THE ORANGUTAN TROPICAL PEATLAND PROJECT

BASELINE FLORA ASSESSMENT AND PRELIMINARY MONITORING PROTOCOL IN THE KATINGAN PEAT SWAMP, CENTRAL KALIMANTAN, INDONESIA

February 2011

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Baseline Flora Assessment and Preliminary Monitoring Protocol in the Katingan Peat Swamp, Central Kalimantan, Indonesia

Report on research commissioned by:

PT. Rimba Makmur Utama / PT. Starling Asia

And performed by:

The Orangutan Tropical Peatland Project (OuTrop)

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Palangka Raya, February 2011

Citation:
Harrison M. E., Kursani, Santiano, Hendri, Purwanto A. and Husson S. J. (2011). *Baseline Flora Assessment and Preliminary Monitoring Protocol in the Katingan Peat Swamp, Central Kalimantan, Indonesia.* Report produced by the Orangutan Tropical Peatland Project for PT. Rimba Makmur Utama / PT. Starling Asia, Palangka Raya, Indonesia.

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Cover image: Tall, unlogged forest in Perigi, Katingan Forest, Central Kalimantan.

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PREAMBLE

The Climate, Community and Biodiversity Alliance (CCBA) Standards are intended to "foster the development and marketing of projects that deliver credible and significant climate, community and biodiversity benefits in an integrated, sustainable manner. Projects that meet the Standards adopt best practices to deliver robust and credible greenhouse gas reductions while also delivering net positive benefits to local communities and biodiversity". Many of the CCBA Standard's checkpoints are either focussed on, or include, aspects of biodiversity, which includes forest flora.

The Orangutan Tropical Peatland Project (OuTrop) was contracted by PT. Rimba Makmur Utama/Starling Resources to help satisfy the CCBA Standard checkpoints related to floral biodiversity and facilitate the acquisition of Approved/Gold Standard status for the proposed Forest Carbon Project in Katingan Regency. This follows on from a previous contract, in which OuTrop provided an assessment of faunal biodiversity and ape population density in the area. Established in 1999, OuTrop is a UK-based group of scientists who carry out research, ecosystem monitoring and conservation management in the peat-swamp forests of the River Sabangau catchment and surrounding areas. Our long-term research focuses are: floral and faunal biodiversity; ecological monitoring; forest ecology, dynamics, phenology and restoration; the distribution, population status, behaviour and ecology of the forest's flagship ape species – the orangutan and agile gibbon – and provide scientific feedback to conservation managers and work with our local partners to implement successful conservation programmes.

In this report, we provide the necessary information to satisfy the biodiversity sections of PT. Rimba Makmur Utama/Starling Resources CCBA application, as pertaining to forest flora. We (i) describe the baseline flora and forest structure of the area, identify High Conservation Value (HCV) floral species and threats to these; (ii) assess the project's impacts on forest flora and structure and recommend floral biodiversity objectives for the project; and (iii) propose a preliminary floral monitoring proposal for assessing the long-term impacts of the project's activities on the area's floral biodiversity and HCVs.

EXECUTIVE SUMMARY

Borneo is one of the world's most floristically diverse regions, and peat-swamp forests harbour a significant proportion of this diversity. Due to its very high carbon content, great potential exists for REDD projects in peat-swamp forests, which can potentially provide much-needed revenue for conserving these forest's unique flora.

PT. Rimba Makmur Utama / Starling Asia's proposed REDD+ concession area covers 227,260 ha of mostly forested peat-swamp forest in the Katingan and Kotawaringan Timur Districts, Central Kalimantan, Indonesia. During November-December 2010, we assessed the flora of this forest, in order to provide a baseline description of the area, and identify any HCV species and the threats these might face. These surveys confirmed that Katingan is home to a highly diverse floral community, including up to 312 species of flora, comprised of 219 tree and 93 non-tree species. Comparison of floral diversity indices for Katingan and other peat-swamp forests indicate high floral diversity in Katingan. Data on tree size distributions, biomass and species abundance are presented. Abundant tree species include a number of important orang-utan foods. Included among the tree species in Katingan are at least six HCV species, including the Critically Endangered *Shorea balangeran* and Endangered *S. teysmanniana*. Estimates for potential population sizes of these species in Katingan, based on plot data, indicate that the concession clearly satisfies both the vulnerability and irreplaceability criteria for classification as a Key Biodiversity Area.

This floral diversity in Katingan is currently facing a variety of threats, however, which need to be countered if the conservation of biodiversity and HCVs in the area is to be successful. The most important threats to the area's biodiversity and HCVs are peat drainage and subsequent fire, illegal logging, gold mining, and potential conversion to oil palm plantations and coal concessions. These threats are attributed to 14 active drivers and six agents of biodiversity loss in Katingan.

Without the project, the most likely land-use scenario is that illegal logging, hunting, peat degradation and other harmful activities will continue, and that risk of fire and encroachment from gold mines and oil palm will increase. This will lead to severe negative impacts on the area's floral diversity and declines in the population size of all the floral HCV species. The majority of the project's activities will be directly beneficial to floral diversity and HCVs in the area, and the overall impact of all the project activities on floral diversity and HCVs will be overwhelmingly positive.

We recommend eleven floral biodiversity objectives be adopted by the project proponents. Further, we propose a preliminary monitoring programme to demonstrate whether the Project has achieved the stated conservation objectives and has had net positive impacts on floral diversity and HCVs. A full floral monitoring programme will be submitted within a year of acceptance to CCBA Standards. This programme will include re-surveys of plots surveyed herein, to provide information on changes in species composition, size distribution, biomass and HCV species' abundance.

Based on these results, it is clear that Katingan is a crucial area for flora conservation. It is also clear that this diversity faces a number of threats, that the project activities will benefit flora conservation and that these activities are very unlikely to occur in the absence of the project. We therefore conclude that the implementation of this project is important for floral diversity conservation, both in Borneo and globally.

ACKNOWLEDGEMENTS

- Starling Resources and PT. Rimba Makmur Utama for research permissions, funding and contracting us to perform this research.
- Rezal Kusumaatmadja for facilitating the research and providing background literature and maps of the area.
- Taryono Darussman and Rumi Naito for facilitating field research and advice.
- Denny Kurniawan for advice and information on River Katingan villages.
- Erna Shinta, Zeri Yeen and Helen Morrogh-Bernard for previous work in compiling the Sabangau flora species list.
- All field assistants and local villagers who helped with data collection, and *klotok* travel to and from the research camps.
- The residents of the villages along the Rivers Mentaya and Katingan, for their kind cooperation, willingness to facilitate our research and answer questionnaires, and allowing us to conduct this research in their forest.

1. SUMMARY RESPONSES TO CCB CHECKPOINTS

In this section, we present the key information resulting from our work in relation to the checkpoints listed in the CCBA Standards (2008), as relevant to forest flora. Reference to further/supporting information on particular topics in the remainder of the report is provided (see also Harrison *et al.*, 2010a).

G1. Original Conditions in the Project Area

G1.7. Current floral diversity and threats to this biodiversity
In total, 204 floral species were detected in the proposed concession through the surveys, including 144 tree and 60 non-tree species. Because the plot area and coverage of different habitat sub-types in these surveys was necessarily limited, these figures will be an underestimate of the total floral diversity of the area. We therefore compared this species list with that of the adjacent, ecologically very similar and protected Sabangau forest, in which OuTrop have built up a comprehensive floral species list over many years of surveys throughout the forest (Morrogh-Bernard, 2009). Using these data together with the precautionary principle, in which species are assumed to be present unless there is good reason to believe otherwise, the precautionary total number of floral species in Katingan is 312, including 219 tree and 93 non-tree species.

Indices of floral diversity derived from these data (species/100 stems and Fisher's alpha) indicate levels of diversity comparable to the nearby Sabangau ecosystem, whose importance for flora conservation is well documented and which supports the world's largest Bornean orangutan and agile gibbon populations. Notably, the abundance of large *Diospyros bantamensis* trees – a key orangutan and gibbon food – is high in Katingan and a number of other important ape foods are also abundant.

This floral biodiversity is currently facing a variety of threats, which will need to be countered if biodiversity conservation in the area is to be successful. The most important of these threats are peat drainage and subsequent fire, illegal logging, gold mining in the north, and potential conversion to oil palm plantations and coal concessions. Other threats include forest conversion for local agriculture, charcoal production in at least one village and use of environmentally harmful methods for extraction of non-timber forest products. This is described in detail in Section 2.4.8.

G1.8. Evaluation of presence of High Conservation Value flora
A detailed description of the importance of the area for floral diversity is provided in Section 2.4.

<u>G1.8.1.a. Protected areas</u> – The Katingan forest is not formally protected for wildlife conservation. Due to the presence of numerous threatened floral species in the area (see below), Katingan can be classified as a biological HCV area or Key Biodiversity Area (KBA). The Katingan forest also provides important biodiversity support functions to the adjacent Sebangau National Park; indeed, for fauna that can either swim or fly, or flora whose pollen or seeds are dispersed by these fauna, wind or water, the Sabangau and Katingan ecosystems are entirely contiguous. Many faunal species, including HCVs such as the white-shouldered ibis (*Pseudibis davisoni*) and Storm's stork (*Ciconia stormii*), will make use of both ecosystems for feeding and/or

breeding purposes. Hydrologically, the two ecosystems are also essentially contiguous and, hence, maintaining natural hydrology in Katingan is important for preventing peat degradation, fire and forest and species loss in Sebangau National Park.

G1.8.1.b. Threatened species – Of the total number of floral species documented in Katingan, one species is listed by the IUCN as Critically Endangered (*Shorea balangeran*), one Endangered (*S. teysmanniana*), four confirmed Vulnerable (*Combretocarpus rotundatus*, *Dyera lowii / polyphylla, S. uliginosa* and *Gonystylus bancanus*) and four potential Vulnerable (*Mangifera* spp., *Canarium sp., Aglaia* sp. and *Knema* sp.) species. Three *Nepenthes* species are protected under Indonesian law and are listed under Appendix II of CITES. A further five orchid species, plus *G. bancanus* are also listed under CITES Appendix II.

Preliminary estimates for potential population sizes of these HCV species in Katingan, based on the plot data obtained during our surveys (see below), indicate that the proposed concession area clearly satisfies both the vulnerability and irreplaceability criteria for classification as a Key Biodiversity Area (see *GL3.1-2* for full details). These figures are unlikely to be overestimates, as they include only trees exceeding 15 cm cbh that were included in our plots and do not include the unsurveyed areas of low-pole forest, which covers 2,140 ha of the total 227,000 ha in the concession. These results confirm the importance of Katingan for both the maintenance of overall floral diversity in Borneo, in addition to conservation of threatened floral species, cementing its status as a Key Biodiversity Area for flora. The threats faced by the area's flora are discussed in Section 2.4.8.

Species	**IUCN status**	**No. stems ≥ 5 cm dbh / ha**	**Extrapolated total no. stems ≥ 5 cm dbh in Katingan**
Shorea balangeran	CR	3.56	629,764
Shorea teysmanniana	EN	73.09	12,929,621
Combretocarpus rotundatus	VU	13.81	2,442,989
Dyera lowii / polyphylla	VU	20.72	3,665,368
Shorea uliginosa	VU	14.60	2,582,740
Gonystylus bancanus	VU	47.04	8,321,376

G1.8.1.c. Endemic species – No species of flora found in Katingan could be confirmed as being endemic to either Indonesia or Borneo. This does not, however, reflect the value of the forest for conserving endemic flora, but merely reflects the incredibly poor documentation of floral species distribution in South-east Asia.

G1.8.1.d. Areas supporting significant biodiversity concentrations – Most of the flora documented in Katingan occur throughout peat-swamp forests in Borneo, and so most habitat sub-types in Katingan will be suitable areas for the majority of the flora documented in the area, provided the forest has not been too disturbed by human activities (areas of recently burnt non-forest supported exceptionally low numbers of species). The presence of tall forest, low-canopy forest and savannah-like areas –

habitat sub-types that we were unable to survey due to logistical constraints – in Katingan also increases the biodiversity potential of the area, by providing habitat sub-types suited to species with varying specialisms. High concentrations of biodiversity and confirmed and potential HCVs were even found in areas of active or very recent illegal logging disturbance, such as Perigi, Terantang and Hantipan. Thus, the entire forested area in Katingan can be considered to support significant concentrations of floral diversity.

<u>G.1.8.2. Areas with viable populations of species in natural patterns of distribution and abundance</u> – Katingan is home to globally significant populations of at least six, and probably ten or more, floral HCV species: *Shorea balangeran*, *S. teysmanniana, S. uliginosa, C. rotundatus*, *D. lowii / polyphylla* and *G. bancanus* confirmed, and *Mangifera* spp., *Canarium sp., Aglaia* sp. and *Knema* sp. potential. Based on the extrapolated population sizes for these HCV species and the large size of the Katingan forest large size (2,273 km^2 of forest; representing 7.6% of the remaining peatland in Central Kalimantan), Katingan will almost certainly contain viable populations of the majority of floral species documented as inhabiting the area. This is supported by calculations of the potential population size of HCVs in the project area (*GL3.2*), which indicate very large populations numbering in the hundreds of thousands or millions. As the entire forested area consists of one block of habitat, with a variety of different habitat sub-types, viable populations of floral species in natural patterns of distribution and abundance can be considered to exist throughout the forested area of the proposed concession. This includes the more stunted areas of low-pole (canopy) forest and savannah-like areas, which are likely home to specialised floral species that thrive in these habitats.

<u>G.1.8.3. Threatened or rare ecosystems</u> – Indonesian peat-swamp forests are being lost at an alarming rate: experts estimate that from 1985-2005 over 30% of Indonesia's peat-swamp forest became degraded and degradation rates continue at a rate of 1.7% a year (Hooijer *et al.*, 2006). Given this rate of degradation, it is clear that peat-swamp forest is a threatened ecosystem.

G2. Baseline Projections

G2.5. Description of how the 'without project' scenario would affect biodiversity in the region

<u>G2.5.1. Habitat availability</u> – In the absence of the project, it is likely that the forest area will be reduced by 20% or more during the lifetime of the project (30 years) and that forest condition will be become severely degraded throughout, due to continued peat degradation, fire, illegal logging and forest conversion (see Section 2.4.8 and Harrison *et al.*, 2010a for a full description of threats). Furthermore, although no concessions are active at present, as most of the forest in Katingan is still classified as "production forest" (*Hutan Produksi*), the threat of concession logging returning to the area also remains. The availability of high-quality habitat and, hence, floral species will also be negatively impacted by illegal logging, through incidental damage, use in logging skids, cutting of lianas, changes in forest micro-habitat reducing habitat suitability, and canal construction, leading to increased peat drainage and vulnerability of the forest to fire. The threat of oil-palm encroachment is also high, with oil-palm plantations already threatening parts of the proposed concession

area. Conversion to oil palm would lead to the near total loss of the converted area's natural forest flora, as it is replaced with oil-palm monoculture, having very serious negative impacts on floral biodiversity in the area. The risk of peat drainage and fire spreading from oil-palm plantations to surrounding areas of unconverted forest would also be high. Conversion for zircon mining is also a very serious threat in the north of the proposed concession area, and coal mining is another potentially serious, but unquantified, threat in parts.

Currently, fishing, agriculture, rattan harvesting, latex collecting (*jelutong* and rubber) and illegal logging are the main options for income for people in villages surrounding the Katingan forest and local people are generally poor. Consequently, they are likely to consider any potential income-generating opportunities available, which can put great pressure on their only abundant natural resource: the forest. As a result, community efforts to regulate activities that reduce habitat availability and are detrimental to biodiversity and HCVs are essentially non-existent and ineffective, particularly on the eastern/Katingan River side of the project area (villagers in this area are prohibited from entering the forest on the other side of this river, which is protected as the Sebangau National Park).

<u>G2.5.2. Landscape connectivity</u> – The threats described above will act to reduce landscape and habitat connectivity in the area, although these losses in connectivity will have less serious impacts on floral diversity than losses in overall habitat availability. The large majority of disturbances to the habitat – fire, timber extraction, forest conversion, mining – occur around the forest edge, with the forest interior currently experiencing little in the way of *direct* human disturbance, owing to the difficulty in accessing these areas and their generally lower productivity (and, hence, less valuable timber trees). Fire, logging and forest conversion in the few kilometres closest to the forest edge could lead to some reduction in landscape connectivity, which would have a negative impact on floral diversity, but the major impact of this on flora is anticipated to be the resultant overall loss of habitat area as the forest is 'eaten away from the edges'.

A potentially serious threat to the forest interior on the highest part of the dome and, thus, to habitat connectivity, is peat collapse, as a result of peat drainage influencing water levels across the entire peat dome, particularly if fire were to take hold in the interior and burn peat below the surface.

<u>G2.5.3. Threatened</u> species – In the absence of the project, the continued presence of the threats described in the above two sub-sections will lead to severe negative impacts on floral diversity and declines in the population size of floral HCVs. In particular, the continuation of illegal logging in the area in the without-project scenario would lead to severe impacts on *S. balangeran*, *S. teysmanniana, S. uliginosa* and *G. bancanus* and potentially even their local extinction. These species are classified by the IUCN as Critically Endangered (*S. balangeran*), Endangered (*S. teysmanniana*) and Vulnerable (*S. uliginosa* and *G. bancanus*) and, based on our plot data, have major population strongholds in the region. Consequently, the loss of these species from Katingan would have serious repercussions for the conservation of these species globally. These tree species all have timber of high commercial value and, consequently, are frequently targeted first by illegal loggers, which is the underlying cause of their current threatened status.

B1. Net Positive Biodiversity Impacts

B1.1. Demonstrating net positive biodiversity impacts

A full flora monitoring programme will be developed and implemented for the proposed concession area. This programme will incorporate repeat monitoring of tree plots established in the area to provide the baseline floral assessment using the methods described in the document (Section 2.3), which include the listed floral HCV species. Once complete, this monitoring programme will allow demonstration of whether the project has achieved the stated floral diversity objectives and has achieved net positive impacts on forest flora diversity and HCVs. The preliminary monitoring programme is discussed in detail in *B3* and Section 4.

B1.2. Demonstration that no HCVs will be negatively affected by the project

As detailed in the Table 3.2 (Section 3.3), overall floral diversity and all of the forest HCVs are anticipated to receive net positive benefits from the proposed project activities (note that, because they face similar specific threats as high-value timber species, the three *Shorea* HCV species and *Gonystylus bancanus* have been grouped together in this table). Of the ten proposed activities, eight have a direct positive impact on forest cover and biomass, overall floral biodiversity and *Dyera lowii/polyphylla*; seven have a positive impact on *Shorea* spp. and *Gonystylus bancanus*; and five have a positive impact on *Combretocarpus rotundatus.* Two project activities are anticipated to have neutral impacts on forest cover and biomass, overall floral diversity and *D. lowii/polyphylla*; and three to have neutral impacts on *Shorea* spp., *G. bancanus* and *C. rotundatus*. Two project activities are anticipated to have negative impacts on *C. rotundatus*, as this species is a 'natural' fast-growing wind-seed dispersed pioneer species that will likely be abundant in disturbed areas subject to replanting, but the overall impact of these project activities on overall floral diversity and the other floral HCVs are overwhelmingly positive. The remainder of the project's activities will have no negative impacts on overall floral diversity or its HCVs. Without the project, these activities would not occur. These projections will be verified during the course of the project via monitoring of the selected HCV species' populations (see *G3* and Section 4).

B1.3. Identification of species to be used in project activities and confirmation of invasive status

The species of flora to be used in the project's activities, and notes on whether these are invasive species, are given in the Table 3.3 (Section 3.5). All of these species are non-invasive, although care must be taken over the use of *Melaleuca* sp. Some species in this genus are native to Kalimantan and are non-invasive; e.g., *M. cajuputi*, but some species are non-native and potentially invasive. For example, *M. quinquenervia*, which is native to Papua New Guinea and Australia and has become one of the most problematic invasive species in the Florida Everglades, USA. The project should therefore take great care to select species of this genus native to the area and non-invasive. Three species – *Dyera costulata, Daemonorops* spp. and *Lophopetalum multinervium* – are native to both Kalimantan and peat-swamp forest, but have not been recorded in either Katingan or the nearby Sabangau. In particular, *D. costulata* should be substituted for *D. lowii / polyphylla*, whose presence in Katingan we confirm herein. It is uncertain whether or not *Daemonorops* spp. and *L. multinervium* exist in Katingan (these are native to Kalimantan and peat-swamp, so it is possible that they are present, but rare and were not detected in our surveys), *Lophopetalum* sp.

has been recorded in Sabangau and it is unlikely that use of these species would create serious problems within the ecosystem, but we nevertheless recommend that caution should be applied in their use until their presence can be confirmed in Katingan. No species from any other taxa will be used during project activities.

B1.4. Identification of species to be used in project activities and confirmation of native status

See Sections *B1.3* and 3.5. All floral species used in the course of the project's activities are native to the area. Care will be taken to avoid the use of non-native *Melaleuca* sp., which has been shown to be invasive in some foreign environments.

B1.5. Guarantee that no genetically modified organisms will be used

The project proponents guarantee that no genetically-modified organisms will be used during project activities. Although the project will not use any genetically-modified organisms, due to the widespread and increasing use of genetically-modified organisms globally, it is impossible to regulate the flow of community resources such as feedstock, and foods such as rice or other grain, used inside and outside of the project area.

B3. Biodiversity Impact Modelling

B3.1. Selecting biodiversity variables to be monitored and frequency of monitoring, and ensuring variables are directly linked to biodiversity objectives and anticipated impacts

In response to our findings on the biodiversity and HCVs in the area, and the threats they face, we recommend eleven floral biodiversity objectives be adopted by the project proponents. These include immediate research objectives to gain additional necessary information on threats in the area, habitat types, HCV populations and forest flora in other habitat sub-types; measures to mitigate threats to floral HCVs; measures to maintain/enhance biodiversity and floral HCVs beyond the project timeframe; and biodiversity monitoring and HCV-specific objectives, specific to forest flora (see Section 3.4 for full details). In terms of forest flora, the main conservation aim is to slow and, ultimately, stop and reverse the loss of forest cover, condition and floral diversity in the proposed concession area, and prevent the loss of any species. Although this aim applies across all species, it is particularly important for HCV floral species.

