criterion A has been be widely applied due to the use of reduction analysis methods, which takes into account habitat loss due to land use change, loss of forest cover and species occurrence within or outside of the countries' protected areas, to provide an estimate of population reduction. Given that much of the data used to infer population decline was from habitat or range loss/change subcriteria c was used with the greatest frequency as evidence for Criterion A.

Almost half the species assessed using Criterion A were assessed under A2 (170 species) which documents the past population decline of a species. The high frequency of use is likely due to a greater amount of information available for historical forest decline as well as information on present threats, habitat protection measures and conservation plans for the species



Comibaena attenuata feeding on flowers of *Shorea xanthophylla* (A.Y.C. Chung)

of concern. An example is *Shorea collaris* (VU A2cd), a Bornean endemic which, although widespread and common, has experienced a decline of over 30% based on Global Forest Watch (WRI 2022) analysis and consideration of other threats to the species.

For species predicted to experience greatest decline in the future or across a moving window encompassing past and future decline criterion A3 or A4 was used, respectively. This was the case for *Vatica parvifolia* (VU A3cd) and *Shorea iliasii* (CR A4cd). These Criteria were used over 100 times illustrating the likelihood of continuing population loss for these species over the next 100 years.

Criterion B

The second most frequently used Criterion was Criterion B, applied 161 times. Criterion B was used for species with small/restricted geographic ranges and continuing decline. Hence, 85% of species assessed using Criterion B are single country endemics. For example *Hopea scabra* (CR B1ab(iii)), which is endemic to Sudest Island, Papua New Guinea, is impacted by threats of land use change and logging on the island.

Hopea fluvialis (Ling CY)

Geographic Analysis

Dipterocarpaceae are found in 46 countries in four continents: Africa (27 species), Asia (500 species), Oceania (12 species) and South America (1 species). The greatest number of genera occur in Asia and most of the genera occur in more than one country (Table 5), with the exception of four genera: *Balanocarpus*, *Pseudomonotes*, *Stemenoporus* and *Vateriopsis* (Table 6).

Malaysia has the highest number of recorded species (340 species), followed by Indonesia (278 species) and Brunei Darussalam (171 species) (Figure 3).

There are 201 (38%) single country endemic species (Appendix 2) and the majority of these (84%) are Threatened (CR - 55 species; EN - 72 species; and VU - 41 species). There are 334 species that are recorded in two countries or more and 189 of these species have been assessed as Threatened (CR - 15 species, EN - 71 species and VU -103 species). Some species are recorded in over 10 countries e.g. *Anisoptera costata* (EN) and *Dipterocarpus alatus* (VU).

Threatened species follow a similar distributional pattern to species diversity. Where there is a high number of species there is also a high number of threatened species (Figures 4 and 5). Consequently Malaysia has the greatest number of Threatened species (211 species) followed by Indonesia (168 species) and Brunei Darussalam (84 species). Across Indonesia, the diversity of species across the archipelago differs, some species may be island endemics while others will occur across the archipelago. Sumatra and Kalimantan being the most species diverse also have the greatest number of Threatened species.

The majority of countries contain at least one threatened species, with the percentage ranging from 21 to 100% (Figures 4 and 5). Most of the threatened genera are from Asia and Oceania, with the exception of *Monotes* and *Vateriopsis* which are found in continental Africa and the Seychelles. Countries that have no threatened species are often in Africa (Case study 2), and the one species endemic to Colombia, *Pseudomonotes tropenbosii* (LC), is assessed as not threatened (Case study 1).

The majority of species in Sri Lanka and India are endemics. Therefore, Sri Lanka (61 native species) and India (31 native species) have proportionally more Threatened species than Malaysia and Indonesia (Figure 5). With the former two having 96% and 83% of species assessed as Threatened respectively compared to 62% and 60% for Malaysia and Indonesia respectively (Figure 5).

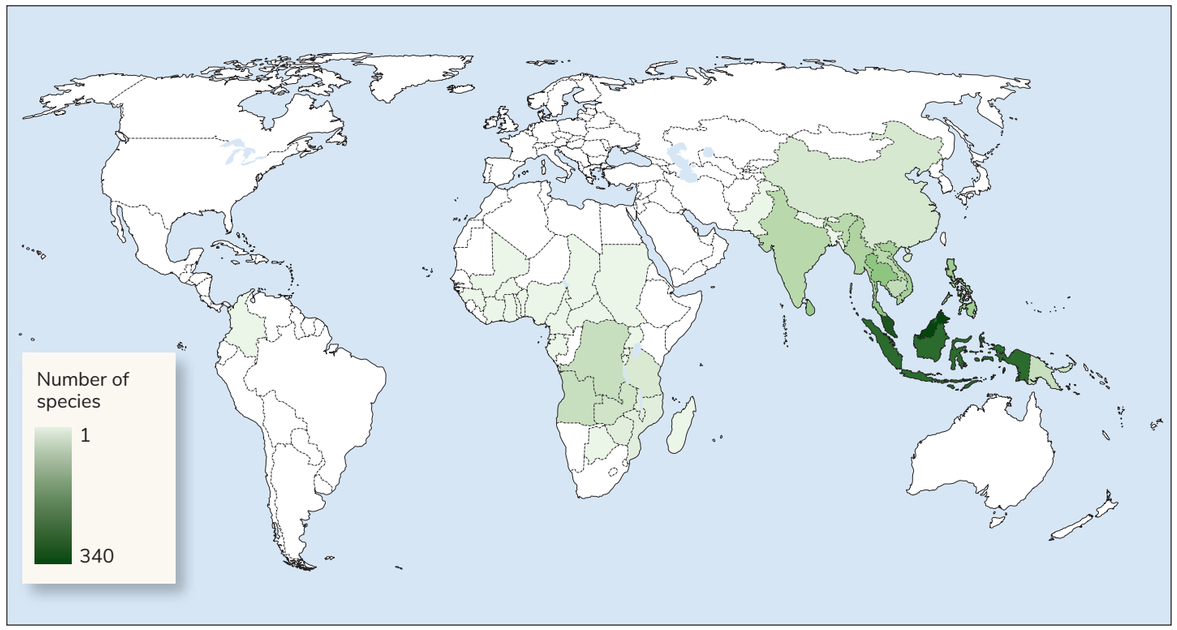


Figure 3: Heatmap for global species diversity of Dipterocarpaceae with lighter green showing low diversity, progressing to dark green with greater diversity.

Hopea enicosanthoides (Ling CY)

Vatica umbonata subsp. *umbonata* (Ulbadus. M)

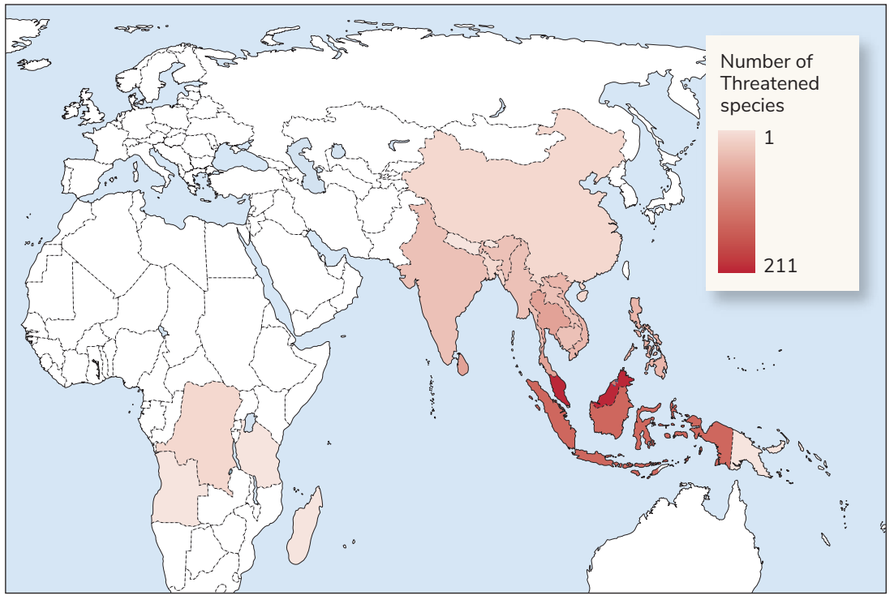


Figure 4: Heat map showing the count of Threatened Dipterocarpaceae present across the globe, with light red tones showing a low number and deep red showing the greatest number.

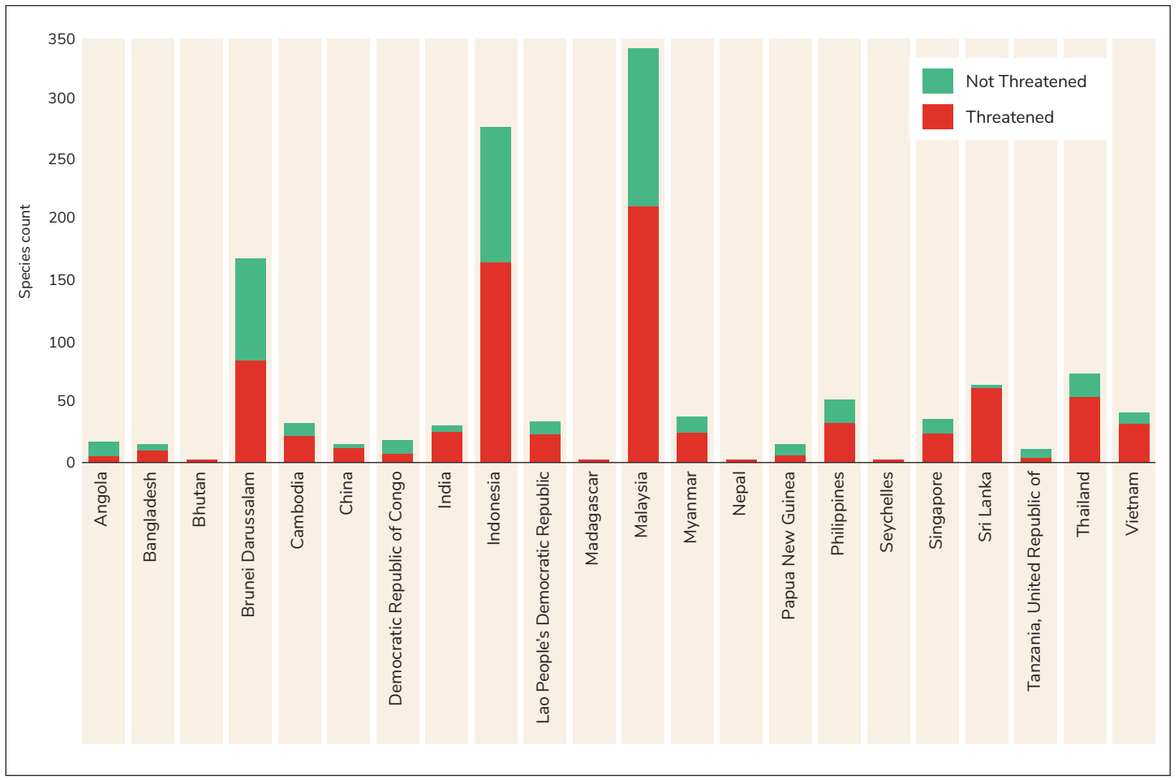


Figure 5: Total number of species in each country split by number of Threatened species (red) and number not-threatened species (green) NOTE: where no Threatened species were recorded in a country, this country has not been included in this figure

Threats

Globally, the major threat to Dipterocarpaceae is agriculture (Figure 6). This threat impacts over 400 species and can threaten a species at a multitude of levels. Land use change for industrial agriculture, for crops such as oil palm, rubber, sugar or plantations for fast growing timber species such as Acaica and Eucalytpus, is a threat to over 250 species. This is a major threat across all genera and specifically species native to lowland forest. Species in highland areas can also be affected by land use change for agriculture, this is often at a small holder level which impacts at least 170 species. This can either be in the form of long term agricultural sites or shifting agriculture for growing cash crops (bananas, rice, tea, coffee, cut flowers).

Logging and wood harvesting is the second major threat to dipterocarps. Similarly to agriculture, logging can occur at different scales. The greatest logging threat to dipterocarps is intentional and at a large scale, with this scale threatening 214 individual species (111 are species of *Shorea*). This differs from other tree groups (e.g. *Magnolia,* Aceraceae etc.), where logging is often unintentional and species decline is a by-product of other logging or land use change activities. Intentional logging has an acute impact on dipterocarps in lowland areas of Southeast Asia. Aside from international trade, logging is also to fulfil domestic needs or subsistence needs, as species in Africa are used.

One threatening activity can often be a catalyst for other threatening events. For example, land use change due to agricultural development is accompanied by the opening of areas for road infrastructure and urban development. On top of this, with the increased accessibility to forested area, it is inevitable that challenges such as encroachment, illegal logging and forest fires will rise. A total of 60 species have fire recorded as a threat, however this number may rise due to prolonged droughts caused by climate change. Thirteen species have been reported to be threatened by climate change.

Mining is also a universal threat impacting dipterocarps across forest types and the geographical range of the family. Although mining is a threat to only 30 species, its impact should not be ignored. A recent study by Giljum *et al.* (2022) found the indirect effects of mining can lead to deforestation as far as 50 km outside the mining area for settlement and lead to other land use changes. Species in Papua New Guinea and Africa are threatened by mining for gold and minerals such as copper, cobalt and uranium, while in lowland rainforests of Indonesia there is limestone and coal mining. In Malaysia, unprotected karst ecosystems are already threatened by mining and emerging threats would be the mining of ultramafic and basic volcanic rock forests.

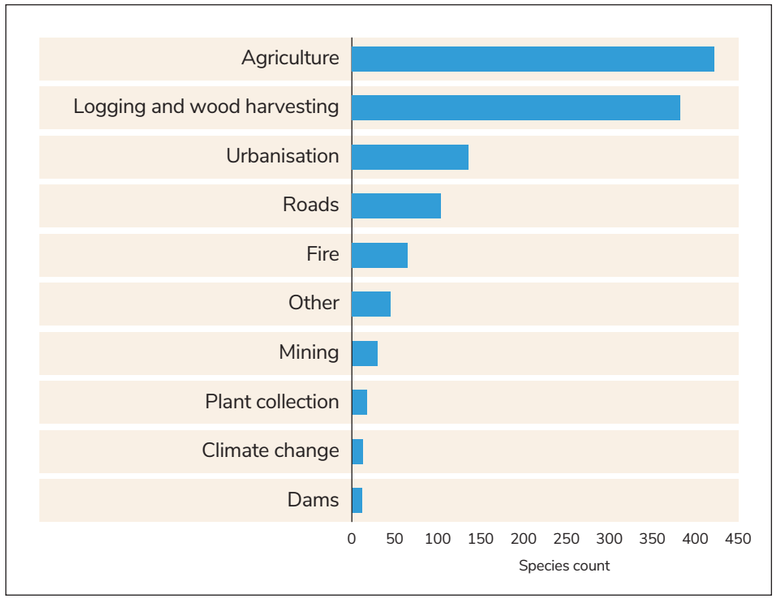


Figure 6: Threats recorded for species of Dipterocarpaceae

Dipterocarpus geniculatus (Ling CY)

Taxonomic analysis

There are 17 genera of Dipterocarpaceae (Figure 7). *Shorea* contains over one third (35%) of the overall Dipterocarpaceae species diversity, being the largest genus with 186 species. It is followed by *Hopea* (112 species), *Vatica* (76 species) and *Dipterocarpus* (65 species). There are also five monotypic genera (Table 6).

Sixty-five percent (65%) of species in *Shorea* are Threatened. *Shorea* species occur in 17 countries all of which are in Asia (Table 5). The genus includes 63 single country endemics, 64% of which are assessed as Threatened.

Anisoptera, *Cotylelobium*, *Dipterocarpus* and *Hopea*, although smaller genera than *Shorea*, host a greater proportion of Threatened species with 70 to 80% of their species assessed as Threatened (Figure 7 and Table 5). These genera are mostly found in Asia and Oceania (Table 5).

Dryobalanops, *Vateria* and *Vatica* all host a similar percentage of Threatened species to *Shorea*, between 57% and 67%, however for *Dryobalanops* and *Vateria* there are far fewer species in the genera. The percentage of Threatened species in *Monotes* and *Parashorea* is below 40% and the genera of *Marquesia* and *Pseudomonotes* contain no threatened species.

Dipterocarpus confertus (Ling CY)

Conversely, there are five genera where all species were assessed as Threatened. One of these genera is *Stemonoporus*, containing 26 species all of which are endemic to Sri Lanka. The greatest threat to these trees is continued decline in habitat area quality, geographic range and severe fragmentation. The other four genera are monotypics (Tables 5 and 6).

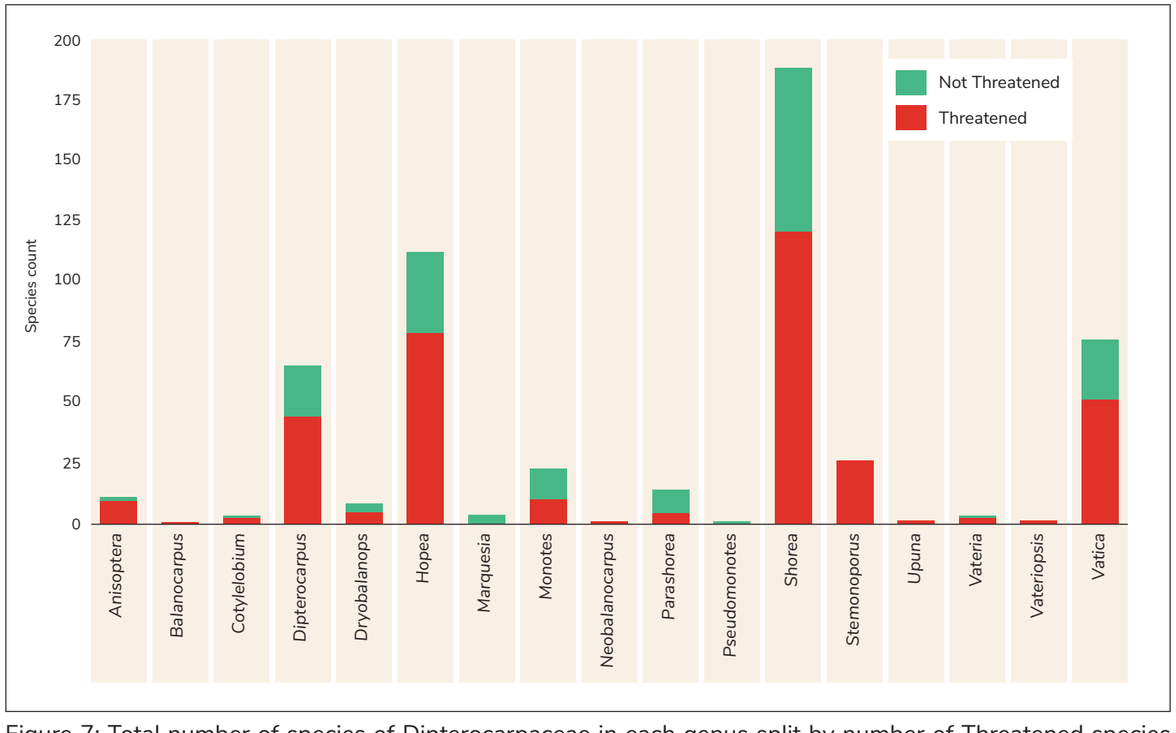


Figure 7: Total number of species of Dipterocarpaceae in each genus split by number of Threatened species (red) and number of not threatened species (green)

Genus	Continent	Number of species	Number of Threatened species	Number of single country endemics	Number of countries recorded
Anisoptera	Asia & Oceania	10	8	0	12
Balanocarpus	Asia	1	1	1	1
Cotylelobium	Asia	5	4	2	6
Dipterocarpus	Asia	65	46	19	14
Dryobalanops	Asia	7	4	1	3
Hopea	Asia & Oceania	112	79	55	15
Marquesia	Africa	3	0	0	6
Monotes	Africa	23	9	10	24
Neobalanocarpus	Asia	1	1	0	2
Parashorea	Asia	14	4	2	10
Pseudomonotes	South America	1	0	1	1
Shorea	Asia	186	120	56	17
Stemonoporus	Asia	26	26	26	1
Upuna	Asia	1	1	0	3
Vateria	Asia	3	2	3	2
Vateriopsis	Africa	1	1	1	1
Vatica	Asia & Oceania	76	51	33	15

Table 5: Summary table of 17 genera of Dipterocarpaceae, including continental occurrence, number of species and Threatened species, rate of endemism.

Taxon Name	Geographic Range	IUCN Red List Category
Balanocarpus kitulgallensis	Sri Lanka	Critically Endangered
Neobalanocarpus heimii	Malaysia (Peninsular Malaysia), Thailand, Singapore	Endangered
Pseudomonotes tropenbosii	Colombia	Least Concern
Upuna borneensis	Brunei Darussalam, Malaysia (Sabah and Sarawak), Indonesia (Kalimantan)	Vulnerable
Vateriopsis seychellarum	The Seychelles	Critically Endangered

Table 6: The five monotypic Dipterocarpaceae genera, with geographic range and IUCN Red List Category

Shorea flemmichii (Vilma Bodos)

Shorea pinanga (Vilma Bodos)

Population trend

Population trend was recorded in the majority of assessments alongside information on population structure, size and extent of decline where available. The majority of species have a declining population trend (407 species – Figure 8). Only 15 species have a stable population trend, and for the remainders (113 species) the population trend is unknown. Seventy-five species are assessed as Threatened but have an unknown population trend. These species are mostly assessed using Criterion B.

Of the 15 species with stable population trend, 12 species are assessed as not threatened and three species are assessed as Threatened (*Shorea bakoensis, S. conica and S. robusta*). In the case of *Shorea bakoensis* (VU D2), it is recorded from two Totally Protected Areas (4,137 ha) in Sarawak where the estimated number of individuals is less than 1,000. Timber harvesting and forest conversion is prohibited in these areas and although the population is small, there is no decline.

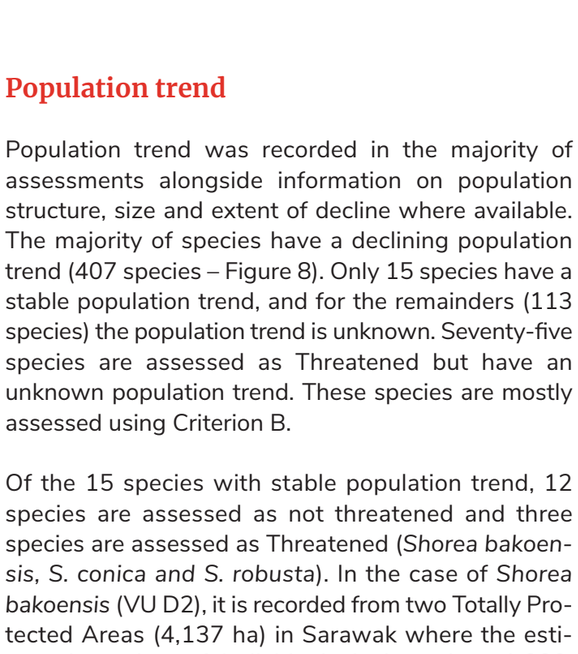


Figure 8: Population trend for all Dipterocarpaceae (blue), compared to the population trend for Threatened Dipterocarpaceae (red)

Shorea rubra (Ling CY)

A species can have a decreasing population trend even if it is not globally assessed as Threatened (Figure 8); this is the case for 59 Least Concern species. These species often have a wide geographic range or where the range is smaller, a large proportion of the population resides in protected areas and therefore the extent of decline is less than the requirements to be assessed in a Threatened category. This is the case for *Vatica micrantha* (LC), a Bornean endemic tree that is in 15 Totally Protected areas across Sabah and Sarawak and additional protected sites in Brunei and Kalimantan. Although the species is frequently encountered, the population is still subject to decline due to occurrence in unprotected, lowland areas which are readily encroached by human activities.