A full biodiversity monitoring programme will be developed and implemented for the proposed concession area, in order to assess whether these floral conservation objectives are being met through the project activities. Methods used will be based on the tree plot methods used in this study and described in this report, which have been used successfully by OuTrop for monitoring changes in forest condition in Sabangau for a number of years. These methods will allow for the assessment of changes in mortality and recruitment rates, tree size distributions and biomass (basal area coverage). They will also allow for assessment in changes in abundance of the floral HCV species, which are included within the plots. Monitoring of forest plots will provisionally be conducted annually for the first five years and each two years thereafter, for the duration of the project timeframe. Not only will this allow for assessment in changes in forest flora as a result of project activities, but it will also aid in the interpretation of the effect of project activities on forest fauna, as these impacts are generally mediated through impacts on forest flora (Gardner, 2010; Lindenmayer and Likens, 2010). This includes faunal HCV species in the area, such as orangutans and gibbons, for which effects of changes in forest flora on population density have been demonstrated.

As outlined in *B1.2* (see Section 3.4 for the full set of biodiversity objectives), we anticipate that the project's activities will maintain the overall floral biodiversity present in the area and prevent the loss of any species, in particular those threatened with extinction. Once complete, this monitoring programme will allow demonstration of whether the project has achieved the stated biodiversity objectives and has achieved net positive biodiversity benefits.

B3.2. Assessing the effectiveness of measures to maintain/enhance high conservation values

As outlined in *B1.2* and Section 3.3, we anticipate that the project's activities will lead to the stabalising of, and eventual increase in, confirmed (*Shorea balangeran*, *S. teysmanniana, S. uliginosa, C. rotundatus*, *D. lowii / polyphylla* and *G. bancanus*) floral HCV species' habitat and population size within the 30-year project period. Monitoring of these confirmed floral HCVs will provisionally be conducted annually for the first five years and each two years thereafter, for the duration of the project timeframe. This will be achieved through repeat surveys of the tree plots established to provide the baseline flora description provided herein. These plots include the confirmed floral HCV species. The field survey methods to be used are standard, have been trialled previously by the project proponents in peat-swamp forest and were used to obtain the density and population estimates provided elsewhere in this document (*G1.8.1.b*, Section 2.4.7). Once complete, this HCV monitoring programme will allow demonstration of whether the project has achieved the stated HCV objectives for maintaining and enhancing these HCV species' populations.

B3.3. Commitment to producing a full monitoring plan

The monitoring plan presented herein is preliminary and will be built upon over the coming year to ensure maximum scientific rigour. A full monitoring programme for floral diversity and HCVs will be submitted within one year of acceptance to CCB standards. This full monitoring plan, and the results of the monitoring work, will be disseminated widely. In addition to presentation in the form of reports to CCBA and other relevant project stakeholders, this information will be made publicly available on the internet and communicated to local communities. We also anticipate publication of results in the scientific literature, at scientific conferences and symposia, and in local, national and international media.

GL3. Exceptional Biodiversity Benefits

GL3.1. Vulnerability

The Key Biodiversity Area (KBA) vulnerability criterion specifies that an area must have at least one individual of a Critically Endangered or Endangered species, or a population of 30 individuals or 10 pairs of a Vulnerable species. Katingan is home to large populations of the Critically Endangered *Shorea balangeran*, the Endangered *S. teysmanniana*, and the Vulnerable *Combretocarpus rotundatus*, *Dyera lowii / polyphylla, S. uliginosa* and *Gonystylus bancanus.* All of these populations far exceed 30 individuals (total population estimates for the proposed concession area are in the hundreds of thousands or millions) and, consequently, the proposed concession area clearly satisfies this criterion on a number of counts.

GL3.2. Irreplaceability

The irreplaceability criterion is comprised of a number of sub-criteria, as follows:

a. Restricted range (global range < 50,000 km^2 or 5% of global population at the site);
b. Species with large but clumped distributions (5% of global population at the site);
c. Globally significant congregations (1% of population seasonally at the site);
d. Globally significant source populations (site is responsible for maintaining 1% of global population);
e. Bio-regionally restricted assemblages.

Because global distributions of tree species' populations are very poorly documented and incomplete for Bornean forest flora, it is difficult to assess rigorously whether any species meets any of these criteria. However, based upon the population estimates of floral HCVs in *G1.8.1.b.* (see also Section 2.4.7), it is clear that Katingan is home to large populations of many HCV species, which likely number in the hundreds of thousands or millions. Considering the projected size of some of these populations, it is extremely likely that Katingan is home to at least 1% of the global population of most, if not all, of these species and, hence, also satisfies the irreplaceability criteria for a KBA. This would likely remain the case even if our estimates are two or more times greater than the actual populations of these species in the proposed concession.

Thus, based on this analysis, it is clear that the proposed concession area qualifies as a Key Biodiversity Area (Langhammer *et al.*, 2007) on the basis of *Shorea balangeran*, *S. teysmanniana*, *Combretocarpus rotundatus*, *Dyera lowii / polyphylla, S. uliginosa, Gonystylus bancanus* and probably numerous other floral species' populations.

2. FLORA PRESENT, IDENTIFICATION OF HCVS AND THREATS

2.1 Section Summary

Borneo is a major hotbed for flora, housing some 15,000 species of flowering plants and 3,000 tree species; equivalent to 4% of the world's plant species. Borneo's peat-swamp forests (PSF) are recognised as containing a large number of endemic species and as an important reservoir of floral diversity, but this floral diversity is threatened by a number of anthropogenic threats, and management interventions to help conserve peat-swamp forest flora are therefore necessary.

We performed field surveys and local community interviews in six locations surrounding the project area, to provide a baseline description of the flora of the proposed REDD+ concession area in the Katingan forest. This included surveying plots of forest trees (≥ 15 cm circumference at breast height/cbh; i.e., 1.3 m above the ground), recording opportunistic sightings of floral species sighted and interviewing local community members to obtain information on floral species of local commercial, medicinal or food importance. All trees in plots were identified using both scientific and local names, measured for diameter at breast height and basal circumference, and tagged with a unique number for future reference. The total plot area was 1.25 ha for trees exceeding 45 cm cbh and 0.41 ha for trees 15-45 cm cbh.

A total 204 floral species were confirmed as present in the proposed concession through the surveys, including 144 tree and 60 non-tree species. Because the plot area and coverage of different habitat sub-types in these surveys was necessarily limited, these figures will be an underestimate of the total floral diversity of the area. We therefore compared this species list with that of the nearby, ecologically very similar and protected Sabangau forest, for which we have built up a comprehensive floral species list over many years of surveys throughout the forest. Using these data together with the precautionary principle, in which species are assumed to be present unless there is good reason to believe otherwise, the precautionary total number of floral species in Katingan is 312, including 219 tree and 93 non-tree species.

Based on analysis of plot data, an average 10.3 tree species can be expected to occur within 100 stems surveyed, which is identical to the figure for Sabangau. Other measures of diversity (Fisher's alpha) show marginally higher levels of floral diversity in Katingan, compared to Sabangau. Abundance of tree species and basal area coverage are also broadly similar to Sabangau, although overall figures are lower for Katingan, probably as a result of continued logging throughout much of the area and/or site-specific vagaries in the Sabangau data. Notably, the abundance of large *Diospyros bantamensis* trees – a key orangutan and gibbon food – is high in Katingan and a number of other important ape foods are also abundant.

The forest is also home to a number of High Conservation Value forest flora, including one Critically Endangered (*Shorea balangeran*), one Endangered (*S. teysmanniana*), four confirmed Vulnerable (*Combretocarpus rotundatus*, *Dyera lowii / polyphylla, S. uliginosa* and *Gonystylus bancanus*) and four potential Vulnerable (*Mangifera* spp., *Canarium sp., Aglaia* sp. and *Knema* sp.) species. Estimates for potential population sizes of these species in Katingan, based on plot data, indicate that the concession clearly satisfies both the vulnerability and irreplaceability criteria for classification as a Key Biodiversity Area. These results confirm the importance of Katingan for both the maintenance of overall floral diversity in Borneo, in addition to conservation of threatened floral species, confirming its status as a Key Biodiversity Area for flora. The threats faced by the area's flora are discussed.

2.2 Background Information

Sundaland is recognised as crucial for global biodiversity conservation, due to its exceptionally high concentration of biodiversity (Myers *et al.*, 2000). Borneo covers only 0.2% of the earth's land surface (743,330 km^2), yet houses a wealth of biodiversity, including up to 15,000 species of flowering plants (as many as the whole African continent) and 3,000 species of tree, representing 4% of the world's plant species (MacKinnon *et al.*, 1996).

Central Kalimantan's peat-swamp forests (PSF) cover a vast area (*ca.* 3 Mha, Page *et al.*, 1999) and were traditionally viewed as being of little value for biodiversity conservation (Merton, 1962; Janzen, 1974). This view led to the Indonesian government allocating all its PSF to logging concessions in the 1960s. More recent work has revealed that this view of PSF was far from true: although PSF supports a lower diversity and density of flora and fauna than dryland rain forests, it contains a large number of endemic species and is recognised as an important reservoir of both floral and faunal biodiversity (Whitmore, 1984; Prentice and Parish, 1992; Page *et al.*, 1997; Shepherd *et al.*, 1997; Struebig *et al.*, 2006; Harrison *et al.*, 2010a; Yule, 2010; OuTrop, unpublished data). Owing to the previous misconception that PSF is relatively poor in terms of floral diversity, the flora of PSF has been studied relatively little compared to dryland forests of the region.

As is the case throughout the more accessible lowlands of Kalimantan, PSFs and their biodiversity are severely threatened through a number of anthropogenic activities, discussed in detail by Harrison *et al.* (2010a). These threats include peat drainage, and consequent peat degradation and fire (Wösten *et al.*, 2008; Harrison *et al.*, 2009; Page *et al.*, 2009a); illegal logging (Morrogh-Bernard *et al.*, 2003); forest conversion, in particular for oil palm and other plantations (Fitzherbert *et al.*, 2008; Danielsen *et al.*, 2009; Harrison *et al.*, 2010a) and wildlife hunting (Struebig *et al.*, 2007; Harrison *et al.*, 2010a).

While targeted primarily towards reducing carbon emissions, Reduced Emissions from Deforestation and Degradation (REDD+) has huge potential for biodiversity conservation in PSF, due to the huge amounts of carbon stored in peat and consequent incentive to provide sustainable financing to protect these biodiversity-rich forests (Venter *et al.*, 2009).

Previous floral surveys have been conducted in Katingan by Darusman (2008). Comparison of this list of tree species with that documented over many years detailed research in Sabangau (Morrogh-Bernard, 2009), indicates that the previous Katingan list is likely incomplete and that some species may have been mis-identified. Darusman (2008) lists a total 48 tree species, compared to 223 documented in Sabangau. Of these 48 species listed for Katingan, 25 are also listed in Sabangau, 20 are not listed, three are queries and there are some other surprising absences in this previous Katingan list, based on expectations from Sabangau. Consequently, in-depth floral surveys are essential for providing an accurate baseline description of the area's biodiversity, conservation value and threats faced.

2.3 Methods

2.3.1 Study Site

The total area of the proposed project concession is 227,260 ha, which falls between the Rivers Mentaya and Katingan, in the Kotawaringan Timur and Katingan Districts, Central Kalimantan, Indonesia (Figure 2.1; this area is referred to as the "Katingan" forest hereafter). This area is part of the extensive belt of peatland that stretches across the lowlands of southern Kalimantan and peat-swamp forest is the dominant habitat in the area. As in other areas of PSF, including the neighbouring Sabangau (Anderson, 1983; Page *et al.*, 1999), the peat in this forest forms a gently sloping dome, which increases in height with increasing distance from the two rivers, up to a depth of 12.5 m (Darusman *et al.*, 2008).

This change in peat depth results in a catena of forest sub-types, replacing each other from the edge to the centre of the dome (Anderson, 1983; Brady, 1997; Stoneman, 1997; Page *et al.*, 1999; Darusman, 2008). Closest to the river would have been riverine forest, but, as in Sabangau (Page *et al.*, 1999), this habitat sub-type is practically extinct in Katingan. Large belts of "mixed-swamp forest", which is characterised by a relatively tall canopy height (closed canopy 15-25 m) and a mixed tree species composition, then occurs on the relatively shallow peat from beyond the level of wet-season flooding until about 8 km from the river (Page *et al.*, 1999; Darusman, 2008). As the peat thickens, the forest enters a transition phase, which terminates in low-pole forest, characterised by permanently high water table, uneven ground, a dense undergrowth of *Pandanus* and a low closed canopy of 12-15 m (Page *et al.*, 1999; Darusman, 2008). On the deepest peat, the forest in Katingan becomes very open, with no closed canopy and very few full-size trees (Darusman, 2008); this is similar to the "very low canopy forest" in Sabangau described by Page *et al.* (1999). This pattern matches that described for other peat-swamp forests in the region (Anderson, 1983; Brady, 1997; Stoneman, 1997). It differs from Sabangau, however, in which the middle of the peat dome is dominated by "tall-pole forest", characterised by relatively tall trees, low water table and relatively open forest floor (Page *et al.*, 1999).

The mean peat thickness across the dome is over three metres, classifying Katingan as a "deep" peat-swamp forest. The flood plains of the two major rivers bordering the forest extend only a short distance from the river banks and, thus, the entire project area receives no nutrient influx from these river floods and can therefore be classified as an "ombrogenous" peat swamp. In ombrogenous peat swamps, the only source of nutrient influx is from aerial precipitation (rain and dust), with small amounts of nutrient influx through microbial nitrogen fixation and faunal migration/animal faeces (Sturges *et al.*, 1974; Jordan, 1985; Page *et al.*, 1999; Sulistiyanto, 2004; Sulistiyanto *et al.*, 2004).

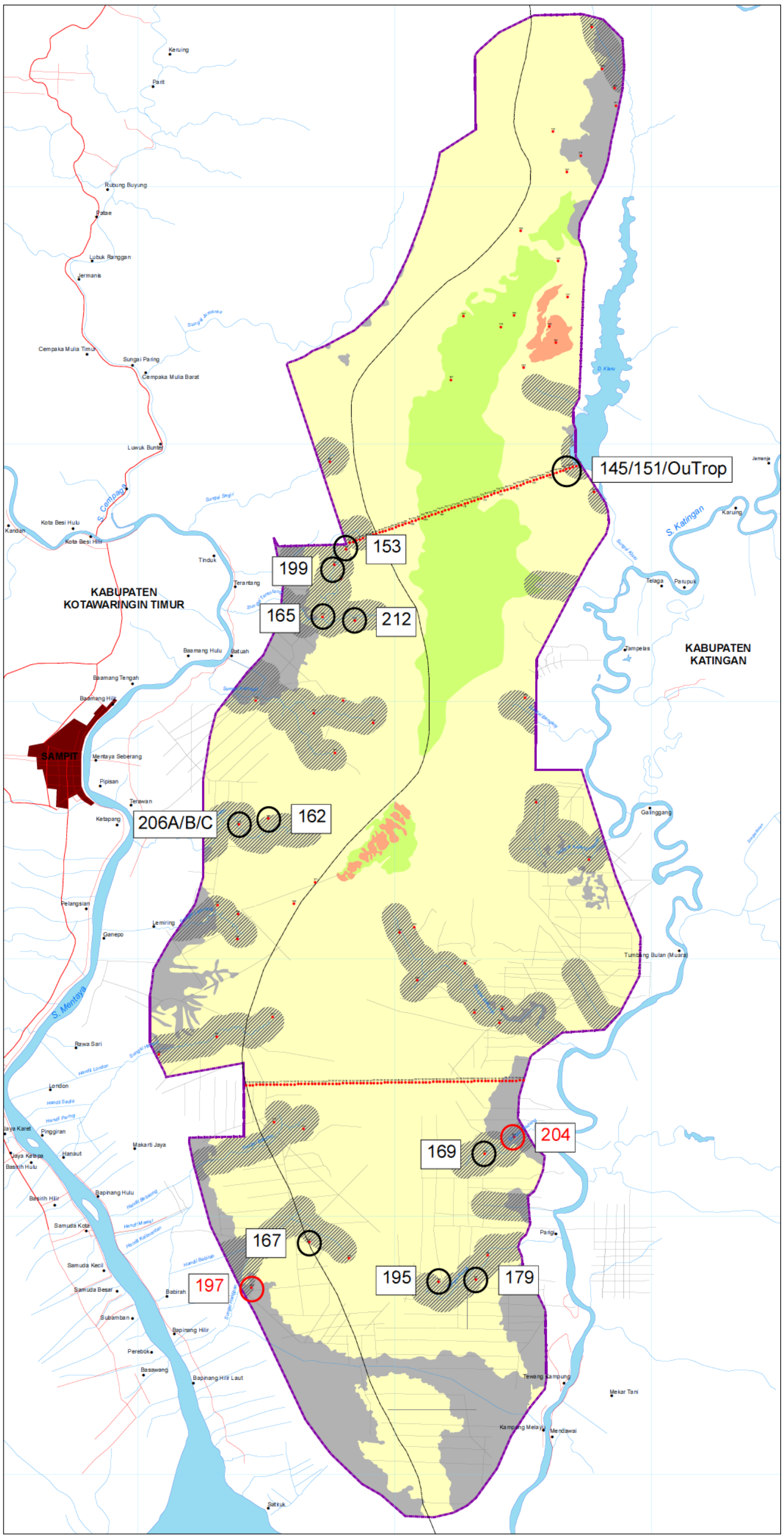

Figure 2.1 Map showing the location of tree plots in the Katingan project area. Circles indicate plot locations; black circles indicate forested plots and red circles highly-degraded non-forest plots. Plot numbers correspond to the numbers given to these plots previously by PT. Starling Asia (Table 2.1). Grey indicates non-forested areas; cream mixed-swamp forest; light green low-pole forest; pink very-low-pole forest; and hashed grey areas are feasible to access from rivers. Baseline map provided courtesy of PT. Starling Asia.

Due to the large size of the proposed concession, it was necessary to select a small sub-sample of the area in which to perform field surveys of forest flora. As initial descriptions of vegetation (Darusman, 2008), plus surveys of orangutan (*Pongo pygmaeus wurmbii*) and gibbon (*Hylobates albibarbis*) density (Harrison *et al.*, 2010a), in the area indicate potentially more productive forest on the Katingan River side of the project area, we selected survey locations on each of the Mentaya and Katingan sides of the proposed concession. The sites surveyed included three sites on the River Mentaya side of the forest – Terantang, Hantipan and Lantabu – and three sites on the Katingan River side – Perigi, Medang and Klaru (Telaga). The location of these survey sites is shown in Figure 2.1. Two of these sites – Terantang and Perigi – were surveyed previously by OuTrop for forest fauna and ape density (Harrison *et al.*, 2010a).

Although desirable to survey, due to likely differences in floral species composition, the forest interior/low-pole areas were unfeasible to access at the time the surveys were conducted (November-December 2010, at the height of the wet season), due to high water levels in the forest and budgetary restrictions. Temporary *pondoks* were erected at each survey site. All sites were in areas of PSF, although these areas differed somewhat in terms of forest condition and current disturbance (see Section 2.4.1).

Community interviews to assess locally-important forest flora were conducted in five villages close to areas surveyed (Figure 2.1), of which two are on the Mentaya side (Terantang and Hantipan) and three on the Katingan side (Perigi, Medang and Telaga).

2.3.2 Timeframe

Surveys were conducted between 28th November and 16th December 2010, with the field time spent approximately equally between the six sites. Community interviews were conducted during the same time frame, as the survey team passed through the different villages.

2.3.3 Methods: Floral Surveys

Floral surveys were conducted through both establishing and identifying all species within tree plots, in addition to compilation of opportunistic records of species encountered outside of plots during the course of the research. This enabled production of a much more complete species list than would have been obtained through tree plots alone, as many PSF tree species are rare and were not recorded in the plots, and many floral species are obviously not trees (see Section 2.4.2). To maximise efficiency, we selected tree plots for surveying that had been previously established by PT. Starling Asia for carbon-monitoring purposes (“Starling plots”, Table 2.1) and in which trees had been tagged previously. In addition, we also established one additional plot measuring 10 x 250 m to increase the area of forest surveyed, in which we affixed new tags to all trees included. Plot boundaries were marked to aid future repeat surveys.

Table 2.1 Permanent carbon-monitoring plots surveyed for forest flora. Plot numbers are those assigned by PT. Starling Asia. "OuTrop" refers to the 10 x 250 m plot established specifically for this research.

Catchment	Location	Plot numbers	Notes
Katingan	Perigi	195, 179	
	Medang	169, 204	204 highly-degraded non-forest
	Klaru	151, 145, OuTrop	
Mentaya	Terantang	212, 153, 165, 199	
	Lantabu	162, 206A, 206B, 206C	
	Hantipan	167, 197	197 highly-degraded non-forest

Each Starling plot surveyed measured 25 x 25 m, in which we identified and measured all trees exceeding 45 cm circumference at breast height (cbh). This is equivalent to 14.32 cm diameter at breast height (dbh). Nested within each of these plots, we surveyed a smaller 10 x 10 m plot, in which all trees exceeding 15 cm cbh (4.77 cm dbh) were identified and measured, although only trees exceeding 5 cm dbh were included in analyses. Such a design is considered more efficient than the use of a single large plot, as the number of species detected (information gain) per unit effort is higher, more different parts of the landscape are sampled, and plots are easier to establish and replicate (Phillips *et al.*, 2003). The nested plot design enabled sufficient data to be collected for both small trees, which occur at high density, and large trees, which occur at much lower density in the forest. In the OuTrop plot, all trees exceeding 15 cm cbh were also tagged, identified and measured. This provided a total plot area of 1.25 ha for 'large' trees and 0.41 ha for 'small' trees, with 0.39 ha for small trees and 1.125 ha for large trees in 'forest', and 0.02 ha for small trees and 0.125 ha for large trees in 'non-forest'. Total plot areas at each survey location are given in Table 2.2.

Standard methods for assessing tropical forest tree flora were employed (Proctor *et al.*, 1983; Ashton and Hall, 1992). Within each plot, each tree greater than the minimum dbh described above was selected, the dbh and basal circumference measured, and the species identified using both Latin and local names. Measurements of dbh were taken 1.3 m above the ground, measured from a calibrated point on each observers' body. In instances where trees had buttress, stilt roots or branch forks that prevented measurement of dbh or basal circumference from the 'correct' location, measurements were taken immediately above the obstruction. Where this was not possible, dbh/basal circumference were estimated by holding the tape measure up and trying to match this to the size of the tree at the appropriate height.

Trees were identified by two trained local botanists (Kursani and Santiano) with extensive experience of performing tree identifications in Bornean rainforests, and PSF in particular. In addition to Latin names, local names used by OuTrop in Sabangau were also recorded, to facilitate matching identifications of tree species between the project area and OuTrop's main research site in Sabangau. Because local names can vary substantially between locations within Borneo, even between locations as close as Katingan and Sabangau, local people also joined the project team

Table 2.2 Plot areas for small (15-45 cm cbh) and large (> 45 cm cbh) trees in each survey location.

Catchment	Location	No. "Starling" plots forest	No. "Starling" plots non-forest	Small trees (10 x 10 m plots)			Large trees (10 x 10 m plots)			Small and large trees (10 x 250 m plots)	
				Total ha	Forest ha	Non-forest ha	Total ha	Forest ha	Non-forest ha	No. "OuTrop" plots	Forest ha
Katingan	Perigi	2	0	0.02	0.02	0	0.125	0.125	0	0	0
	Medang	1	1	0.02	0.01	0.01	0.125	0.0625	0.0625	0	0
	Klaru	2	0	0.02	0.02	0	0.125	0.125	0	1	0.25
Mentaya	Terantang	4	0	0.04	0.04	0	0.250	0.250	0	0	0
	Lantabu	4	0	0.04	0.04	0	0.250	0.250	0	0	0
	Hantipan	1	1	0.02	0.01	0.01	0.125	0.0625	0.0625	0	0

to provide information on local names used in Mentaya/Katingan. These names are presented in the species list (Section 2.4.2) and should facilitate future floral surveys in the region, providing that local people accompanying survey teams are both local to that location and adequately experienced in the area's flora.

Non-tree flora were also surveyed, both inside and outside of tree plots. Due to the fact that many non-tree plants are small, occur at very high density, live in the canopy and/or grow in such a way that it is very difficult to ascertain where one individual ends and another begins (e.g., lianas, which grow up into the canopy and may grow together in large numbers, with each individual stem from the ground occupying the canopy of many different trees), they are difficult to count. Consequently, we documented non-tree fauna on a check-list basis and did not attempt to assess densities. The final species lists were compiled by two experts in peat-swamp forest flora, with extensive experience of both field identification and scientific analysis of floral data (Harrison and Husson).

2.3.4 Methods: Community surveys

In order to provide information on floral species important to local communities, informal questionnaires were also performed in villages close to the field survey locations (Section 2.3.1). These questionnaires included questions relating to species of commercial, medicinal and food value to local communities (see Appendix I for full questionnaires). All questionnaires were conducted by Indonesian assistants in local languages, as our previous experience has indicated that informal interviews are most likely to yield enthusiastic responses and reliable data.

2.3.5 Comparisons with Neighbouring Sites

Even with intensive sample effort, certain rarer species of flora may not be detected via the surveys described above. Thus, in line with the precautionary principle towards the maintenance/enhancement of HCVs (the importance of which is highlighted in the CCBA Standards), we also draw comparisons between the project area and the neighbouring Sabangau peat-swamp forest, for which we have already compiled a detailed floral species list and which is very similar to Katingan in terms of peat depth and habitat characteristics. Unless there was good reason to believe otherwise, we assumed that species known to exist in Sabangau are also present within the project area.

2.3.6 Identifying and Describing Threats

Anthropogenic threats to biodiversity, and particularly HCVs, in the project area were identified and described previously (Harrison *et al.*, 2010a). This previous list of threats is as relevant to flora as it is to fauna, because the majority of threats listed apply to all species within the ecosystem. Specific additional threats to forest flora are assessed here where relevant, based on the interview data and literature review conducted previously (Harrison *et al.*, 2010a), in addition to new observations derived during this set of floral surveys.

2.4 Results

2.4.1 Forest condition

Here, we provide a basic description of the forest condition at each survey site, with a focus on how this relates to flora. Additional descriptions of forest condition and pictures from the Terantang and Perigi sites are provided by Harrison *et al.* (2010a).

2.4.1.1 Mentaya – Terantang

Overall forest condition along the River Terantang is very similar to that documented previously for mixed-swamp forest in Sabangau (Page *et al.*, 1999). The first 2-3 km of the river are lined by mangroves. Further up there is a lot of *Pandanus*, which is followed by a large open area where the forest has been burnt (Figure 2.2). In the dry season, the river channel is burnt to clear the *Pandanus*; sometimes the fires get out of control and go beyond the river banks. A band of 500 m or more of clear land exists before the start of any kind of forest on either side of the river. In the open area there are some rice fields and a few camps that appear not to be used constantly. After a couple of kilometers of clearing, the open area narrows and the forest eventually borders the river edge (Figure 2.7 in Harrison *et al.*, 2010a). The forest inside the proposed concession area and around the research camp was highly disturbed as a result of past and present logging activity.

Figure 2.2 Open burnt area of forest bordering the River Terantang bank just outside the project area.

2.4.1.2 Mentaya – Hantipan

Hantipan is a small village, with a population of approximately 100-200 heads of family comprised of a mix of ancestral Dayakas and recent immigrants. Most peoples' daily business is as fishermen; some are starting to plant rubber and fruits. The local people did not express any concern when the survey team arrived at the village to make the tree plots. This apparent lack of concern regarding new people entering the village may be a result of many of the villagers themselves being new to the area.

Upon entry into the River Hantipan tributary, a large number of wooden rafts were seen on the river bank, loaded with either unprocessed timber or wood that has been processed into boards and beams. Further along the river, many piles of logs were encountered, along with loggers extracting and processing the wood. In surveying plot 167, a logging skid was encountered and inside the plot the trees were very damaged, with few sizeable trees remaining, as a result of persistent illegal logging in the area. The second plot (197) was even more damaged, with only one small tree remaining in the plot.

2.4.1.3 Katingan – Telaga / Klaru

Telaga is a fairly large village along a tributary of the Katingan River. The village is approximately 1 km long and has a population of 400-500 heads of family. Telaga villagers are local Dayaks with a family history of living in the village, although immigrants have been arriving in the village from the outset to search of work. Many have married local residents. Because Telaga is located in a fairly low-lying area, the majority of the population work as fishermen. There is no farming population, because villagers can only grow crops during the dry season when water level is low and, when the wet season arrives, the gardens flood and crops die. Villages therefore seek to meet their daily household needs through fishing, as the village is located by a large lake containing abundant fish populations. Fish captures can be up to 30-60 kg/fisherman/day, with catches of up to 90-120 kg/fisherman/day in certain seasons. This rich fish resource is under threat, however, due to poor management and water pollution. Upon entering the River Klaru tributary, the water was very dirty and polluted due to illegal gold mining being conducted upriver. Miners tend to be immigrants from other regions, rather than long-term local residents.

Upon arriving in the village, residents were concerned and the survey team was treated with suspicion, as they thought we were attempting to raid the illegal gold mines. This confusion was easily settled through discussion, after which the villagers accepted the team's presence with enthusiasm and a number of villagers joined the team to help with the fieldwork. One of the plots was situated on the banks of the river and water depth was ± 2 m at the time of the surveys; a small boat and swimming were needed to measure the existing trees in the plot.

2.4.1.4 Katingan – Perigi and Medang

Perigi is a fairly small village, with about 400 inhabitants, as many people move to other areas to find work, including on oil palm plantations. Because of the difficulty in finding work in the area, most people work as fishermen, and plant rice and vegetables. For people who have money to invest, the construction of swiftlet houses is becoming increasingly common. As in our previous faunal surveys (Harrison *et al.*, 2010a), some resistence to the survey team was encountered from local villagers and the village head, who were again concerned about the Katingan forest being made into a national park similar to Sebangau, with the implication that forest access would then be forbidden on both sides of the Katingan River. These fears were allayed after discussions with the villagers and village head, however, after which permission was granted to perform the survey work along the River Perigi and Medang (which is also included under the jurisdiction of Perigi Village).

The second plot surveyed in Medang (plot 204) was in the middle of a very open area and only one tree was found within the plot. On the return journey from Medang, two loggers were encountered riding a boat and hauling logs onto it. After further discussions with villagers in the area, it appears that there are still many people who come into the forest to harvest timber for domestic (non-commercial) purposes. Overall, the forest in Perigi and Medang is very similar to that documented previously for mixed-swamp forest in Sabangau (Page *et al.*, 1999), but, as a consequence of commercial illegal logging five or ten years ago, plus the continued small-scale logging described above, there are also lots of open areas in the forest here and there are few remaining large trees (canopy *ca*. 10 m, with only a few trees taller). The River Perigi joins the Katingan just south of the village. The forest is rather open along the river edges, with only a few larger trees (Figure 2.9 in Harrison *et al.*, 2010a). Less than 1 km from the village, the forest along the river banks has suffered severe fire damage on both sides and there is a wide open area for several kilometers before a canopy closed over the river again. There is a lot of rattan (*Calamus* spp.) and lianas in the area. The forest floor is remarkably open, allowing visibility up to about 50 m. There were few large trees alongside the river on the journey up, but the forest was highest near the river by the research camp. From 100-300 m into the forest, the canopy was lower (*ca.* 7-12 m). Beyond this, there were many areas void of trees (Figure 2.10 in Harrison *et al.*, 2010a), with more forest cover returning around 700 m from camp, where there was a 100-m long patch of tall forest with many big trees that appeared to have escaped logging (Figure 2.3).

2.4.2 Floral species present and diversity

Based on the results of our surveys, plus previous floral descriptions for the neighbouring Sabangau (Page *et al.*, 1999; Morrogh-Bernard, 2009), a total 312 floral species likely exist in the proposed concession area, including 219 tree species and 93 non-tree species (Table 2.3). Using the precautionary principle recommended by CCBA (2008), this should be considered the minimum total species richness of the proposed concession area. Of these species, a total 204 were confirmed during our field surveys, including 144 tree species and 60 non-tree species. A total 104 tree species were detected in plots, highlighting the value of opportunistic sampling to complement records obtained through plots. Only two species, *Syzygium cf. valevenosum* and *Pithecellobium clypearia*, were found in the non-forest plots; the latter of which was not detected in any of the forest plots.

Clearly, the number of species recorded in a particular forest will be dependent on the area of forest surveyed, with an increased possibility that all species will be detected with increasing plot area. Because it is logistically impossible to sample the entire area of forest in the proposed concession area, it is therefore highly likely that this species list is incomplete. In recognition of this problem, it is now commonplace in studies of forest flora to present indices of diversity that attempt to account for, and hence be independent of, sample size. Two such indices are the number of species recorded/100 stems and Fisher's alpha (e.g., Paoli *et al.*, 2010). These statistics are provided for Katingan, Sabangau and 'average' PSF in Table 2.4.

Figure 2.3 Area of tall forest in Perigi that has escaped logging.

As can be seen, Katingan compares favourably with both Sabangau and the 'average' PSF. This is despite the fact that the total number of species confirmed in Katingan is less than that confirmed in Sabangau, owing to the larger plot area and many years of data collection including more habitat sub-types in Sabangau. Species richness in Katingan is very similar to that in Sabangau and when using the precautionary total number of species (including Sabangau records) falls outside of the 95% confidence interval for 'average' PSF, based on the Fisher's alpha index, which is particularly robust to differences in sample size.

Table 2.3 List of floral species in Katingan forest. "Confirmed?" indicates those species that were detected during the current set of floral surveys, including records from both plots and opportunistic observations. Additional species included in the list, but not confirmed during surveys, are known to exist in Sabangau and, hence, presumed to also occur in Katingan. Species known only to occur in the tall-pole forest in Sabangau have not been included, as this habitat sub-type is thought not to exist in Katingan. IUCN categories: LR/NT = lower risk/near threatened; LR/CD = lower risk/conservation dependent; VU = vulnerable; EN = endangered; CR = critically endangered (the latter three are officially considered as "threatened").

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Anacardiaceae	*Bouea oppositofolia*	Tamehas	Unknown	Unknown	Tree			
Anacardiaceae	*Buchanania cf. arborescens*	Kenyem Burung	Unknown	Sangeh	Tree			
Anacardiaceae	*Campnosperma auriculatum*	Hantangan	Unknown	Hantangan	Tree		Yes	
Anacardiaceae	*Campnosperma coriaceum*	Terantang	Unknown	Terantang	Tree		Yes	
Anacardiaceae	*Campnosperma squamatum*	Nyating	Unknown	Unknown	Tree		Yes	
Anacardiaceae	*Mangifera* sp.	Binjai	Unknown	Binjai	Tree	VU?	Yes	Some *Mangifera* sp. listed as VU, some as EN/CR (but unlikely to be this species), some not listed
Anisophyllaceae	*Combretocarpus rotundatus*	Tumih	Unknown	Unknown	Tree	VU	Yes	
Annonaceae	*Artobotrys cf. roseus*	Kalalawit hitam	Unknown	Unknown	Liana		Yes	
Annonaceae	*Artobotrys suaveolins*	Bajakah balayan	Unknown	Unknown	Liana		Yes	
Annonaceae	*Cyathocalyx biovulatus*	Kerandau	Unknown	Unknown	Tree		Yes	
Annonaceae	*Cyathocalyx* sp.	Kerandau	Unknown	Unknown	Tree		Yes	
Annonaceae	*Fissistigma* sp.	Unknown	Unknown	Unknown	Liana			
Annonaceae	*Polyalthia glauca*	Kayu Bulan	Unknown	Unknown	Tree			
Anonnaceae	*Polyalthia hypoleuca*	Alulup	Saluang	Banitan	Tree		Yes	
Anonnaceae	*Polyalthia sumatrana*	Alulup	Saluang	Banitan	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Anonnaceae	*Mezzetia leptopoda / parviflora*	Pisang-pisang besar	Mahabai-mahabai	Unknown	Tree		Yes	
Anonnaceae	*Mezzetia umbellata*	Pisang-pisang kecil	Mahabai	Unknown	Tree		Yes	
Annonaceae	*Xylopia coriifolia*	Nonang	Unknown	Unknown	Tree			
Anonnaceae	*Xylopia fusca*	Jangkang kuning / rahanjang	Jangkang jangkar	Unknown	Tree		Yes	
Annonaceae	*Xylopia cf. malayana*	Tagula	Unknown	Unknown	Tree			
Apocynaceae	*Alstonia scholoris*	Pulai	Unknown	Palawi	Tree		Yes	
Apocynaceae	*Alyxia* sp.	Bajakah kelanis	Pulas santan	Unknown	Liana		Yes	
Apocynaceae	*Dyera lowii / polyphylla*	Jelutung / pantung	Unknown	Pantung	Tree	VU	Yes	*D. lowii* and *polyphylla* synonymous
Apocynaceae	*Parameria* sp.	Unknown	Unknown	Unknown	Liana			
Apocynaceae	*Willughbea* sp.	Bajakah dango	Unknown	Unknown	Liana		Yes	
Aquifoliaceae	*Ilex cymosa*	Unknown	Unknown	Unknown	Tree		Yes	
Aquifoliaceae	*Ilex hypoglauca / wallichi*	Sumpung / kambasira	Unknown	Kambasira	Tree		Yes	
Aquifoliaceae	*Ilex* sp.	Unknown	Unknown	Unknown	Tree		Yes	
Araceae	*cf. Anthurium* sp.	Lampuyang	Unknown	Unknown	Epiphyte		Yes	
Araceae	*Raphidophora* sp.	Unknown	Unknown	Unknown	Liana			
Araliaceae	*Schleffera* sp.	Sapahurung	Unknown	Unknown	Liana		Yes	
Arecaceae (*Palmae*)	*Calamus* sp.	Uey liling	Unknown	Uey Liling	Climber		Yes	
Arecaceae (*Palmae*)	*Calamus* sp. *cf. caesius*	Uey Sigi	Unknown	Unknown	Climber			

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Arecaceae (*Palmae*)	*Calamus* sp. *cf. trachycoleus*	Uey Irit	Unknown	Unknown	Climber			
Arecaceae (*Palmae*)	*Korthalsia hispida*	Uwei ahaas	Unknown	Uwei ahas / rotan ahas	Epiphyte		Yes	
Arecaceae (*Palmae*)	*Korthalsia* sp.	Uey paka	Unknown	Unknown	Climber		Yes	
Palmae	*Pinanga* sp.	Pinang Jouy	Unknown	Unknown	Shrub			
Arecaceae (*Palmae*)	*Salacca* sp.	Salak hutan / lokip	Unknown	Unknown	Shrub		Yes	
Asclepiadaraceae	*Astrostemma spartioides*	Anggrek Rangau	Unknown	Unknown	Epiphyte			
Asclepiadaraceae	*Dischidia cf. latifolia*	Unknown	Unknown	Unknown	Epiphyte			
Asclepiadaraceae	*Dischidia* sp.	Bajakah Tapuser	Unknown	Unknown	Epiphyte			
Asclepiadaraceae	*Hoya* sp.	Unknown	Unknown	Unknown	Epiphyte			
Asparagaceae	*Dracaena* sp.	Akar tewu kaak	Unknown	Unknown	Liana		Yes	Used medicinally by humans and orangutans
Blechnaceae	*Stenochlaena palustri*	Kalakai	Unknown	Unknown	Fern		Yes	
Burseraceae	*Canarium* sp.	Geronggang Putih	Unknown	Unknown	Tree	VU?	Yes	Some *Canarium* sp. listed as VU; rest not listed
Burseraceae	*Santiria cf. laevigata*	Irat	Unknown	Kayu kacang	Tree		Yes	
Burseraceae	*Santiria griffithii*	Teras bamban	Roko-roko	Unknown	Tree	LR/NT	Yes	
Burseraceae	*Santiria* spp.	Gerrongang Putih	Hampuak	Unknown	Tree		Yes	
Celastraceae	*Kokoona* sp.	Unknown	Bunga-bunga / culokut	Unknown	Tree		Yes	
Celesteraceae	*Lophopetalum* sp.	Mahuwi	Unknown	Unknown	Tree			
Chrysobalanaceae	*Licania splendens*	Bintan	Unknown	Unknown	Tree		Yes	
Clusiaceae	*Calophyllum hosei*	Jinjit /	Nangka-	Unknown	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
(*Guttiferae*)		bintangor	nangka					
Clusiaceae (*Guttiferae*)	*Callophyllum sclerophyllum*	Kapurnaga jangkar	Unknown	Unknown	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Calophyllum soulattri*	Takal	Unknown	Unknown	Tree			
Clusiaceae (*Guttiferae*)	*Calophyllum* sp.	Kapurnaga Kalakei	Unknown	Unknown	Tree			
Clusiaceae (*Guttiferae*)	*Calophyllum* sp.	Mahadingan	Unknown	Unknown	Tree			
Clusiaceae (*Guttiferae*)	*Calophyllum* sp.	Kapurnaga	Unknown	Kapur naga	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Calophyllum* sp.	Mahadingan	Unknown	Parut	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Calophyllum* sp.	Kapurnaga laut	Meranti putih	Unknown	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Garcinia bancanus*	Manggis	Unknown	Unknown	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Garcinia* sp.	Aci	Unknown	Gandis	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Garcinia* sp.	Manggis	Unknown	Gantalang	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Garcinia* sp.	Aci	Unknown	Mahalilis	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Garcinia* sp.	Gantalan	Unknown	Unknown	Tree			
Clusiaceae (*Guttiferae*)	*Garcinia* sp.	Mahalilis	Unknown	Unknown	Tree			
Clusiaceae (*Guttiferae*)	*Garcinia* sp. *cf. parvifolia*	Gandis	Unknown	Unknown	Tree		Yes	
Clusiaceae (*Guttiferae*)	*Garcinia* sp. *cf. hombroniana*	Unknown	Unknown	Unknown	Tree			
Clusiaceae (*Guttiferae*)	*Mesua* sp.	Tabaras akar tinggi	Nangka-nangka 1	Unknown	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Combretaceae	*Combretum* sp.	Bajakah Tampelas ?	Unknown	Unknown	Liana			
Crypteroniaceae	*Dactylocladus stenostachys*	Mertibu	Unknown	Unknown	Tree		Yes	
Cyperaceae	*Thoracostachyum bancanum*	Unknown	Unknown	Unknown	Sedge			
Dipterocarpaceae	*cf. Anisoptera* sp.	Keruing Sabun	Unknown	Unknown	Tree			
Dipterocarpaceae	*Cotylebium cf. lanceolatum*	Rasak Galeget	Unknown	Unknown	Tree			
Dipterocarpaceae	*Cotylebium melanoxylon*	Unknown	Unknown	Unknown	Tree			
Dipterocarpaceae	*Dipterocarpus borneensis*	Keruwing	Nangka-nangka 2	Unknown	Tree		Yes	
Dipterocarpaceae	*Shorea balangeran*	Kahui	Unknown	Unknown	Tree	CR	Yes	
Dipterocarpaceae	*Shorea crassa*	Unknown	Unknown	Unknown	Tree			
Dipterocarpaceae	*Shorea platycarpa*	Unknown	Meranti	Unknown	Tree		Yes	
Dipterocarpaceae	*Shorea teysmanianna*	Meranti semut	Meranti bunga / karamunting	Meranti bunga	Tree	EN	Yes	
Dipterocarpaceae	*Shorea uliginosa*	Meranti batu	Meranti bijai / bajang	Meranti batu	Tree	VU	Yes	
Dipterocarpaceae	*Vatica mangachopai*	Rasak Napu	Unknown	Unknown	Tree			
Ebenaceae	*Diospyros bantamemsis*	Malam-malam	Kacapuri	Kacapuri	Tree		Yes	
Ebenaceae	*Diospyros cf. evena*	Gulung haduk	Unknown	Ehang / uwar ehang	Tree		Yes	
Ebenaceae	*Diospyros confertiflora*	Arang	Unknown	Unknown	Tree			
Ebenaceae	*Diospyros lanceifolia*	Arang	Unknown	Unknown	Tree		Yes	
Ebenaceae	*Diospyros siamang*	Ehang	Unknown	Unknown	Tree		Yes	
Ebenaceae	*Diospyros* sp.	Kayu Arang Apui	Unknown	Unknown	Tree			
Ebenaceae	*Diospyros* sp.	Arang	Unknown	Unknown	Tree			
Elaeocarpaceae	*Elaeocarpus acmocarpus*	Patanak	Unknown	Unknown	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Elaeocarpaceae	*Elaeocarpus cf. griffithi*	Rarumpuit	Unknown	Unknown	Tree			
Elaeocarpaceae	*Elaeocarpus marginatus*	Kejinjing	Unknown	Unknown	Tree			
Elaeocarpaceae	*Elaeocarpus mastersii*	Mangkinang	Rimai	Sangeh	Tree		Yes	
Elaeocarpaceae	*Elaeocarpus* sp.	Patanak galeget	Bangkinang tikus	Hampuak	Tree		Yes	
Elaeocarpaceae	*Elaeocarpus* sp.	Pasir Payau	Unknown	Unknown	Tree			
Elaeocarpaceae	*Elaeocarpus* sp.	Ampaning Nyatu	Unknown	Unknown	Tree			
Euphorbiaceae	*Antidesma coriaceum*	Dawat	Mata undang	Unknown	Tree		Yes	
Euphorbiaceae	*Antidesma phanerophe*	Matan undang	Unknown	Matan undang	Tree		Yes	
Euphorbiaceae	*Antidesma* sp.	Matan undang	Unknown	Asam	Tree		Yes	
Euphorbiaceae	*Baccaurea bracteata*	Rambai hutan daun besar	Unknown	Hampuak	Tree		Yes	
Euphorbiaceae	*Baccaurea stipulata*	Kayu Tulang	Unknown	Unknown	Tree			
Euphorbiaceae	*Blumeodendron tokbrai / elateriospermum*	Kenari	Unknown	Kerandau	Tree		Yes	
Euphorbiaceae	*Cephalomappa* sp.	Karandau putih	Jangkang	Unknown	Tree		Yes	
Euphorbiaceae	*Cephalomappa* sp.	Karandau putih	Sarakat / tempurung	Unknown	Tree		Yes	
Euphorbiaceae	*Glochidion cf glomerulatum*	(Buah) Bintang	Unknown	Gandis	Tree		Yes	
Euphorbiaceae	*Glochidion* sp.	Rasak	Unknown	Unknown	Tree		Yes	
Euphorbiaceae	*Macaranga* sp.	Mahang Batu	Unknown	Unknown	Tree			
Euphorbiaceae	*Maccaranga caladiifolia*	Mahang bitik / sumut	Unknown	Mahang	Tree		Yes	
Euphorbiaceae	*Neoscortechinia forbesii*	Kerandau putih	Unknown	Unknown	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Euphorbiaceae	*Neoscortechinia kingii*	Pupu pelanduk	Sarakat	Unknown	Tree		Yes	
Euphorbiaceae	*Pimelodendron griffithianum*	Unknown	Unknown	Unknown	Tree			
Fabaceae (*Leguminosae*)	*Adenanthera pavonina*	Tapanggang	Bure-bure	Unknown	Tree		Yes	
Fabaceae (*Leguminosae*)	*Archidendron borneensis*	Kacing Nyaring	Unknown	Unknown	Tree			
Fabaceae (*Leguminosae*)	*Dalbergia* sp.	Unknown	Unknown	Unknown	Liana			
Fabaceae (*Leguminosae*)	*Dialium patens*	Kala Pimping Napu	Unknown	Unknown	Tree			
Fabaceae (*Leguminosae*)	*Dialium* sp.	Unknown	Roko-roko	Unknown	Tree		Yes	
Fabaceae (*Leguminosae*)	*Koompassia malaccensis*	Bangaris	Unknown	Bangaris	Tree	LR/CD	Yes	
Fabaceae (*Leguminosae*)	*Leucomphalos callicarpus*	Bajakah tampelas	Unknown	Unknown	Liana		Yes	
Fabaceae (*Leguminosae*)	*Ormosia* sp.	Unknown	Unknown	Unknown	Tree			
Fabaceae (*Leguminosae*)	*Pithecellobium clypearia*	Tabure / tapanggang	Unknown	Sabure	Tree		Yes	Found only in non-forest plot
Fagaceae	*Castanopsis foxworthyii / jaherii*	Takurak	Unknown	Unknown	Tree			
Fagaceae	*Lithocarpus conocarpus*	Pampaning Bayang	Unknown	Unknown	Tree		Yes	
Fagaceae	*Lithocarpus rassa*	Pampaning	Unknown	Unknown	Tree			
Fagaceae	*Lithocarpus* sp.	Pampaning Bayang Buah Besar	Unknown	Unknown	Tree			
Fagaceae	*Lithocarpus* sp.	Pampaning Suling	Unknown	Unknown	Tree			