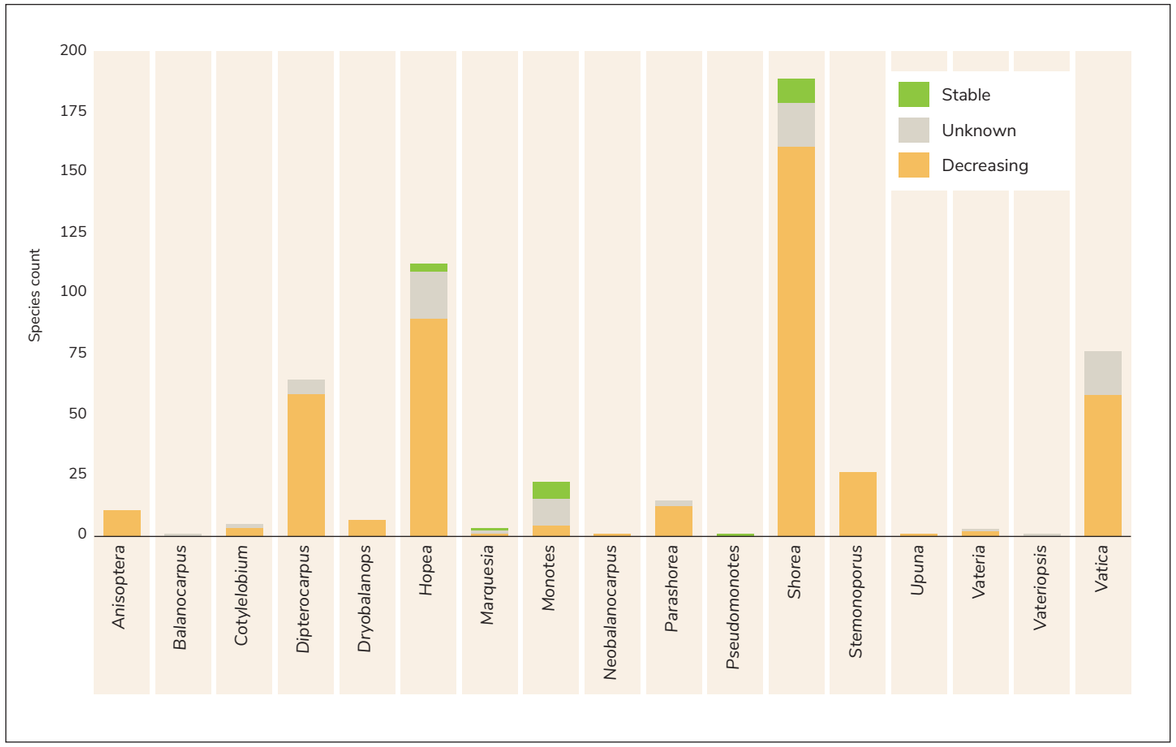


Figure 9: Total number of species in each genus split by population trend: Decreasing (orange), Unknown (grey), Stable (green).

Taxonomically, species experiencing decline are found in 14 genera (Figure 9). For the genera of *Anisoptera, Dryobalanops, Neobalananocarpus, Stemenoporus and Vateria*, all species suffer a continuing decline (Figure 9). Geographically, population decline is experienced most acutely in Asia. The majority of single country endemics also have a declining population trend (111 species).

Shorea smithiana (David Bartholomew)

Habitat

Dipterocarpaceae are reported to occur in 15 habitat types following the IUCN Red List Habitats Classification Scheme, Version 3.1 (2012). Some species have a wide distribution range and occur in multiple habitat types, while some have a restricted range and habitat preference. For example, *Parashorea malaanonan* (LC) has a wide distribution range occurring in four countries in Southeast Asia and has an altitudinal range up to 1,300 m. While, *Shorea micans* (LC), a Sabah endemic, has a smaller distribution occurring in ultramafic forests with an altitudinal range up to 500 m. Similarly, *Vatica flavida* (CR) is endemic to the freshwater swamp forests of Perak in Peninsular Malaysia.

By far the most common habitat type reported is the Subtropical/ Tropical moist lowland forest below 1,200 m (Table 7). It is a very broad definition of lowland habitat, and more information is available regarding habitat at the country level in the country pages. Dipterocarps are found in lowland forests across their geographical range and the majority of species (68%) found in lowland forests are Threatened.

Habitat	Number of species	Number of threatened species
Subtropical/Tropical moist lowland forest below 1,200 m	473	324
Subtropical/Tropical dry forest	45	23
Subtropical/Tropical montane forest	33	13
Subtropical/Tropical swamp forest	27	23

Table 7: Top four habitats for dipterocarps following IUCN Red List Habitat Classification Scheme

Dipterocarps are found in subtropical/tropical dry forest across continental Africa (11 species) and in Southeast Asia, where *Dipterocarpus*, *Hopea*, *Shorea* and *Vatica* species have all been recorded. Although African species are found in dry forest they may also occur in savannah or Miombo forest (Case study 2).

All species recorded from montane forest and swamp forest are from Asia. The number of recorded species from subtropical/tropical montane forest is less than the lowlands because as the elevation increases, the diversity decreases. Fewer species in montane areas are Threatened as much of the forest remains intact due to limited threats or threats occur to a reduced extent. *Vatica* and *Shorea* species are the most frequently recorded from this forest type.

Of all habitat types, tropical swamp forests have the greatest proportion of Threatened dipterocarp species with 23 out of 27 species (85%) assessed as Threatened. This is expected given the alarming rate of Peat Swamp Forest conversion in Southeast Asia (Miettinen *et al.* 2012) for the purposes of agricultural development and human settlement. This type of forest is also prone to fire outbreak.

While the majority of species have a known habitat type, there are nine species reported to have unknown habitat types, in which three species are Threatened, while the remaining six are Data Deficient.

Uses

There are 395 species of Dipterocarpaceae with a recorded use in their assessment. Of these, 253 species are assessed as Threatened, including 33 species assessed as Critically Endangered.

The major use of Dipterocarpaceae is for timber: construction or structural materials and household goods (Figure 10). Dipterocarps are used for timber across their geographical range, in all four continents in which they are present. Also, almost all genera (13) are utilised for timber.

Other uses include the production of non-timber forest products (NTFPs) such as food, fuel, resin, medicine and animal fodder (Figure 10).

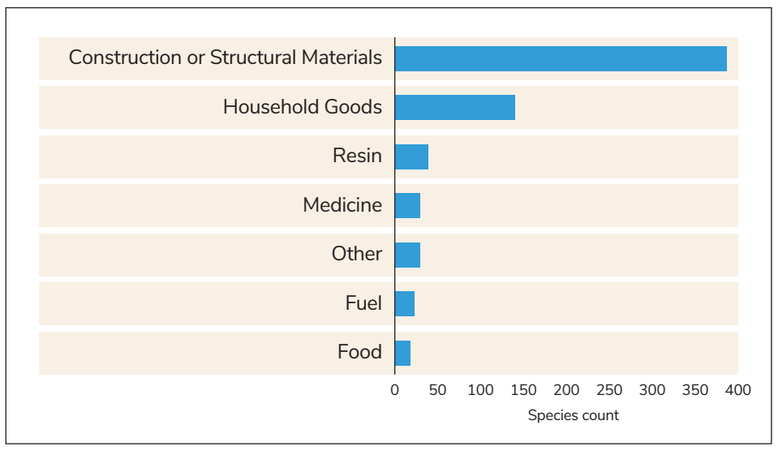


Figure 10: Count of uses for Dipterocarpaceae

Shorea woodii (Ling CY)

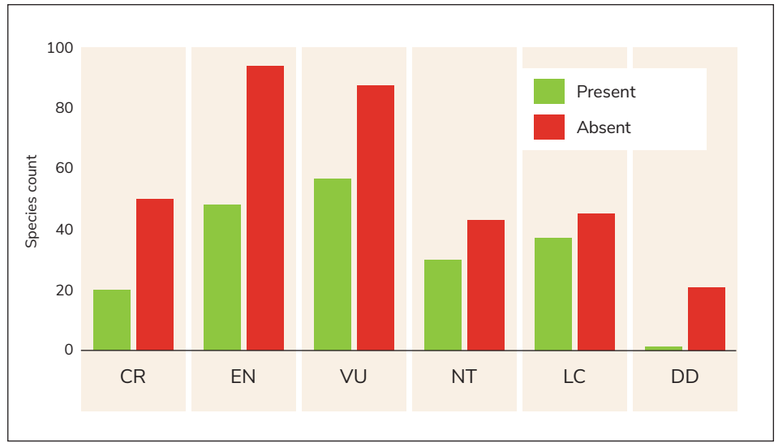


Figure 11: Presence and absence of Dipterocarpaceae species in protected areas per IUCN Red List Category.

Shorea pinanga (Vilma Bodos)

The most common NTFP-use is for resin (7% of species), either in liquid (oleoresin) or solid (dammar) form. Oleoresin is collected from species of *Dipterocarpus* (incl. *D. dyeri* (EN), *D. costatus* (VU) and *D. turbinatus* (VU)) through artificial wounding or burning of trees, to promote resin production. This resin is used as varnish or lacquer, if mixed with dammar from *Shorea* and *Hopea* species, it can be used as caulk. Additionally, nuts from species such as *Shorea macrophylla* (LC), *S. pinanga* (LC), and *S. stenoptera* (NT) are utilised by rural communities in Kalimantan, Sarawak and elsewhere to make a cocoa butter equivalent. While nuts of *Shorea robusta* (VU) are crushed to make seed meals as part of cattle and poultry feed. Use of species and specific species groups are discussed in the country pages.

In situ and *ex situ* conservation

In situ conservation

In situ conservation sites include; protected areas, national parks, forest reserves, wildlife reserves, wilderness areas, community conservation sites and nature reserves. A total of 379 species, representing 71% of dipterocarp species are recorded in at least one *in situ* conservation site, of which 237 species are Threatened (Figure 11). Although a high proportion of Threatened species are found in *in situ* conservation sites, the majority of Critically Endangered species (48) are still not found in them.

Ex situ conservation

Nearly 64% of Dipterocarpaceae are not known from *ex situ* collections. In total, 194 dipterocarp species have *ex situ* collections (Figure 12) established in botanical gardens, parks, nurseries, seed banks, germplasm collections or arboreta across the globe. Most of the species (103 species) are recorded in only one collection and only two species are found in more than 10 *ex situ* collections: *Hopea odorata* (VU) and *Dipterocarpus alatus* (VU).

The majority of species in *ex situ* collections are Threatened species (Figure 12). However, there is still a large number of Threatened dipterocarps not found in *ex situ* collections (231 species). The majority of species found in *ex situ* collections are from the Malaysian-Indonesia hotspot.

Ex situ collections are also not taxonomically diverse. Only the genera of *Cotylelobium*, *Dryobalanops* and *Vateria* have the majority of species in *ex situ* collections which in total represents only 10 species. The greatest collection needs are for Threatened species in the largest Dipterocarpaceae genera as 102 *Shorea* species and 74 *Hopea* species are not currently recorded in *ex situ* collections. Of the monotypic genera only *Upuna* and *Neobalanacarpus* are known to be present in *ex situ* collections.

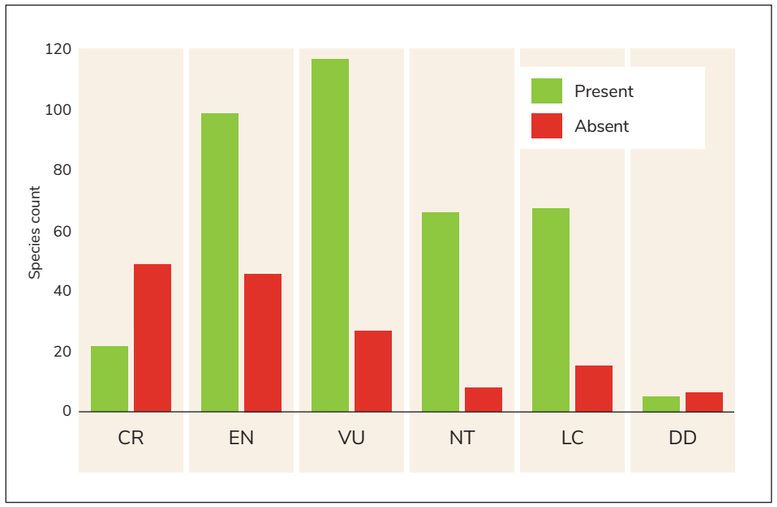


Figure 12: Presence and absence of Dipterocarpaceae species in ex *situ* collections per IUCN Red List Category

Upuna borneensis (Ling CY)

Conservation and research needs for Dipterocarpaceae

Conservation and research recommendations were given for 500 dipterocarps. Given the diversity and number of threatened dipterocarps, there are numerous conservation actions and research needs for the group.

The need for ex *situ* collection was recorded with the most frequency (366 species - Figure 13) across Red List assessments for the family. Prioirty should be given to species not currently in collections, especially the 48 species not covered by ex *situ* or *in situ* conservation actions.

Another major conservation need is *in situ* conservation. This includes activities at the habitat level, such as improving and expanding habitat protection. It can also include restoring and rehabilitating degraded areas. Species level *in situ* conservation action is also needed such as species recovery plans, reintroduction and improved harvest and trade management (species management – 150 species). Both *in situ* and ex *situ* conservation activities need to be supported by law and policy, education and continued research and monitoring efforts

The family would also benefit from research on taxonomy, distribution and ecology, especially for the 22 species that are assessed as Data Deficient. Additionally, monitoring of populations, habitats, harvest and trade will yield information needed for the assessment of effectiveness of conservation actions and decision making relating to this family.

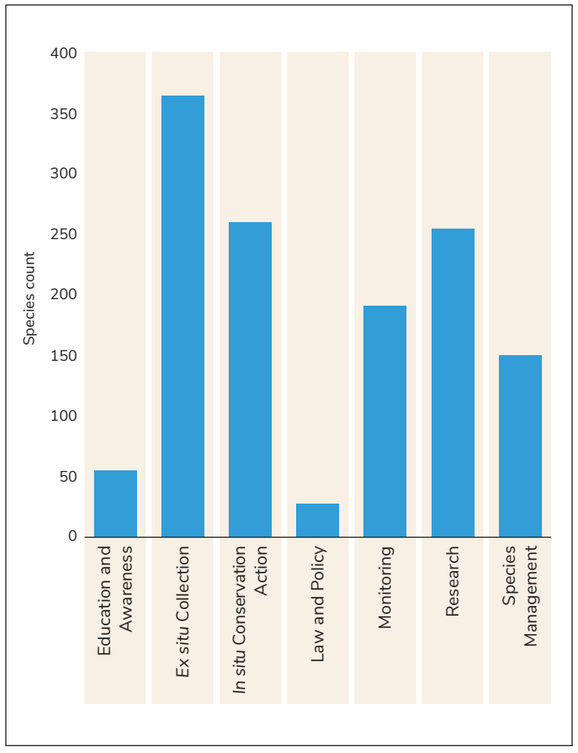


Figure 13: Summary of conservation needs for Dipterocarpaceae

Discussion and Next Steps

The impact of major threats

Agriculture and land use change

Globally, among the many land use change activities contributing to population decline and habitat loss, agricultural development is listed as the major cause. This is also the major threat to all tree species (BGCI 2021). Species in moist lowland forests are most at risk due to the topographic suitability, economical feasibility and substantial return of these areas for commercial crop farming and timber plantation. Conversion and draining of Peat Swamp Forests for agricultural purposes is also practised in the Southeast Asian countries (Miettinen et *al.* 2012), causing a particular threat to species here. Furthermore, as lowland areas become more populated, threats in highland areas are increasing due to land use change. This is not just restricted to shifting agriculture but also smaller holders and cash crop plantings.

Land use change for agriculture causes irreversible habitat loss. This large scale landscape change does not only lead to habitat and biodiversity loss but the continual anthropogenic activities will have further negative impacts on remnant forests, especially in a fragmented forest landscape. These fragments are not just at greater risk of encroachment, forest fires and edge effects, but also species succession and ecosystem service provision. Land use change is also commonly accompanied by development activities such as road building, construction of dams, urbanisation, and mining.

Logging, harvest and trade

Logging is the second major threat to this family, as dipterocarp timber is much demanded in both international and domestic markets. This has been a historical and continuing threat, with logging activities not ceasing as long as there is a demand for timber resources.

In recent decades, countries and related agencies have reviewed their commitments and policies in forest governance, through which, some have begun to employ Sustainable Forest Management (SFM) schemes. These schemes put into consideration ecological, economical and social aspects in the management and utilisation of forest resources. This expands on the use of selective logging methods that were previously used. One such scheme is Reduced Impact Logging (RIL) (Malaysia country pages). The advantages of such schemes focus on safeguarding of environmental services and biological qualities, enhancing the forest's natural ability to regenerate while reducing the negative impacts caused by logging.

To a degree, such schemes do offer protection for certain species and in certain areas, however they are their most effective when properly enforced, which has its associated difficulties. There is also no obligation for all forested areas (e.g. private or state lands) to be managed using these schemes and some countries are yet to develop these policies and schemes. The impact can also be limited as the consideration on harvesting is not species oriented (except for species on prohibited harvesting lists), instead it is on timber stock, harvesting limit, expected yield and the annual allowable cut set.

Vateriopsis seychellarum (Bruno Senterre)

Vatica oblongifolia (E. Khoo)

In general there can be a disconnect between timber resources and their biodiversity, both for dipterocarps and other timber tree species. Currently there is no method of tracing dipterocarp logs and products in the market at the species level. The timber is either traded using common names, wood type or trade codes. This creates a knock on impact to management and conservation activity, as the extent of harvesting at a species level may not be fully understood.

Fire and climate change

With the increasing rate of deforestation and habitat degradation due to human activities, coupled with the effects of climate change where prolonged drought periods are exacerbated during El Niño events, the increase of fire outbreaks is expected. Fires across the Indonesian states of Kalimantan and Sumatra in the late 20th and early 21st centuries have seen the destruction of its lowland dipterocarp forests (Langer and Siegert 2009, Miettenen et *al*. 2012). The impact of this is felt across all habitat types, especially in Peat Swamp Forests due to the fuel provided by existing decomposing organic materials.

Increased fire occurrence is a concern for dipterocarps. The family's reliance on irregular mast fruiting events and variable recruitment rate across species means, their ability to recover from fire incidences is low; should they be able to, it would be a slow process. In turn, this provides an oppurtunity for the establishment of invasive species such as *Acacia mangium* and *Imperata cylindrica* or for the conversion of burnt sites to agricultural land.

Global warming in recent years has seen extreme weather fluctuation such as increased rainfall and prolonged drought periods. How these affect dipterocarp mortality, habitat quality, physiological functioning, phenology, recruitment and distribution remains unknown. Species from different forest types have variable adaptibility and response towards the rapidly changing climate, and this has yet to be understood. Despite initial investigative work that has begun to look at climate change impacts like distribution modelling (Deb et *al*. 2017) and drought effects (Miyamoto et *al*. 2021), questions still remain on the effectiveness of the current management regime and ways to mitigate effects of climate change.

Conservation actions and the way forward

For dipterocarps, a holistic conservation approach with proactive measures needs to be undertaken. Globally, prioritisation needs to be given to the conservation of Critically Endangered species (70 species), however regional efforts and conservation priorities are needed to complement and contribute to the conservation of species in other categories. In the last decade, growing effort and initiatives have been taken on the publication of regional assessments which have helped to provide a platform from which to expand dipterocarp conservation and better our understanding of the family.

Continual action is essential to grow conservation activities in place, simultaneously lessons learned and best practises should be shared to enhance efforts. Across the globe, political will and commitment aside, factors that constrain conservation efficacy in different countries are more or less the same: financial and human resources. In short, sustainable funding is needed for all aspects of management, enforcement, monitoring and research as there is still much to be learned about this family. Secondly, human resources in terms of capacity building, knowledge, technological transfer and stakeholder engagement, are essential particularly with regards to species conservation and site management.

Many of the conservation actions listed below are currently pursued; some actions are well established while others are at their initial stages.

Expand and enhance *in situ* conservation actions

Since the establishment of the Aichi Biodiversity Targets, numerous countries have made the commitment to set aside 17% of their land as protected areas made up of national parks, wildlife reserve networks or key biodiversity area systems. As The new Kunming-Montreal Global Biodiversity Framework (2022) calls for effective management and conservation of at least 30% of land and sea for nature by 2030, it is hoped there will be a continual increase of protected areas (PAs).

The lack of reference and knowledge regarding the environmental and species composition of old growth forests has posed challenges in managing and monitoring biodiversity in current protected areas - as many of these sites have experienced disturbances in one form or another. Therefore, for *in situ* conservation, efforts need to be given to the management and monitoring of such sites, with emphasis on long term effectiveness, considerations of law enforcement; resource availability; edge effects; viable population sizes; community involvement; landscape approach and many others factors. In South Asia, studies have shown that 44% of the protected areas are less than 5 km^2, in which 22% are less than 1 km^2 (Chowhudry et *al*. 2022). It is only a matter of time when small fragments of protected areas are converted due to degrading habitat quality and pressure from surrounding anthropogenic activities. Steps need to be taken to prevent such change from occurring.

- Investigate further the *in situ* conservation needs for the 48 Critically Endangered species not recorded in the PA system, where possible include the habitats into the PA system or if not possible consider species for ex *situ* collection.
- In existing *in situ* sites the following should be considered
  - Identification of Key Biodiversity Areas (KBAs).
  - Study on the habitat integrity, quality and connectivity of the current PA systems and potential threats affecting biodiversity trends in the long term.
  - Implementation of targeted area/ species management plans.
  - Adopt an integrated landscape approach in the management and governance of PAs at the state/country and transboundary level.
- For site management, research in silviculture treatment, habitat quality, phenology, plant physiology, seedling recruitment and others are much needed to periodically improve and review the management system.
- Both long and short term research projects are needed to study the effects of climate change on dipterocarps expanding the work in Deb et *al*. 2017 and Miyamoto et *al*. 2021.

Shorea leprusola (Henti Hendalastuti)

Work towards sustainable management of dipterocarps

The demand for raw materials and continuous logging of this family has led timber harvesting to be the second greatest threat to dipterocarp species. Although commitments and effort have been made by governmental and related agencies in improving the management of selective logging schemes, more can be done to enhance and extend the application of these schemes across the globe.