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Fagaceae	*Lithocarpus* sp. *cf. dasystachys*	Pampaning Bitik	Unknown	Putar-putar	Tree		Yes	
Fagaceae	*Lithocarpus spp.*	Pampaning	Unknown	Pampaning	Tree		Yes	
Flagellariaceae	*Flagellaria* sp.	Uey Namei	Unknown	Unknown	Climber		Yes	
Gesneraceae	*Aeschynanthus* sp.	Unknown	Unknown	Unknown	Liana			
Gnetaceae	*Gnetum* sp.	Bajakah Luaa	Unknown	Unknown	Liana			
Gnetaceae	*Gnetum* sp.	Oto Oto	Unknown	Unknown	Liana			
Hypericaceae	*Cratoxylon arborescens*	Geronggang	Unknown	Unknown	Tree		Yes	
Hypericaceae	*Cratoxylum glaucum*	Garunggaang merah	Unknown	Gerunggang	Tree		Yes	
Icacinaceae	*Platea exelsa*	Kambalitan	Jangkar	Unknown	Tree		Yes	
Icacinaceae	*Platea* sp.	Lampesu	Unknown	Unknown	Tree			
Icacinaceae	*Stemonurus scorpiodes /* spp.	Tabaras yang tdk punya akar	Sarakat / tempurung / otak udang	Enyak beruk	Tree		Yes	
Icasinaceae	*Stemonorus secondiflorus*	Tabaras yang tdk punya akar	Unknown	Unknown	Tree		Yes	
Icasinaceae	*Stemonorus* sp.	Tabaras	Unknown	Unknown	Tree		Yes	
Lauraceae	*Actinodaphne* sp.	Unknown	Unknown	Unknown	Tree			
Lauraceae	*Alseodaphne coreacea*	Gemor	Unknown	Gemor	Tree		Yes	
Lauraceae	*Cinnamomum* sp. *cf. sintoc*	Sintok	Unknown	Unknown	Tree			
Lauraceae	*Crypthocarya* sp.	Tampang / medang	Unknown	Unknown	Tree		Yes	
Lauraceae	*Litsea / Crytocaria* sp.	Tampang	Kayu bulan	Unknown	Tree		Yes	*Litsea* taxonomy very complex
Lauraceae	*Litsea / Crytocaria* sp.	Tampang	Pirawas	Unknown	Tree		Yes	

Family	**Species**	**Sabangau name**	**Mentaya name**	**Katingan name**	**Growth Form**	**IUCN listing**	**Confirmed?**	**Notes**
Lauraceae	*Litsea cf. elliptica*	Medang (Species Medang)	Unknown	Unknown	Tree			
Lauraceae	*Litsea cf. rufo-fusca*	Tampang	Unknown	Unknown	Tree		Yes	
Lauraceae	*Litsea grandis*	Medang / tabitik	Katiau	Unknown	Tree		Yes	
Lauraceae	*Litsea ochrea*	Unknown	Unknown	Unknown	Tree		Yes	
Lauraceae	*Litsea* sp.	Medang	Unknown	Gula-gula	Tree		Yes	
Lauraceae	*Litsea* sp.	Medang	Unknown	Madang	Tree		Yes	
Lauraceae	*Litsea* sp.	Medang	Katiau	Unknown	Tree		Yes	
Lauraceae	*Litsea* sp.	Tampang	Unknown	Unknown	Tree			
Lauraceae	*Litsea* sp. *cf. resinosa*	Medang Marakuwung	Unknown	Unknown	Tree		Yes	
Lauraceae	*Nothaphoebe* sp.	Medang	Unknown	Unknown	Tree			
Lauraceae	*Phoebe* sp. *cf. grandis*	Tabitik	Madang	Unknown	Tree		Yes	
Lecythidaceae	*Barringtonia longisepala*	Putat	Unknown	Katune	Tree			
Lecythidaceae	*Barringtonia* sp.	Katune	Unknown	Putat	Tree		Yes	
Liliaceae	*Hanguana malayana*	Bakong himba	Unknown	Bakung	Shrub		Yes	
Linaceae	*Ctenolophon parvifolius*	Kayu Cahang	Kalepek	Unknown	Tree		Yes	
Loganiaceae	*Fragraea accuminatisma*	Unknown	Unknown	Unknown	Tree			
Loganiaceae	*Fragraea* sp.	Bajakah kalamuhe	Unknown	Unknown	Liana		Yes	
Loranthaceae	*Dendrophtoe incurvata*	Unknown	Unknown	Unknown	Parasite			
Loranthaceae	*Lepidaria* sp.	Mentawa	Unknown	Unknown	Parasite			
Magnoliaceae	*Magnolia bintulensis*	Medang limo	Unknown	Asam-asam	Tree		Yes	
Melastomataceae	*Melastoma malabathricum*	Karamunting	Unknown	Unknown	Shrub		Yes	
Melastomataceae	*Melastoma* sp.	Karamunting Danum	Unknown	Unknown	Shrub			

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Melastomataceae	*Memecylon* sp.	Tabati	Unknown	Nasi-nasi	Tree		Yes	
Melastomataceae	*Memecylon* sp.	Tabati himba	Bati-bati	Unknown	Tree		Yes	
Melastomataceae	*Memecylon* sp.	Milas daun kecil	Galam tikus	Unknown	Tree		Yes	
Melastomataceae	*Memecylon* sp.	Tabati himba	Ubar merah	Unknown	Tree		Yes	
Melastomataceae	*Pternadra* sp.	Unknown	Unknown	Kambusulan	Tree		Yes	
Melastomataceae	*Pternandra cf. coerulescens / galeata*	Kemuning yg bergaris tiga	Unknown	Unknown	Tree			
Meliaceae	*Aglaia rubiginosa*	Kajalaki	Kajalaki	Kajalaki	Tree	LR/NT	Yes	
Meliaceae	*Aglaia* sp.	Bangkuang Napu	Unknown	Unknown	Tree	LR/NT-VU?		Some *Aglaia* sp. listed VU, some LR/NT, some not listed
Meliaceae	*Chisocheton amabilis*	Unknown	Bunga matahari	Babaka	Tree		Yes	
Meliaceae	*Chisocheton* sp.	Unknown	Bunga matahari	Unknown	Tree			
Meliaceae	*Chisocheton* sp.	Mariuh	Unknown	Unknown	Tree			
Meliaceae	*Chisocheton* sp.	Latak Manuk	Unknown	Unknown	Tree		Yes	
Meliaceae	*Sandoricum beccanarium*	Papong	Papong	Papong	Tree		Yes	
Menispermaceae	*Fibraurea tinctoria*	Bajakah kalamuhe	Unknown	Unknown	Liana		Yes	
Moraceae	*Ficus cf. spathulifolia*	Lunuk Punai	Unknown	Unknown	Fig			
Moraceae	*Ficus cf. stupenda*	Lunuk Tingang	Unknown	Unknown	Fig			
Moraceae	*Ficus deltoidea*	Lunuk	Unknown	Tabat barito	Fig		Yes	
Moraceae	*Ficus* sp.	Lunuk buhis	Unknown	Unknown	Fig		Yes	
Moraceae	*Ficus* sp.	Lunuk tabuan	Unknown	Unknown	Fig		Yes	
Moraceae	*Ficus* sp.	Sasendok	Unknown	Unknown	Fig		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Moraceae	*Ficus* sp.	Lunuk sasendok	Unknown	Unknown	Fig		Yes	
Moraceae	*Ficus* sp.	Lunuk Bunyer	Unknown	Unknown	Fig			
Moraceae	*Ficus* sp.	Lunuk Sambon	Unknown	Unknown	Fig			
Moraceae	*Ficus* sp.	Lunuk	Unknown	Unknown	Fig			
Moraceae	*Ficus* spp.	Lunuk	Unknown	Lunuk	Fig		Yes	
Moraceae	*Parartocarpus venenosus*	Tapakan / lilin-lilin	Unknown	Unknown	Tree		Yes	
Myristicaceae	*Gymnacranthera farquhariania*	Mendarahan daun kecil	Mandarahan	Unknown	Tree		Yes	
Myristicaceae	*Gymnacranthera* sp.	Mandarahan	Unknown	Darah-darah	Tree		Yes	
Myristicaceae	*Horsfieldia crassifolia*	Mendarahan daun besar	Dara-dara	Unknown	Tree	LR/NT	Yes	
Myristicaceae	*Knema intermedia*	Karandau merah	Latak manuk / jangkang	Unknown	Tree	LR/NT	Yes	
Myristicaceae	*Knema* sp.	Mendarahan daun kecil	Unknown	Kayu daha	Tree	LR/NT-VU?	Yes	Some *Knema* sp. Listed as LR/NT, some VU, some not listed
Myristicaceae	*Myristica lowiana*	Mahadarah Hitam	Unknown	Unknown	Tree	LR/NT		
Myrsinaceae	*Ardisia cf. sanguinolenta*	Kalanduyung himba	Unknown	Unknown	Tree			
Myrsinaceae	*Ardisia* sp.	Kamba Sulan	Unknown	Unknown	Tree			
Myrsinaceae	*cf. Rapanea borneensis*	Mertibu	Unknown	Unknown	Tree			
Myrtaceae	*Eugenia spicata*	Kayu lalas daun besar	Unknown	Galam tikus	Tree		Yes	
Myrtaceae	*Syzygium caladiifolia*	Hampuak	Unknown	Tatumbu	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Myrtaceae	*Syzygium cf. valevenosum*	Kayu Lalas Daun Besar	Unknown	Unknown	Tree		Yes	
Myrtaceae	*Syzygium clavatum*	Unknown	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium havilandii*	Tatumbu	Ubar putih	Unknown	Tree		Yes	
Myrtaceae	*Syzygium* sp.	Galam tikus	Unknown	Galam	Tree		Yes	
Myrtaceae	*Syzygium* sp.	Galam tikus	Unknown	Jambu-jambu	Tree		Yes	
Myrtaceae	*Syzygium* sp.	Hampuak galeget	Ubar merah	Unknown	Tree		Yes	
Myrtaceae	*Syzygium* sp.	Hampuak galeget	Ubar putih	Unknown	Tree		Yes	
Myrtaceae	*Syzygium* sp.	Milas	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp.	Kemuning Putih	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp.	Milas	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp. *cf. campanulatum*	Tampohot Batang	Ubar merah	Unknown	Tree		Yes	
Myrtaceae	*Syzygium* sp. *cf. Elaeocarpus spicata*	Kayu Lalas Daun Kecil	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp. *cf. lineatum*	Jambu Jambu	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp. *cf. nigricans*	Jambu Burung Kecil	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp.	Jambu Burung Kecil	Unknown	Unknown	Tree			
Myrtaceae	*Syzygium* sp. *cf. garcinifolia*	Jambu burung	Unknown	Jambu-jambuan	Tree		Yes	
Myrtaceae	*Tristaniopsis obovata*	Blawan	Unknown	Unknown	Tree			*Tristaniopsis* taxonomy very complex
Myrtaceae	*Tristaniopsis* sp.	Blawan merah	Balawan	Unknown	Tree		Yes	
Myrtaceae	*Tristaniopsis* sp.	Blawan punai	Balawan	Unknown	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Myrtaceae	*Tristaniopsis* sp.	Blawan	Plawan	Unknown	Tree		Yes	
Myrtaceae	*Tristaniopsis* sp. *cf. bakhuizena*	Blawan Buhis	Unknown	Unknown	Tree			
Myrtaceae	*Tristaniopsis* sp. *cf. merguensis*	Blawan putih	Balawan	Unknown	Tree		Yes	
Myrtaceae	*Tristaniopsis whiteana*	Blawan	Unknown	Unknown	Tree			
Nepenthaceae	*Nepenthes ampullaria*	Pusuk kameluh / ketupat hinut / kantong semar	Unknown	Kantong semar	Climber	LR/NT	Yes	Protected in Indonesia, CITES Appendix II
Nepenthaceae	*Nepenthes gracilis*	Ketupat hinut / kantong semar	Unknown	Unknown	Climber	LR/NT	Yes	Protected in Indonesia, CITES Appendix II
Nepenthaceae	*Nepenthes rafflesiana*	Ketupat hinut / kantong semar	Unknown	Cepet sangumang	Climber	LR/NT	Yes	Protected in Indonesia, CITES Appendix II
Nephrolepiadaceae	*Nephrolepis* sp.	Paku Jampa	Unknown	Unknown	Fern		Yes	
Ochnaceae	*Euthemis leucarpa*	Unknown	Unknown	Unknown	Shrub			
Ochnaceae	*Euthemis* sp.	Unknown	Unknown	Unknown	Shrub			
Oleaceae	*Chionanthus* sp.	Unknown	Unknown	Unknown	Tree			
Orchidaceae	*Eria* sp.	Anggrek bawang	Unknown	Unknown	Epiphyte		Yes	CITES Appendix II
Orchidaceae	Unknown	Pahakung	Unknown	Unknown	Epiphyte		Yes	CITES Appendix II
Orchidaceae	Unknown	Pahakung tanduk	Unknown	Unknown	Epiphyte		Yes	CITES Appendix II
Orchidaceae	Unknown	Anggrek garu	Unknown	Unknown	Epiphyte		Yes	CITES Appendix II
Orchidaceae	Unknown	Anggrek hitam	Unknown	Unknown	Epiphyte		Yes	CITES Appendix II
Orchidaceae	Unknown	Anggrek buntut naga	Unknown	Unknown	Epiphyte		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Pandanaceae	*Freycinetia* sp.	Akar gerising	Unknown	Unknown	Climber		Yes	
Pandanaceae	*Freycinetia* sp.	Katipei Pari	Unknown	Unknown	Climber			
Pandanaceae	*Pandanus / Freycinetia* sp.	Gerising	Unknown	Unknown	Shrub			
Pandanaceae	*Pandanus* sp.	Pandan	Unknown	Unknown	Pandan		Yes	
Pandanaceae	*Pandanus* sp.	Rasau	Unknown	Unknown	Pandan		Yes	
Pandanaceae	*Pandanus* sp.	Rasau kelep	Unknown	Unknown	Pandan		Yes	
Pandanaceae	*Pandanus* sp.	Sambalaun	Unknown	Unknown	Pandan		Yes	
Pandanaceae	Unknown	Lampasau	Unknown	Unknown	Pandan		Yes	
Piperaceae	*Piper* sp.	Sirih himba	Unknown	Sirih samuang	Climber		Yes	
Piperaceae	cf. *Piper* sp.	Sirih sangahau	Unknown	Unknown	Climber		Yes	
Pittosporaceae	*Pittosporum* sp.	Parupuk	Unknown	Parupuk	Tree		Yes	
Poaceae (*Palmae*)	*Metroxylon* sp.	Hambiey	Unknown	Unknown	Shrub			
Podacarpaceae	*Dacrydium pectinateum*	Alau	Unknown	Unknown	Tree	LR/NT	Yes	
Polygalaceae	*Xanthophyllum ellipticum*	Kemuning	Unknown	Unknown	Tree		Yes	
Polygalaceae	*Xanthophyllum stipitatum*	Kemuning	Ubar putih	Unknown	Tree		Yes	
Rhamnaceae	*Zizyphus angustifolius*	Bajakah karinat	Unknown	Unknown	Liana		Yes	
Rhamnaceae	*Zyzyphus angustifolius*	Karinat	Unknown	Unknown	Liana			
Rhizophoreaceae	*Cariliia brachiata*	Gandis	Unknown	Unknown	Tree			
Rhizophoreaceae	*Gynotroches* sp.	Kelumun	Unknown	Unknown	Tree			
Rubiaceae	*Canthium* sp. *dydimum.*	Kopi-kopi	Unknown	Kayu kalalawit	Tree		Yes	
Rubiaceae	*Gardenia tubifera*	Saluang Belum	Rangda	Randa	Tree		Yes	
Rubiaceae	*Ixora havilandii*	Keranji	Unknown	Unknown	Tree			
Rubiaceae	*Jakiopsis ornata*	Unknown	Unknown	Salumbar	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Rubiaceae	*Lucinea* sp.	Bajakah Tabari	Unknown	Unknown	Liana			
Rubiaceae	*Nauclea* sp.	Unknown	Unknown	Unknown	Tree		Yes	
Rubiaceae	*Timonius* sp.	Unknown	Unknown	Unknown	Shrub			
Rubiaceae	*Uncaria* sp.	Kalalawit bahandang / merah	Unknown	Unknown	Liana		Yes	
Rutaceae	*Evodia glabra*	Unknown	Unknown	Sagagulang 2	Tree		Yes	
Rutaceae	*Tetractomia tetrandra*	Rambangun	Asam-asam 1	Sagagulang 1	Tree		Yes	
Sapindaceae	*cf. Cubilia cubili*	Kahasuhuy	Unknown	Unknown	Tree			
Sapindaceae	*Nephellium lappaceum*	Manamun	Unknown	Unknown	Tree			
Sapindaceae	*Nephellium maingayi*	Kelumun Buhis	Piais / ubar putih	Piais	Tree		Yes	
Sapindaceae	*Nephellium* sp.	Kaaja	Unknown	Unknown	Tree		Yes	
Sapindaceae	*Pometia pinnata*	Rambutan gundul	Unknown	Takasai	Tree		Yes	
Sapindaceae	*Xerospermum laevigatum / noronhianum*	Kelumun Bakei	Unknown	Unknown	Tree		Yes	
Sapotaceae	*Isonandra lanceolata*	Nyatoh Palanduk	Unknown	Unknown	Tree		Yes	
Sapotaceae	*Isonandra* sp.	Nyatoh Palanduk	Unknown	Unknown	Tree			
Sapotaceae	*Madhuca cf. pierri*	Nyatoh Undus	Unknown	Unknown	Tree			
Sapotaceae	*Madhuca mottleyana*	Katiau	Kanjalaki	Unknown	Tree		Yes	
Sapotaceae	*Palaquium cochlearifolium*	Nyatu gagas	Nyatu duduk / babi	Unknown	Tree		Yes	
Sapotaceae	*Palaquium leiocarpum*	Hangkang	Unknown	Unknown	Tree			Most common species in NLPSF, Sabangau
Sapotaceae	*Palaquium pseudorostratum*	Nyatoh Bawoi	Unknown	Unknown	Tree		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Sapotaceae	*Palaquium* spp. *ridleyii / cf. xanthochymum*	Nyatu burung	Nyatuh duduk	Unknown	Tree		Yes	
Sapotaceae	*Planchonella cf. maingayi*	Sangkuak	Unknown	Unknown	Tree		Yes	
Selaginellaceae	*Selaginella* sp.	Jenis pakis	Unknown	Hawok	Fern		Yes	
Simaroubaceae	*Quassia borneensis*	Kayu Takang	Unknown	Unknown	Tree			
Smilacaceae	*Smilax* sp.	Bajakah Tolosong	Unknown	Unknown	Liana			
Sterculiaceae	*Sterculia rhoiidifolia*	Loting	Unknown	Unknown	Tree		Yes	
Sterculiaceae	*Sterculia* sp.	Muara bungkang	Unknown	Unknown	Tree		Yes	
Sterculiaceae	*Sterculia* sp.	Galaga	Unknown	Unknown	Tree			
Tetrameristaceae	*Tetramerista glabra*	Ponak	Kayu sabun	Kayu sabun / ponak	Tree		Yes	
Theaceae	*Ploiarium alternifolium*	Asam Asam	Unknown	Unknown	Tree / shrub		Yes	
Theaceae	*Ternstroemia bancanus*	Tabunter	Unknown	Unknown	Tree			
Theaceae	*Ternstroemia hosei*	Unknown	Unknown	Unknown	Tree			
Theaceae	*Ternstroemia magnifica*	Tabunter	Unknown	Unknown	Tree		Yes	
Thymeleaeaceae	*Gonystylus bancanus*	Ramin	Unknown	Ramin	Tree	VU	Yes	CITES Appendix II
Tiliaceae	*Microcos (Grewia)* sp.	Brania Himba	Kayu saluang	Unknown	Tree		Yes	
Verbenaceae	*Clerodendron* sp.	Supang	Unknown	Unknown	Tree		Yes	
Vitaceae	Unknown	Unknown	Unknown	Unknown	Liana		Yes	
Vitaceae	*Ampelocissus rubiginosa*	Bajakah Panamar Pari	Unknown	Unknown	Liana			
Vitaceae	*Ampelocissus* sp.	Bajakar oyang / liana anggur	Unknown	Unknown	Liana		Yes	

Family	Species	Sabangau name	Mentaya name	Katingan name	Growth Form	IUCN listing	Confirmed?	Notes
Vitaceae	Unknown	Anggur hutan	Unknown	Unknown	Epiphyte		Yes	
Vitaceae	*Vitis* sp.	Anggur hutan	Unknown	Unknown	Liana		Yes	
Zingiberaceae	*Alpinia* sp.	Suli Batu	Unknown	Unknown	Shrub			
Zingiberaceae	*Zingiber* sp.	Suli tulang	Unknown	Unknown	Shrub		Yes	
Unknown	Unknown	Kalakai palanduk	Unknown	Unknown	Fern		Yes	
Unknown	Unknown	Tagentu	Unknown	Unknown	Fern		Yes	
Unknown	Unknown	Rampiang	Unknown	Unknown	Fern		Yes	
Unknown	Unknown	Sirih sangumang	Unknown	Unknown	Climber		Yes	
Unknown	Unknown	Bari-bari	Unknown	Unknown	Climber		Yes	
Unknown	Unknown	Takapal	Unknown	Unknown	Climber		Yes	
Unknown	Unknown	Silu kelep	Unknown	Unknown	?		Yes	
Unknown	Unknown	Langkabuk	Langkabuk	Unknown	?		Interviews	Local medicinal value
Unknown	Unknown	Mali-mali	Mali-mali	Unknown	?		Interviews	Local medicinal value
Unknown	Unknown	Pasak bumi	Unknown	Unknown	?		Interviews	Local medicinal value

Table 2.4 Diversity indices for forest flora in Katingan, Sabangau and 'average' peat-swamp forest.

Metric	Katingan			Sabangau	'Average' PSF	Notes
	All plots	Forest plots only	Non-forest plots only			
No. species (inc. all Sabangau records)	312	-	-	-	-	
No. tree species (inc. Sabangau records)	219	-	-	-	-	
No. non-tree species (inc. Sabangau records)	95	-	-	-	-	
No. floral species confirmed	204	-	-	318	-	
No. tree species confirmed	144	145	2	223	-	1 species shared between forest and non-forest; 1 species unique to non-forest plot
No. non-tree species confirmed	60	-	-	95	-	
No. tree species in plots	104	103	2	103	-	
Total no. tree stems in plots	1,012	1,010	2	1,001	-	
No. tree species/100 stems (inc. all Sabangau records)	14.23	14.37	100*	-	-	Precautionary total estimate for Katingan (precautionary principle)
No. tree species/100 stems (species in plots only)	10.28	10.20	100*	10.29	15.1 ± 4.0	Will be erroneously low, as distinct species with different local names of the same genus were lumped under one "sp."
Fisher's alpha (species and stems in plots only)	29.45	28.99	n/a	28.79	18.2 ± 6.2	

Katingan figures from this study (plot areas as in Table 2.2); Sabangau (total plot area 0.9 ha) and 'average' figures from (Paoli *et al.*, 2010) and Husson *et al.* (unpublished). Species/100 stems is equal to the total number of species in the plots divided by the total number of stems in the plots, scaled to 100 stems (Paoli *et al.*, 2010).
* In theory, these values indicate very high species richness. In practice, however, this must be considered in light of the exceptionally low total number of species detected in these plots, leading to the conclusion that species richness is incredibly low in non-forest plots.

2.4.3 Dominant species

Densities (number of stems/ha) of tree species over 5 and 20 cm dbh, along with their relative rankings, listed alphabetically, are given in Table 2.5. The same data, ordered by rank, are given in Tables 2.6 and 2.7, for trees over 5 and 20 cm dbh, respectively. By some distance, the most common tree throughout the concession area is *Syzygium* spp., although it should be remembered that this actually represents a number of species within the same genus, which are very similar and often difficult to distinguish in the field. The next most common tree was *Tetractomia tetrandra*, followed by *Diospyros cf. evena, Shorea teysmanianna, Tetramerista glabra* and *Stemonurus scorpiodes /* spp. For larger trees over 20 cm dbh, the most common species was *Diospyros bantamemsis,* followed by *Tristaniopsis* spp. (again, species within this genus are very difficult to distinguish in the field and this therefore represents a number of species within this genus), *Campnosperma coriaceum* and, at equal levels of abundance, *Litsea cf. rufo-fusca, Horsfieldia crassifolia, Syzygium* spp.*,* and *Tetractomia tetrandra.*

Of these abundant large tree species in Katingan, all are orangutan foods in Sabangau (Harrison, 2009). Large trees are particularly important for orangutans, as these provide the larger fruit crop sizes, on which orangutans are dependent. The fruit of *Diospyros bantamemsis, Campnosperma coriaceum, Litsea cf. rufo-fusca,* and *Syzygium* spp. all feature prominently in orangutan diet in Sabangau (Harrison, 2009), indicating that these species are likely to be very important for orangutans in Katingan. Other important orangutan fruit speciess in Sabangau also rank within the top-ten most common large tree species in Katingan: *Dyera lowii / polyphylla, Calophyllum hosei, Litsea cf. resinosa* and *Litsea* spp.*, Madhuca mottleyana, Palaquium cochlearifolium* and *Tetramerista glabra.*

The species composition of trees over 20 cm dbh in Katingan is broadly comparable to that in Sabangau, with many species shared in the list of top-20 most abundant large tree species at both sites (Table 2.8). Overall, there would appear to be fewer trees over 20 cm dbh in Katingan than Sabangau, which is likely due to increased contemporary logging pressure in Katingan, but could also be a result of site-specific vagiaries resulting from the fact that all the Sabangau plots are located in a relatively small area of forest, compared to the large spatial distribution of the Katingan plots in this study. Most notable is the lack of *Palaquium leiocarpum* in the Katingan plots, which is by far the most abundant species in Sabangau, indicating that, although similar, these two sites are not identical. This is likely a result of a specific set of conditions (e.g., drainage, peat depth, gradient, nutrient influx/availability), as this species appears much more abundant in the Natural Laboratory of Peat-Swamp Forest (NLPSF) study area in Sabangau, where the Sabangau plots are located, than in other areas of the Sabangau forest. In particular, the Katingan forests are more minerotrophic (i.e., receive nutrients from rivers originating in the interior of the island that are rich in nutrients) than the NLPSF research site in Sabangau, which is entirely ombrotrophic (i.e., receives all its nutrients from aerial precipitation of rain and dust). Such factors (not all of which we completely understand) likely underlie many natural differences between areas of outwardly similar peat-swamp forest.

Table 2.5 Mean densities of tree species over 5 and 20 cm dbh in Katingan (all plots), listed alphabetically by Family. Densities "< 0.88" indicate species confirmed as present in Katingan, but that were not found in the plots.

Family	**Species**	**No. stems / ha ≥ 5 cm dbh**	**Relative rank ≥ 5 cm dbh**	**No. stems / ha ≥ 20 cm dbh**	**Relative rank ≥ 20 cm dbh**
Anacardiaceae	*Campnosperma auriculatum*	5.13	70	< 0.88	53
Anacardiaceae	*Campnosperma coriaceum*	49.13	10	6.22	3
Anacardiaceae	*Campnosperma squamatum*	3.45	77	< 0.88	53
Anacardiaceae	*Mangifera* sp.	< 0.88	100	< 0.88	53
Anisophyllaceae	*Combretocarpus rotundatus*	13.81	42	2.67	19
Annonaceae	*Cyathocalyx* spp.	30.19	21	2.67	19
Anonnaceae	*Mezzetia leptopoda / parviflora*	17.26	33	1.78	28
Anonnaceae	*Mezzetia umbellate*	7.01	64	1.78	28
Anonnaceae	*Polyalthia hypoleuca*	12.03	47	< 0.88	53
Anonnaceae	*Polyalthia sumatrana*	< 0.88	100	< 0.88	53
Annonaceae	*Xylopia coriifolia*	11.15	49	< 0.88	53
Anonnaceae	*Xylopia fusca*	8.58	55	0.89	33
Annonaceae	*Xylopia cf. malayana*	5.13	70	< 0.88	53
Apocynaceae	*Alstonia scholoris*	< 0.88	100	< 0.88	53
Apocynaceae	*Dyera lowii / polyphylla*	20.72	30	3.56	10
Aquifoliaceae	*Ilex cymosa*	38.46	18	< 0.88	53
Aquifoliaceae	*Ilex hypoglauca / wallichi*	11.15	49	< 0.88	53
Aquifoliaceae	*Ilex* sp.	6.02	66	< 0.88	53
Burseraceae	*Canarium* sp.	3.45	77	< 0.88	53
Burseraceae	*Santiria cf. laevigata*	7.69	59	< 0.88	53
Burseraceae	*Santiria griffithii*	9.47	53	0.89	33
Burseraceae	*Santiria* spp.	12.82	45	< 0.88	53
Celastraceae	*Kokoona* sp.	3.45	77	0.89	33
Chrysobalanaceae	*Licania splendens*	15.38	38	< 0.88	53

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh	No. stems / ha ≥ 20 cm dbh	Relative rank ≥ 20 cm dbh
Clusiaceae (*Guttiferae*)	*Calophyllum hosei*	18.15	32	3.56	10
Clusiaceae (*Guttiferae*)	*Calophyllum* spp.	16.27	37	< 0.88	53
Clusiaceae (*Guttiferae*)	*Garcinia* sp. (aci / gandis)	< 0.88	100	< 0.88	53
Clusiaceae (*Guttiferae*)	*Garcinia* sp. (manggis / gantalang)	< 0.88	100	< 0.88	53
Clusiaceae (*Guttiferae*)	*Garcinia* sp. (aci / mahalilis)	< 0.88	100	< 0.88	53
Clusiaceae (*Guttiferae*)	*Garcinia* sp. *cf. parvifolia*	< 0.88	100	< 0.88	53
Clusiaceae (*Guttiferae*)	*Garcinia* spp.	41.13	16	< 0.88	53
Clusiaceae (*Guttiferae*)	*Mesua* sp.	20.82	29	2.67	19
Crypteroniaceae	*Dactylocladus stenostachys*	6.12	65	2.67	19
Dipterocarpaceae	*Dipterocarpus borneensis*	0.89	96	< 0.88	53
Dipterocarpaceae	*Shorea balangeran*	3.56	76	3.56	10
Dipterocarpaceae	*Shorea platycarpa*	< 0.88	100	< 0.88	53
Dipterocarpaceae	*Shorea teysmanianna*	73.09	4	3.56	10
Dipterocarpaceae	*Shorea uliginosa*	14.60	41	< 0.88	53
Ebenaceae	*Diospyros bantamemsis*	16.89	35	14.22	1
Ebenaceae	*Diospyros cf. evena*	77.91	3	0.89	33
Ebenaceae	*Diospyros lanceifolia*	6.02	66	0.89	33
Ebenaceae	*Diospyros siamang*	8.58	55	0.89	33
Ebenaceae	*Diospyros* sp.	4.34	75	0.89	33
Elaeocarpaceae	*Elaeocarpus acmocarpus*	< 0.88	100	< 0.88	53
Elaeocarpaceae	*Elaeocarpus mastersii*	26.53	23	< 0.88	53
Elaeocarpaceae	*Elaeocarpus* sp.	< 0.88	100	< 0.88	53
Euphorbiaceae	*Antidesma coriaceum*	< 0.88	100	< 0.88	53
Euphorbiaceae	*Antidesma phanerophe*	< 0.88	100	< 0.88	53
Euphorbiaceae	*Antidesma* sp.	< 0.88	100	< 0.88	53
Euphorbiaceae	*Baccaurea bracteata*	34.22	20	< 0.88	53

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh	No. stems / ha ≥ 20 cm dbh	Relative rank ≥ 20 cm dbh
Euphorbiaceae	*Baccaurea stipulata*	2.56	84	< 0.88	53
Euphorbiaceae	*Blumeodendron tokbrai / elateriospermum*	14.70	40	0.89	33
Euphorbiaceae	*Cephalomappa* sp. (karandau putih / jangkang)	2.56	84	< 0.88	53
Euphorbiaceae	*Cephalomappa* sp. (karandau putih / sarakat / tempurung)	2.56	84	< 0.88	53
Euphorbiaceae	*Glochidion cf glomerulatum*	< 0.88	100	< 0.88	53
Euphorbiaceae	*Glochidion* sp.	< 0.88	100	< 0.88	53
Euphorbiaceae	*Maccaranga caladiifolia*	< 0.88	100	< 0.88	53
Euphorbiaceae	*Neoscortechinia forbesii*	< 0.88	100	< 0.88	53
Euphorbiaceae	*Neoscortechinia kingii*	5.23	69	< 0.88	53
Fabaceae (*Leguminosae*)	*Adenanthera pavonina*	7.69	59	< 0.88	53
Fabaceae (*Leguminosae*)	*Archidendron borneensis*	2.56	84	< 0.88	53
Fabaceae (*Leguminosae*)	*Dialium.sp*	2.56	84	< 0.88	53
Fabaceae (*Leguminosae*)	*Koompassia malaccensis*	1.78	93	1.78	28
Fabaceae (*Leguminosae*)	*Pithecellobium clypearia*	< 0.88	100	< 0.88	53
Fagaceae	*Lithocarpus conocarpus*	45.47	14	2.67	19
Fagaceae	*Lithocarpus* sp. *cf. dasystachys*	22.29	28	0.89	33
Fagaceae	*Lithocarpus* spp.	15.38	38	< 0.88	53
Hypericaceae	*Cratoxylon arborescens*	0.89	96	0.89	33
Hypericaceae	*Cratoxylum glaucum*	40.24	17	0.89	33
Hypericaceae	*Cratoxylum* sp.	8.58	55	0.89	33
Icacinaceae	*Platea exelsa*	< 0.88	100	< 0.88	53
Icacinaceae	*Stemonurus scorpiodes /* spp.	60.07	6	0.89	33
Icasinaceae	*Stemonorus secondiflorus*	< 0.88	100	< 0.88	53
Icasinaceae	*Stemonorus* sp.	< 0.88	100	< 0.88	53
Lauraceae	*Alseodaphne coreacea*	7.69	59	< 0.88	53

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh	No. stems / ha ≥ 20 cm dbh	Relative rank ≥ 20 cm dbh
Lauraceae	*Crypthocarya* sp.	46.15	13	< 0.88	53
Lauraceae	*Litsea cf. rufo-fusca*	43.01	15	5.33	4
Lauraceae	*Litsea ochrea*	2.56	84	< 0.88	53
Lauraceae	*Litsea* sp. *cf. resinosa*	37.09	19	3.56	10
Lauraceae	*Litsea* spp.	46.67	12	3.56	10
Lauraceae	*Phoebe* sp. *cf. grandis*	19.15	31	4.44	8
Lecythidaceae	*Barringtonia* sp.	2.56	84	< 0.88	53
Linaceae	*Ctenolophon parvifolius*	10.36	51	2.67	19
Magnoliaceae	*Magnolia bintulensis*	26.74	22	4.44	8
Melastomataceae	*Memecylon* spp.	25.74	24	0.89	33
Melastomataceae	*Pternadra* sp.	5.13	70	< 0.88	53
Meliaceae	*Aglaia rubiginosa*	8.68	54	2.67	19
Meliaceae	*Chisocheton amabilis*	6.02	66	0.89	33
Meliaceae	*Chisocheton* sp. (latak manuk)	7.69	59	< 0.88	53
Meliaceae	*Sandoricum beccanarium*	25.64	25	< 0.88	53
Moraceae	*Parartocarpus venenosus*	1.78	93	1.78	28
Myristicaceae	*Gymnacranthera farquhariania*	3.45	77	< 0.88	53
Myristicaceae	*Gymnacranthera sp*	< 0.88	100	< 0.88	53
Myristicaceae	*Horsfieldia crassifolia*	54.36	8	5.33	4
Myristicaceae	*Knema intermedia*	13.03	44	< 0.88	53
Myristicaceae	*Knema* sp.	< 0.88	100	< 0.88	53
Myrtaceae	*Eugenia spicata*	< 0.88	100	< 0.88	53
Myrtaceae	*Syzygium cf. valevenosum*	3.45	77	0.89	33
Myrtaceae	*Syzygium havilandii*	23.28	26	< 0.88	53
Myrtaceae	*Syzygium* sp. *cf. Elaeocarpus spicata*	23.28	26	1.78	28
Myrtaceae	*Syzygium* spp.	129.13	1	5.33	4

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh	No. stems / ha ≥ 20 cm dbh	Relative rank ≥ 20 cm dbh
Myrtaceae	*Tristaniopsis* spp.	56.03	7	8.00	2
Pittosporaceae	*Pittosporum* sp.	< 0.88	100	< 0.88	53
Podacarpaceae	*Dacrydium pectinateum*	10.26	52	< 0.88	53
Polygalaceae	*Xanthophyllum ellipticum*	1.78	93	< 0.88	53
Polygalaceae	*Xanthophyllum stipitatum*	2.56	84	< 0.88	53
Rubiaceae	*Canthium* sp. *dydimum.*	2.56	84	< 0.88	53
Rubiaceae	*Gardenia tubifera*	< 0.88	100	< 0.88	53
Rubiaceae	*Jakiopsis ornata*	< 0.88	100	< 0.88	53
Rubiaceae	*Nauclea* sp.	0.89	96	0.89	33
Rutaceae	*Evodia glabra*	< 0.88	100	< 0.88	53
Rutaceae	*Tetractomia tetrandra*	108.31	2	5.33	4
Sapidanceae	*Nephellium maingayi*	7.79	58	0.89	33
Sapindaceae	*Nephellium* sp.	3.45	77	< 0.88	53
Sapindaceae	*Pometia pinnata*	< 0.88	100	< 0.88	53
Sapindaceae	*Xerospermum laevigatum / noronhianum*	7.69	59	< 0.88	53
Sapotaceae	*Isonandra lanceolata*	12.82	45	< 0.88	53
Sapotaceae	*Madhuca mottleyana*	11.35	48	3.56	10
Sapotaceae	*Palaquium cochlearifolium*	16.48	36	3.56	10
Sapotaceae	*Palaquium pseudorostratum*	49.81	9	2.67	19
Sapotaceae	*Palaquium* spp. *ridleyii / cf. xanthochymum*	17.26	33	2.67	19
Sapotaceae	*Planchonella cf. maingayi*	0.89	96	0.89	33
Sterculiaceae	*Sterculia rhoiidifolia*	5.13	70	< 0.88	53
Sterculiaceae	*Sterculia* sp.	2.67	83	0.89	33
Tetrameristaceae	*Tetramerista glabra*	60.17	5	3.56	10
Theaceae	*Ploiarium alternifolium*	5.13	70	< 0.88	53
Theaceae	*Ternstroemia magnifica*	13.71	43	< 0.88	53

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh	No. stems / ha ≥ 20 cm dbh	Relative rank ≥ 20 cm dbh
Thymeleaeaceae	*Gonystylus bancanus*	47.04	11	< 0.88	53
Tiliaceae	*Microcos (Grewia)* sp.	< 0.88	100	< 0.88	53
Unknown	Unknown (latak manuk)	< 0.88	100	< 0.88	53
Verbenaceae	*Clerodendron* sp.	< 0.88	100	< 0.88	53

Table 2.6 Mean densities of tree species over 5 cm dbh in Katingan (all plots), listed in rank order. Species not detected in the plots are excluded.