- Encouraging private landowners and small holders to adopt sustainable management schemes and practises. One such globally recognised methodology that could be applied is the Forest Stewardship Council or The Programme for the Endorsement of Forest Certification.
- National timber harvest legislation should be updated to reflect the current threat status of species, therefore ensuring highly threatened species are managed and limited throughout trade.
- Research on the effectiveness of sustainable logging practices for maintaining species diversity, viable population sizes, regeneration and ecosystem stability are needed.
- Additional research on how systems of functional restoration, replanting and plantation can support logging concessions would be beneficial.
- Work towards the identification of species/timber groups in trade, at various points of the supply chain, building on DNA work currently ongoing on this aspect. In particular, obtain data on species that are heavily targeted, which can in turn inform harvest and policy decision making.

Raise awareness and build collaborations

- Create opportunities for involvement in conservation actions for communities residing in and adjacent to PAs, including involvement in species management programs and conservation management plans for PAs or boundary areas of the PA system. Knowledge sharing with all stakeholders towards being environmental stewards should be supported.
- Promote collaborations and share best practices in various fields of research and conservation particularly for *ex situ* and *in situ* conservation management. Strengthen regional networks working towards shared goals for dipterocarps, through discussions and meetings in various organisations and consortias such as the Global Conservation Consortium for Dipterocarps (GCCD).
- Educating schools, universities, ministries and the general public on topics such as importance of dipterocarps as a natural resource, their current threats and conservation needs. In particular, catalyse information sharing with consumers, so they understand where the timber is sourced and can make more informed decisions

***Ex situ* conservation actions**

- In the absence of habitat protection, imposing threats and lack of collection in known protected sites, the last option is the establishment of *ex situ* collections, in particular for Critically Endangered species.
- Encourage national greening programs to plant native dipterocarp species and where possible threatened dipterocarps. These actions should be supported by research into best methods of propagation, and planting for dipterocarps as well as establishing production and restoration nurseries.

Shorea macrophylla (Ling CY)

Conclusions

Just as dipterocarps are diverse, so are their conservation needs. Threats towards this family are interlinked and in order to address the issues and challenges present, research and conservation activities for dipterocarps should not occur in silos. The conservation actions and recommendations given here are a global call to action, and suggest actions needed at a global scale. However, conservation is carried out at the local level and efforts need to make regional and national sense as well. Nationally, current efforts on survey, monitoring, protection, conservation and education need to be maintained. While globally, there is a need to encourage and create opportunities for knowledge sharing as well as working to provide sustainable support and funding for conservation action.

As discussed at different stages of the report, conservation focus can be at the level of genera, regional, habitat or species. However, there is an urgent need for species specific conservation action plans. For example *Shorea tumbuggaia* (EN) an Indian endemic, is in decline due to land use change and unregulated timber harvest as the oleoresin is needed for pharmaceutical purposes. Research is needed in the sustainable harvest of oleoresin while maintaining population stability. Another example is the rare *Shorea thorelii* (VU), which has experienced population decline due to logging and habitat degradation, therefore targeted trade policy and conservation planning is needed to bring this species back from the brink.

The conservation need for dipterocarps is great, but not impossible. In producing *The Red List of Dipterocarpaceae*, a call to action was answered across the world to develop an understanding of the extinction risk to this special group of trees. It is through the efforts of this group that this report could be produced, and it is through their efforts and support of the institutions for whom they work that conservation for dipterocarps is keenly being pursued. Already there are global initiatives working to protect forests and national programmes to protect and manage dipterocarps and individual species-level conservation programmes saving dipterocarps from extinction. All of these offer cause for hope. Here we call on the rest of the botanical and conservation communities, across botanic garden, arboreta, forestry institutes and universities to save threatened dipterocarp species.

Case studies

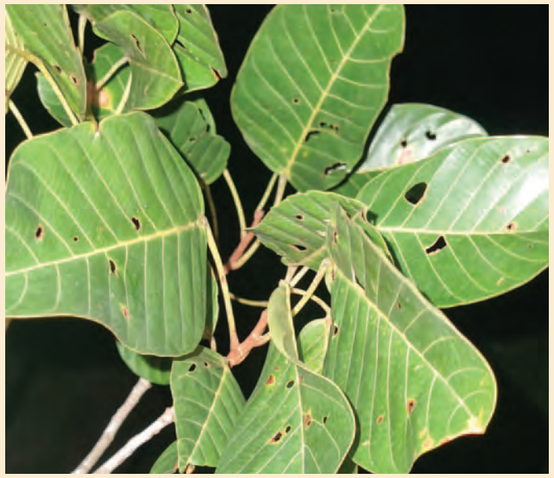
Case study 1: *Pseudomonotes tropenbosii*: the only South American dipterocarp

Aída M. Vasco-Palacios, Nicolás Castaño Arboleda & Sonia Sua Tunjano

Pseudomonotes tropenbosii A.C.Londoño, E.Alvarez & Forero (first published in Brittonia 47: 230 (1995)) is an endemic tree from the Amazonian region in Colombia. It is the only Neotropical species of the family Dipterocarpaceae, and a monotypic genus in subfamily Monotoideae (Maury-Lechon and Curtet 1998). *Pseudomonotes* trees are 25-30 m tall and occur in terra-firme forests in the Amazonian region, primarily in the wet tropical biome. This species has a restricted distribution, and only a few populations in Colombian territory have been reported. The populations grow in small patches of less than 10 ha and are surrounded by a terra-firme mixed forest or flooding forest. Populations of this tree have been found in the Middle Caquetá Amazon region, and one small population in the south of Colombia on sandy sediments.

The ectomycorrhizal (EcM) symbiosis is an ecological feature of *P. tropenbosii*. Ectomycorrhizal fungi are common and diverse, both in terms of species and known EcM lineages. Currently, 89 species of EcM fungi have been found associated with this dipterocarp (Vasco-Palacios and Boekouth 2022). Two new and endemic species of macrofungi were described associated with this tree, *Austroboletus amazonicus* and *Sarcodon colombiensis* (Vasco-Palacios *et al*. 2005, de Grupe *et al*. 2014).

Pseudomonotes tropenbosii is assessed as Least Concern (Lopez-Gallego and Morales 2020) for the IUCN Red List (it has not yet been considered on the National Red List of Colombia). The population is thought to be stable as the forests in these areas are still in relatively good condition (Lopez-Gallego and Morales 2020). However, the populations are located close to indigenous villages. In this region, indigenous peoples use the terra-firme forests to establish chagras or farming areas, where they could destroy entire patches of species. Also, this region is being negatively impacted by illegal mining (Forest 500 initiative). These actions may become future threats to the species. No conservation actions are currently in place for this species. Protection of habitat is needed, which would also entail informing the local communities about the importance of these sites and enforcing policy on land use. Further surveys in the Amazonian region are recommended, to try and identify more populations. Without conservation of the tree species, there is also potential extinction risk to the endemic ectomycorrhizal fungi, known only to be associated with *P. tropenbosii* (Vasco-Palacios *et al*. 2020).



Pseudomonotes tropenbosii (Jorge Mario Vélez)

Case study 2: Dipterocarps in Africa

Peter Meerts and Megan Barstow

Distribution and diversity

The global biodiversity hotspot for Dipterocarpaceae is obviously in Southeast Asia, however some species are also found outside of the region and recorded in countries across Africa, Papua New Guinea and even Colombia.

There are 27 species native to the African continent and Dipterocarpaceae are recorded in 27 countries across the continent. The recorded genera are *Monotes* (23 species), *Marquesia* (3 species) and *Vateriopsis* (1 species), all of which are found exclusively in Africa. There are at least eight distinguishing features between *Marquesia* and *Monotes* (Meerts et *al*. 2017). Both genera are recorded to occur only in continental Africa and Madagascar and together with the South American genus *Pseudomonotes*, they form a distinct subfamily, *Monotoideae*, that occupies a basal position in the Dipterocarpaceae phylogeny (Maury-Lechon and Curtet 1998, Ashton 2003). On the other hand, *Vateriopsis* belongs to the Asiatic subfamily Dipterocarpoideae.

Monotes and *Marquesia*

Monotes are trees and shrubs that are characteristic of dry tropical forests of South-Central Africa and were first described in the 1800's as the first African representatives of the Dipterocarpaceae family (Meerts et *al*. 2017). Being the most species rich genus of Dipterocarpaceae across Africa, *Monotes* contains ten single country endemics while the most widespread species is *Monotes kerstingii* found in 14 countries. *Monotes* species are typically difficult to separate taxonomically, with a number of intermediate species historically recorded. Much taxonomic work was carried out for this genus in the 1900's, with most collections and taxonomic accounts produced by Duvigneaud (Meerts et *al*. 2017). The most recent revision for *Monotes* was published in 2017, which broadly applies a wider species concept and synthetic treatment.

With a record of 15 species, Upper Katanga (i.e. the southernmost part of Democratic Republic of the Congo, included in the Zambezian region) stands out as a prominent centre of diversity of African Dipterocarpaceae. There, *Monotes* and *Marquesia* are characteristic of dry, semideciduous woodlands, locally known as miombo woodlands, dominated by *Brachystegia, Isoberlinia* and *Julbernardia* (Duvigneaud 1958, Werger and Coetzee 1978). Several widespread species appear to be more polymorphic in this region compared to the rest of their range, including *Monotes katangensis*, *M. adenophyllus* and *M. hypoleucus* (Meerts et *al*. 2017, Meerts 2017). This points to Upper Katanga as a possible centre of speciation of *Monotes*. In line with this hypothesis, Upper Katanga hosts three narrow endemics, *M. doryphorus*, *M. duvigneaudii* and *M. hirtii*.

Monotes hypoleucus is a polymorphic species, the members of which were treated at species rank until recently. The extreme forms are striking, but when they integrate it is almost impossible to define the objective limits between them. The most remarkable of these forms are treated at varietal level by Meerts et *al*. (2017) and Meerts (2017).

Vateriopsis

Vateriopsis seychellarum (CR) is endemic to the Seychelles occurring solely on the island of Mahe. It is the only representative of the family in the country and occupies the remaining forest fragments on the island. Forest loss over the past centuries was driven by timber exploitation and land conversion to cinnamon and fruit tree plantations. The exploitation of *V. seychellarum* for timber has led to population decline, with only 132 trees recorded across 11 sites left. Some of these sites recorded only one mature tree and some of these trees are estimated to be between 100 and 200 years old. The remaining trees retained high genetic diveristy, as they are remnants of large historical populations (Kettle et *al*. 2012). *Ex situ* collections need to be established. Collections have to come from the larger subpopulations to ensure the greatest genetic diversity is captured for subsequent breeding programmes to take place. Propagation protocols will need to be in place for collections to be established. At a later stage, propagated materials can be used for reintroduction and population reinforcement across the range. Selected sites should be picked to enhance connectivity between localities.

Country	Species Count	Native taxa
Angola	14	*Marquesia macroura*, *Monotes adenophyllus*, *Monotes africanus*, *Monotes dasyanthus*, *Monotes glaber*, *Monotes glandulosus*, *Monotes gossweileri*, *Monotes engleri*, *Monotes hypoleucus*, *Monotes paivae*, *Monotes pearsonii*, *Monotes redheadii*, *Monotes rubriglans* & *Monotes xasenguensis*
Benin	1	*Monotes kerstingii*
Botswana	1	*Monotes glaber*
Burkina Faso	1	*Monotes kerstingii*
Burundi	1	*Monotes hypoleucus*
Cameroon	1	*Monotes kerstingii*
Central African Republic	1	*Monotes kerstingii*
Chad	1	*Monotes kerstingii*
Congo, The Democratic Republic of the	15	*Marquesia acuminata*, *Marquesia macroura*, *Monotes adenophyllus*, *Monotes africanus*, *Monotes autennei*, *Monotes dasyanthus*, *Monotes doryphorus*, *Monotes duvigneaudii*, *Monotes glaber*, *Monotes hirtii*, *Monotes hypoleucus*, *Monotes katangensis*, *Monotes magnificus*, *Monotes pearsonii* & *Monotes rubriglans*
Côte d'Ivoire	1	*Monotes kerstingii*
Equatorial Guinea	1	*Marquesia excelsa*
Gabon	1	*Marquesia excelsa*
Ghana	1	*Monotes kerstingii*
Guinea	1	*Monotes kerstingii*
Madagascar	1	*Monotes madagascariensis*
Malawi	3	*Monotes africanus*, *Monotes engleri* & *Monotes magnificus*
Mali	1	*Monotes kerstingii*
Mozambique	3	*Monotes africanus*, *Monotes engleri* & *Monotes katangensis*
Nigeria	1	*Monotes kerstingii*
Seychelles	1	*Vateriopsis seychellarum*
South Sudan	1	*Monotes kerstingii*
Sudan	1	*Monotes kerstingii*
Tanzania, United Republic of	8	*Marquesia macroura*, *Monotes adenophyllus*, *Monotes africanus*, *Monotes hypoleucus*, *Monotes katangensis*, *Monotes lutambensis*, *Monotes magnificus* & *Monotes rufotomentosus*
Togo	1	*Monotes kerstingii*
Uganda	1	*Monotes kerstingii*
Zambia	12	*Marquesia acuminata*, *Marquesia macroura* , *Monotes adenophyllus*, *Monotes autennei*, *Monotes africanus*, *Monotes dasyanthus*, *Monotes engleri*, *Monotes glaber*, *Monotes hypoleucus*, *Monotes katangensis*, *Monotes magnificus* & *Monotes redheadii*
Zimbabwe	3	*Monotes engleri* , *Monotes glaber* & *Monotes katangensis*

Dipterocarpaceae native to each country in Africa

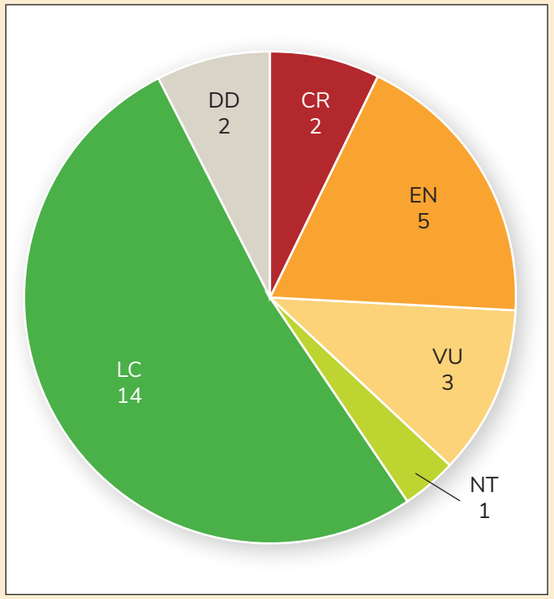
Threats to African Dipterocarpaceae

Of the 27 species, the majority are assessed as Least Concern (14 species), one species is assessed as Near Threatened, while 10 species are assessed as Threatened (CR - 2 species, EN – 5 species, VU – 3 species) and two species are assessed as Data Deficient. Unlike in the global asessment of all dipterocarps, the most frequently used Criteria is Criterion B. The Threatened species are likely to be found in few localities, having a small geographic range and are experiencing continuing decline.

In terms of species diversity, Zambia, Angola and the Democratic Republic of the Congo (DRC) have the greatest diversity with 12, 14 and 15 species respectively (table on page 29). Unsurprisingly countries with high species diversity also have more threatened species, Angola has three threatened species and DRC has five. In the Upper Katanga, although the Miombo woodlands still cover quite a large area, they are decreasing steadily due to charcoal production, shifting agriculture, and mining activities, which threatens the species found there.

Across the continent, the greatest threat is shifting agriculture, affecting 15 species. Although there are threats from logging, it is on a subsistence scale and half of the logging cases are recorded as 'unintentional'. Therefore, the threat is due to commercial timber harvesting of an area rather than targeted harvesting of dipterocarp species in the area. Neither

Monotes katangensis (Pierre Meerts)



Threat status of species native to Africa

Monotes nor *Marquesia* are valued in carpentry (Delevoy 1929, 1930), but if available they are used locally as construction timber (Lemmens 2010). This highlights an important difference between African dipterocarps and those from Southeast Asia; across Africa the group is not highly sought after for its timber and often the trees are shorter than those recorded in Southeast Asia. In fact only eight species have trade and use records in their Red List assessments (*Marquesia acuminata, M. macroura, M. africanus, M. engleri, M. glaber, M. hypoleucus, M. katangensis* and *M. kerstingii*). All utilised species are assessed as Least Concern and the three named uses for these species are as fuel, timber and medicine.

With many species having a small geographical range, there is an urgent need to conduct field surveys to assess the current status of populations of the Threatened species, obtain information on remaining localities, and collect materials for *ex situ* conservation. Additionally, none of the three aforementioned narrow endemics (*Monotes doryphorus, M. duvigneaudii* and *M. hirtii*.) appear to have been collected recently, therefore data gathering is needed for these species and the two species assessed as Data Deficient (*Monotes glandulosus* and *M. xasenguensis*).

Taxon	Distribution	IUCN Assessment
Marquesia acuminata	Congo, The Democratic Republic of the; Zambia	LC
Marquesia excelsa	Equatorial Guinea; Gabon	LC
Marquesia macroura	Angola; Congo, The Democratic Republic of the; Tanzania, United Republic of; Zambia	LC
Monotes adenophyllus	Angola; Congo, The Democratic Republic of the; Tanzania, United Republic of; Zambia	LC
Monotes africanus	Angola; Congo, The Democratic Republic of the; Malawi; Mozambique; Tanzania, United Republic of; Zambia	LC
Monotes autennei	Congo, The Democratic Republic of the; Zambia	LC
Monotes dasyanthus	Angola; Congo, The Democratic Republic of the; Zambia	LC
Monotes doryphorus	Congo, The Democratic Republic of the	VU B2ab(iii)
Monotes duvigneaudii	Congo, The Democratic Republic of the	EN B2ab(iii)
Monotes engleri	Angola; Malawi; Mozambique; Zambia; Zimbabwe	LC
Monotes glaber	Angola; Botswana; Congo, The Democratic Republic of the; Zambia; Zimbabwe	LC
Monotes glandulosus	Angola	DD
Monotes gossweileri	Angola	LC
Monotes hirtii	Congo, The Democratic Republic of the	EN B2ab(iii)
Monotes hypoleucus	Angola; Burundi; Congo, The Democratic Republic of the; Tanzania, United Republic of; Zambia	LC
Monotes katangensis	Congo, The Democratic Republic of the; Mozambique; Tanzania, United Republic of; Zambia; Zimbabwe	LC
Monotes kerstingii	Benin; Burkina Faso; Cameroon; Central African Republic; Chad; Côte d'Ivoire; Ghana; Guinea; Mali; Nigeria; South Sudan; Sudan; Togo; Uganda	LC
Monotes lutambensis	Tanzania, United Republic of	CR B1ab(iii); D
Monotes madagascariensis	Madagascar	EN B1ab(i,ii,iii,iv,v)+ 2ab(i,ii,iii,iv,v)
Monotes magnificus	Congo, The Democratic Republic of the; Malawi; Tanzania, United Republic of; Zambia	LC
Monotes paivae	Angola	EN B2ab(iii)
Monotes pearsonii	Angola; Congo, The Democratic Republic of the	VU B2ab(iii)
Monotes redheadii	Angola; Zambia	NT B1a
Monotes rubriglans	Angola; Congo, The Democratic Republic of the	VU B2ab(iii)
Monotes rufotomentosus	Tanzania, United Republic of	EN B2ab(iii)
Monotes xasenguensis	Angola	DD
Vateriopsis seychellarum	Seychelles	CR B1ab(iii)

Dipterocarpaceae species native to countries in Africa with their geographic range and IUCN Red List Category and Criteria.

Country profiles

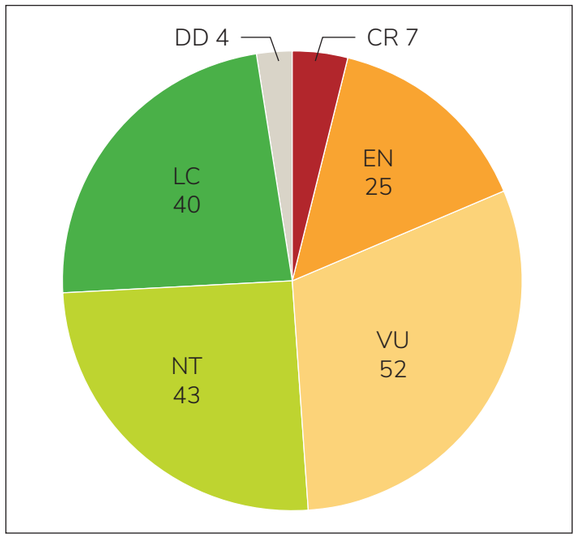
Dipterocarpaceae in Brunei Darussalam

Berudin Z.H., Kampong M., and Cicuzza D.

Introduction

Brunei Darussalam is among the countries with a high percentage of forest cover, with approximately 72.1% of the country's land area under forest cover. The country is well known for its evergreen tropical rainforest and rich biodiversity. In total, seven types of forest can be found in Brunei Darussalam, among which the Mixed Dipterocarp Forest (MDF) is the most dominant forest type. This forest type makes up 41% of the country's entire forests. The Dipterocarpaceae family plays an ecologically important role in the tropical rainforests.

In Brunei Darussalam, nine genera with 171 species of dipterocarp are recorded. From this number, 94 species are Bornean endemics however no known single country endemics are recorded in Brunei Darussalam. The Brunei National Herbarium (BRUN) holds the largest dipterocarp collection in the country and among this collection there are 14 dipterocarp TYPE specimens from Brunei Darussalam.



Threat status of species native to Brunei Darussalam as per the IUCN Red List

Key Facts	
No. of native species	171 (0 endemics)
No. of genera	9
No. of threatened species	84 (7 - CR, 25 - EN, 52 - VU)
Habitat	Mixed Dipterocarp lowland forest
Uses	Timber
Major Threats	Development activities
Conservation need	National assessments, population and distribution research and survey, continued ex situ collection

Threat Status

Of the 171 species native to Brunei Darussalam, 84 are assessed as Threatened, 83 are Not Threatened and four species are Data Deficient. There are seven Critically Endangered species.

In Brunei Darussalam species may be threatened by development projects. However, the major threats to species in Brunei occur outside of the country's borders, and therefore the threats to these species are consistent with those species found across Borneo. Meaning major threats are from unsustainable and illegal logging and agricultural expansion for agro-industrial activity. With these threats not present in Brunei it is a haven for dipterocarps, offering the populations an area of security and stability.

Use and management of dipterocarps

Aside from the ecological value, this family also plays an important economic role in the timber industry. This is due to their physical characteristics, such as strength, durability and appearance which make them favourable for a wide variety of uses and added value products such as building construction, furniture, and handicrafts.

Seed harvesting using Big Shot in the Southeast Asia forests (E. Khoo)

The Forestry Department of Brunei Darussalam has been given the mandate to ensure that the country's forest resources are managed in accordance to the Sustainable Forest Management (SFM) principals. The Department is guided by the Forest Act[1] and the National Forestry Policy[2]. The Forest Act in general outlines the basic law for administration of forest resources, including the harvesting of forest resources. The National Forest Policy on the other hand, provides the comprehensive planning, management principles and guidelines for the country's forest resources.