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh
Myrtaceae	*Syzygium spp.*	129.13	1
Rutaceae	*Tetractomia tetrandra*	108.31	2
Ebenaceae	*Diospyros cf. evena*	77.91	3
Dipterocarpaceae	*Shorea teysmanianna*	73.09	4
Tetrameristaceae	*Tetramerista glabra*	60.17	5
Icacinaceae	*Stemonurus scorpiodes / spp.*	60.07	6
Myrtaceae	*Tristaniopsis spp.*	56.03	7
Myristicaceae	*Horsfieldia crassifolia*	54.36	8
Sapotaceae	*Palaquium pseudorostratum*	49.81	9
Anacardiaceae	*Campnosperma coriaceum*	49.13	10
Thymeleaeaceae	*Gonystylus bancanus*	47.04	11
Lauraceae	*Litsea spp.*	46.67	12
Lauraceae	*Crypthocarya sp.*	46.15	13
Fagaceae	*Lithocarpus conocarpus*	45.47	14
Lauraceae	*Litsea cf. rufo-fusca*	43.01	15
Clusiaceae (*Guttiferae*)	*Garcinia spp.*	41.13	16
Hypericaceae	*Cratoxylum glaucum*	40.24	17
Aquifoliaceae	*Ilex cymosa*	38.46	18
Lauraceae	*Litsea sp. cf. resinosa*	37.09	19
Euphorbiaceae	*Baccaurea bracteata*	34.22	20
Annonaceae	*Cyathocalyx spp.*	30.19	21
Magnoliaceae	*Magnolia bintulensis*	26.74	22
Elaeocarpaceae	*Elaeocarpus mastersii*	26.53	23
Melastomataceae	*Memecylon spp.*	25.74	24
Meliaceae	*Sandoricum beccanarium*	25.64	25
Myrtaceae	*Syzygium havilandii*	23.28	=26
Myrtaceae	*Syzygium sp. cf. Elaeocarpus spicata*	23.28	=26
Fagaceae	*Lithocarpus sp. cf. dasystachys*	22.29	28
Clusiaceae (*Guttiferae*)	*Mesua sp.*	20.82	29
Apocynaceae	*Dyera lowii / polyphylla*	20.72	30
Lauraceae	*Phoebe sp. cf. grandis*	19.15	31
Clusiaceae (*Guttiferae*)	*Calophyllum hosei*	18.15	32
Anonnaceae	*Mezzetia leptopoda / parviflora*	17.26	=33
Sapotaceae	*Palaquium spp. ridleyii / cf. xanthochymum*	17.26	=33
Ebenaceae	*Diospyros bantamemsis*	16.89	35
Sapotaceae	*Palaquium cochlearifolium*	16.48	36
Clusiaceae (*Guttiferae*)	*Calophyllum spp.*	16.27	37
Chrysobalanaceae	*Licania splendens*	15.38	=38
Fagaceae	*Lithocarpus spp.*	15.38	=38
Euphorbiaceae	*Blumeodendron tokbrai / elateriospermum*	14.70	40
Dipterocarpaceae	*Shorea uliginosa*	14.60	41

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh
Anisophyllaceae	*Combretocarpus rotundatus*	13.81	42
Theaceae	*Ternstroemia magnifica*	13.71	43
Myristicaceae	*Knema intermedia*	13.03	44
Burseraceae	*Santiria spp.*	12.82	=45
Sapotaceae	*Isonandra lanceolata*	12.82	=45
Anonnaceae	*Polyalthia hypoleuca*	12.03	47
Sapotaceae	*Madhuca mottleyana*	11.35	48
Annonaceae	*Xylopia coriifolia*	11.15	=49
Aquifoliaceae	*Ilex hypoglauca / wallichi*	11.15	=49
Linaceae	*Ctenolophon parvifolius*	10.36	51
Podacarpaceae	*Dacrydium pectinateum*	10.26	52
Burseraceae	*Santiria griffithii*	9.47	53
Meliaceae	*Aglaia rubiginosa*	8.68	54
Anonnaceae	*Xylopia fusca*	8.58	=55
Ebenaceae	*Diospyros siamang*	8.58	=55
Hypericaceae	*Cratoxylum sp.*	8.58	=55
Sapidanceae	*Nephellium maingayi*	7.79	58
Burseraceae	*Santiria cf. laevigata*	7.69	=59
Fabaceae (*Leguminosae*)	*Adenanthera pavonina*	7.69	=59
Lauraceae	*Alseodaphne coreacea*	7.69	=59
Meliaceae	*Chisocheton* sp. (latak manuk)	7.69	=59
Sapindaceae	*Xerospermum laevigatum / noronhianum*	7.69	=59
Anonnaceae	*Mezzetia umbellata*	7.01	64
Crypteroniaceae	*Dactylocladus stenostachys*	6.12	65
Aquifoliaceae	*Ilex sp.*	6.02	=66
Ebenaceae	*Diospyros lanceifolia*	6.02	=66
Meliaceae	*Chisocheton amabilis*	6.02	=66
Euphorbiaceae	*Neoscortechinia kingii*	5.23	69
Anacardiaceae	*Campnosperma auriculatum*	5.13	=70
Annonaceae	*Xylopia cf. malayana*	5.13	=70
Melastomataceae	*Pternadra sp.*	5.13	=70
Sterculiaceae	*Sterculia rhoiidifolia*	5.13	=70
Theaceae	*Ploiarium alternifolium*	5.13	=70
Ebenaceae	*Diospyros sp.*	4.34	75
Dipterocarpaceae	*Shorea balangeran*	3.56	76
Anacardiaceae	*Campnosperma squamatum*	3.45	=77
Burseraceae	*Canarium sp.*	3.45	=77
Celastraceae	*Kokoona sp.*	3.45	=77
Myristicaceae	*Gymnacranthera farquhariania*	3.45	=77
Myrtaceae	*Syzygium cf. valevenosum*	3.45	=77
Sapindaceae	*Nephellium sp.*	3.45	=77
Sterculiaceae	*Sterculia sp.*	2.67	83
Euphorbiaceae	*Baccaurea stipulata*	2.56	=84
Euphorbiaceae	*Cephalomappa sp.*	2.56	=84
Euphorbiaceae	*Cephalomappa sp.*	2.56	=84

Family	Species	No. stems / ha ≥ 5 cm dbh	Relative rank ≥ 5 cm dbh
Fabaceae (*Leguminosae*)	*Dialium sp.*	2.56	=84
Lauraceae	*Litsea ochrea*	2.56	=84
Lecythidaceae	*Barringtonia sp.*	2.56	=84
Polygalaceae	*Xanthophyllum stipitatum*	2.56	=84
Rubiaceae	*Canthium sp. dydimum.*	2.56	=84
Fabaceae (*Leguminosae*)	*Archidendron borneensis*	2.56	=84
Fabaceae (*Leguminosae*)	*Koompassia malaccensis*	1.78	=93
Moraceae	*Parartocarpus venenosus*	1.78	=93
Polygalaceae	*Xanthophyllum ellipticum*	1.78	=93
Dipterocarpaceae	*Dipterocarpus borneensis*	0.89	=96
Hypericaceae	*Cratoxylon arborescens*	0.89	=96
Rubiaceae	*Nauclea sp.*	0.89	=96
Sapotaceae	*Planchonella cf. maingayi*	0.89	=96

Table 2.7 Mean densities of tree species over 20 cm dbh in Katingan (all plots), listed in rank order. Species not detected in the plots are excluded.

Family	Species	No. stems / ha ≥ 20 cm dbh	Relative rank ≥ 20 cm dbh
Ebenaceae	*Diospyros bantamemsis*	14.22	1
Myrtaceae	*Tristaniopsis spp.*	8.00	2
Anacardiaceae	*Campnosperma coriaceum*	6.22	3
Lauraceae	*Litsea cf. rufo-fusca*	5.33	=4
Myristicaceae	*Horsfieldia crassifolia*	5.33	=4
Myrtaceae	*Syzygium spp.*	5.33	=4
Rutaceae	*Tetractomia tetrandra*	5.33	=4
Lauraceae	*Phoebe sp. cf. grandis*	4.44	=8
Magnoliaceae	*Magnolia bintulensis*	4.44	=8
Apocynaceae	*Dyera lowii / polyphylla*	3.56	=10
Clusiaceae (*Guttiferae*)	*Calophyllum hosei*	3.56	=10
Dipterocarpaceae	*Shorea balangeran*	3.56	=10
Dipterocarpaceae	*Shorea teysmanianna*	3.56	=10
Lauraceae	*Litsea sp. cf. resinosa*	3.56	=10
Lauraceae	*Litsea spp.*	3.56	=10
Sapotaceae	*Madhuca mottleyana*	3.56	=10
Sapotaceae	*Palaquium cochlearifolium*	3.56	=10
Tetrameristaceae	*Tetramerista glabra*	3.56	=10
Anisophyllaceae	*Combretocarpus rotundatus*	2.67	=19
Annonaceae	*Cyathocalyx spp.*	2.67	=19
Clusiaceae (*Guttiferae*)	*Mesua sp.*	2.67	=19
Crypteroniaceae	*Dactylocladus stenostachys*	2.67	=19
Fagaceae	*Lithocarpus conocarpus*	2.67	=19
Linaceae	*Ctenolophon parvifolius*	2.67	=19
Meliaceae	*Aglaia rubiginosa*	2.67	=19

Family	**Species**	**No. stems / ha ≥ 20 cm dbh**	**Relative rank ≥ 20 cm dbh**
Sapotaceae	*Palaquium pseudorostratum*	2.67	=19
Sapotaceae	*Palaquium spp. ridleyii / cf. xanthochymum*	2.67	=19
Anonnaceae	*Mezzetia leptopoda / parviflora*	1.78	=28
Anonnaceae	*Mezzetia umbellata*	1.78	=28
Fabaceae (*Leguminosae*)	*Koompassia malaccensis*	1.78	=28
Moraceae	*Parartocarpus venenosus*	1.78	=28
Myrtaceae	*Syzygium sp. cf. Elaeocarpus spicata*	1.78	=28
Anonnaceae	*Xylopia fusca*	0.89	=33
Burseraceae	*Santiria griffithii*	0.89	=33
Celastraceae	*Kokoona sp.*	0.89	=33
Ebenaceae	*Diospyros cf. evena*	0.89	=33
Ebenaceae	*Diospyros lanceifolia*	0.89	=33
Ebenaceae	*Diospyros siamang*	0.89	=33
Ebenaceae	*Diospyros sp.*	0.89	=33
Euphorbiaceae	*Blumeodendron tokbrai / elateriospermum*	0.89	=33
Fagaceae	*Lithocarpus sp. cf. dasystachys*	0.89	=33
Hypericaceae	*Cratoxylon arborescens*	0.89	=33
Hypericaceae	*Cratoxylum glaucum*	0.89	=33
Hypericaceae	*Cratoxylum sp.*	0.89	=33
Icacinaceae	*Stemonurus scorpiodes / spp.*	0.89	=33
Melastomataceae	*Memecylon spp.*	0.89	=33
Meliaceae	*Chisocheton amabilis*	0.89	=33
Myrtaceae	*Syzygium cf. valevenosum*	0.89	=33
Rubiaceae	*Nauclea sp.*	0.89	=33
Sapidanceae	*Nephellium maingayi*	0.89	=33
Sapotaceae	*Planchonella cf. maingayi*	0.89	=33
Sterculiaceae	*Sterculia sp.*	0.89	=33

Table 2.8 Mean densities of top-20 tree species over 20 cm dbh in Katingan and Sabangau. Same-colour highlights between the two sites indicate species in the top-20 list at both sites. Sabangau data from Harrison *et al.* (2010b).

Katingan			Sabangau		
Family	**Species**	**No. stems / ha ≥ 20 cm dbh**	**Family**	**Species**	**No. stems / ha ≥ 20 cm dbh**
Ebenaceae	*Diospyros bantamemsis*	14.22	Sapotaceae	*Palaquium leiocarpum*	32.08
Myrtaceae	*Tristaniopsis* spp.	8.00	Anacardiaceae	*Campnosperma coriaceum*	12.92
Anacardiaceae	*Campnosperma coriaceum*	6.22	Annonaceae	*Xylopia fusca*	12.50
Lauraceae	*Litsea cf. rufo-fusca*	5.33	Apocynaceae	*Dyera lowii / polyphylla*	11.25
Myristicaceae	*Horsfieldia crassifolia*	5.33	Myristicaceae	*Horsfieldia crassifolia*	11.25
Myrtaceae	*Syzygium* spp.	5.33	Clusiaceae (*Guttiferae*)	*Calophyllum hosei*	10.83
Rutaceae	*Tetractomia tetrandra*	5.33	Dipterocarpaceae	*Shorea teysmanniana*	10.83
Lauraceae	*Phoebe* sp. *cf. grandis*	4.44	Ebenaceae	*Diospyros bantamensis*	8.33
Magnoliaceae	*Magnolia bintulensis*	4.44	Myrtaceae	*Syzygium garcinifolia*	7.08
Apocynaceae	*Dyera lowii / polyphylla*	3.56	Crypteroniaceae	*Dactylocladus stenostachys*	5.83
Clusiaceae (*Guttiferae*)	*Calophyllum hosei*	3.56	Anisophyllaceae	*Combretocarpus rotundatus*	5.00
Dipterocarpaceae	*Shorea balangeran*	3.56	Annonaceae	*Mezzetia leptopoda / parviflora*	5.00
Dipterocarpaceae	*Shorea teysmanianna*	3.56	Meliaceae	*Aglaia rubiginosa*	4.58
Lauraceae	*Litsea* sp. *cf. resinosa*	3.56	Euphorbiaceae	*Neoscortechinia kingii*	4.17
Lauraceae	*Litsea* spp.	3.56	Sapotaceae	*Palaquium ridleyii*	4.17
Sapotaceae	*Madhuca mottleyana*	3.56	Fabaceae	*Koompassia malaccensis*	3.75
Sapotaceae	*Palaquium cochlearifolium*	3.56	Hypericaceae	*Cratoxylon arborescens*	3.75
Tetrameristaceae	*Tetramerista glabra*	3.56	Myrtaceae	*Syzygium* sp. *cf. nigricans*	3.33
Various	*Combretocarpus rotundatus*, *Cyathocalyx* spp., *Mesua* sp., *Dactylocladus stenostachys*, *Lithocarpus conocarpus*, *Ctenolophon parvifolius*, *Aglaia rubiginosa*, *Palaquium pseudorostratum*, *P.* spp. *ridleyii / cf. xanthochymum*	2.67	Clusiaceae	*Calophyllum soulattri*	2.92

The abundance of large *Diospyros bantamensis* trees – a very important orangutan and gibbon food in peat-swamp forest – is almost twice as high in Katingan compared to Sabangau and *Syzygium* spp. may also be more abundant (this is also an important ape food genus). Other important ape food species in Sabangau, such as *Litsea* spp., *Madhuca mottleyana*, *Palaquium cochlearifolium, Tetramerista glabra, Lithocarpus conocarpus, Ctenolophon parvifolius* and *P. pseudorostratum* are also more abundant in Katingan, supporting the assertion that this forest is good ape habitat (though some other ape food species are also less abundant in Katingan). Unsurprisingly, however, the most important orang-utan foods trees in Sabangau are frequently also the most abundant in the environment and so low abundances in Katinagan of certain important ape food tree species in Sabangau should not be taken as evidence that Katingan is poorer in terms of ape foods. Indeed, it is most likely that different foods – i.e., those most abundant at the two sites – will be important for orang-utans and gibbons in Katingan than Sabangau. The assertion that Katingan is a good ape habitat in terms of food availability is, of course, best illustrated by the relatively high densities of orang-utans and gibbons found in Katingan (Harrison *et al.*, 2010a).

2.4.4 Size distributions

The size distribution of trees within Katingan, based on 5-cm dbh classes, is shown in Table 2.9. As expected, small trees occur at much higher densities than do larger trees. Furthermore a very substantial difference exists between densities of all tree size classes between the forest and non-forest plots, with the latter having very much lower tree densities and a complete lack of trees over 15 cm dbh.

Table 2.9 Size distributions of trees in Katingan, based on dbh class.

	Density stems / ha		
Dbh class	**All plots**	**Forest plots only**	**Non-forest plots only**
5-9.9	1190.2	1251.3	50.0
10-14.9	368.5	389.6	50.0
15-19.9	121.6	135.1	0
20-24.9	72.8	80.9	0
25-29.9	30.4	33.8	0
30-34.9	12.8	14.2	0
35-39.9	4.8	5.3	0
40-44.9	1.6	1.8	0
50-54.9	2.4	2.7	0
55-59.9	1.6	1.8	0
65-69.9	0.8	0.9	0
Total ≥ 5 dbh	1,807.6	1,917.3	100.0
Total ≥ 20 dbh	127.2	141.3	0
Total ≥ 30 dbh	24.0	26.7	0
Percentage stems ≥ 20 dbh	7.0	7.4	0
Percentage stems ≥ 30 dbh	1.3	1.4	0

2.4.5 Living Tree Biomass

Tree biomass was not possible to assess directly during this study. As such, we used basal tree area coverage as an indirect indicator of tree biomass. Tree basal area coverage was 33.3 m^2 / ha in forest plots and 1.53 m^2 / ha in non-forest plots for all trees over 15 cm cbh. Restricting the data set to only trees exceeding 7 cm dbh (the mimimum size included in previous plots used to estimate basal area in Sabangau), basal area was 29.6 m^2 / ha for forest plots and 1.53 m^2 / ha for non-forest plots. For the forested plots, this value is lower than that recorded in Sabangau in 2003 (38.1 m^2 / ha), when illegal logging was rampant (Husson *et al.*, 2007), as is the case now in Katingan. This, plus the relatively low density of trees exceeding 20 cm dbh, indicates that Katingan has suffered heavily at the hands of loggers; a situation that is likely to continue in the absence of increased protection through the proposed REDD+ project.

2.4.6 Locally significant species

A number of plant species are used by local communities for commercial, medicinal and food purposes (Tables 2.10-12). Many of these are harvested from wild plants in the forest, whereas others are planted specifically. Of the planted species, some originate from the forest (e.g., *Calamus* sp. / rattan) and some are introduced (e.g., *Ananas comosus* / coconut). All of the medicinal plants are native and are harvested from the forest. Many are used at numerous locations throughout the catchment (e.g., *akar kuning* for typhoid treatment), whereas others were used at only one location in our sample (e.g., *akar tampelas* for diarrhoea treatment). Some have multiple uses; e.g., *Dyera lowii/polyphylla*, which is harvested for both its commercially valuable latex and edible leaves (though the former practice is more widespread).

2.4.7 Confirmed and Potential High Conservation Value Species (HCVs) Present

Of the species listed in Table 2.3, one is considered Critically Endangered (*Shorea balangeran*), one Endangered (*S. teysmanniana*), four confirmed Vulnerable (*Combretocarpus rotundatus*, *Dyera lowii / polyphylla, S. uliginosa* and *Gonystylus bancanus*) and four potential Vulnerable (*Mangifera* spp., *Canarium sp., Aglaia* sp. and *Knema* sp.) by the International Conservation Union (IUCN). The three confirmed *Nepenthes* species are all protected under Indonesian law. International trade is restrited for all three *Nepenthes* spp., all Orchidaceae (at least five species in Katingan), and *Gonystylus bancanus*, with these species all listed under Appendix II of the Convention in International Trade in Endangered Species (CITES).

2.4.8 Threats to Biodiversity in the Region

Nationwide, peat-swamp forests are being lost at an alarming rate: from 1985-2005 it is estimated that over 30% of Indonesia's peat-swamp forest became degraded and degradation rates continue at a rate of 1.7% a year (Hooijer *et al.*, 2006). The peat-swamp forest of Katingan is no exception and is threatened by a number of anthropogenic activities. These threats are largely the same as those faced by the forest's fauna, which are described in detail by Harrison *et al.* (2010a). Here, we provide an overview of these threats as relates specifically to flora and refer the reader to Harrison *et al.* (2010a) for more in-depth descriptions of the nature of each of these threats.

Table 2.10 Important commercial plant species for local communities.

Location	Family	Species	Local name	Habitat	Introduced?	Part taken	Product obtained
Tarantang	Apocynaceae	*Dyera lowii / polyphylla*	Jelutung	Forest	Native	Latex	Used to manufacture chewing gum, glue and other products
	Arecaceae (*Palmae*)	*Calamus* sp.	Rattan	Planted	Native	Stem	Used to manufacture home furniture, etc.
	Lauraceae	*Alseodaphne coriacea*	Gemor	Forest	Native	Bark	Used to manufacture mosquito repellents
Hantipan	Apocynaceae	*Dyera lowii / polyphylla*	Jelutung	Forest	Native	Latex	Used to manufacture chewing gum, glue and other products
	Bromeliaceae	*Ananas comosus*	Coconut	Planted	Introduced	Fruit	For cooking oil
	Euphorbiaceae	*Hevea braziliensis*	Karet / rubber	Planted	Introduced	Latex	Used to manufacture car tyres and shoes
	Lauraceae	*Alseodaphne coriacea*	Gemor	Forest	Native	Bark	Used to manufacture mosquito repellents
	Various	Various	All timber species	Forest	Native	Stem	Construction / building material
Perigi	Apocynaceae	*Dyera lowii / polyphylla*	Jelutung	Forest	Native	Latex	Used to manufacture chewing gum, glue and other products
	Arecaceae (*Palmae*)	*Calamus* sp.	Rattan	Planted	Native	Stem	Used to manufacture home furniture, etc.
	Euphorbiaceae	*Hevea braziliensis*	Karet / rubber	Planted	Introduced	Latex	Used to manufacture car tyres and shoes
	Lauraceae	*Alseodaphne coriacea*	Gemor	Forest	Native	Bark	Used to manufacture mosquito repellents
Medang	Apocynaceae	*Dyera lowii / polyphylla*	Jelutung	Planted	Native	Latex	Used to manufacture chewing gum, glue and other products
	Lauraceae	*Alseodaphne coriacea*	Gemor	Forest	Native	Bark	Used to manufacture mosquito repellents
Telaga	Apocynaceae	*Dyera lowii / polyphylla*	Jelutung	Forest	Native	Latex	Used to manufacture chewing gum, glue and other products
	Lauraceae	*Alseodaphne coriacea*	Gemor	Forest	Native	Bark	Used to manufacture mosquito repellents

Table 2.11 Important medicinal plant species for local communities.