To ensure timber harvesting from designated production forests is sustainably managed, law and policy stipulates that the guidelines of the Brunei Selective Felling System (BSFS) are to be strictly adhered to by logging companies and supervised by the Forestry Department. The BSFS ensures only selected timbers are logged and threatened species are avoided. BSFS involves pre and post logging assessment of the timber stand through the marking of potential harvestable trees. BSFS also adopts a diameter control system in which only obligatory species of trees above their specified minimum DBH (Diameter at Breast-Height) are selected for harvesting. For example, certain species of *Dryobanalops* (Kapor) and *Shorea* (Meranti) are only to be logged with minimum DBH of 58cm and above. BSFS also involves silvicultural treatments such as enrichment planting, climber liberation cutting and timber stand improvement in logged over forests.

Conservation

Aside from harvesting, both the Forest Act and National Forestry Policy also place great emphasis on the importance of biodiversity conservation and protection. It outlines the comprehensive planning of the biodiversity conservation initiative of the country. This includes the establishment of the Forestry Department's Forest Nursery and *Ex-Situ* collections. The Forest Nursery serves to secure and provide a steady supply of planting materials of native tree species for rehabilitation projects, plantation development, silvicultural applications and community based initiatives. This includes the procurement and nursing of dipterocarp seedlings. The establishment of the Forestry *ex situ* collections focuses on establishing living collections of various groups of forest plants. One example is the collection established in the Forestry Department's Arboretum that is located within the Sungai Liang Recreation Park.

The arboretum houses more than 170 tree species and it includes 35 species of dipterocarp (see p. 35). This forest park is one of the common destinations for environmental educational tours, research and training.

Alongside the Forestry Department, institutions such as the Universiti Brunei Darussalam (UBD) also play a role in the conservation of Dipterocarpaceae. One of the notable projects is the "Securing the Future of Threatened Tree Giants in Borneo" which was funded by the National Geography Society. Through this project, UBD's Botanical Research Center (BRC) planted five Critically Endangered Bornean native dipterocarp species in UBD's botanic garden. Currently, the species are nurtured in the BRC and will be permanently situated inside the botanical garden to enable UBD to study these threatened species and learn how to propagate them for restoration purposes in the future.

In terms of restoration success stories, an exemplary example is the restoration project that was conducted in the Peat Swamp Forest (PSF) of Kuala Belait District. Being part of the Forestry Department's ongoing restoration commitment, more than 600 *Dryobalanops rappa* seedlings were planted within the degraded PSF. At the same time, UBD in collaboration with Singapore MIT Alliance for Research and Technology (SMART) utilized a citizen science approach and planted 200 *Shorea albida* seedlings in the same site. Both of these projects obtained favourable survival rate which were made possible as a result of prior hydrological restoration efforts at the project site. This is a perfect example of reforestation model and can be replicated in other degraded PSF areas. Furthermore, this success is a stepping stone to further develop restoration strategies and programmes for threatened species such as *Shorea albida*.

The country is committed to managing its forest resources in a sustainable manner, which includes the conservation of key and threatened floral species. It is believed that the current management strategies implemented by the Government are in line with the principal of sustainability, especially with regard to forest resources. Undeniably there are certain gaps when it comes to the management of specific floral families or species and in this regard, the Dipterocarpaceae family. Therefore, for better management purposes, comprehensive assessment of their threat status, population dynamics and spatial distribution within the country is crucial. It is believed that information from such assessments will positively influence their management strategies and precise conservation actions to be undertaken.

Seed collection for National Geographic Society project (Jean Linsky)

Endnotes

[1] Forest Act, Chapter 46, Laws of Brunei (revised 2013)

[2] National Forestry Policy, 1989

	Taxon name	Red List Category
1	*Anisoptera laevis*	VU
2	*Anisoptera marginata*	VU
3	*Cotylelobium burckii*	EN
4	*Cotylelobium melanoxylon*	LC
5	*Dipterocarpus borneensis*	NT
6	*Dipterocarpus crinitus*	VU
7	*Dipterocarpus globosus*	LC
8	*Dipterocarpus sarawakensis*	VU
9	*Dryobalanops aromatica*	VU
10	*Dryobalanops beccarii*	LC
11	*Dryobalanops rappa*	EN
12	*Hopea coriacea*	VU
13	*Hopea dyeri*	NT
14	*Shorea acuta*	LC
15	*Shorea agami*	NT
16	*Shorea albida*	VU
17	*Shorea beccariana*	LC
18	*Shorea curtisii*	LC
19	*Shorea geniculata*	VU
20	*Shorea havilandii*	LC
21	*Shorea inaequilateralis*	EN
22	*Shorea laxa*	LC
23	*Shorea macrophylla*	LC
24	*Shorea multiflora*	LC
25	*Shorea ochracea*	VU
26	*Shorea pachyphylla*	EN
27	*Shorea parvifolia*	LC
28	*Shorea patoiensis*	NT
29	*Shorea quadrinervis*	VU
30	*Shorea rubella*	VU
31	*Shorea rubra*	NT
32	*Shorea scaberrima*	NT
33	*Shorea scabrida*	NT
34	*Upuna borneensis*	VU
35	*Vatica micrantha*	LC

Note: LC – Least Concern; NT – Near Threatened; DD - Data Deficient: VU – Vulnerable; EN – Endangered; CR – Critically Endangered. [Source: Brunei National Herbarium (BRUN)]

List of dipterocarps in Brunei Darussalam Forestry Department's Arboretum.

Dipterocarpaceae in China

Jian-Wei Tang, Yun-Xue Xiao and Wen-Bin Yu

Diversity

In China, the tropical rainforests are located at the northern edge of the Southeast Asian tropics, occurring in Hainan, Southwest Guangxi, South Yunnan and Southeast Xizang. Within these areas, the northernmost *Parashorea chinensis* forest is in Bama County, Guangxi. Studies in the tropical rainforests of Xishuangbanna have shown that within these rainforests, dipterocarp species occupy the main canopy strata. In addition, these forests have high biodiversity with 339 different species with DBH ≥ 10 cm present and 468 species with DBH > 1.0 cm, in a single 20 ha, (Lan et al. 2012). The forest also has important ecological functions including carbon sinks (net productivity 18.38 t ha-^{1} yr-^{1}, Tan et al. 2015); soil moisture and water balance regulation; regional climate regulation; and habitat for various life forms. Natural resources from these forests contribute to the local economy, through the provision of natural produce and products and nature tourism opportunities.

Key Facts	
No. of native species	12 (0 endemics)
No. of genera	5
No. of threatened species	9 (7 - EN, 2 - VU) & 1 EX
Habitat	Tropical lowland forest
Uses	No longer utilised
Major Threats	Logging, habitat fragmentation and loss to pulp plantation and cash crops
Conservation need	Reforestation, conservation research

Research

Research and conservation for Dipterocarpaceae in China can be divided into two phases. During the 1950s to 1980s, the focus was species discovery, with the first record of the dipterocarp species being *Vatica mangachapoi* in Hainan (Qu 1956). Then in the 1970s, a new species, *Parashorea chinensis* (an emergent tree up to 80 m tall) was discovered in the Mengla County of Xishuangbanna in the south of Yunnan by researchers from Xishuangbanna Tropical Botanical Garden (XTBG), Chinese Academy of Sciences and Guangxi Forestry Survey and Design Team. Thereafter, more dipterocarp species were recorded, including *Dipterocarpus retusus*, *D. turbinatus*, *Hopea reticulata*, *Shorea assamica*, and *Vatica guangxiensis* (Lin 1978, Yang and Xu 1978). In the 1980s, the second phase of Dipterocarpaceae research took place, which focused on studies of population structure and dynamics, community ecology and conservation. For example:

Parashorea chinensis forest in Bubeng, Mengla County, Xishuangbanna (Hua Zhu)

- *Parashorea chinensis* became one of the well studied species through research collaborations between researchers in Yunnan and Guangxi, who studied the species biological characteristics, wood properties, growth process, community structure and genetic diversity.
- Researchers from XTBG and Yunnan Academy of Forestry and Grassland (YAFG) initiated studies on *D. retusus*, *D. turbinatus* and *S. assamica* forests.
- At Sun Yat-Sen University and Hainan University and Research Institute of Tropical Forestry (RITF), Chinese Academy of Forestry studies were focused on *H. hainanensis*, *H. reticulata* and *V. mangachapoi* forests in Hainan.

Institutes/Collaborative agencies	Research Focus
Xishuangbanna Tropical Botanical Garden (XTBG)	• Taxonomy, seed biology, population dynamics, genetic diversity, community structure, and afforestation. • The garden's dipterocarp collection consists of seven genera, containing 34 species collected from multiple local populations in China and the SE Asia region.
Yunnan Academy of Forestry and Grassland (YAFG)	• Afforestation research • Arboretum with dipterocarp collection • Efforts towards introduction of some dipterocarp species distributed in Yunnan
Sun Yat-Sen University, Hainan University and RITF.	• Dipterocarpaceae species in Hainan.
Chinese Academy of Sciences and Guangxi Nanning Liangfengjiang National Forest Park	• Population and community ecology of *Parashorea chinensis* and *Vatica guangxiensis* in Guangxi.

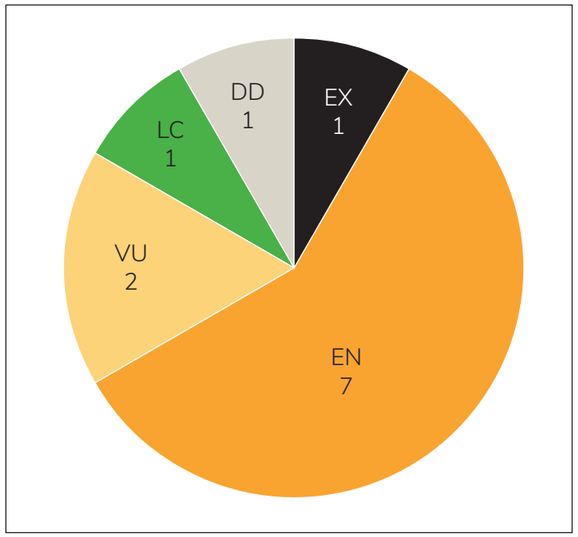
Research and collaborative works carried out by various institutes and universities in China.

In China, various institutes are involved in the research of the Dipterocarpaceae family, some of them are listed in the table above. As for botanical collections, 15 living collections are set up in botanical gardens, arboretums, institutions and universities across China.

Threats

In China there are five genera (*Dipterocarpus*, *Hopea*, *Parashorea*, *Shorea and Vatica*) with 12 species recorded. In the recent publication "List of National Key Protected Wild Plants" (2021), five species (*D. retusus*, *H. hainanensis*, *P. chinensis*, *S. assamica*, *V. guangxiensis*) are listed as first-class protected species, and four species (*H. chinensis*, *H. reticulata*, *H. shingkeng*, *V. mangachapoi*) are listed as second-class protected species. *Hopea shinkeng*, which is native to both China and India, is the only species of dipterocarp assessed as Extinct. On the IUCN Red List, seven Chinese dipterocarp species are assessed as Endangered, two are assessed as Vulnerable and one is assessed as Least Concern. Most Threatened species are experiencing major population decline (over 30% over three generations) and are assessed using Criterion A. Some also have a small geographic range and experience continuing decline (Criterion B).

Shorea assamica in Yingjiang, Yunnan (Jian-Wei Tang)



Threat status of species native to China as per the IUCN Red List

The major threats to these species come from anthropogenic disturbance and land use change, such as forest clearance for cultivation of rubber trees, eucalyptus, teak and other cash crops. Past habitat loss and forest fragmentation have led to changes in the ecological environment. Colonization of these fragmented patches by plants such as bamboos and wild bananas is another factor that has lead to the suppression of natural regeneration of dipterocarps and increased mortality of existing seedlings and saplings in the area.

Conservation

Since 1958, the government of China has established 18 Nature Reserves (ten National, seven Provincial and one County-level) and one National Forest Park, with the aim to protect the existing wild fauna and flora populations in the country (see table below).

The involvement of local communities in conservation actions is essential. To further enhance the management of Nature Reserves, villagers living adjacent to the reserves are trained to become forest rangers and take up patrolling in these areas. Recently, XTBG launched a programme on landscaping with threatened plants in both the countryside and residential areas. Through this programme, a number of dipterocarp trees were planted in three Dai villages and schools near XTBG.

Historically in China, dipterocarps existed in big populations but now they have become infrequent. Although reforestation activities are carried out, usage of species from this family are limited. So far, only *Parashorea chinensis* has been used for this purpose. Experimental plantations using Dipterocarpaceae have been carried out with *P. chinensis* cultivated in Napo County of Guangxi, XTBG, Nabanhe and Puwen Experimental Forest Farm of Xishuangbanna in Yunnan. In XTBG, trials on various planting densities of *P. chinensis* plantation and mixed species planting of *P. chinensis* - *Phoebe puwenensi* were conducted. While at other sites, mixed species planting (*Parashorea chinensis*/*Pometia pinnata*/*Peltophorum pterocarpum* at Puwen Experimental Forest Farm) and intercropping (*Parashorea chinensis*/rubber in Nabanhe watershed) were established. Alongside these activities, monoculture plantations were set up for *Hopea hainanensis* and *D. retusus* in small areas in XTBG.

Dipterocarp Garden at XTBG (Guang-Yu Liu)

Region/Province	National Nature Reserve	Provincial Nature Reserve	County Nature Reserve	National Forest Park
Guangxi	1	1	-	-
Hainan	4	3	-	1
Yunan	5	3	1	-

The number of reserves and parks in each region/province.

Dipterocarpaceae in India

Deepu, S. and Dhyani, A.

Diversity, use and importance

Dipterocarps are one of the most sought after timber species in South and Southeast Asia. Some of the forests are termed Dipterocarp forests owing to their abundance and coverage in these forests. The Indo-Sri Lankan region is a hotspot of Dipterocarpaceae in the Indian Subcontinent (Kundu 2008) particularly in the Western Ghats where they are dominant members of wet evergreen and semi-evergreen forests. In India, dipterocarps are mostly found in forests below 1500 m and form a high proportion of the canopy. Based on their distribution, it can be said that Indian dipterocarps are restricted to peninsular India, North-Eastern India and the Andaman Islands. *Shorea robusta* shows a wider distribution with habitat plasticity.

In peninsular India, lowland evergreen vegetation dominated by dipterocarps is one of the most depleted forest types (Meher-homji 1996). In several places, these forest types have been converted for agroforestry, oil palm and rubber plantation (Achard *et al.* 2014, Carlson *et al.* 2017). The selective and illegal felling of dipterocarps due to their commercial importance in the form of timber and non-timber forest products has led to the dwindling of dipterocarp populations in the past. Prior to this, and where populations are still large, dipterocarps are flagship tree species, providing the architecture of low-elevation evergreen forests. They play an important role in regulating ecosystem function and maintaining community stability. For example *Dipterocarpus bourdilonii* is a keystone species contributing to the forest composition and architecture of the low-elevation forest type (Puttaswamy *et al.* 2012).

The demand for dipterocarp products in Indian markets is high, with timber being the most common and popular usage. Dipterocarp timber is used for a variety of purposes, including for plywood, agricultural implements, carriage and wagon construction, railway sleepers, boat building, jetty piles, furniture, cartwheels,

Key Facts	
No. of native species	31 (14 endemics)
No. of genera	5
No. of threatened species	25 (4 - CR, 12 - EN, 9 - VU) & 1 EX
Habitat	Wet evergreen and semi-evergreen forest
Uses	Timber (light and heavy construction), Medicine, Damar
Major Threats	Logging and agroindustry
Conservation need	Monitoring, *ex situ* collection

beams, planks, poles, roofing, flooring, and in bridge construction. *Shorea assamica*, *S. robusta*, *Dipterocarpus* spp., and *Hopea odorata* are well-known in trade. Some species of *Dipterocarpus* and *Shorea* are used to make dug-outs, while a few *Hopea* species are used for boat building. Apart from their timber value, dipterocarps are also extensively harvest for their resin, oleoresin, oil and tannin. *Shorea*, *Vateria* and *Hopea* provide dammer of commercial value. In particular, Chua oil, rock dammar, white dammar and sal dammar are popular. Resin is widely used medicinally, for home varnishing and for making candles etc. (Shrijani *et al.* 2018). *Dipterocarpus alatus*, *D. costatus*, *D. gracilis*, *D. indicus*, *D. turbinatus*, *Hopea odorata*, *Shorea tumbuggaia*, *S. robusta*, and *Vateria indica* are used as medicines.

Vateria indica seedlings transplantation (Anurag Dhyani)

History of Research and Organizations involved

The first taxonomic account of Indian dipterocarps dates to 1874. However, there were earlier accounts on several genera in the perspective of forestry and silviculture, including the management of Indian Dipterocarps (Troup 1921), timber-yielding dipterocarps of India (Gamble 1902) and later works by Kurz (1870), King (1893), Fischer (1926, 1927), Parker (1927, 1930, 1934), Parkinson (1932, 1934, 1937). These all provide valuable information on the dipterocarps of the Indian subcontinent. The most comprehensive account of the family in South Asia was published by Kerala Forest Research Institute in 1978, containing information on taxonomy, distribution, ecology, silviculture, wood, non-wood products and uses of different species. Species-level works were later conducted on *Hopea* and *Dipterocarpus* as part of several restoration programmes. Some of the pioneer institutes in India working on the Indian Dipterocarps are Kerala Forest Research Institute (KFRI), Kerala Forest Department, Institute of Wood Science and Technology (IWST), Botanical Survey of India (BSI), Forest Research Institute (FRI), Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI). Conservation collections of the majority of the dipterocarp species are found in these institutes.

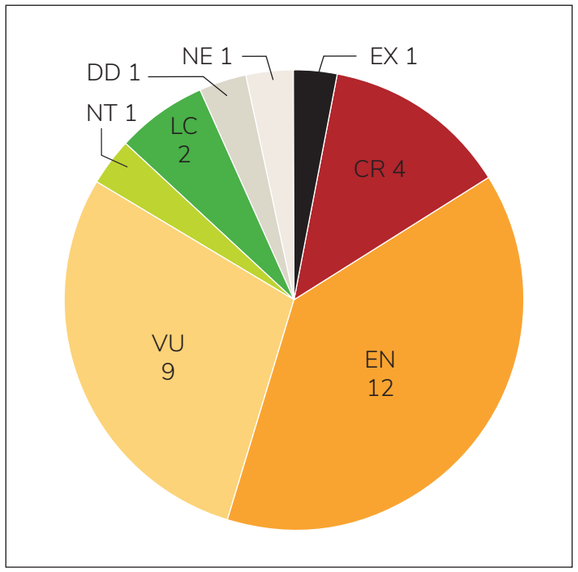
Threats

Indian dipterocarps are represented by five genera and 31 species; out of these, 14 species are endemic to the country. With 25 species (80%) reported as Threatened, most of the Indian dipterocarps are at risk of extinction in the wild. This includes four species assessed as Critically Endangered, 12 as Endangered, and nine species as Vulnerable. One species, *Hopea jacobi*, though assessed as Critically Endangered, is not known by any recent collections and more research is needed to confirm the population status of this species. Additional research is also needed for the one species assessed as DD, *Vatica lanceifolia*.

Recent efforts to find *Hopea shingkeng* in the wild by experts in Arunachal Pradesh were not successful (pers. comm.). This may be due in part to the use of the same common name for different species and unfortunately, the species is not well represented in Indian herbaria. It is therefore assessed as Extinct. On the other hand, *Hopea sasidharanii*, a recently described species has not yet been assessed (NE).

The main threats to dipterocarps are large-scale usage of timber for various purposes. Recent studies showed that dipterocarps endemic to India have limited population sizes with a low number of mature individuals, irregular flowering, high embryo mortality rate and low fruit and seed set due to incompatibility. All of which contribute to the decline of the family in the country.

Hopea erosa, *H. jacobi*, *H. racophloea* and *Vateria macrocarpa*, are only known from limited localities, and their high degree of habitat specificity makes them rare (Sasidharan 2017). Deforestation and habitat destruction due to various human activities such as construction and development activities also leads to their rarity. For most of the dipterocarps in India, population reduction of over 30% is expected over the past three generations, due to the historical conversion of forest areas and also the harvesting of mature large trees as timber.



Threat status of species native to India as on the IUCN Red List

Vateria indica seed germination (Anurag Dhyani)

Some species, like *Vatica chinensis*, were once quite common in the sacred groves and other plains in South India, but these areas succumbed to destruction over time, leading to a reduced population. According to Sasidharan (2017) and Swarupanandan et *al*. (2013), the high habitat specificity of dipterocarps in India is the reason for their rarity and is a risk to their survival as it can lead to a loss of genetic diversity by inbreeding. Climate change is affecting the periodicity of rain and having negative impacts on dipterocarps. Also, natural calamities in the form of slope movements have led to the loss of populations of some species in recent years (Sivadas et *al*. 2019).

Conservation needs

Conservation activities for Indian dipterocarps are limited. Few studies have been conducted, and more efforts are needed to conserve this highly threatened group. Generally, dipterocarps have low regeneration and survival in the wild (Sukesh and Chandrashekar 2011). Kerala Forest Research Institute (KFRI) has conducted restoration trials of several endemic dipterocarps. To assess the survival of *Dipterocarpus bourdillonii*, a total of 1,200 seedlings and 150 seedlings were planted *in situ* and *ex situ* respectively, high seedling survival was observed in the *ex situ* (78%) compared to the *in situ* (54%) site. Major reasons for seedling mortality were trampling and grazing by wild animals (elephants and sambar deer), pest infestation, forest fires, stem borer attacks, and weed growth (Swarupanandan et *al*. 2013). In a separate study, *Hopea glabra* and *H. utilis* exhibited comparatively lower regeneration and seedling survival among the genus *Hopea*. Germplasm storage of dipterocarps is very limited in the country. The recalcitrant nature of seeds does not promote long-term storage; they lose viability within 15 days (Pillai et *al*. 2018) and therefore alternative solutions need investigation.

To support conservation efforts for dipterocarps, long-term monitoring is essential to understand the population status, trend, and distribution for all species in the country. In the Western Ghats, dipterocarps occur in many of the protected areas, the populations are also present in reserve forests as well as in plains. Sites not currently in protected areas should be considered for protection alongside conservation actions involving local communities. There is a need for *ex situ* collections in multiple and diverse, locations close to the natural habitat. In addition, the augmentation of seedlings in natural habitats may help to conserve rare dipterocarps. Botanic gardens and Forest departments should take immediate action to conserve these threatened species.

Dipterocarpaceae in Indonesia

Kusumadewi, Y., Rachmat, H.H., Kusuma, Y.W.C. and Barstow, M.

Diversity, use and importance

Dipterocarpaceae is the most common family encountered in Indonesia's tropical rainforest and plays an important role in the forest ecosystem function. They are found to grow mainly in the lowland forest, however they are also found in various other habitat types. Some species are known to grow in extreme ecosystems with poor soil nutrients and poor drainage such as karst, coastal hills, peat forest, limestone hills, and heath forest (Maharani et *al*. 2013, Purwaningsih and Kintamani 2018).

The country has 278 dipterocarp species, of which 27 species from six genera are endemic to the country. The dipterocarp diversity in Indonesia is second to that recorded in Malaysia and the native species have a wide distribution ranging across the Archipelago from Aceh in Sumatra, to Papua province of New Guinea. The centre of diversity for the country's dipterocarps is in the state of Kalimantan on the island of Borneo (Ashton 1982, Soerianegara and Lemmens 1994). Within the country, the lowest number of recorded dipterocarp species is in the Lesser Sunda Islands where only three species are recorded to date.

Dipterocarpaceae are large trees with some recorded to be able to reach up to 70-80 m, thus making this family an important supplier of timber for the timber industry. In Indonesia, the export of dipterocarp timber reached its highest during the 1980s, a result of tree stock availability across several habitats. The timber trade is not limited to the local market but also expands to the international market. In general, Meranti is the most exported group and has been shipped to countries such as Japan, India, China, France, America, Australia, Germany, North Korea, South Africa, Denmark and the Netherlands. Data from International Timber Trade Organisation (ITTO) in 2019 shows that commonly harversted species for timber industries are Meranti (*Shorea* spp.), Keruing (*Dipterocarpus* spp.) and Kapur (*Dryobalanops* spp.) groups. Aside from sawn timbers, the family is exported in the form of other wood products such as plywood, laminated blocks, timber doors, finger joint laminating, moulding, solid laminating boards, veneers and furniture. Although the timber from this family is still being traded today, the trade volume has much decreased due to the reduction in tree populations.

Key Facts	
No. of native species	278 (27 endemics)
No. of genera	9
No. of threatened species	168 (21 - CR, 60 - EN, 87 - VU)
Habitat	Mostly lowland mixed dipterocarp forest, also karst, coastal and limestone hills, peat and heath forest
Uses	Timber (heavy construction), Dammar, Tengkawang
Major Threats	Logging and agroindustry
Conservation need	*In situ* conservation, law enforcement, ex *situ* collection, population studies and monitoring, raising public awareness.

Cotylelobium burckii (Agusti Randi)

Indonesia

Apart from timber produce, dipterocarp fruits and resins are also used as non-timber forest products in Indonesia. The red *Shorea* species commonly known as Tengkawang, has large fruits that are harvested for oil extraction, to produce butter and cooking products (Maharani et *al*. 2016, Kusumadewi et *al*. 2021).). While species like *Dryobalanops aromatica* (Syn: *D. sumatrensis*) has long been used for essential oil production, with oils extracted from its leaves (Pasaribu et *al*. 2014, Aswarandi and Kholibrina 2020). Resins (damar) may also be extracted from dipterocarps (Prasetyo 2013, Gusmailina 2015). Resins from certain species of *Dipterocarpus*, *Hopea*, and *Shorea* are used for caulking e.g. boats (Saridan 2012, Gusmailina 2015, Nono 2017 , Uslinawaty et *al*. 2021).

Threats

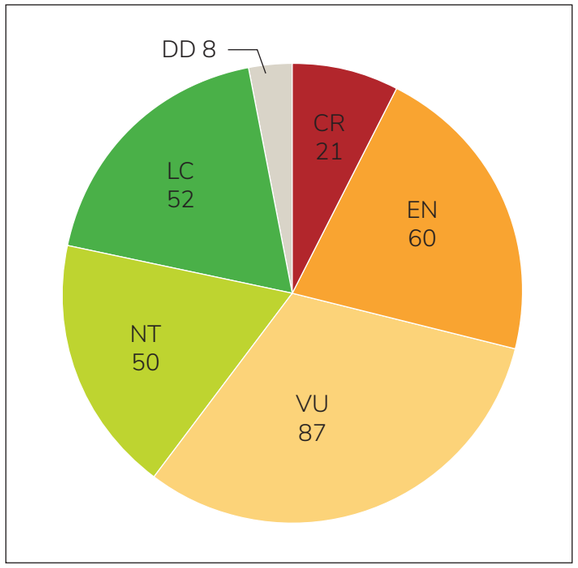
Of the 27 endemic species recorded, 85% of species are Threatened in Indonesia (23 species), comparatively 58% of native trees which are more widely distributed are Threatened (145 species).

The most frequent threat category assigned is Vulnerable. For both native trees and endemic trees the greatest threat is from land use change for agriculture development, followed by logging and timber harvesting.

Research and conservation

Research and conservation work on dipterocarps started in Indonesia dating back to the colonial era (pre 1945). Intensive biodiversity exploration across the archipelago was carried out by Dutch researchers focusing on taxonomic studies. This is evident by the large repository of herbarium specimens recorded in the 1800's (www.gbif.org). The Bogor Botanic Garden was established in West Java on 18th May 1817 and houses a number of dipterocarp species collected from across the archipelago. With the growing number of dipterocarp specimens and research opportunities, several more arboreta were established in other regions alongside increased work in various organizations, agencies and universities.

Both government and private organisations are involved in the research and management of Dipterocarpaceae such as reforestation, and ex *situ* conservation. Their efforts are listed in the tables on pages 44 and 45. It is also essential that protected areas are expanded where possible to include threatened species, with greater enforcement and more protective measure put in place, for the most threatened taxa.



Threat status of species native to Indonesia as per the IUCN Red List

The Conservation Nursery in Bogor, managed by the Ministry for Environment and Forestry, supports propagation trials, conservation research and the planting of timber. Nursery stock is also available to the public for those interested in sourcing native dipterocarp species for planting purposes. Plant collections are made from wild trees with the aim to conduct vegetative propagation of the planting materials established.

Deforestation in dipterocarp forest (Agusti Randi)

Dipterocarp collections are well established at Bogor Botanic Gardens. This has led to research and propagation trials at the garden and surveys and field collections to locate and collect plant materials for rarer species. Trips have been conducted to Mursala Island, which is home to 22 species of dipterocarp (Robiansyah et *al*. 2020), including several threatened species. These species require immediate conservation action as the island was heavily logged (Robiansyah et *al*. 2020). Another example is *Vatica pentandra*, a species that is endemic to Kalimantan but has not been collected since 1955. Surveys carried out in 2020 at 12 possible occurrence sites have drawn disappointing results. The updated IUCN Red List assessment for the species is Critically Endangered with a possibility of being extinct.

Government Agencies/Institution

Forest Management Unit of Pulau Laut Sebuku, Provincial Forest Service, South Kalimantan Province
- Reforestation programme
  - The development of Meranti Forest is accompanied by planting activities in nurseries, testing intensive silvicultural patterns, developing Dipterocetum (an arboretum containing only dipterocarps), Forest and Land Rehabilitation and routine Forest Safety Patrols.
  - Through these conservation efforts, 250 hectares of intensive silvicultural planting has been carried out: 10 hectares of Dipterocetum have been developed, enrichment planting carried out in 120 hectares; and 1,235 hectares of forest and land has been rehabilitated.

Forest Research and Development Agency - Ministry of Environment and Forestry
- Research activities
  - Darmaga Forest Research (57 ha), this area has a collection of 18 species of *Shorea* (10 spp.), *Dipterocarpus* (4 spp.) and *Hopea* (4 spp.).
  - Carita Forest (1400 ha), the forest has a collection of *Shorea*, *Dipterocarpus*, *Hopea*, and *Dryobalanops* species.
  - Yanlapa Forest research (47 ha) has a collection of *Shorea* species such as *Shorea pinanga*, *S. selanica*, *S. stenoptera* and *S. palembanica*.
  - Haurbentes Forest research (105 ha) has a collection of 27 species - *Dipterocarpus* (2 sp), *Dryobalanops* (2 spp.), *Shorea* (21 spp.), *Hopea* (6 spp.) and *Vatica* (1 spp.).
  - Collections of herbarium specimens of *Dipterocarps*

National Research and Innovation Agency Indonesia
- Botanic gardens at Bogor and Cibinong have dipterocarp collections for ex *situ* conservation research and education purposes.
- Extensive research and exploration studies on dipterocarps
- Collection of herbarium specimens of dipterocarps

Protected Forest Management Unit II Batam
- Dipterocetum: enrichment and conservation programme
  - Currently has more than 20 species planted in 5 ha of protection forest with possible extension to 40 ha of protection forest area and more species to be planted.
  - Natural wildings planted in this area originated from islands within Riau Kepulauan Province

Provincial Forest Service of South Kalimantan
- City forest

Tropical Rain Forest Park (Taman Hutan Hujan Tropis) within the provincial government business district of South of Kalimantan in an area of 36 Ha planted with more than 10 species of Dipterocarpaceae.

Universities/ Higher Education Institution

Universitas Tanjungpura – West Kalimantan
- The Arboretum Sylva Untan located in a University campus of Universitas Tanjungpura in Pontianak West Kalimantan was established in 1988, with the aim of becoming a small replica of Kalimantan forests including native and endemic trees. The arboretum is 2.3 hectares in size located in the heart of Pontianak. There are 52 native dipterocarp species growing in the arboretum, including 28 Bornean endemic species and 33 species that are assessed as Threatened on the IUCN Red List. These trees flower regularly and produce fruits, leading to the natural regeneration of the artificial forest.

IPB University
- Gunung Walat University Forest (GWUF) is an educational forest managed by the Faculty of Forestry and Environment, IPB University, which was established in 1951 and is located in Sukabumi Regency, West Java Province, Indonesia. GWUF has planted several tengkawang-producing species such as *Shorea leprosula*, *S. stenoptera*, *S. mecisopteryx*, *S. pinanga*, and *S. palembanica* to conserve these species in West Java, enriching the stands in GWUF, and it is also expected that these species will contribute to GWUF provisioning services through tengkawang production.
- IPB University has also planted several Threatened dipterocarp species such as *Dipterocarpus littoralis* and *Dryobalanops sumatrensis* in the Faculty of Forestry and Environment area in IPB Dramaga Campus for conservation, research and education purposes.

Forest Companies

PT. Arara Abadi
- 8 ha man-made dipterocarp forest in Perawang-Riau established in 1997-2000. Species planted include *Shorea leprosula*, *S. selanica* and *S. balangeran*

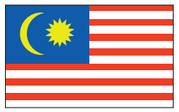
PT. Riau Andalan Pulp and Paper
- Experimental plots for native peat swamp tree species including peat swamp dipterocarp species such as *Shorea uligunosa* and *S. balangeran*

PT. Sarpatim, PT. Erna, PT. SBK, PT. BWL, PT. ITCI, PT. SJM are among another 20 forest concessionaries obligated to adopt a government-compulsary programme of SILIN (Silviculture Intensive) to manage their concession areas using Intensive enrichment planting of selected fast growing dipterocarps species (*Shorea leprosula*, *S. parvifolia*, *S. johorensis*, *S. platyclados*, *S. macrophylla*, and *S. stenoptera*). These activities include adopting line or gap planting technique, and breeding programmes to produce fast growing dipterocarps clones (with the annual increment of more than 1.67 cm)

Upper dipterocarp forest (Agusti Randi)

Fruit of *Shorea stenoptera* (Agusti Randi)

Dipterocarpaceae in Malaysia



Khoo, E., Ling, C.Y., Chua, L.S.L., Bodos, V., Majapun, R., Maycock, C., Nilus, R., Pereria, J.T., Sang, J. and Sugau, J.

Dipterocarp trade and uses

The beginning of commercial forestry in Malaysia started in the late 18th century. It stemmed from the interests in the commercialization of large timber stands in the country's rich tropical rainforests. Since that time, Dipterocarpaceae have remained one of the focal families of timber species. These timbers are traded under the Balau, Red Meranti, Yellow Meranti, White Meranti and Selangan batu timber groupings.

Among the ten genera present in the country, *Shorea* is undisputedly the most prized. While some of the *Shorea* species are better known as Meranti at the national level, in Sabah, the general trade name used is 'Seraya'. Even to this day, the most sought after timber species by importers and manufacturers are these groups due to their high quality timber. The timber from the *Shorea* group is known to produce a wide and versatile range of timber products used for heavy or medium construction (e.g. bridges, wharves, railway sleepers, power-pole lines, heavy duty flooring, door and window frames, vehicle bodies and boat building); decorative (light duty flooring, panelling, furniture) or general utility (joinery, low grade decking, boat planking and musical instruments); veneer; and plywood (Wong 2002). Apart from *Shorea*, other genera also contribute to the timber trade i.e. *Dipterocarpus* spp. (Keruing), *Dryobalanops* spp. (Kapur), *Vatica* spp. (Resak) and *Hopea* spp. (Luis).

Culturally, species from Dipterocarpaceae also have culinary uses. When available, fruits from species such as *Shorea macrophylla, S. pinanga, S. palembanica*, and other species in the Section Pachycarpae are harvested to produce illipe butter. The product is either exported as a high grade cocoa butter substitute for chocolate or used by the local communities as fat to flavour cooked rice. Illipe nuts are also consumed as a vegetable dish.

Key Facts	
No. of native species	340 (53 endemics)
No. of genera	10
No. of threatened species	211 (27 - CR, 79 - EN, 105 - VU)
Habitat	Mixed dipterocarp forest, peat and freshwater swamp forest, dry forest (Kerangas), upper montane forest
Uses	Timber, food source (vegetable, illipe butter)
Major Threats	Agro-industry, logging, urban site and road expansion
Conservation need	Ecological and population research, ex situ collection, study into impacts of climate change, DNA barcoding and timber species identification, public awareness campaigns

Mixed Dipterocarp forest, Sabah (David Bartholomew)

Research history and ongoing work

Across the country, the focus given to the research and development of Dipterocarpaceae surpasses those of other tree families. Initial research studies in the late 19th century were centred around taxonomy and systematics, along with an emphasis on wood and timber properties. Given the economic value, it is not surprising that the majority of past studies focused on timber production, management and wood utilization. Some of the notable publications of early research into Dipterocarpaceae are: "The Timbers of the Malay Peninsula" (Ridley 1901), "Commercial Timber Trees of the Malay Peninsula" (Foxworthy 1927), "The Dipterocarpaceae of the Malay Peninsula" (Foxworthy 1932), "Foresters' Manual of Dipterocarps" (Symington 1943), "A Manual of the Dipterocarp Trees of Brunei State and of Sarawak" (Ashton 1968), "Timbers of Sabah" (Burgess 1966) and "Dipterocarps of Sabah" (North Borneo) (Wood et *al*. 1964).

In the mid-1980s and 1990s, two Long-Term Ecological Research Plots (LTERPs) were set up in Pasoh Forest Reserve (Peninsular Malaysia) and Lambir Hills National Park (Sarawak) in collaboration with the ForestGeo network (https://forestgeo.si.edu/sites/malaysia) for the purpose of monitoring population dynamics. Subsequently, studies were expanded to include research on ecological behaviour (phytogeography, demography, reproduction amongst others), storage of plant and seed materials, population genetics, DNA barcoding, Species Distribution Modelling (SDM), threat assessment and others. Presently, greater attention is placed on the conservation of the family and the ecosystems within which they exist. This shift in focus is necessary as the conservation of forest genetic resources, in particular timber resources, is an integral part of Sustainable Forest Management (SFM), an approach used to ensure sustainable timber production.

Dipterocarp forest resource management, operations and governance

Malaysia is made up of three regions, Peninsular Malaysia, Sabah and Sarawak. Under the country's constitution, forestry is a state matter and each of the states has jurisdiction over their forest resources. This allows the states to enact forestry laws and policies independently to complement those that are enacted at the Federal level. Malaysia's forest policies are determined by three separate bodies: the Forestry Department Peninsular Malaysia, Sabah Forestry Department and Forest Department Sarawak. In terms of resource management, operation and governance, the country employs the Sustainable Forest Management (SFM) approach. Under this approach, management activities are governed and regulated by various National/State legislations and policies such as Wildlife Conservation Act No. 716 (2010), National Forestry Act No. 313 (1984), Wildlife Protection Ordinance (1998), National Parks Ordinance (1998), Forest Enactment (1968), Forest Rules (1969), Sarawak's State Policy on Forest Management Certification, Malaysia Policy on Forestry (2021), Sabah Forest Policy (2018), among others. With regards to international agreements, Malaysia is a party to the International Tropical Timber Agreement 1994.

Mixed Dipterocarp forest, Sarawak (Julia Sang)

Across the country, there are differences in the criteria applied between the different regions when it comes to logging within production forest reserves. Generally, the Forest Management Units (FMUs) will either comply with the Malaysian Timber Certification Scheme (MTCS-PRFC), Malaysian Criteria and Indicators for Sustainable Forest Management (MC&I 2020) or Forest Stewardship Council (FSC) criteria.

Apart from sustainability, one of the primary goals is the conservation of Rare, Threatened and Endangered (RTE) dipterocarp species. One of the conservation actions taken is the establishment of the country's Protected Areas (PAs) and Forest Reserves (FRs) network. Currently, 12.6% of the terrestrial land in Malaysia is classified as PA (UNEP-WCMC 2022) consisting of 472 PAs. Ten are known to contain at least 40% of the country's biodiversity (Chua et *al*. 2022).

Region	Timber Harvesting Practice
Peninsular Malaysia	Timber harvesting is governed by "Selective Management System (SMS)" (Thang 1986) which aims to optimise an economic harvest, ensure sufficient residual stocking for the next cutting cycle, and protect the ecological integrity of the forest. In brief, the SMS entails the selection of optimum felling regimes based on pre-felling (Pre-F) forest inventory data. Pre-F in the area to be logged is determined based on diameter at breast height (dbh) and volume growth, mortality and regeneration data. The allocation of Annual Allowable Cuts is determined yearly at the state level based on data from the National Forest Inventory that is conducted once every decade. A minimum of 32 trees per hectare of commercial species with dbh>30 cm must be retained. The diameter cutting limit (DCL) prescribed for timber groups was increased to the current threshold of 55 cm for non-dipterocarps, 65 cm for dipterocarps and 75 cm for *Neobalanocarpus heimii* (Dipterocarpaceae). Post-felling inventory is done after logging and silviculture treatment is undertaken, where necessary, to spur recovery, regeneration and growth. The permitted harvest rotation is 30 years. Preparation and implementation of state-level forest management plans and 5-year operational plans are mandatory.
Sabah	Logging in Sabah began as early as 1879 and grew with the introduction of mechanized equipment. The Reduced Impact Logging (RIL) technique was adopted in 1996. The main operation consists of pre-harvesting, harvesting and post-harvesting. The cutting limit prescribed for non-dipterocarps is 45 cm, while for dipterocarps it is 60 – 120 cm. The RIL technique has been implemented since 2011 in forest reserves managed by either the Forestry Department or Sustainable Forest Management License Agreement (SFMLA) holders. Third party independent auditors are usually engaged in RIL compliance assessment. It is compulsory for all SFMLA holders to be audited under the Sabah Timber Legality Assurance System (TLAS)
Sarawak	In Sarawak, beginning 2019, all long-term Forest Timber Licensees must obtain Forest Management Certification. Timber harvesting must employ RIL that includes a 25-year cutting cycle and a minimum diameter cutting limit (DCL) of 50 cm dbh for dipterocarps and 45 cm dbh for non-dipterocarps (Anon 2019). Species listed under the Wildlife Protection Ordinance (1998) must be marked during pre-felling inventory to avoid deliberate or unintentional harvest. Growth and regeneration of timber species is periodically assessed by the licensee through permanent sample plots. Pre-felling & post-felling inspection is undertaken by Forest Department Sarawak. Sarawak has also imposed the Timber Legality Verification System.

The different timber harvesting practices within forest reserves in the three regions.

In situ conservation

To have a better understanding of dipterocarp species present within the protected area network, all three regions in the country have carried out a sub-national Dipterocarpaceae threat assessments. In the most recent assessments, Peninsular Malaysia has five taxa that are Critically Endangered (*Dipterocarpus obtusifolius* var. *subnudus*, *D. semivestitus*, *Shorea hemsleyana* ssp. *hemsleyana*, *S. lamellata* and *S. lumutensis*) and do not occur within the PA network. As for Sabah, 166 species (91%) are recorded within PAs, while 16 species occur outside. Of those recorded outside, nine species are threatened, while seven species are Data Deficient. In Sarawak, 89% of the Dipterocarpaceae species occur in one or more Totally Protected Area; while the remaining 30 species (11%) are not conserved in the state's PAs. This includes the Critically Endangered *Dipterocarpus coriaceus*, *Shorea peltata* and *S. revoluta*.

Ex situ conservation

The establishment of *ex situ* collections is essential to support the conservation of threatened species in the wild. In Peninsular Malaysia, at least 66 dipterocarp species (Yong et *al*. 2011) are grown in the Forest Research Institute Malaysia's (FRIM) for the purpose of research, germplasm conservation and education.

For Sabah, among state agencies, institutions and NGOs collaborative conservation studies are common practice. *Ex situ* collections of Sabah endemics, *Shorea kudatensis*, *Shorea symingtonii* (VU) and *Dipterocarpus ochraceus* (EN) were established in Timimbang FR, Botitian FR, Khazanah Sandakan FD (HQ) FR and also in Sabah Parks research station. In addition, Sabah Forestry Department collaborates with the Tropical Rainforest Conservation Research Centre in the establishment of a "Tropical Rainforest Living Collection" of dipterocarp species in Merisuli (Ulu Segama Forest Reserve). A total of 58 species were collected from forest reserves, germinated, grown and later planted at the living collection sites.

In Sarawak, threatened species such as *Hopea enicosanthoides* (EN), *Shorea elliptica* (EN), *S. induplicata* (CR), *S. inaequilateralis* (CR), *S. rotundifolia* (CR), *S. praestans* (CR) and *Dipterocarpus coriaceous* (CR) are conserved in the Semengoh Nature Reserve. In addition, nine other *Shorea* species (*S. macrophylla*, *S. hemsleyana*, *S. obovoidea*, *S. palembanica*, *S. pinanga*, *S. scrobiculata*, *S, seminis*, *S. splendida* and *S. stenoptera*) were planted in the 1950s in the Landeh Engkabang Plantation, Semengoh Nature Reserve as part of experimental plantations of Engkabang.

Forest restoration

In line with the national initiatives towards Greening Malaysia: 100 million Tree Planting, approximately 33 million trees have been planted to date throughout the country. Sarawak aims to plant 35 million trees by 2025. Some dipterocarp species are used in Forest Landscape Restoration (FLR) in the region and include *Cotylelobium burckii*, *Dryobalanops aromatica*, *Hopea vaccinifolia*, *H. macrantha*, *Shorea havilandii*, *S. laxa*, *S. longiflora*, *S. macroptera*, *S. multiflora*, *S. ovata*, *S. retusa*, *S. revoluta*, *S. rugosa*, *S. splendida*, *S. venulosa* and *Vatica borneensis* (FDS 2020). As for Sabah, multiple tree planting events were organized and restoration work carried out in accordance to the standard requirement of SFM practices. Numerous collaborative restoration projects with the local communities and NGOs were conducted such as the Rhino Ridge Fund (RRF) and Forever Sabah (FS) who work on programs towards restoring and connecting forest patches within the state. Similar efforts are being attempted in Peninsular Malaysia.