Location	Family	Species	Local name	Habitat	Introduced?	Part taken	Used to treat
Tarantang	Fabaceae (*Leguminosae*)	*Leucomphalos callicarpus*	Akar tampelas	Forest	Native	Stem and roots	Diarrhoea
	Loganiaceae / Menispermaceae	*Fragraea* sp. / *Fibraurea tinctoria*	Akar kuning	Forest	Native	Stem and roots	Typhoid
	Unknown	Unknown	Langkubuk	Forest	Native	Leaves	Chicken pox and similar infections
	Unknown	Unknown	Mali-mali	Forest	Native	Leaves	Skin wounds
Hantipan	Fabaceae (*Leguminosae*)	*Leucomphalos callicarpus*	Akar tampelas	Forest	Native	Stem and roots	Diarrhoea
	Loganiaceae / Menispermaceae	*Fragraea* sp. / *Fibraurea tinctoria*	Akar kuning	Forest	Native	Stem and roots	Typhoid
	Unknown	Unknown	Pasak bumi	Forest	Native	Roots	Malaria
Parigi	Loganiaceae / Menispermaceae	*Fragraea* sp. / *Fibraurea tinctoria*	Akar kuning	Forest	Native	Stem and roots	Typhoid
	Rubiaceae	*Gardenia tubifera*	Saluang belum	Forest	Native	Roots	Back pain
	Unknown	Unknown	Pasak bumi	Forest	Native	Roots	Malaria
Madang	Loganiaceae / Menispermaceae	*Fragraea* sp. / *Fibraurea tinctoria*	Akar kuning	Forest	Native	Stem and roots	Typhoid
	Rubiaceae	*Gardenia tubifera*	Saluang belum	Forest	Native	Roots	Back pain
	Unknown	Unknown	Pasak bumi	Forest	Native	Roots	Malaria
Telaga	Loganiaceae / Menispermaceae	*Fragraea* sp. / *Fibraurea tinctoria*	Akar kuning	Forest	Native	Stem and roots	Typhoid
	Unknown	Unknown	Pasak bumi	Forest	Native	Roots	Malaria

Table 2.12 Important food plant species for local communities.

Location	Family	Species	Local name	Habitat	Introduced?	Part taken	Cooking method
Tarantang	Sapotaceae	*Madhuca mottleyana*	Katiau	Forest	Native	Young leaves	Boiled or fried
	Apocynaceae	*Dyera lowii / polyphylla*	Jelutung	Forest	Native	Young leaves	Boiled or fried
	Unknown	Unknown	Akar kait	Forest	Native	Young leaves	Boiled or fried
	Blechnaceae	*Stenochlaena palustris*	Kalakai	Forest	Native	Young leaves	Boiled or fried
	Various	Various	Jamur (mushrooms)	Forest	Native	Whole fungus	Boiled or fried
Hantipan	Poaceae	*Oryza sativa*	Padi (rice)	Planted	Introduced	Fruit	Boiled
	Euphorbiaceae	*Manihot esculenta*	Singkong (cassava)	Planted	Introduced	Leaves and tuber	Boiled or fried
	Solanaceae	*Solanum melongena*	Terong (aubergine)	Planted	Introduced	Fruit	Boiled or fried
	Solanaceae	*Capsicum* spp.	Cabe (chilli)	Planted	Introduced	Fruit	Crushed for sambal
	Blechnaceae	*Stenochlaena palustris*	Kalakai	Forest	Native	Young leaves	Boiled or fried
	Various	Various	Jamur (mushrooms)	Forest	Native	Whole fungus	Boiled or fried
Perigi	Poaceae	*Oryza sativa*	Padi (rice)	Planted		Fruit	Boiled
	Blechnaceae	*Stenochlaena palustris*	Kalakai	Forest	Native	Young leaves	Boiled or fried
	Various	Various	Jamur (mushrooms)	Forest	Native	Whole fungus	Boiled or fried
	Arecaceae (*Palmae*)	*Calamus* sp.	Rotan	Planted	Native	Young stem	Boiled or fried
Madang	Blechnaceae	*Stenochlaena palustris*	Kalakai	Forest	Native	Young leaves	Boiled or fried
	Various	Various	Jamur (mushrooms)	Forest	Native	Whole fungus	Boiled or fried
	Arecaceae (*Palmae*)	*Calamus* sp.	Rotan	Planted	Native	Young stem	Boiled or fried
Telaga	Blechnaceae	*Stenochlaena palustris*	Kalakai	Forest	Native	Young leaves	Boiled or fried
	Various	Various	Jamur (mushrooms)	Forest	Native	Whole fungus	Boiled or fried
	Arecaceae (*Palmae*)	*Calamus* sp.	Rotan	Planted	Native	Young stem	Boiled or fried

2.4.8.1 Illegal logging
Illegal logging occurs across much of the proposed concession area, particularly on the Mentaya side, and this poses a severe threat to the area's floral biodiversity and HCVs. Most, if not all, areas of the concession that are economically feasible to log (i.e., practically all areas, apart from interior low-pole forest that is hard to access and has a low abundance of larger commercially-valuable trees) have been logged at some point. This includes both large-scale commercial illegal logging and small-scale extraction of poles for local accommodation needs, which poses a lesser threat (see Section 2.4.1). The widespread nature of this threat is evidenced from an inspection of satellite images of the area, on which a huge number of canals used by illegal loggers to extract timber from the forest are evident. These canals are, in fact, considered the most severe threat to peat-swamp forest in the area (more so than the actual extraction of timber by illegal loggers), due to their drainage of the peat substrate and consequent impacts on ecosystem stability and fire risk (Section 2.4.8.5).

Illegal logging poses an obvious threat to forest flora, as it involves the direct extraction of trees. Of particular concern is that many of the most valuable timber species likely to be targeted by (commercial) loggers are also the most threatened: *Shorea balangeran* (Critically Endangered), *S. teysmanniana* (Endangered), *S. uliginosa* and *Gonystylus bancanus* (Vulnerable). Indeed, the commercial value of these species' timber is the primary reason underlying their threatened status. Non-target floral species will also be negatively impacted by illegal logging, through incidental damage, use in logging skids, cutting of lianas, changes in forest micro-habitat reducing habitat suitability, and canal construction, leading to increased peat drainage and vulnerability of the forest to fire (see Section 2.4.8.5).

2.4.8.2 Concession logging
According to the Forestry Department's 2009 Spatial Plan for Kalimantan Tengah, the large majority of the forest in the proposed concession area is classified as Production Forest (*Hutan Produksi*), in which logging concessions could potentially be granted. Indeed, according to PT. Starling Asia's Technical Proposal, a number of logging concessions had previously been granted for the area, although these are now no longer active or have been revoked. However, while the area remains production forest, there may be a risk of concessions being granted for logging and the resumption of legal commercial logging in the area at some point in the future.

The threats from concession logging are very similar to those listed above for illegal logging (removal of target tree species, incidental damage, use of non-target species in skids, liana cutting and changes in forest micro-habitat), although some threats may be less intense in logging concessions. Firstly, concession loggers are technically bound by regulations concerning the species and sizes of tree that they may harvest, which should theoretically pose risk to threatened species, such as the high-timber-value HCV species in Katingan: *S. balangeran, S. teysmanniana, S. uliginosa* and *Gonystylus bancanus*. In practice, this may not be the case, however, as such rules are generally poorly enforced, leading to continued harvesting of threatened species. The current high levels of illegal logging around the proposed concession, which is entirely illegal and should, in theory, be relatively much easier to regulate than monitoring specific tree species and sizes extracted, is evidence of this risk. Secondly, previous logging concessions in peat-swamp forest have constructed railways from the forest edge to the centre of the peat dome (Morrogh-Bernard *et al.*, 2003). Timber is hauled to railways along logging skids and then extracted from the forest using the railway. This is less much less damaging to the peat than extracting timber via the canals used by illegal loggers, as it does not drain the peat, therefore posing less of a risk to overall forest integrity. Nevertheless, despite the potentially reduced severity of the impacts from logging concessions compared to illegal logging, the overall impact of logging concessions on flora diversity and HCVs will still be severely negative.

2.4.8.3 Forest conversion to non-forest land uses

Conversion of forest to other non-forest land uses (including agriculture, gold mines, oil palm and potentially coal) poses a very severe threat to forest flora. For a detailed description of these threats, including oil palm, in Katingan, please refer to Harrison *et al.* (2010a). Only two tree species (*Pithecellobium clypearia* and *Syzygium cf. valevenosum*) were found in the non-forest plots, compared to 103 species in the forest plots. Furthermore, only *P. clypearia* was found in only the non-forest plots, whereas 102 species were found in only the forest plots, including all of the area's HCV species. This provides very strong support for the protection of intact areas of forest and avoidance of conversion of forest to non-forest in order to conserve the area's floral diversity and HCVs.

2.4.8.4 Charcoal production

This may be specific to the Lemiring village and, though it may pose a threat to forest flora locally, this depends on the exact method of extraction and processing. At present, there are insufficient data to provide a complete assessment of this threat. Based on current information, however, charcoal production presently appears to form, at most, a medium-level threat localised to the Lemiring area.

2.4.8.5 Peat drainage and fire

As evidenced through inspection of satellite images, a huge number of illegal logging canals have been dug throughout the proposed concession area, which are used by loggers to float timber out of the forest to rivers, primarily during the wet season. These canals are a severe threat to the entire forest, as they drain the peat. As long as the canals remain open, this threat can continue to operate long after illegal loggers may have left an area. When dry, the peat is susceptible to degradation and becomes highly vulnerable to fire, threatening the integrity of the entire ecosystem (Page *et al.*, 2002; Wösten *et al.*, 2008; Harrison *et al.*, 2009; Page *et al.*, 2009a). Because peat drainage threatens the entire stability of the forest, this is a severe threat for all the floral biodiversity and HCVs found in the area.

Under natural hydrological conditions (i.e., very wet), fire is a rare occurrence in PSF and, consequently, PSF trees are generally poorly adapted towards coping with fire fire (most have very thin bark), so tree mortality post-fire is high. Although fires are generally low intensity, their slow spread rate means fire is in contact with trees for long periods, heating up the bark. Fire can kill 23-44% of trees > 10 cm DBH (diameter at breast height) and 95% of stems > 1 cm DBH, and alter species composition, with little regeneration even 15 years after burning (Cochrane *et al.*, 1999; Cochrane, 2003). Tree mortality in severely burnt areas is virtually 100%, as most trees fall once the supporting peat is burnt away (Figure 2.4).

a.

b.

Figure 2.4 (a and b, overleaf). Mass tree falls and deaths following a severe peat-swamp forest fire in Sabangau in 2003. Post-fire tree mortality from this event was virtually 100%. Pictures by Emily Jones (a) and Marie Hamard (b).

Some PSF trees appear relatively better adapted at coping with forest fires than others, however, or at least return quickly to burnt areas in the aftermath of fires. Examples of such species are *Combretocarpus rotundatus*, *Cratoxylon* spp. and *Tristianopsis* spp. (Page *et al.*, 2009b), the former of which is classified as Vulnerable by the IUCN and is considered an HCV species for Katingan. *C. rotundatus* has thick outer bark, has wind-dispersed seeds and deep central roots, so tend to cope relatively well with fire. Consequently, they are commonly the only species still left standing in an area following fire and are one of the first species to recolonise burnt areas (Page *et al.*, 2009b). *Tristaniopsis* is closely related to *Eucalyptus*, which frequently experiences forest fires in Australia, and has very peely bark. This may help protect trees, as the bark burns quickly, preventing the fire from reaching dangerous temperatures around the tree.

2.8.4.6 Harvesting of non-timber forest products

As in other areas of PSF, including Sabangau, collection of *jelutong* (*Dyera lowii / polyphylla*) latex from forest trees is common in communities bordering the Katingan forest. This activity does not harm the trees or wildlife and can potentially form part of an economy based on sustainable forest use, provided that canals are not built and/or dams destroyed to extract the product from the forest. Demand for these products is currently high, leading to continued exploitation of these products by local communities.

Rubber (*Hevea braziliensis*) plantations also exist in some places (including Hanaut, Lemiring, Terantang and Perigi), particularly along both the River Mentaya, though some of these are not yet old enough to have yielded results. This rubber can also fetch high prices. Assuming that these plantations do not encroach further upon the forest and that appropriate care is taken to prevent fire in these plantations, they do not pose any immediate threat to the forest's floral biodiversity and HCVs. Unfortunately, based on our previous interview results (Harrison *et al.*, 2010a), it appears that forest is currently being cleared for plantations in some areas.

Rattan (primarily *Calamus* and *Daemonorops* spp.) harvesting occurs in many areas of Katingan and, again, this does not pose a direct threat to floral biodiversity in the region, provided that the above conditions are met. Rattan is collected in the wild and grown in gardens along the River Mentaya, and projects are also underway to promote the local rattan industry as a sustainable and environmentally-friendly local economy in Galinggang, Muara Bulan and Baun Bango villages along the Katingan River, with the aim of producing high-quality product suitable for export (D. Kurniawan, pers. comm.). Such plantations now exist along 90 km on the banks of the Rivers Katingan and Musang. In some villages, e.g., Terantang Hilir, rattan harvesting has now become one of the primary income sources. The price is less along the Katingan River than Mentaya, probably because the buyers come from Sampit and must pay higher transport costs to get to Katingan River villages.

Forest fruits are rarely collected, as there is little quality fruit native to the forest. There is little or no orchid collection. Medicinal plants are collected for local use only and are not sold (see Section 2.4.6). The bark of gemur (*Alseodaphne coriacea*), which is used in the production of mosquito coils or cosmetics, is collected and sold in many areas along both the Mentaya and Katingan rivers (Table 2.10). Although previously common and still practiced in most areas surrounding the concession, this activity is becoming rarer, as the species approaches local extinction due to over harvesting (it was not detected in any of our tree plots).

According to reports from the Starling team, the resin of certain dipterocarp trees is collected in at least one village bordering the proposed concession area (Mentaya Seberang, just across the River Mentaya from Sampit). This is unlikely to be a detrimental activity for the area's biodiversity, provided the trees are not harmed and no other potentially harmful activities accompany the resin collection.

2.4.8.7 Climate change

If it leads to changes in rainfall regimes, in particular increased frequency and/or intensity of drought, human-induced climate change could potentially threaten the Katingan peat swamp and its associated floral biodiversity and HCVs. In particular, the frequency of El Niño events is thought to have increased since the mid-1970's, due to global warming (Trenberth and Hoar, 1997). El Niño events are typically associated with drought conditions in Indonesia and, consequently, fire in peat swamps (Page *et al.*, 2002; Wosten *et al.*, 2008; Harrison *et al.*, 2009) Thus, potential increased incidence of El Niño events due to climate change could impact the frequency and severity of fire, which would have negative impacts on biodiversity and HCVs in the region. In addition to increased drought and fire risk, it is also anticipated that Kalimantan will receive higher annual rainfall (i.e., more concentrated in certain seasons), leading to increased wet-season flooding (Hulme and Sheard, 1999). This combination of higher annual rainfall, and more extreme wet and dry seasons, is very likely to have an impact on flora communities, though this is presently impossible to quantify. Changes in rainfall regimes and/or temperature may also influence the physiology of certain tree species and in particular flowering and fruiting phenology (*cf.* Corlett and Lafrankie, 1998; Harrison *et al.*, 2010c), although this threat is currently impossible to confirm or quantify.

2.5 Importance of Katingan Peat Swamp for Flora Conservation

Our surveys confirm that Katingan is home to a high diversity of flora, including both threatened species and species protected under Indonesian law. Due to the large size of the proposed concession area (227,260 ha), it will be a critical stronghold for many of the floral species found here.

The Key Biodiversity Area (KBA) criteria consider both an area's *vulnerability* and its *irreplaceability* (Langhammer *et al.*, 2007). In order to meet the vulnerability criteria, a site should contain at least one individual of a Critically Endangered or Endangered species, or at least 30 individuals of a vulnerable species. Katingan satisfies this criterion for at least six and possibly ten or more species.

The irreplaceability criterion is comprised of a number of sub-criteria, as follows:

i. Restricted range (global range < 50,000 km^2 or 5% of global population at the site);
ii. Species with large but clumped distributions (5% of global population at the site);
iii. Globally significant congregations (1% of population seasonally at the site);
iv. Globally significant source populations (site is responsible for maintaining 1% of global population);
v. Bio-regionally restricted assemblages.

Because global distributions of tree species' populations are very poorly documented and incomplete for Bornean forest flora, it is difficult to assess rigorously whether any species meet these criteria. However, based upon the stem densities in Table 2.5 and assuming that these species are ubiquitously distributed throughout the 176,900 ha of mixed-swamp forest (the forest type we surveyed) in the proposed concession area, it is clear that Katingan is home to large populations of many HCV species (Table 2.13). Although the assumption of ubiquitous distribution will not be entirely correct, it must also be remembered that these calculations are based upon only those stems exceeding 5 cm dbh and that they do not include the unsurveyed areas of low-pole forest, which cover some 2,140 ha in the concession. These projections are probably therefore more likely to be underestimates than overestimates. Considering the projected size of some of these populations, it is extremely likely that Katingan is home to at least 1% of the global population of most, if not all, of these species and, hence, also satisfies the irreplaceability criteria for a KBA. This would likely remain the case even if our estimates are two or more times greater than the actual populations of these species in the proposed concession.

Table 2.13 Extrapolated total population sizes for Katingan proposed concession area (176,900 ha) of threatened species.

Species	IUCN status	No. stems ≥ 5 cm dbh / ha	Extrapolated total no. stems ≥ 5 cm dbh / ha in Katingan
Shorea balangeran	CR	3.56	629,764
Shorea teysmanniana	EN	73.09	12,929,621
Combretocarpus rotundatus	VU	13.81	2,442,989
Dyera lowii / polyphylla	VU	20.72	3,665,368
Shorea uliginosa	VU	14.60	2,582,740
Gonystylus bancanus	VU	47.04	8,321,376

3. PROJECT IMPACTS AND MITIGATING NEGATIVE IMPACTS

3.1 Section Summary

In order to halt and reverse floral biodiversity and HCV loss, it is necessary to identify the drivers and agents behind the threats faced in an area (SCBD, 2010). Currently, fishing, agriculture, rattan harvesting, latex collecting (*jelutong* and rubber) and illegal logging are the main options for income for people in villages surrounding the Katingan forest, and local people are generally poor. Consequently, they are likely to consider any potential income-generating opportunities available, which can put great pressure on their only abundant natural resource: the forest. Our previous work in the area (Harrison *et al.*, 2010a), indicated fourteen active drivers of biodiversity loss in Katingan and six agents of biodiversity loss. The agents behind these drivers are private companies, local communities, hunters, soldiers/the police and government. Ultimately, the need for food and money to supply local peoples' needs, and the quest for profit among large and small companies, and individuals, are the main factors behind all of these drivers and motivating the agents.

In the absence of the project, the most likely land-use scenario is that illegal logging, hunting, peat degradation and other harmful activities will continue, and risk of fire, encroachment from gold mines and oil palm will increase. This will lead to severe negative impacts on the area's floral biodiversity and declines in the population size of the area's floral HCVs, in particular those with the most commercially valuable timber that are often targeted by loggers (*Shorea* spp. and *Gonystylus bancanus*). Of the ten proposed activities, eight have a direct positive impact on forest cover and biomass, overall floral biodiversity and *Dyera lowii/polyphylla*; seven have a positive impact on *Shorea* spp. and *G. bancanus*; and five have a positive impact on *Combretocarpus rotundatus.* Two project activities will have neutral impacts on forest cover and biomass, overall floral diversity and *D. lowii/polyphylla*; and three have neutral impacts on *Shorea* spp., *G. bancanus* and *C. rotundatus*. Two project activities are anticipated to have negative impacts on *C. rotundatus*, but the overall impact of these activities of floral diversity and the other floral HCVs are overwhelmingly positive. Without the project, these activities would not occur and, thus, we offer our full recommendation towards implementation of the proposed project activities.

One of the floral HCVs identified (*D. lowii/polyphylla*) is of direct importance to local communities' wellbeing, as a result of its commercially-valuable latex, which can be sustainably harvested. The other HCV species also have value to local communities as timber products, but harvesting practices are not sustainable (illegal logging). No species planned for use in project activities are invasive and all are native, though care must be taken over the selection of *Melaleuca* sp., as some introduced species have become invasive in some parts of the world. Potential risks to anticipated biodiversity benefits from climate change are discussed.

In response to our findings on the biodiversity and HCVs in the area, and the threats they face, we recommend eleven floral biodiversity objectives be adopted by the project proponents. These include immediate research objectives to gain additional necessary information on threats in the area, habitat types, HCV populations and forest flora in other habitat sub-types; measures to mitigate threats to floral HCVs; measures to maintain/enhance biodiversity and floral HCVs beyond the project timeframe; and biodiversity monitoring and HCV-specific objectives, specific to forest flora.

3.2 Drivers of Biodiversity Loss

A full description of the drivers of faunal biodiversity loss in Katingan has been provided by Harrison *et al.*)2010a). Most of these drivers also apply to forest flora and we refer the reader to Harrison *et al.* (2010a) for a full description of these. A summary of those active drivers relevant to forest flora is given in Table 3.1.

Table 3.1 Drivers and agents of floral biodiversity loss in Katingan.