Dipterocarp seedlings (David Bartholomew)

Threat status

Malaysia hosts the greatest number of dipterocarp species in the world. Across the three regions there are 340 native species including 53 endemic species. Globally 211 species (62%) native to Malaysia are assessed as Threatened. There are 64 species assessed as Near Threatened, 57 as Least Concern and eight species are Data Deficient. Of the 53 endemic species, 42 are assessed as Threatened (79%). Major threats across the country are broadly similar, with land use change for agriculture the greatest threat to species. Additionally over-harvest of the species for timber has been a historical threat. Logging is still a current and ongoing threat to some species, particularly outside protected and managed areas.

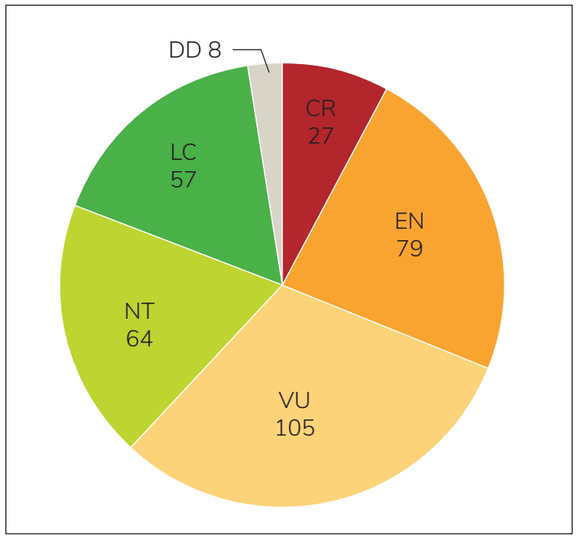
Of the three regions, Sarawak has the greatest diversity of dipterocarp species hosting over 250 species, followed by Sabah with just over 180 species and Peninsular Malaysia with 160 species. Each region has at least 10 endemic species. The breakdown of categories for dipterocarps native to each region is given in the table below, and follows the same patterns as species diversity, with Sarawak having the greatest number of Threatened species.

Challenges and knowledge gaps

It is only in recent years that research for Dipterocarpaceae has shifted towards conservation. In the country, much of the ecological and population research was carried out on widespread species, with only a handful on threatened species that have small populations and restricted distributions examined. There is a great knowledge gap in aspects such as inter and intra population genetic diversity, phenology, mycorrhiza interactions, species population dynamics, and the effects of climate change. In addition, the lack of botanists and para-taxonomists has greatly slowed down research in lesser-known threatened species. In general, within the FMU, dipterocarps are commonly grouped as Meranti, Selangan batu, Keruing, Kapur, rather than at the taxa level. Lacking correct identification makes it difficult to know what species are being extracted from the forest.

Category	Peninsular Malaysia	Sabah	Sarawak
CR	11	8	18
EN	39	32	51
VU	53	59	79
NT	26	39	50
LC	25	41	49
DD	6	4	3

IUCN Categories and Criteria used for dipterocarps in Sabah, Sarawak and Peninsular Malaysia



Threat status of species native to Malaysia as per the IUCN Red List

Shorea rotundifolia (Vilma Bodos)

Hopea altocollina (Vilma Bodos)

Future study

Of immediate need is the propagation and establishment of *ex situ* collections for the threatened species. Additionally field surveys need to be carried out for those species that are assessed as Data Deficient to ascertain whether the species is extant, under collected or in need of immediate conservation measures. Cross institutional partnerships across multiple disciplines needs to be promoted at both the state and national level, not just for the purpose of technology and knowledge transfer for example in the application of DNA barcoding and AI (Artificial intelligence) technologies, but also to improve current forest management capacities. For example, under the Malaysian Timber Certification Scheme (2020) Principle 6 "*Forest management shall conserve biological diversity and its associated values ..... by so doing, maintain the ecological functions and the integrity of the forest.*" the indicator for the criteria listed under this principle requires an Environmental Impact Assessment (EIA) to be carried out and potential impacts on the RTEs species to be done. Effective partnerships among governing agencies, researchers and FMU holders will allow for not just knowledge transfer of what is threatened, as listed in the National or regional Red List series (Malaysian Plant Red List, Sabah Plant Red List and Sarawak Plant Red List), but will also open the channel for better communication. This will aid in the sharing of technical expertise for potential conservation measures to be implemented at the sites of interests. As for educating and instilling a conservation mindset among the public, effort should not be restricted to environmental education among the younger generation, instead it should be incorporated as part of eco-tourism activities such as that done by KOPEL in Sabah. Therefore, reaching out to a wider audience of different age groups.

Conservation in Malaysia - Example 1: Saving the Critically Endangered Fresh Water Swamp Dipterocarps in Peninsular Malaysia

The district of Perak Tengah in Perak is home to at least 25 species of dipterocarp, of which 76% are globally Threatened. In particular, the freshwater swamp forests of Universiti Teknologi MARA (Seri Iskandar Campus) and Universiti Teknologi PETRONAS has four Critically Endangered species, namely *Dipterocarpus semivestitus*, *Shorea hemsleyana*, *S. macrantha* and *Vatica flavida*. The populations were inventoried and mapped; and specific recommendations for their conservation were conveyed to the authorities. Zonation of areas designed for multiple uses forms a key recommendation to enhance the integration of biodiversity conservation into education centres.

Mixed dipterocarp forest (E.Khoo)

Conservation in Malaysia - Example 2: KOPEL- The Core Business

KOPEL is a village based co-operative of local communities that are made up of fishermen and farmers staying at Batu Puteh in the Kinabatangan district of Sabah. The village is located adjacent to the Pin Supu FR. In the late 1990s, the villages decided to develop eco-tourism as means to generate income. They believed that to ensure this venture's sustainability, they would have to factor in the conservation of their surrounding forest ecosystem and biodiversity. For the last 20 years with help and support from various organizations, tourists and volunteers they have planted more than 400,000 trees of various species as part of the forest restoration work. Additionally, their conservation activities have expanded to include lake restoration, cave restoration, wildlife monitoring, water quality monitoring and environmental education. (https://www.kopelkinabatangan.com/)

Conservation in Malaysia - Example 3: Rhino and Forest Fund

Founded in 2009, the organization signed an agreement with the Sabah Forestry Department in 2010 to work on the reforestation of degraded forest areas and the acquisition and reforestation of oil palm plantations. This is done with the intention of connecting fragmented forest reserves for both species protection and improvement of wildlife habitats in southeastern Sabah. To date they have secured more than two thousand hectares of land areas outside the forest reserves and planted over 25,000 trees across six sites. Among those planted are dipterocarp species that were procured from adjacent forest reserves. (https://rhinoandforestfund.org/en/our-work-protect-rainforests-in-borneo/)

Conservation in Malaysia - Example 4: Forever Sabah – Watershed and Communities

This 25-year programme aims to support Sabah's transition into a diversified, equitable, circular economy, and one of the focal areas of this programme is "Forest, Water & Soil". The Telupid Forest Complex (TFC) comprises several fragmented forest reserves and the aim is to transform this complex into a "Living Landscape", to strengthen the ecosystem, species and cultural resilience under pressure from climate change and economic development. The work involves various agencies within the state and also researchers from various fields. One scope of effort includes the restoration of forested areas that were damaged by fires and illegal forest clearance. (https://www.foreversabah.org/)

Shorea praestans (Vilma Bodos)

Conservation in Malaysia - Example 5: Face Foundataion Rainforest Rehabilitation Project (INFAPRO): Restoration of Tropical Rainforests

This project started in 1992 and aims to restore an area of 25,000 ha of logged over forest. The project is a collaboration between the Sabah Foundation and Face the Future based in the Netherlands. A mixture of enrichment planting and silvicultural treatment is being used to restore the forest. More than 2 million trees have been planted to date, the majority of which are dipterocarps. The site is a focal point of research and training on forest restoration and dipterocarp ecology. (https://facethefuture.com/projects/sabah-maleisie-bosherstel-en-bescherming)

Dipterocarpaceae in the Philippines

Malabrigo, Jr. P.L, Eduarte, G.T., Tobias, A.B., Gibe, R.C., Solatre, J.S., Tating, M.M.B., Evangelista, V.M. and Umali, A.G.A.

Diversity and uses

Dipterocarp trees are highly valued as an important source of quality timber (Reyes 1921) in the Philippines, as well as the whole of Southeast Asia (Fernando 2009, Rana et *al*. 2012). They are also the major component of vegetative soil cover in the country (Rojo 2000). Dipterocarps nowadays are in imminent danger and disappearing at an alarming rate due to indiscriminate logging, shifting cultivation, and transformation into settlements or agricultural land (Rath et *al*. 1998, Langenberger 2006).

Key Facts	
No. of native species	53 natives (25 endemics)
No. of genera	6
No. of threatened species	33 (7 - CR, 15 - EN, 11 - VU)
Habitat	Lowland forest
Uses	No longer utilised
Major Threats	Logging, urbanisation, shifting agriculture
Conservation need	Establish conservation nurseries, ecological research

Recognizing the risk of species extinction, several laws and policies were enacted by the Department of Environment and Natural Resources (DENR) which aims to protect and conserve the remaining dipterocarp forests. These includes DAO #24 Series of 1991 – limitation of logging to second-growth forests; DAO #25 Series of 1992 – creation of the National Protected Areas System; and DAO #21 Series of 1996 – establishment of 10-ha dipterocarp plantations per year in all regions of the country (DENR-ERDB 2015). Additionally, various dipterocarp species have been included in the DAO 2017-11, or the Updated National List of Threatened Philippine Plants and their Categories. These species are protected through the administrative order pursuant to Republic Act No. 9147 or the Wildlife Resources Conservation and Protection Act of 2001. Republic Act No. 9147 states that illegal and excessive tampering of the species from its natural habitats, together with other species specified therein, are prohibited (DENR 2017). The unauthorized utilization, trade, and disturbances made in its natural habitats are punishable by the law.

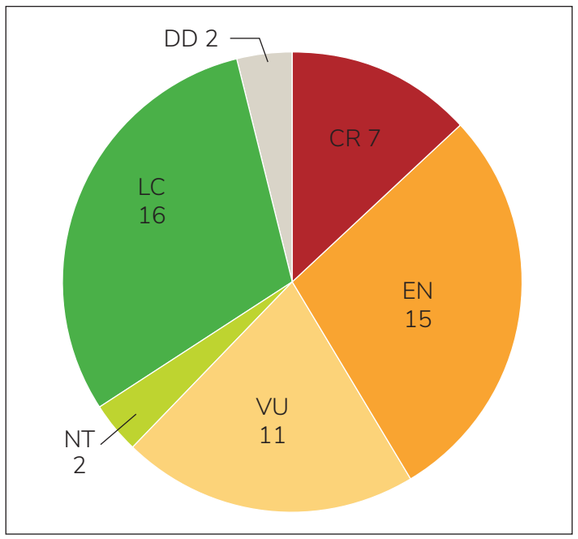
There are 53 dipterocarp species belonging to six genera (*Anisoptera*, *Dipterocarpus*, *Hopea*, *Parashorea*, *Shorea*, and *Vatica*) in the Philippines. With the total number of species globally, Philippines has one of the highest rates of endemism (47%) when it comes to dipterocarps. The country has 25 country endemics (Pelser et *al*. 2011). The towering trees of dipterocarps serves as perfect habitat for the country's national bird, the stunning Philippine eagle (*Pithecophaga jefferyi*), a top predator and a Critically Endangered species (DENR 2022). Interestingly, Consunji (2012) noted that the shorter canopy of Philippine dipterocarps compared to the region is seen as an evolutionary adaptation of the species in cyclone-prone forests of the Philippines.

Shorea contorta (Megan Barstow)

Research and conservation

The Philippine Red List or the DAO 2017-11 (Updated National List of Threatened Philippine Plants and their Categories) categorized 35 species in a threatened category (CR to VU) (DENR 2017). On the other hand, the assessment by Energy Development Corporation (the sole partner of BGCI in the Global Tree Assessment of Philippine native trees) for the IUCN Red List, produced assessments based on recent population surveys of dipterocarps in the country. It listed seven species as Critically Endangered, 15 as Endangered, 11 as Vulnerable, two as Near Threatened, 16 as Least Concern and two as Data Deficient. Most notable among the CR species is *Vatica elliptica*, with only eleven (11) mature individuals recorded in its single locality in Mt. Calades, Zamboanga Peninsula. Most dipterocarps are threatened due to their restricted distribution range and small population size coupled with continuing decline in the extent of their natural habitat due to various anthropogenic activities such as shifting cultivation, illegal logging, and expansion of agricultural lands (Pang *et al.* 2021).

The existing laws and policies issued by the DENR along with the established National Integrated Protected Areas System (NIPAS Act of 1992) and identified key biodiversity areas serve as guides and measures in imposing *in situ* conservation. With the growing threats, the restocking of remaining dipterocarp forests throughout the country was initiated through mass propagation and nursery management (DENR-ERDB 2015). In addition, 27 Philippine dipterocarps are known to be cultivated in 85 botanic gardens globally (BGCI 2022c). Several dipterocarp species were also recommended to be used as planting materials through the Executive Order 26 or the National Greening Program.



Threat status of species native to The Philippines as per the IUCN Red List

The most notable *ex situ* conservation action for Philippine dipterocarps is that of Energy Development Corporation (EDC), the leading renewable energy company in the country. Recognizing the urgency to save the remaining populations of unique dipterocarps, EDC initiated a noble tree conservation program called BINHI (Filipino term for seedling). For the past 14 years, EDC has worked to document and protect the remaining populations of dipterocarps in the country (Malabrigo *et al.* 2016, Malabrigo *et al.* 2017). The company's state of the art vegetative material recovery facility has already developed protocols for the mass propagation of most dipterocarp species through cuttings with survival rate ranging from 93-97%. Many of the planted seedlings among EDC's more than 200 partner institutions (mostly schools and universities) are now the source of seeds for future mother trees. More importantly, all botanical information gathered from the project's experiences including new distributions, phenology, and propagation technology were recently published into a book "BINHI Tree for the Future" to disseminate the project learning and experiences to a larger audience.

Unsuccessful reforestation can be attributed to the lack of knowledge in ecological factors affecting growth and development of dipterocarp trees (Brown and Mathews 1914). In fact, there have been reports that organizations who are directly involved in the national greening program prefer the use of exotic species rather than the indigenous species (COA 2019). Furthermore, conservation of a species' population is not guaranteed due to several threats, which may cause rapid declines in the population if destructive activities continue in the habitat. Thus, species-specific conservation programs and site-based conservation approaches such as the declaration of critical habitat areas or local conservation sites where the species is found is highly recommended. Further inventory and research are needed to account for the total remaining population size of each species in the wild. This will help in creating a relevant conservation and management action plan.

Dipterocarpaceae in Singapore

Ganesan, S.K., Chong, K.Y., Lim, R.C.J., Lua H.K., Ng, X.Y. and Velautham, E.

Dipterocarps trade and uses: economy & culture

Historically, Singapore was a centre for the trade of dipterocarp timber. The timber traded in Singapore mainly came from other countries as the supply of timber in Singapore was exhausted early in the country's history due to the uncontrolled clearing of forest for agriculture and human settlement. There are 10 genera and 36 species of Dipterocarpaceae in Singapore. These are found in the Bukit Timah Nature Reserve, Central Catchment Nature Reserve and the Singapore Botanic Gardens' Rain Forest. Outside the nature reserves, relic trees occur in the Changi Tree Conservation Area, Western Catchment and the Southern Islands.

Key Facts	
No. of native species	36 (0 endemics)
No. of genera	7
No. of threatened species	24 (0 - CR, 10 - EN, 14 - VU)
Habitat	Lowland forest
Uses	Historically for timber, no longer utilised
Major Threats	Small populations, past uncontrolled clearing of forest for agriculture and human settlement
Conservation need	Life history research, population reinforcement

Conservation actions

Due to the small areas of remaining habitats and low numbers of mature individuals, most of the 36 species of Dipterocarpacaeae found in Singapore are in various categories of threat status at the National level. Various conservation measures are in place to mitigate this. They are described below.

***In situ* conservation**

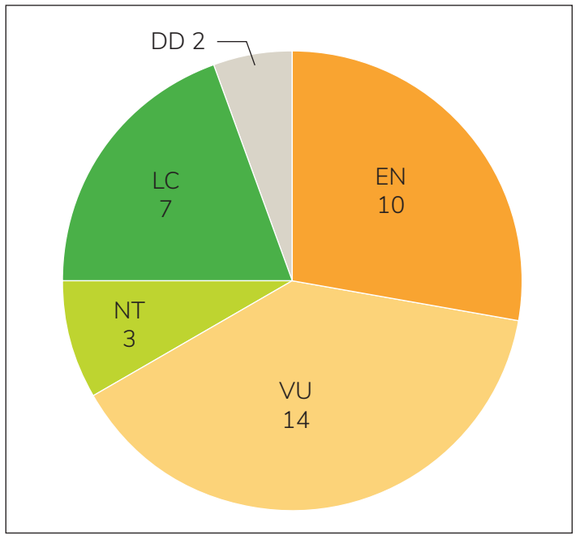
Dipterocarps in Singapore are mainly found in Nature Reserves where they are protected by law from land development and logging. Dipterocarp trees on military training land are protected by their inaccessibility due to the locations' remoteness and restricted access.

***Ex situ* conservation**

Ex situ conservation in Singapore can be found in the Living collections and Seed bank. The Singapore Botanic Gardens (SBG) Living Collection team manages an *ex situ* conservation collection of 5,800 specimens from 277 species from both Singapore and the surrounding region. These specimens are actively managed (via horticultural and arboricultural interventions) to ensure they reach reproductive maturity and produce seeds as young as possible so as to increase numbers of the rare species.

Dipterocarp seedling grown at the Plant Resource Centre, Singapore Botanic Gardens (Elango Velauthum)

Research on their growth requirements and asexual propagation are carried out at SBG's Plant Resource Centre. As and when the numbers of specimens are satisfactorily increased, they are then shared for planting around areas managed by the National Parks Board (NParks) throughout Singapore. Dipterocarps in Singapore' are monitored opportunistically for phenology in the two nature reserves, and other areas when encountered during ad-hoc surveys. If seen to be flowering, further monitoring is continued until the end of the fruiting period for seed collection. Seeds are then brought back to the nursery for processing, germination and growing for several years until the sapling stage, before planting out to suitable sites in the nature reserves and buffer areas. Twenty-one of the 36 native species have been collected for cultivation in the last five years and over 600 saplings have been planted out. Three species have been tested for seed storage suitability for long-term seed banking and were found not to be suitable.



Threat status of species native to Singapore as per the IUCN Red List

Reforestation, restoration and species reintroduction

Saplings of native dipterocarps grown from seeds in NParks' Native Plant Centre, nurseries in the Nature Reserves, and SBG's Plant Resource Centre are used for reforestation and restoration efforts in Nature Reserves, Nature Parks and the Singapore Botanic Gardens. These efforts ensure the long-term sustainability of the populations of native dipterocarp species in Singapore.

Future – challenges and knowledge gaps

The extant dipterocarps in Singapore, like other dipterocarps in the immediate surrounding region, reproduce during the infrequent and unpredictable masting events, which pose challenges for seed collection. It impacts conservation efforts such as propagation of seedlings for enhancement planting or reforestation and ex *situ* conservation.

As a result of past logging and agricultural activities, surviving mature trees for many species occur in low densities in small patches in a matrix of secondary vegetation and may be further fragmented by roads and water bodies. This is likely to create a barrier to pollinator movement and gene flow. Further studies need to be conducted to confirm if this is impacting the proportion of aborted fruits and/or viable seeds and the vigour of seeds and seedling recruitment. Some species appear to be less affected than others, either because of higher densities of individuals in persisting populations, or because of associations—possibly predicted via certain floral traits—with pollinators that are less affected by landscape fragmentation. Legacies of past land use on the current soil microbial community may also have impacts especially on dipterocarp seedling establishment and growth.

For some of the more common dipterocarp species in Singapore, there appear to be large gaps for some cohorts as inferred from a relative lack of trees in the smaller size classes. There has been a gradual attrition of the larger mature forest trees due to natural mortality but also sometimes as casualties of weather events. Even with highly successful seed collection and seedling enhancement planting efforts, it would take decades to restore the demographic structure such that there are continuous generations of smaller trees to replace the larger ones.

Dipterocarpaceae in Sri Lanka

Gunatilleke, N., Gunatillke, S. and Ranasinghe, S.

Image 1: Dipterocarp–dominated lowland rainforest (MDF) in Sinharaja (Nimal Gunatilleke)

Key Facts	
No. of native species	61 (57 endemics)
No. of genera	8
No. of threatened species	59 (17 - CR, 22 - EN, 20 - VU)
Habitat	Mixed dipterocarp forest (lowland and lower montane)
Uses	Food, solvent extraction & historically for timber
Major Threats	Habitat fragmentation, small-holder agricultural encroachment
Conservation need	Establish and monitor restoration plots and corridors, forest mapping, law enforcement

Introduction

Dipterocarps are the physiognomic and floristic backbone of the lowland and most of the lower montane rain forests (Mixed Dipterocarp Forests - MDFs) in Sri Lanka. The past and present distribution of the members of this family, reveals the biogeographic and conservation value of these relict MDFs (evolved from the biota of the Indian Plate); postulated as a gateway to dipterocarp diversity in Southeast Asia. Their mass flowering and mast fruiting episodes during ENSO events, especially among the partially sympatric clades of *Shorea*, offer fascinating research opportunities on the historical and ecological biogeography of dipterocarps, and the necessary conservation measures required.

In Southwest Sri Lanka, MDF is the dominant forest, found in both the pre-humid lowland (<900m) and lower montane (900m – 1300m) regions. The dipterocarp species found in these different forests are variable, while a few dipterocarp taxa extend into the bordering seasonal evergreen forests (Table right - Ashton 1977). This highlights the role played by the Indian plate in Sri Lanka's historical plant geography, which is likely to have increased the representation of signature relict flora and MDF in Sri Lanka. For example, *Mesua-Shorea* forest formation occurs in aseasonal lowland hill forests (Image 1). In the same region, *Dipterocarpus zeylanicus* can be mono-dominant in gallery forests, while in the lower montane forests, *Shorea gardneri* is the dominant species (Image 2). Additionally, along the southwest escarpment of the central massif, there are several co-dominant species of the endemic genus *Stemonoporus* together with a host of non-dipterocarp species.

Species	Remarks
Dipterocarpus zeylanicus	Found in isolated locations where the soil has permanent high moisture content in the seasonally dry zone.
Hopea brevipetiolaris	Known from ridges in the semi-evergreen forests
Hopea cordifolia and Vatica chinensis	Locally abundant in Gallery forests in seasonally dry forests in the Uva province.
Shorea dyeri	Extends its distribution to the semi-evergreen region in Uva.

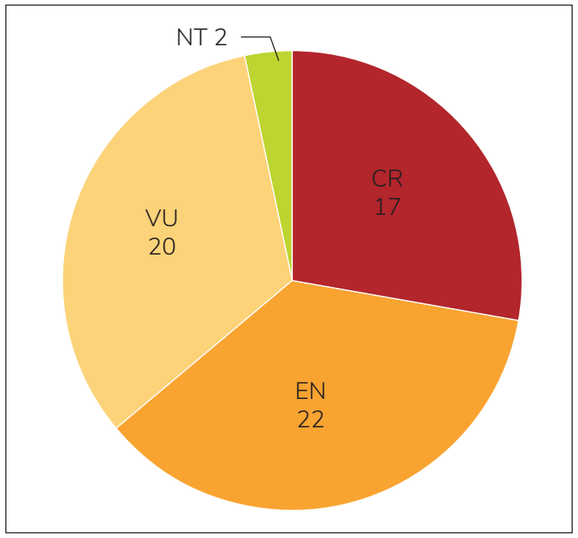
Dipterocarp species found outside MDF forest

Image 2: *Shorea gardneri* – dominated lower montane forests of southwest Sri Lanka (Nimal Gunatilleke)

Dipterocarps are the only canopy-dominant tree family with near endemism in Sri Lanka; some of these species are partially sympatric exhibiting remarkable biological features. These include subtle species-habitat associations, mass flowering (Image 4) and mast fruiting. They also have diverse ectomycorrhizal symbiosis. These are fascinating features that challenge *inter alia* forest restoration pursuits. Research to understand these biological features and restoration potential is now central to the work of universities, students, and local people.

Across Sri Lanka, dipterocarps have many uses. Oil extraction by making stem cavities in *Dipterocarpus glandulosus* is an ancient practice in extracting a solvent used in temple painting. The fruits of some dipterocarps are traditionally used in preparing sweet cakes, a nutritional porridge, and also cooked as a vegetable (Image 3). Historically, dipterocarps were cut for timber and

Image 3. Dried cotyledons of several *Shorea* species used in the preparation of traditional sweet cakes (Nimal Gunatilleke)



Threat status of species native to Sri Lanka as per the IUCN Red List

there was a long history of research on the 'sustained yield timber management' by the Forest Department. Research regarding the natural regeneration of both hardwood and peeler wood in logged-over forests was carried out as well. A ban imposed in the 1980s suspended official logging of the MDFs for the local peeler and hardwood industry. Today, there is a moratorium on logging in natural forests and aseasonal forests, most of these sites have been declared as conservation forests.

Threat status

The family is represented in Sri Lanka by eight genera, in which two genera, *Stemonoporus* and *Balanocarpus*, are endemic to the island. All 26 species of *Stemenoporus* are Threatened and the one species of *Balancarpus* is also threatened. In total, fifty nine species or 96% of species recorded on the island are assessed as Threatened. The two species that are not listed in a Threatened category are - *Vateria copallifera* and *Dipterocarpus zeylanicus*, both species are assessed as Near Threatened.

The major threat to the dipterocarp species in Sri Lanka is from small-scale encroachments by local villagers, especially at the periphery of the already highly fragmented relict forest parcels. These parcels are usually isolated amongst ever-expanding small-holder agricultural pursuits.

Conservation in place and needs

In Sri Lanka, since the moratorium on logging in the 1980s, all MDFs are conserved for their rich biodiversity and the multitude of ecosystem services they provide. The MDFs in Sinharaja and Central Highlands have been listed as World Heritage Sites, in addition Sinharaja and Kanneliya rainforests have been declared as International Biosphere Reserves. The remaining forests are being surveyed for declaration as either forest reserves of conservation forests in which comprehensive management plans have been prepared for some of them.

One of them is the recently developed Sinharaja Forest Range Landscape Management Plan (SFR-LMP). This is a 10-year action plan (2022-2032) with the purpose to conserve and manage the unique biological diversity of the wet lowland MDFs. It also aims to promote sustainable socio-economic development and the well-being of its people through joint decision-making. If successfully implemented, it has the potential to be upscaled to the entire MDF region in southwest Sri Lanka and beyond.

The Royal Botanic Gardens at Peradeniya maintain a representative sample of several threatened dipterocarp species, while the Sitawaka Botanic Gardens located in southwest Sri Lanka is planning to conserve sample populations of selected threatened dipterocarps. Additionally, in collaboration with Dilmah Conservation and the Botanic Gardens Department of Sri Lanka, researchers from the Rajarata University are establishing a MDF corridor restoration project.

Over the last few decades, the Forest Department has successfully established several monoculture plantation blocks of *Dipterocarpus zeylanicus* and has used several dipterocarp species in enrichment planting within exotic *Pinus caribaea* plantations. Demonstration plots have been established by researchers from several collaborating local and overseas universities to study the dynamics of several canopy-dominant dipterocarp species.

A number of local non-government organizations (NGOs) and Community Based Organisations (CBOs) are engaged in rainforest conservation and forest restoration. One leading initiative is the Preserving Land and Nature Trust (PLANT) established by the Wildlife and Nature Protection Society of Sri Lanka. This Trust purchases forested MDF fragments in the vicinity of forest reserves for conservation purposes. Another is the work by IUCN with the Ecosystem Conservation and Management Project (ESCAMP) of the World Bank, to scale-up forest landscape restoration (FLR) in Sri Lanka. This is to ensure that there are well-trained forest landscape restoration practitioners who are familiar with the ecological, social, economic and political dimensions of restoring large tracts of land in Sri Lanka, with particular emphasis on MDFs.

There is more to be done when it comes to dipterocarps conservation. There is a need for public-private partnerships e.g. working with the cash-crop plantation sector (tea, rubber, oil palm, and cinnamon) into research methods to implement, monitor and sustain MDF corridor restoration.

The existing legal framework seems to be adequate to address deforestation and forest degradation through unlawful activities. However, the facilitation of 'conservation/ecology-drone technology' would be a useful measure in providing evidence to improve enforcement of such legislation. Drone technology can be used for conservation-related activities including forest stand mapping, threat detection, conservation mapping and develop an understanding of dipterocarp life history. This low-cost technology should be supplied to foresters as well as environmentally concerned CBO members around forest reserves to help in developing forest conservation as a citizen science program.

Image 4. Shorea flowering stand (Nimal Gunatilleke)

Case study: *Shorea ovalifolia*

The general public and amateur botanists can also contribute significantly to the conservation of dipterocarp species. One such case, was finding new individuals of *Shorea ovalifolia* (Thwaites) P.S.Ashton (Synonym *Doona ovalifolia*) which was previously considered to be extinct in the wild and to only exist at the Royal Botanic Gardens (RBG), Peradeniya. Even at the gardens the remaining trees had been damaged by bad weather in 2012 and very few seedlings have been successfully raised.

However, in 2020 information from a villager, Mr. Lasitha Prageeth, was shared on a Facebook page. Upon investigations to the site in February 2020, by Mr. Bathiya Gopallawa and RBG Herbarium staff, the species was confirmed to be *Shorea ovalifolia*. This tree is called “Piniberaliya” by villagers in the Ayagama-Pimbura area and is found in a home garden near Pimbura. At this site, there were two mature trees of about 20-30 meters in height and in full bloom. Samples to produce a herbarium voucher were taken alongside DNA extractions. These would be used to enable further identification and clarification studies.

Another one-day field visit was conducted in July 2020 to collect fruiting materials for propagation practices at the botanic gardens. Despite flooding in the area, staff were able to collect 30 individual seedlings and 20 seeds from the two trees. According to the information given by villagers, forest patches close to the existing population were also being explored to find the potential existence of *Shorea ovalifolia*.

Collected samples from the Pimbura site are now successfully grown in the plant nursery at the RBG, Peradeniya and a few individuals have been added to the *ex situ* collection. If reintroductions are to be made in the future further nursery practices need to be trialled and propagation methods studied. These are currently be being conducted by Dr. Achala Attanayake, the Head of the RBG at Peradeniya.

Finally, some other endemics and threatened plants were also recorded during the 2020 field expedition including, *Rinorea benghalensis, Polyalthia moonii* and *Dipterocarpus glandulosus*.

Sinharaja World Heritage Site, Sri Lanka. Much of the canopy is dominated by *Shorea trapezifolia* (Nimal Gunatilleke)

Vateria copallifera fruits (Nimal Gunatilleke)

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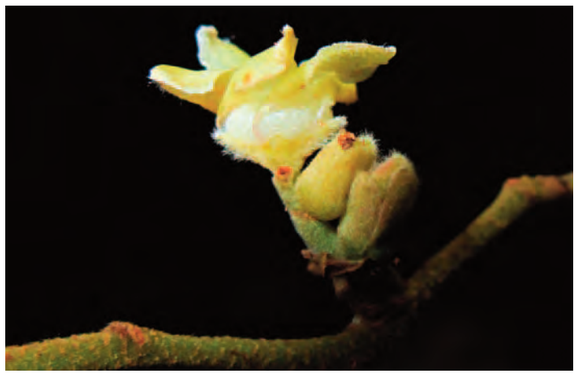
Appendix 1

Species list and threat categories

Taxon Name	Author	IUCN Category and Criteria	Country Count
Hopea shingkeng	(Dunn) Bor	EX	2
Balanocarpus kitulgallensis	Kosterm.	CR B1ab(iii)+2ab(iii); D	1
Cotylelobium lewisianum	(Trimen ex Hook.f.) P.S.Ashton	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Dipterocarpus bourdillonii	Brandis	CR C2a(i)	1
Dipterocarpus cinereus	Slooten	CR A2cd+3cd; B1ab(i,ii,v); C2a(i,ii); D	1
Dipterocarpus coriaceus	Slooten	CR A2cd+4c	2
Dipterocarpus cuspidatus	P.S.Ashton	CR A4acd	1
Dipterocarpus lamellatus	Hook.f.	CR A2c; D	2
Dipterocarpus littoralis	Blume	CR B1ab(i,ii,iii,v); C1+2a(i); D	1
Dipterocarpus pseudocornutus	P.S.Ashton	CR B1ab(iii)+2ab(iii)	1
Dryobalanops fusca	Slooten	CR A4cd	2
Hopea auriculata	Foxw.	CR C2a(i); D	1
Hopea bancana	(Boerl.) Slooten	CR A2cd+3cd; B1ab(i,ii,v); C2a(i,ii); D	1
Hopea basilanica	Foxw.	CR B2ab(i,ii,iii,v); C2a(i)	1
Hopea bilitonensis	P.S.Ashton	CR A2c	2
Hopea brachyptera	(Foxw.) Slooten	CR B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	1
Hopea cordata	J.E.Vidal	CR B1ab(i,ii,iii,v)	1
Hopea depressinerva	P.S.Ashton	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea erosa	(Bedd.) Slooten	CR C2a(i)	1
Hopea inexpectata	P.S.Ashton	CR B1ab(iii)+2ab(iii)	1
Hopea jacobi	C.E.C.Fisch.	CR B1ab(iii,v)+2ab(iii,v)	1
Hopea macrocarpa	Poopath & Sookch.	CR B1ab(iii)	1
Hopea micrantha	Hook.f.	CR A4cd	3
Hopea obscurinerva	P.S.Ashton	CR B2ab(i,ii,iii,v)	1
Hopea reynosoi	H.G.Gut., Rojo & Madulid	CR B1ab(iii)+2ab(iii)	1
Hopea rudiformis	P.S.Ashton	CR A2cd	2
Hopea santosiana	H.G.Gut., Rojo & Madulid	CR B1ab(iii)+2ab(iii)	1
Hopea scabra	P.S.Ashton	CR B1ab(iii)	1
Monotes lutambensis	Verdc.	CR B1ab(iii); D	1
Parashorea globosa	Symington	CR B2ab(iii)	2
Shorea dispar	P.S.Ashton	CR A3cd	1
Shorea falcata	J.E.Vidal	CR A2cd; C1+2a(i)	1
Shorea foraminifera	P.S.Ashton	CR A4c	2
Shorea iliasii	P.S.Ashton	CR A4cd	2
Shorea induplicata	Slooten	CR A4cd; C2a(i)	2
Shorea lumutensis	Symington	CR B1ab(iii)	1
Shorea macrantha	Brandis	CR A4cd	2
Shorea montigena	Slooten	CR C2a(i)	1

Taxon Name	Author	IUCN Category and Criteria	Country Count
Shorea ovalifolia	(Thwaites) P.S.Ashton	CR B2ab(i,ii,iii)	1
Shorea praestans	P.S.Ashton	CR A3cd+4cd	1
Shorea revoluta	P.S.Ashton	CR A2cd	3
Shorea rotundifolia	P.S.Ashton	CR A3cd+4cd	1
Shorea teysmanniana	Dyer ex Brandis	CR A2cd+4cd	3
Stemonoporus affinis	Thwaites	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus angustisepalus	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus bullatus	Kosterm.	CR B1ab(i,ii,iii)	1
Stemonoporus gilimalensis	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus gracilis	Kosterm.	CR B1ab(i,ii,iii)	1
Stemonoporus kanneliyensis	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus laevifolius	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus lanceolatus	Thwaites	CR B1ab(i,ii,iii)	1
Stemonoporus lancifolius	(Thwaites) P.S.Ashton	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus latisepalus	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus marginalis	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus moonii	Thwaites	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus nitidus	Thwaites	CR	1
Stemonoporus scaphifolius	Kosterm.	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Vateria macrocarpa	B.L.Gupta	CR B1ab(iii,v)	1
Vateriopsis seychellarum	(Dyer) F.Heim	CR B1ab(iii)	1
Vatica adenanii	Meekiong, Nizam, Latiff, Tawan & Yahud	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Vatica bantamensis	Benth. & Hook.f.	CR B1ab(iii,v)+2ab(iii,v); C2a(ii)	1
Vatica cauliflora	P.S.Ashton	CR A4cd	1
Vatica elliptica	Foxw.	CR B1ab(i,ii,iii,v)+2ab(i,ii,iii,v); C1+2a(i,ii); D	1
Vatica flavida	Foxw.	CR A2bc; B1ab(iii); D	1
Vatica kanthanensis	Saw	CR B1ab(i,ii,iii,v)+2ab(i,ii,iii,v); C2a(i,ii); D	1
Vatica mendozae	H.G.Gut., Rojo & Madulid	CR B1ab(iii)+2ab(iii)	1
Vatica patentinervia	P.S.Ashton	CR D	2
Vatica pentandra	P.S.Ashton	CR B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Vatica soepadmoi	P.S.Ashton	CR A2c; B1ab(i,ii)+2ab(i,ii); D	1
Vatica venulosa	Blume	CR A2cd+4cd	3
Vatica yeechongii	Saw	CR A4c	1
Anisoptera costata	Korth.	EN A2acd	11
Anisoptera reticulata	P.S.Ashton	EN A3cd+4cd	3
Anisoptera scaphula	(Roxb.) Kurz	EN A2cd	5
Cotylelobium burckii	(F.Heim) F.Heim	EN A4cd	3
Cotylelobium scabriusculum	(Thwaites) Brandis	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Dipterocarpus acutangulus	Vesque	EN A2cd	3
Dipterocarpus chartaceus	Symington	EN A2cd	2
Dipterocarpus conformis	Slooten	EN A2cd	3
Dipterocarpus dyeri	Pierre ex Laness.	EN A2cd	5
Dipterocarpus fusiformis	P.S.Ashton	EN A2cd; B2ab(i,ii,iii,iv)	2
Dipterocarpus geniculatus	Vesque	EN A4cd	3
Dipterocarpus glabrigemmatus	P.S.Ashton	EN B2ab(iii,v)	1
Dipterocarpus glandulosus	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Dipterocarpus grandiflorus	(Blanco) Blanco	EN A2cd	8

Taxon Name	Author	IUCN Category and Criteria	Country Count
Dipterocarpus hasseltii	Blume	EN A2cd	8
Dipterocarpus indicus	Bedd.	EN C2a(i)	1
Dipterocarpus insignis	Thwaites	EN B2ab(i,ii,iii)	1
Dipterocarpus intricatus	Dyer	EN A2cd	4
Dipterocarpus kerrii	King	EN A2cd	9
Dipterocarpus ochraceus	Meijer	EN B1ab(i,ii,v)+2ab(i,ii,v)	1
Dipterocarpus orbicularis	Foxw.	EN B2ab(iii)	2
Dipterocarpus perakensis	P.S.Ashton	EN B1ab(iii,v)+2ab(iii,v)	1
Dipterocarpus retusus	Blume	EN A2cd	9
Dipterocarpus rotundifolius	Foxw.	EN B2ab(ii,iii)	1
Dipterocarpus semivestitus	Slooten	EN B2ab(i,iii)	2
Dipterocarpus sublamellatus	Foxw.	EN A2cd+4cd	3
Dipterocarpus tempehes	Slooten	EN A4cd	2
Dryobalanops rappa	Becc.	EN A4cd	3
Hopea aequalis	P.S.Ashton	EN A4cd	3
Hopea altocollina	P.S.Ashton	EN A4cd; B2ab(i,ii,iii)	1
Hopea apiculata	Symington	EN B1ab(iii,v)	1
Hopea brevipetiolaris	(Thwaites) P.S.Ashton	EN A1a; B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea cagayanensis	(Foxw.) Slooten	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea canarensis	Hole	EN B1ab(i,iii,v)	1
Hopea celebica	Burck	EN A2cd	1
Hopea centipeda	P.S.Ashton	EN A4cd	3
Hopea cernua	Teijsm. & Binn.	EN A2cd	3
Hopea chinensis	(Merr.) Hand.-Mazz.	EN B1ab(iii,v)+2ab(iii,v)	2
Hopea cordifolia	Trim.	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea discolor	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea enicosanthoides	P.S.Ashton	EN A4c; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	1
Hopea ferrea	Laness.	EN A2cd	5
Hopea foxworthyi	Elmer	EN B2ab(i,ii,iii)	1
Hopea glabra	Wight & Arn.	EN C2a(i); D	1
Hopea gregaria	Slooten	EN A2cd	1
Hopea griffithii	Kurz	EN A2cd	6
Hopea hainanensis	Merr. & Chun	EN A2cd	2
Hopea helferi	(Dyer) Brandis	EN A2cd	5



Shorea rubra (Ling CY)

Shorea rotundifolia (Vilma Bodos)

Taxon Name	Author	IUCN Category and Criteria	Country Count
Hopea longirostrata	P.S.Ashton	EN B2ab(i,ii,iii,v)	1
Hopea megacarpa	P.S.Ashton	EN B2ab(i,ii,iii)	2
Hopea mindanensis	Foxw.	EN B2ab(i,ii,iii)	1
Hopea mollissima	C.Y.Wu	EN A2cd	2
Hopea parvifolia	(Warb.) Slooten	EN B2ab(iii)	1
Hopea pedicellata	(Brandis) Symington	EN A2cd	4
Hopea philippinensis	Dyer	EN C2a(i)	1
Hopea polyalthioides	Symington	EN B2ab(iii); D	1
Hopea quisumbingiana	H.G.Gut.	EN C2a(i)	1
Hopea racophloea	Dyer	EN C2a(i)	1
Hopea recopei	Pierre ex Laness.	EN A2c	4
Hopea reticulata	Tardieu	EN B2ab(iii)	2
Hopea samarensis	H.G.Gut.	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea semicuneata	Symington	EN A2c	2
Hopea subalata	Symington	EN B1ab(iii)+2ab(iii); D	1
Hopea thorelii	Pierre	EN A2cd	3
Hopea utilis	(Bedd.) Bole	EN B1ab(ii,iii,v)+2ab(ii,iii,v); C2a(i); D	1
Hopea vacciniifolia	Ridl. ex P.S.Ashton	EN A4c	3
Monotes duvigneaudii	Meerts	EN B2ab(iii)	1
Monotes hirtii	P.A.Duvign.	EN B2ab(iii)	1
Monotes madagascariensis	Humbert	EN B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)	1
Monotes paivae	Catarino & E.S.Martins	EN B2ab(iii)	1
Monotes rufotomentosus	Gilg	EN B2ab(iii)	1
Neobalanocarpus heimii	(King) Poopath, Sookch. & Santisuk	EN A2cd	3
Parashorea aptera	Slooten	EN A2c	1
Parashorea chinensis	Hsie Wang	EN A2cd	3
Shorea alutacea	P.S.Ashton	EN A3cd+4acd; B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea arsorianoi	H.G.Gut., Rojo & Madulid	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea astylosa	Foxw.	EN C2a(i)	1
Shorea biawak	P.S.Ashton	EN B2ab(i,ii,iii)	3
Shorea bracteolata	Dyer	EN A2cd	5
Shorea brunnescens	P.S.Ashton	EN A4cd	3
Shorea calcicola	P.S.Ashton	EN B2ab(i,ii)	1
Shorea conica	Slooten	EN A2cd	1
Shorea cordata	P.S.Ashton	EN B2ab(iii)	2
Shorea domatiosa	P.S.Ashton	EN A2cd	3
Shorea elliptica	Burck	EN A2cd	2
Shorea faguetiana	F.Heim	EN A2cd	4
Shorea farinosa	C.E.C.Fisch.	EN A2cd	4
Shorea glauca	King	EN A2cd	3
Shorea gratissima	(Wall. ex Kurz) Dyer	EN A2cd	6
Shorea henryana	Pierre	EN A2cd	5
Shorea hulanidda	Kosterm.	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea hypochra	Hance	EN A2cd	6
Shorea inaequilateralis	Symington	EN A4cd	3
Shorea javanica	Koord. & Valeton	EN B1ab(iii)	1
Shorea lamellata	Foxw.	EN A2cd+4cd	2

Taxon Name	Author	IUCN Category and Criteria	Country Count
Shorea longisperma	Roxb.	EN A2cd	3
Shorea materialis	Ridl.	EN A3cd+4cd	3
Shorea pachyphylla	Ridl. ex Symington	EN A4cd	3
Shorea pallescens	P.S.Ashton	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea pallidifolia	P.S.Ashton	EN A2cd	2
Shorea platycarpa	F.Heim	EN A4cd	4
Shorea splendida	(de Vriese) P.S.Ashton	EN A4cd	2
Shorea sumatrana	(Slooten) Desch	EN A2cd	3
Shorea tenuiramulosa	P.S.Ashton	EN A4cd	1
Shorea tumbuggaia	Roxb.	EN B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	1
Shorea uliginosa	Foxw.	EN A2cd+4cd	2
Shorea virescens	Parijs	EN A2cd+4cd	3
Shorea woodii	P.S.Ashton	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea zeylanica	(Thwaites) P.S.Ashton	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus canaliculatus	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus cordifolius	(Thwaites) Alston	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus elegans	(Thwaites) Alston	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus oblongifolius	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus petiolaris	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus reticulatus	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus revolutus	Trim. ex Hook.f.	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus rigidus	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus scalarinervis	Kosterm.	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Stemonoporus wightii	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Vatica abdulrahmaniana	Chua	EN A1c	1
Vatica affinis	Thwaites	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Vatica chartacea	P.S.Ashton	EN A4cd	2
Vatica chinensis	L.	EN A2c+3c	2
Vatica congesta	P.S.Ashton	EN B2ab(iii)	2
Vatica diospyroides	Symington	EN B1ab(i,iii,iv,v)	1
Vatica endertii	Slooten	EN A4cd; B2ab(i,ii,iii)	2
Vatica flavovirens	Slooten	EN D	1
Vatica globosa	P.S.Ashton	EN A4cd	2
Vatica guangxiensis	S.L.Mo	EN B1ab(iii)	2
Vatica havilandii	Brandis	EN A2c+4c	3
Vatica lobata	Foxw.	EN A2c; B2ab(ii,iii)	1
Vatica mizaniana	Chua	EN B1ab(iii)+2ab(iii)	1
Vatica najibiana	Ummul-Nazrah	EN B1ab(iii)+2ab(iii)	1
Vatica obovata	Slooten	EN A2c; B2ab(i,ii)	1
Vatica pachyphylla	Merr.	EN B2ab(i,ii,iii,v); C2a(i)	1
Vatica pallida	Dyer	EN A2c; B1ab(iii)+2ab(iii)	1
Vatica paludosa	Kosterm.	EN B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Vatica philastreana	Pierre	EN B2ab(ii,iii,iv,v)	4
Vatica rotata	P.S.Ashton	EN A4cd	2
Vatica rynchocarpa	P.S.Ashton	EN A2cd+3cd+4cd	3
Vatica scortechinii	Ridl.	EN B2ab(iii)	1
Vatica subglabra	Merr.	EN A2cd	1
Vatica teysmanniana	Burck	EN A2c	1