	Agent of deforestation				
Active drivers of biodiversity loss	Private companies	Local communities	Hunters	Soldiers / police	Government
1. Conversion for crops	●	●			
2. Conversion for non-crop plantations	●	●			
3. Conversion for settlements		●			●
4. Illegal logging for local needs		●		●	
5. Illegal logging for commercial sale	●			●	
6. Use of fire to clear land	●	●			
7. Use of fire in local disputes		●			
8. Accidental fires	●	●	●		
9. Peat drainage	●	●		●	●
10. Gold mining	●				
11. Harvesting NTFPs	●				
12. Clearance for transport infrastructure	●				●
13. Charcoal production	●	●			

NTFP = non-timber forest product.

3.3 Impact of Project Activities on Floral Diversity and HCVs

In the absence of the project, the most likely land-use scenario is that current levels of unsustainable forest-resource exploitation will continue (Harrison *et al.*, 2010a). Illegal logging, hunting, peat degradation and other harmful activities will continue, risk of fire will increase, and the area will face increased risk from encroachment of gold mines and oil-palm plantations. This will lead to severe negative impacts on forest cover and condition, with consequent severe negative impacts on the area's floral biodiversity, including the survival of HCV species in the area. Specifically, this will lead to declines in the population size of the four floral HCVs most commonly targeted by loggers, due to the high commercial value of their timber – *Shorea balangeran* (Critically Endangered), *S. teysmanniana* (Endangered), *S. uliginosa* and *Gonystylus bancanus* (Vulnerable). Because the latex of *Dyera lowii / polyphylla* is commercially valuable, there is increased incentive for local people to protect this species. This puts it at lower risk of timber harvesting, although it still remains vulnerable to other threats, such as peat drainage and forest fires.

Combretocarpus rotundatus populations may even benefit from forest disturbance, as this species is a fast-growing, wind-seed dispersed pioneer species, which is one of the first to recolonise deforested areas. Nevertheless, despite this, the overall impact of the business-as-usual / without-project scenario is one of continued floral diversity loss and, ultimately, likely local extinction of some species, including HCVs.

According to the Technical Proposal provided by PT. Starling Asia, the project activities listed in Table 3.2 will be undertaken in the proposed concession area. In Table 3.2 we also provide a summary of the impacts of these activities on the area's floral biodiversity and HCVs. Of the ten proposed activities, eight are expected to have a direct positive impact on forest cover and biomass, overall floral biodiversity and *D. lowii/polyphylla*; seven to have a positive impact on *Shorea* spp. and *G. bancanus*; and five to have a positive impact on *C. rotundatus.* Two project activities are anticipated to have neutral impacts on forest cover and biomass, overall floral diversity and *D. lowii/polyphylla*; and three to have neutral impacts on *Shorea* spp., *G. bancanus* and *C. rotundatus*. Two project activities are anticipated to have negative impacts on *C. rotundatus.* Those project activities identified as having a neutral direct impact generally have an indirect positive impact (e.g., ecological monitoring). The overall impacts of the project activities on forest cover and condition, overall floral biodiversity and the area's floral HCVs are therefore overwhelmingly positive. Overall, the overall suite of project activities will also be positive for *C. rotundatus*, despite the possibility that some project activites may negatively influence this species. The activities that may negatively influence this species will, however, have overall positive benefits on forest fauna (Harrison *et al.*, 2010a) and flora, including the other floral HCVs and, thus, we recommend that these activities still be employed. Based on the precautionary principle, we see no reason to delay the onset of any of these activities.

3.4 Recommended Floral Biodiversity Objectives

Because many of the threats faced by forest flora and HCVs are the same as those faced by forest fauna, many of the objectives listed by Harrison *et al.* (2010a) are also relevant for forest flora. Relevant objectives for forest flora are described below.

3.4.1 Immediate Research Objectives

1. Obtain more complete information on the geographic extent and geographical variations in intensity of the various threats identified in Section 2.4.8.
2. Obtain more accurate spatial data on the distribution of habitat sub-types in the area and the total area covered by these habitat sub-types.
3. Conduct surveys of floral HCVs in all major habitat sub-types in the area, including low-pole forest and more areas of highly-disturbed/non-forest.

3.4.2 Measures to Mitigate Threats to Floral HCVs

4. Implement the suggested activities described in the Technical Proposal to protect the forest, which have been identified above as having net positive impacts on both the conservation of overall floral biodiversity and HCVs in the region.

Table 3.2 Impact of project activities on floral biodiversity and HCVs. Arrows indicate whether the proposed project activity will have a positive, negative or neutral impact on overall floral biodiversity and specific HCVs. Because they face similar specific threats as high-value timber species, the three *Shorea* HCV species and *Gonystylus bancanus* have been grouped together.

	Impact on…					
Project activity	**Forest cover and biomass**	**Overall floral diversity**	***Shorea* spp. and *G. bancanus***	***D. lowii/ polyphylla***	***C. rotundatus***	**Comments**
Hydrological stabilisation through dam construction	↑	↑	↑	↑	↑	Crucial for maintaining forest integrity and, hence, for the conservation of all floral biodiversity and HCVs.
Enrichment planting in disturbed areas	↑	↑	↑	↑	↓	Species to be planted include some HCV species (*Shorea* sp. and *G. bancanus*), providing clear benefits for these. Recovery of disturbed areas will attract primates and other seed dispersers into the area and, given time, seed dispersal by these fauna in degraded areas will result in increased floral species diversity. *C. rotundatus* may suffer negative impacts, as this is often a pioneer that 'naturally' recolonises disturbed areas and may be displaced by planted species.
Replanting in non-forest areas	↑	↑	↑	↑	↓	Species to be planted include some HCV species (*S. balangeran* and *D. lowii/polyphylla*), providing direct benefits for these. As above, this will also lead to increased seed dispersal with consequent positive impacts on floral biodiversity, though *C. rotundatus* may suffer negative impacts, as it is displaced by planted species.

Project activity	Impact on… Forest cover and biomass	Overall floral diversity	*Shorea* spp. and *G. bancanus*	*D. lowii/ polyphylla*	*C. rotundatus*	Comments
Forest protection – illegal logging and encroachment prevention	↑	↑	↑	↑	↑	Particular focus in north around gold mining areas. This is important for preventing total loss of natural forest flora in this and other parts of the proposed concession area, including all HCV species. Important for HCV conservation, as all HCV species are to some extent harvested for timber.
Monitoring of permanent sample plots for flora, fauna, water level, peat depth, etc.	↔	↔	↔	↔	↔	No direct impact on floral biodiversity or HCVs, but important in determining the impact of other project activities on these, and will have indirect positive impacts through enabling efficient targeting of resources and rapid responses.
Enhance the role of sustainable non-timber forest resources in the local economy	↑	↑	↑	↑	↑	Positive impacts on forest flora, as sustainable harvesting replaces unsustainable illegal logging and other activites that have a negative impact on floral biodiversity. Positive impacts on *D. lowii/polyphylla* particularly likely, due to the economic importance of its latex.
Develop a comprehensive management plan for selected animal species, including:						
Fauna habitat surveys to identify which areas are used by selected species	↔	↔	↔	↔	↔	No direct impact, but important for identifying and managing areas of relatively intact habitat most suitable for forest fauna, so will therefore have indirect positive impact on flora.
Managing core areas of animal habitat	↑	↑	↑	↑	↑	Areas of core faunal habitat (in particular orangutans and gibbons) are relatively pristine areas of mixed-swamp forest, which will also contain the highest diversity of flora and largest numbers of floral HCVs. Thus, floral biodiversity and HCVs will also benefit from such management.

Project activity	Impact on… Forest cover and biomass	Overall floral diversity	*Shorea* spp. and *G. bancanus*	*D. lowii/ polyphylla*	*C. rotundatus*	Comments
Animal habitat development (striving to develop core habitat areas)	↑	↑	↑	↑	↑	Benefits as above through improving the size of core habitat areas and improving overall forest condition, which will have positive impacts on floral biodiversity and HCVs.
Animal population development through assessing age-sex ratios and possible recolonisation in core habitat areas	↔	↑	↔	↑	↔	Positive impact on flora with seeds dispersed by apes, so overall positive impact on floral diversity. *D. lowii/polyphylla* seeds frequently consumed by orangutans and will be occasionally dispersed. Other HCV species unlikely to be dramatically impacted.

3.4.3 Measures to Maintain/Enhance floral diversity and HCVs Beyond the Project Timeframe

5. To slow and, ultimately, stop and reverse the loss of forest cover, condition and floral diversity in the proposed concession area. This will involve reducing the threats faced from illegal logging, fire and forest conversion.
6. To achieve by the end of the project timeframe an economy in villages surrounding the project area that is dependent on environmentally sustainable activities with positive or neutral biodiversity impacts, and does not depend on timber, forest conversion, wildlife hunting or other unsustainable practices with negative impacts on forest flora. This will then allow local communities to satisfy their economic needs without having detrimental impacts on floral diversity and HCVs. Protection of *D. lowii/polyphylla* in order that its latex can be sustainably harvested is particularly recommended.
7. To have successfully restored the area's natural hydrology well in advance of the end of the project time frame. Without this, the integrity of the forest is likely to be either completely destroyed or severely and irreversibly damaged throughout the concession area by the end of the project timeframe. This is critical for maintaining the area's floral diversity and HCVs beyond the project timeframe.

3.4.4 Biodiversity Monitoring and HCV-Specific Objectives

8. To achieve increases in forest cover, above-ground biomass/unit area and condition, and maintain or increase floral species diversity.
9. For each identified and potential floral HCV species, to:
    a. Slow the rate of species' populations and habitat decline (estimated through reductions in the rate of forest loss, as actual rates of population decline are not available prior to the onset of the project) and stabilise these within 5-10 years.
    b. Specifically, for the three primate HCV and other potential HCV species that can be feasibly monitored, to achieve population stability and an increase in estimated population size of at least 5% by the end of the project period (30 years for the REDD project; though note that the concession applied for is 60 years).
10. To prevent the local extinction of any native species in the project area.
11. Implement a monitoring programme for establishing whether these floral conservation objectives have been met by the project's activities (see Section 4 for more details).

3.5 Analysis of Species Used in Project Activities

The species of flora to be used in the project's activities, and notes on whether these are non-native and/or invasive species are given in Table 3.3. All of these species are non-invasive and are native to Borneo, although care must be taken over the use of *Melaleuca* sp. Some species in this genus are native and non-invasive; e.g., *M. cajuputi* (Applegate *et al.*, 2001), but some species are non-native and potentially invasive. For example, *M. quinquenervia*, which is native to Papua New Guinea and Australia, and has become one of the most problematic invasive species in the Florida Everglades, USA (Laroche and Ferriter, 1992). We therefore recommend great care

Table 3.3. Species of flora to be used in project activities, and confirmation of native and non-invasive status.

Species	Invasive?	Native to Kalimantan?	Native to PSF?	Native to Katingan?	Comments
Alseodaphne coriacea	N	Y	Y	Y	
Alstonia sp.	N	Y	Y	Y	
Calumus spp.	N	Y	Y	Y	
Campnosperma auriculatum	N	Y	Y	Y	
Daemonorops spp.	N	Y	Y	N	
Dyera lowii / polyphylla	N	Y	Y	Y	
Dyera costulata	N	Y	Y	N	
Gonystylus bancanus	N	Y	Y	Y	
Gluta renghas	N	Y	Y	Y	
Lophopetalum multinervium	N	Y	Y	Y (genus)	
Melaleuca sp.	?	?	?	N	Depends on species –some species non-native and invasive (see text)
Shorea sp., including *S. balangeran*	N	Y	Y	Y	

be taken to select species of this genus native to the area and non-invasive, although it is unlikely that any invasive, non-native species will be easily obtainable locally.

Three species – *Dyera costulata, Daemonorops* spp. and *Lophopetalum multinervium* – are native to both Kalimantan and peat-swamp forest, but have not been recorded in either Katingan or the nearby Sabangau. In particular, *D. costulata* should be substituted for *D. lowii / polyphylla*, whose presence in Katingan we confirm herein. It is uncertain whether or not *Daemonorops* spp. and *L. multinervium* exist in Katingan (these are native to Kalimantan and peat-swamp, so it is possible that they are present, but rare and were not detected in our surveys), *Lophopetalum* sp. has been recorded in Sabangau and it is unlikely that use of these species would create serious problems within the ecosystem, but we nevertheless recommend that caution should be applied in their use until their presence can be confirmed in Katingan. No species from any other taxa will be used during project activities.

No species from any other taxa or genetically-modified organisms will be used during project activities. Alhough the project will not use any genetically-modified organisms, due to the widespread and increasing use of genetically-modified organisms globally, it is impossible to regulate the flow of community resources such as feedstock, and foods such as rice or other grain, used inside and outside of the project area.

3.6 Potential Risk to Floral Diversity Benefits from Climate Change

As discussed in Section 2.4.8.7, climate change may lead to changes in rainfall regimes, which could reduce the impacts of the project's hydrological restoration and fire prevention and control activities. As peat drainage and consequent fire is one of the most important threats to flora in the region (see *G1.7, G2.5* and Section 2.4.8.5), this would have negative impacts on floral diversity. Increased annual rainfall and, hence, wet season flooding (Hulme and Sheard, 1999) may negatively impact restoration efforts, as planted seedlings frequently die if flooded conditions continue for too long (Harrison *et al.*, unpublished). Salt-water intrusion would pose a risk to all of the project's anticipated flora diversity impacts in affected areas, as it may make the habitat uninhabitable by almost all native flora, causing forest die-off and death of planted trees.

4. MONITORING PROTOCOL

4.1 Section Summary

Biodiversity monitoring is essential for ensuring effective conservation in an area, as it enables (i) the effectiveness (or not) of conservation activities to be assessed; (ii) the adapatation of conservation activities to ensure maximum conservation success; and (iii) consideration of the potential impacts of novel conservation activities on biodiversity. Ultimately, this enables the efficient allocation of limited financial (and other) resources towards activities that actually have the desired positive impacts on biodiversity.

Monitoring forest flora is a critical component of an effective biodiversity monitoring programme for two main reasons. Firstly, flora is clearly a very important component of overall forest biodiversity. Secondly, many of the impacts of human disturbances and, hence, of management activities to mitigate these disturbances, on forest fauna are mediated through impacts on forest flora. Monitoring forest flora is therefore essential for interpreting the reasons behind observed trends in faunal populations and, consequently, for devising strategies to effectively mitigate these threats and conserve forest fauna.

A preliminary protocol for monitoring methods and frequency is presented below; a full monitoring programme will be submitted within one year of acceptance to CCBA standards. Methods used will be based on the tree plot methods used in this study and described in this report (Section 2.3), which have been used successfully by OuTrop for monitoring changes in forest condition in Sabangau for a number of years. These methods will allow for the assessment of changes in mortality and recruitment rates, tree size distributions and biomass (basal area coverage). The methods will also allow for assessment in changes in abundance of the floral HCV species, which are all included within the plots. Monitoring of forest plots will provisionally be conducted annually for the first five years and each two years thereafter, for the duration of the project timeframe. Once complete, this monitoring programme will allow demonstration of whether the project has achieved the stated floral biodiversity objectives and has had net positive impacts on forest flora and HCVs.

4.2 Background: Ecological Monitoring and Biodiversity Conservation – the Importance of Monitoring Forest Flora

Biodiversity monitoring is essential for ensuring effective conservation in an area, as it enables (i) the effectiveness (or not) of conservation activities to be assessed; (ii) the adapatation of conservation activities to ensure maximum conservation success; and (iii) consideration of the potential impacts of novel conservation activities on biodiversity (Gardner, 2010; Lindenmayer and Likens, 2010). Ultimately, this enables the efficient allocation of limited financial (and other) resources towards activities that actually have the desired positive impacts on biodiversity.

Monitoring forest flora is a critical component of an effective biodiversity monitoring system for two main reasons. Firstly, flora is clearly a very important component of overall forest biodiversity and, as such, is important to monitor in its own right. Indeed, classification of an area as “forest” or otherwise is based entirely upon its flora and many conservation objectives are focussed towards preserving forest flora. Secondly, many of the impacts of human disturbances and, hence, of management activities to mitigate these disturbances, on forest fauna are mediated through impacts on forest flora. For example, changes in forest flora resulting from human activities are known to influence HCV fauna species, such as the orangutan (Felton *et al.*, 2003; Husson *et al.*, 2009). Monitoring forest flora is therefore essential for interpreting the reasons behind observed trends in faunal populations and, consequently, for devising strategies to effectively mitigate these threats and conserve forest fauna. This is particularly true in instances where numerous management interventions are occurring concurrently and it is difficult to assess the relative impacts of the different interventions on biodiversity, as is the case in this project.

4.3 Flora Monitoring Methods and Frequency

As selection of potential indicators is still ongoing, the methods and frequency of monitoring is therefore likely to undergo some modification before the submission of a final monitoring protocol, within a year of acceptance to the CCBA standards. The following methods and schedule should therefore be regarded as preliminary.

4.3.1 Methods

Methods for repeat monitoring of forest flora will follow those used in this study, which have been successfully employed for monitoring of forest flora by OuTrop in Sabangau for a number of years (Husson *et al.*, 2007, unpublished data). The following information will be recorded during repeat surveys:

- Whether tagged trees are still alive. Because all tagged trees have now been identified to species, this will allow both overall and species-specific mortality rates to be assessed.
- The dbh and basal circumference of all tagged trees. This will enable changes in tree size distributions and biomass to be assessed.
- Inclusion of new trees into the plots. These are trees that did not exceed the minimum 15 cm cbh size for inclusion in the current surveys, but that will have grown large enough to be included in future surveys. The above data and identification will be recorded for all of these new trees. This will enable assessment of both overall and species-specific patterns of tree recruitment and, when combined with data on mortality rates, will enable assessment of reasons underlying overall changes in species' abundance (mortality *vs.* recruitment) and living *vs.* dead tree biomass.

It is also desirable to increase the number of plots within the proposed concession area, in order to (i) increase the confidence that can be ascribed to our estimates of species composition, abundance, size distributions and basal coverage within the mixed-swamp forest habitat sub-type; and (ii) sample the other habitat sub-types in the area, in particular the low-pole forest, which likely differs substantially from the mixed-swamp forest in terms of all the above variables.

4.3.2 Monitoring frequency

Monitoring of forest flora and forest condition will be conducted annually for the first five years and each two years thereafter, for the duration of the project timeframe.

Once complete, this monitoring programme will allow demonstration of whether the project has achieved the stated floral biodiversity objectives and has had net positive impacts on forest flora.

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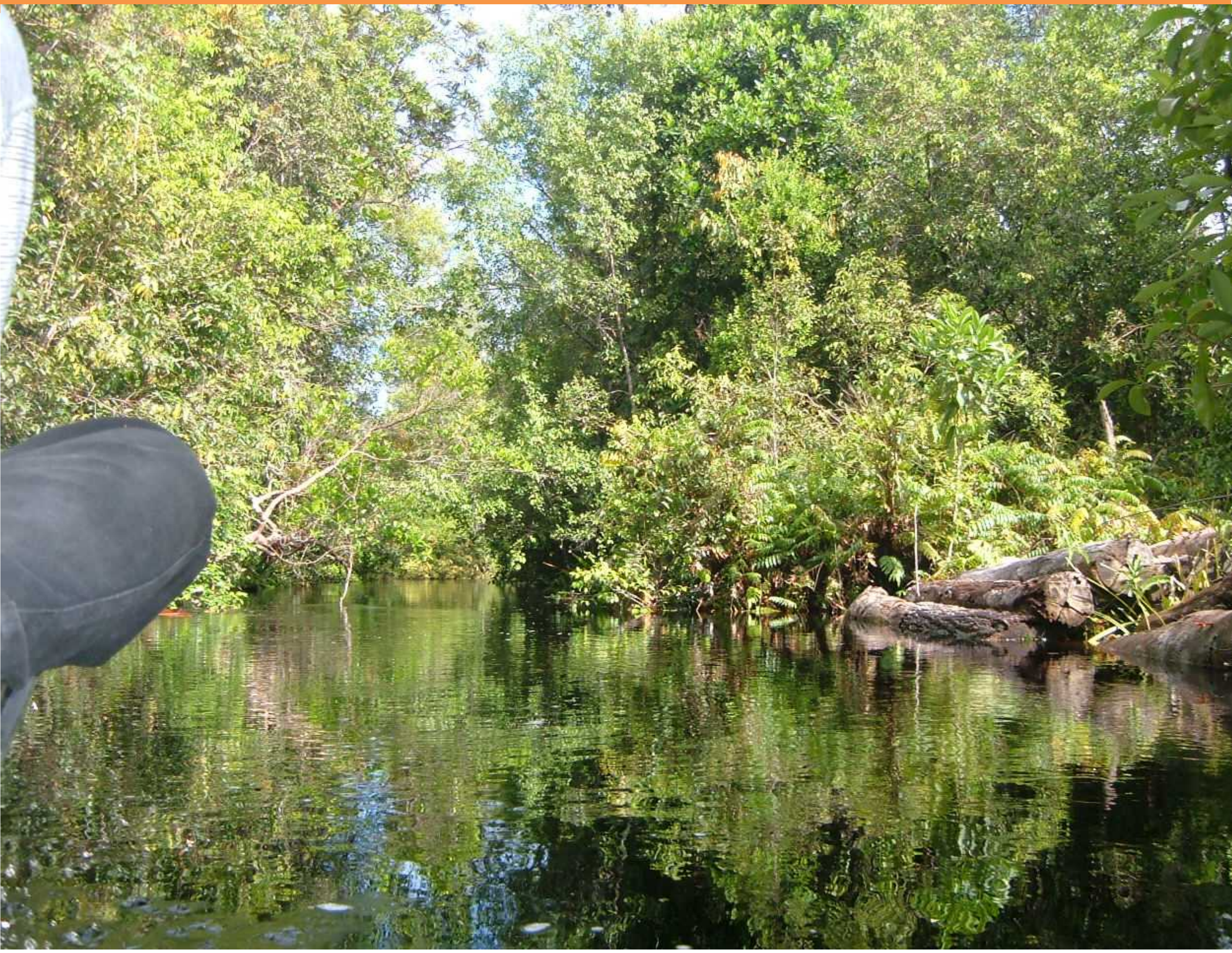

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