Taxon Name	Author	IUCN Category and Criteria	Country Count
Anisoptera aurea	Foxw.	VU B1ab(iii)+2ab(iii)	1
Anisoptera curtisii	Dyer ex King	VU A2acd	5
Anisoptera laevis	Ridl.	VU A2acd	5
Anisoptera marginata	Korth.	VU A2cd	3
Anisoptera thurifera	(Blanco) Blume	VU A3cd	3
Cotylelobium lanceolatum	Craib	VU A2c	5
Dipterocarpus alatus	Roxb. ex G.Don	VU A2cd	9
Dipterocarpus applanatus	Slooten	VU A4cd	2
Dipterocarpus baudii	Korth.	VU A2cd	6
Dipterocarpus concavus	Foxw.	VU A4cd	2
Dipterocarpus costatus	C.F.Gaertn.	VU A2cd	8
Dipterocarpus crinitus	Dyer	VU A2cd	3
Dipterocarpus elongatus	Korth.	VU A2cd+4cd	4
Dipterocarpus fagineus	Vesque	VU A4cd	2
Dipterocarpus gracilis	Blume	VU A2cd	10
Dipterocarpus hispidus	Thwaites	VU B1ab(i,ii,iii)	1
Dipterocarpus mundus	Slooten	VU A3cd	2
Dipterocarpus pachyphyllus	Meijer	VU A2cd	3
Dipterocarpus palembanicus	Slooten	VU A2cd+4cd	3
Dipterocarpus rigidus	Ridl.	VU A4cd	2
Dipterocarpus sarawakensis	Slooten	VU A2cd+4cd	3
Dipterocarpus stellatus	Vesque	VU A3cd+4cd	3
Dipterocarpus turbinatus	C.F.Gaertn	VU A2cd	8
Dryobalanops aromatica	C.F.Gaertn.	VU A2cd	3

Gunung Dahu Forest Indonesia (Megan Barstow)

Taxon Name	Author	IUCN Category and Criteria	Country Count
Dryobalanops keithii	Symington	VU A3cd	2
Hopea acuminata	Merr.	VU C2a(i)	1
Hopea andersonii	P.S.Ashton	VU A4cd	2
Hopea beccariana	Burck	VU A2cd	3
Hopea celtidifolia	Kosterm.	VU A2c; B1ab(i,ii,iii)+2ab(i,ii,iii)	2
Hopea coriacea	Burck	VU A2cd+4cd	3
Hopea ferruginea	Parijs	VU A2cd+4cd	4
Hopea glaucescens	Symington	VU A4c	1
Hopea johorensis	Symington	VU B1ab(iii,v)	1
Hopea jucunda	Thwaites	VU B1ab(i,ii,iii)	1
Hopea kerangasensis	P.S.Ashton	VU A2cd+4cd	2
Hopea malibato	Foxw.	VU B2ab(i,ii,iii,v); C2a(i)	1
Hopea mengarawan	Miq.	VU A2cd+4cd	3
Hopea modesta	(A.DC.) Kosterm.	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Hopea myrtifolia	Miq.	VU A4c	2
Hopea nigra	Burck	VU B2ab(i,ii,iii,iv)	1
Hopea oblongifolia	Dyer	VU B2ab(iii)	2
Hopea odorata	Roxb.	VU A2cd	8
Hopea pachycarpa	(F.Heim) Symington	VU A4cd	3
Hopea pentanervia	Symington ex G.H.S.Wood	VU A3cd+4cd	3
Hopea pierrei	Hance	VU A2d	5
Hopea ponga	(Dennst.) Mabb.	VU A2c	1
Hopea pubescens	Ridl.	VU A2bc+4c	1
Hopea sangal	Korth.	VU A2cd	5
Hopea sublanceolata	Symington	VU A2cd	2
Monotes doryphorus	P.A.Duvign.	VU B2ab(iii)	1
Monotes pearsonii	H.H.Bancr.	VU B2ab(iii)	2
Monotes rubriglans	H.H.Bancr.	VU B2ab(iii)	2
Parashorea stellata	Kurz	VU A2cd	6
Shorea acuminatissima	Symington	VU A3cd	3
Shorea affinis	(Thwaites) P.S.Ashton	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea albida	Symington ex A.V.Thomas	VU A2cd+4cd	3
Shorea andulensis	P.S.Ashton	VU A2cd	3
Shorea atrinervosa	Symington	VU A4cd	3
Shorea bakoensis	P.S.Ashton	VU D1+2	1
Shorea balangeran	Burck	VU A2cd	1
Shorea bentongensis	Foxw.	VU A2cd; B2ab(iii)	1
Shorea blumutensis	Foxw.	VU A4c	2
Shorea bullata	P.S.Ashton	VU A2cd	3
Shorea chaiana	P.S.Ashton	VU A3cd	2
Shorea collaris	Slooten	VU A2cd	2
Shorea collina	Ridl.	VU B1ab(iii,v)	2
Shorea confusa	P.S.Ashton	VU A2cd+4cd	3
Shorea congestiflora	(Thwaites) P.S.Ashton	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea cordifolia	(Thwaites) P.S.Ashton	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea cuspidata	P.S.Ashton	VU A2cd	2
Shorea dealbata	Foxw.	VU B2ab(ii,iv)	2
Shorea disticha	(Thwaites) P.S.Ashton	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1

Taxon Name	Author	IUCN Category and Criteria	Country Count
Shorea dyeri	Thwaites ex Trimen	VU B1ab(i,ii,iii)	1
Shorea falcifera	Dyer ex Brandis	VU A2cd+4cd	2
Shorea falciferoides	Foxw.	VU A4cd	4
Shorea ferruginea	Dyer ex Brandis	VU A2c	3
Shorea flaviflora	G.H.S.Wood ex P.S.Ashton	VU A3cd	2
Shorea flemmichii	Symington	VU A4c; B2ab(iii,v)	2
Shorea foxworthyi	Symington	VU A2c	4
Shorea furfuracea	Miq.	VU B2ab(i,ii,iii,v)	1
Shorea gardneri	(Thwaites) P.S.Ashton	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea geniculata	Symington ex P.S.Ashton	VU A2cd	3
Shorea gibbosa	Brandis	VU A4cd	4
Shorea guiso	(Blanco) Blume	VU A2cd	6
Shorea hemsleyana	King ex Foxw.	VU A2acd	3
Shorea hypoleuca	Meijer	VU A2cd	1
Shorea inappendiculata	Burck	VU A4cd	3
Shorea isoptera	P.S.Ashton	VU A2cd	3
Shorea johorensis	Foxw.	VU A4cd	4
Shorea ladiana	P.S.Ashton	VU A2cd	2
Shorea laevis	Ridl.	VU A2cd	5
Shorea lissophylla	Thwaites	VU B1ab(i,ii,iii)	1
Shorea longiflora	(Brandis) Symington	VU A2cd	3
Shorea macrobalanos	P.S.Ashton	VU A3cd	2
Shorea malibato	Foxw.	VU B2ab(i,ii,iii,v); C2a(i)	1
Shorea mecistopteryx	Ridl.	VU A2cd+4cd	3
Shorea megistophylla	P.S.Ashton	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea mujongensis	P.S.Ashton	VU A4cd	2
Shorea oblongifolia	Thwaites	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea obovoidea	Slooten	VU A4cd	2
Shorea obscura	Meijer	VU A4cd	3
Shorea ochracea	Symington	VU A4cd	3
Shorea ochrophloia	Symington	VU A2cd	3
Shorea peltata	Symington	VU A2cd	2
Shorea polyandra	P.S.Ashton	VU A2cd+4cd	2
Shorea quadrinervis	Slooten	VU A2cd+4cd	3
Shorea resinosa	Foxw.	VU A4c	2
Shorea retinodes	Slooten	VU A2c	1
Shorea retusa	Meijer	VU A2cd+4cd	2
Shorea richetia	Symington	VU B1ab(iii)	2
Shorea robusta	C.F.Gaertn.	VU A2cd	5
Shorea roxburghii	G.Don	VU A2cd	7
Shorea rubella	P.S.Ashton	VU A2cd	2
Shorea rugosa	F.Heim	VU A4cd	3
Shorea selanica	(Valmont) Blume	VU A2cd+4cd	1
Shorea singkawang	(Miq.) Burck	VU A2cd	3
Shorea slootenii	P.S.Ashton	VU A2cd	3
Shorea smithiana	Symington	VU A2cd+4cd	3
Shorea stipularis	Thwaites	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Shorea subcylindrica	Slooten	VU A2cd	2

Taxon Name	Author	IUCN Category and Criteria	Country Count
Shorea superba	Symington	VU A2cd+4cd	3
Shorea symingtonii	G.H.S.Wood	VU A2c	1
Shorea thorelii	Pierre ex Laness.	VU A2cd	5
Shorea trapezifolia	(Thwaites) P.S. Ashton	VU B1ab(i,ii,iii)	1
Shorea worthingtonii	P.S.Ashton	VU B1ab(i,ii,iii)	1
Stemonoporus acuminatus	Bedd.	VU B1ab(i,ii,iii)	1
Stemonoporus gardneri	Thwaites	VU B1ab(i,ii,iii)+2ab(i,ii,iii)	1
Upuna borneensis	Symington	VU A2cd	3
Vateria indica	L.	VU A2cd	1
Vatica badiifolia	P.S.Ashton	VU A2cd	3
Vatica compressa	P.S.Ashton	VU A3cd+4cd; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	1
Vatica glabrata	P.S.Ashton	VU B1ab(iii,v)+2ab(iii,v)	2
Vatica hullettii	(Ridl.) P.S.Ashton	VU B1ab(iii)	1
Vatica javanica	Slooten	VU B2ab(iii)	1
Vatica maingayi	Dyer	VU A2c+4c	5
Vatica mangachapoi	Blanco	VU A2c	4
Vatica maritima	Slooten	VU A2cd	3
Vatica obscura	Trimen	VU B1ab(i,ii,iii)	1
Vatica parvifolia	P.S.Ashton	VU A3cd	3
Vatica pauciflora	Blume	VU A2cd	5
Vatica pedicellata	Brandis	VU A2c; B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	1
Vatica perakensis	King	VU B2ab(iii)	2
Vatica sarawakensis	F.Heim	VU A4cd	3
Vatica stapfiana	(King) Slooten	VU A2cd	3
Anisoptera megistocarpa	Slooten	NT A2cd	4
Dipterocarpus borneensis	Slooten	NT A2cd	3
Dipterocarpus caudiferus	Merr.	NT A2cd	3
Dipterocarpus confertus	Slooten	NT A4cd	3
Dipterocarpus costulatus	Slooten	NT A2cd	3
Dipterocarpus eurhynchus	Miq.	NT A4cd	4
Dipterocarpus humeratus	Slooten	NT A2cd	3
Dipterocarpus lowii	Hook.f.	NT A2cd	3
Dipterocarpus obtusifolius	Teijsm. ex Miq.	NT A2cd+3cd+4cd	6
Dipterocarpus tuberculatus	Roxb.	NT A2cd	7
Dipterocarpus verrucosus	Foxw. ex Slooten	NT A2cd	4
Dipterocarpus zeylanicus	Thwaites	NT B1b(iii)	1
Hopea bullatifolia	P.S.Ashton	NT A4cd	2
Hopea dyeri	F.Heim	NT A2cd+4cd	3
Hopea fluvialis	P.S.Ashton	NT A4cd	3
Hopea forbesii	(Brandis) Slooten	NT A2cd	2
Hopea glabrifolia	C.T.White	NT B1ab(i,iii)	1
Hopea iriana	Slooten	NT	2
Hopea montana	Symington	NT B2b(iii)	2
Hopea nutans	Ridl.	NT A2cd+4cd	3
Hopea sphaerocarpa	(F.Heim) P.S.Ashton	NT A2c	2
Hopea sulcata	Symington	NT A3c	1
Hopea tenuivervula	P.S.Ashton	NT A2cd	3
Hopea treubii	F.Heim	NT A2cd	2

Taxon Name	Author	IUCN Category and Criteria	Country Count
Hopea ultima	P.S.Ashton	NT B2ab(i,ii,iii,v)	1
Hopea wyattsmithii	G.H.S.Wood ex P.S.Ashton	NT A4cd	2
Monotes redheadii	P.A.Duvign.	NT B1a	2
Parashorea densiflora	Slooten & Symington	NT A2cd	3
Parashorea lucida	(Miq.) Kurz	NT A4cd	2
Parashorea macrophylla	Wyatt-Sm. ex P.S.Ashton	NT A4cd	3
Shorea agami	P.S.Ashton	NT A2cd	3
Shorea almon	Foxw.	NT A4cd	4
Shorea amplexicaulis	P.S.Ashton	NT A4cd	3
Shorea angustifolia	P.S.Ashton	NT A4cd	3
Shorea asahi	P.S.Ashton	NT A2cd	3
Shorea carapae	P.S.Ashton	NT A4cd	3
Shorea ciliata	King	NT A3c	1
Shorea coriacea	Burck	NT A2cd+4cd	3
Shorea dasyphylla	Foxw.	NT A2cd+4cd	3
Shorea exelliptica	Meijer	NT A2c	3
Shorea faguetioides	P.S.Ashton	NT A2cd	3
Shorea kudatensis	G.H.S.Wood ex Meijer	NT B2ab(i,ii,iii)	1
Shorea lepidota	(Korth.) Blume	NT A2cd+4cd	3
Shorea leprosula	Miq.	NT A2cd	4
Shorea lunduensis	P.S.Ashton	NT B1ab(iii)+2ab(iii)	2
Shorea maxima	(King) Symington	NT A3c	1
Shorea maxwelliana	King	NT A2cd+4cd	3
Shorea myrionerva	Symington ex P.S.Ashton	NT A2cd+4cd	3
Shorea obtusa	Wall. ex Blume	NT A2cd	4
Shorea palembanica	Miq.	NT A4cd	3
Shorea patoiensis	P.S.Ashton	NT A2cd+4cd	3
Shorea pauciflora	King	NT A2cd+3cd	4
Shorea pilosa	P.S.Ashton	NT A2cd	2
Shorea platyclados	Slooten ex Foxw. & Slooten	NT A2cd+3cd	3
Shorea rubra	P.S.Ashton	NT A2cd	3
Shorea sagittata	P.S.Ashton	NT A3cd	1
Shorea scaberrima	Burck	NT A4cd	3
Shorea scabrida	Symington	NT A2cd	3
Shorea scrobiculata	Burck	NT A2cd+4cd	3
Shorea stenoptera	Burck	NT A2cd	2
Shorea submontana	Symington	NT A3c	1
Shorea waltonii	G.H.S.Wood ex Meijer	NT B2ab(i,ii,iii)	1
Shorea xanthophylla	Symington	NT A4cd	2
Vateria copallifera	(Retz.) Alston	NT	1
Vatica borneensis	Burck	NT A4cd	2
Vatica brevipes	P.S.Ashton	NT A4cd	2
Vatica brunigii	P.S.Ashton	NT A2cd+4cd	3
Vatica coriacea	P.S.Ashton	NT A4cd	3
Vatica cuspidata	(Ridl.) Desch	NT A3c	2
Vatica dulitensis	Symington	NT A4cd	3
Vatica heteroptera	Symington	NT A2c; B1b(iii)	1
Vatica nitens	King	NT A4c	4

Taxon Name	Author	IUCN Category and Criteria	Country Count
Vatica vinosa	P.S.Ashton	NT A2cd	3
Anisoptera grossivenia	V.Sloot.	LC	3
Cotylelobium melanoxylon	(Hook.f.) Pierre	LC	4
Dipterocarpus cornutus	Dyer	LC	3
Dipterocarpus globosus	Vesque	LC	3
Dipterocarpus kunstleri	King	LC	5
Dipterocarpus nudus	Vesque	LC	2
Dipterocarpus oblongifolius	Blume	LC	4
Dipterocarpus validus	Blume	LC	3
Dryobalanops beccarii	Dyer	LC	3
Dryobalanops lanceolata	Burck	LC	3
Dryobalanops oblongifolia	Dyer	LC	2
Hopea bracteata	Burck	LC	4
Hopea dryobalanoides	Miq.	LC	3
Hopea mesuoides	P.S.Ashton	LC	2
Hopea nervosa	King	LC	3
Hopea nodosa	Slooten	LC	1
Hopea novoguineensis	Slooten	LC	2
Hopea papuana	Diels	LC	2
Hopea parviflora	Bedd.	LC	1
Hopea plagata	(Blanco) S.Vidal	LC	3
Hopea pterygota	P.S.Ashton	LC	3
Hopea rugifolia	P.S.Ashton	LC	2
Hopea similis	Slooten	LC	2
Hopea vesquei	F.Heim	LC	2
Marquesia acuminata	(Gilg) R.E.Fr.	LC	3
Marquesia excelsa	R.E.Fr.	LC	2
Marquesia macroura	Gilg	LC	4

Dipterocarpus elongatus (S.K.Ganesan)

Shorea praestans (Vilma Bodos)

Taxon Name	Author	IUCN Category and Criteria	Country Count
Monotes adenophyllus	Gilg	LC	4
Monotes africanus	A.DC.	LC	6
Monotes autennei	P.A.Duvign.	LC	2
Monotes dasyanthus	Gilg	LC	3
Monotes engleri	Gilg	LC	4
Monotes glaber	Sprague	LC	5
Monotes gossweileri	De Wild.	LC	1
Monotes hypoleucus	(Welw.) Gilg	LC	5
Monotes katangensis	(De Wild.) De Wild.	LC	5
Monotes kerstingii	Gilg	LC	14
Monotes magnificus	Gilg	LC	4
Parashorea malaanonan	(Blanco) Merr.	LC	4
Parashorea parvifolia	Wyatt-Sm. ex P.S.Ashton	LC	3
Parashorea tomentella	(Symington) Meijer	LC	2
Pseudomonotes tropenbosii	A.C.Londoño, E.Alvarez & Forero	LC	1
Shorea acuminata	Dyer	LC	2
Shorea acuta	P.S.Ashton	LC	2
Shorea argentifolia	Symington	LC	3
Shorea assamica	Dyer	LC	7
Shorea balanocarpoides	Symington	LC	3
Shorea beccariana	Burck	LC	3
Shorea contorta	S.Vidal	LC	1
Shorea crassa	P.S.Ashton	LC	3
Shorea curtisii	Dyer ex King	LC	5
Shorea fallax	Meijer	LC	3
Shorea havilandii	Brandis	LC	2
Shorea hopeifolia	(F.Heim) Symington	LC	4
Shorea kunstleri	King	LC	4
Shorea laxa	Slooten	LC	2
Shorea macrophylla	(de Vriese) P.S.Ashton	LC	3
Shorea macroptera	Dyer	LC	5
Shorea micans	P.S.Ashton	LC	1
Shorea monticola	P.S.Ashton	LC	2
Shorea multiflora	(Burck) Symington	LC	3
Shorea negrosensis	Foxw.	LC	1
Shorea ovalis	Blume	LC	4
Shorea ovata	Dyer ex Brandis	LC	4
Shorea palosapis	Merr.	LC	1
Shorea parvifolia	Dyer	LC	3
Shorea parvistipulata	F.Heim.	LC	3
Shorea pinanga	Scheff.	LC	3
Shorea polita	S.Vidal	LC	1
Shorea polysperma	Merr.	LC	1
Shorea pubistyla	P.S.Ashton	LC	2
Shorea seminis	Slooten	LC	4
Shorea siamensis	Miq.	LC	6
Shorea venulosa	G.H.S.Wood ex Meijer	LC	2
Vatica albiramis	Slooten	LC	2

Taxon Name	Author	IUCN Category and Criteria	Country Count
Vatica granulata	Slooten	LC	3
Vatica lowii	King	LC	2
Vatica micrantha	Slooten	LC	3
Vatica oblongifolia	Hook.f.	LC	3
Vatica odorata	(Griff.) Symington	LC	10
Vatica rassak	(Korth.) Blume	LC	4
Vatica umbonata	(Hook.f.) Burck	LC	3
Dipterocarpus condorensis	Pierre	DD	5
Dipterocarpus scaber	Buch.-Ham.	DD	1
Hopea aptera	P.S.Ashton	DD	1
Hopea dasyrrhachis	Slooten	DD	2
Hopea latifolia	Symington	DD	3
Hopea ovoidea	P.S.Ashton	DD	1
Hopea paucinervis	Parijs	DD	1
Monotes glandulosus	Pierre	DD	1
Monotes xasenguensis	H.H.Bancr.	DD	1
Parashorea buchananii	(C.E.C.Fisch.) Symington	DD	2
Parashorea dussaudii	Tardieu	DD	2
Parashorea smythiesii	Wyatt-Sm. ex P.S.Ashton	DD	3
Parashorea warburgii	Brandis	DD	1
Shorea kuantanensis	P.S.Ashton	DD	1
Vatica bella	Slooten	DD	2
Vatica chevalieri	(Gagnep.) Smitinand	DD	1
Vatica cinerea	King	DD	6
Vatica griffithii	Brandis	DD	1
Vatica harmandiana	Pierre	DD	5
Vatica lanceifolia	(Roxburgh) Blume	DD	4
Vatica palungensis	P.S.Ashton	DD	1
Vatica ridleyana	Brandis	DD	2

Shorea rotundifolia (Ling CY)

Shorea cuspidata (Ling CY)

Appendix 2

The number of single country endemics per country and the number of threatened single country endemics per country.

Country	Number of single country endemic	No. of threatened single country endemics
Angola	4	1
Bangladesh	1	0
Colombia	1	0
Democratic Republic of the Congo	3	3
India	14	12
Indonesia	27	23
Madagascar	1	1
Malaysia	53	42
Myanmar	1	0
Papua New Guinea	4	2
Philippines	25	20
Seychelles	1	1
Sri Lanka	58	56
Tanzania, United Republic of	2	2
Thailand	2	2
Viet Nam	4	3

Upuna borneensis (Ling CY)

Vatica sarawakensis (Vilma Bodos)

Appendix 3

Table of report, case studies and country page authors and institutions

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