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The structure, composition, and threatened plants in The Kinarum Protected Forest, South Kalimantan, Indonesia

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Abstract. *Dodo, Hidayat S. 2020. The structure, composition, and threatened plants in The Kinarum Protected Forest, South Kalimantan, Indonesia. Biodiversitas 21: 2603-2618.* Kinarum Protected Forest (Kinarum PF) is one of the remaining tropical forest areas in Tabalong District, South Kalimantan, Indonesia. It is feared that deforestation will occur in this forest due to various human activities. The research was conducted to determine the structure and composition of vegetation in Kinarum PF which several decades ago was once a forest concession area. This research also explored the existence of threatened, endemic, and protected plants. Research has been carried out using the track plot method. The total research area is 0.6 ha consisting of three transect lines with five plots measuring 20 x 20 m^2 each transect. Data were analyzed with important value index (IVI), dominance index, species diversity index, and species abundance index. The results recorded 460 specimens belonging to 121 species, 86 genera, and 43 families. Most species are from the family Lauraceae followed by Moraceae and Rubiaceae. The results also recorded 42 species included in the IUCN red list plants, eight of which are classified as threatened plants, namely *Aglaia angustifolia, Artocarpus tamaran, Dracontomelon costatum, Durio dulcis, Durio kutejensis, Eusideroxylon zwageri*, *Myristica magnifica,* and *Shorea guiso.* These plants have an average IVI value less than 10% and the species abundance index is close to zero. In general, the forest condition is classified as moderate with a diversity index value at each growth stage in the range of values 1-3. However, IVI of each species, especially those belonging to the threatened, endemic, and protected plants are on average low.

Keywords: Endemic, Kinarum protected forest, protected plant, structure and composition, threatened

INTRODUCTION

Indonesia comprises only 1.3 percent of the earth's land surface, it harbors a disproportionately high share of the world's biodiversity, including 11 percent of the world's plant species, 10 percent of its mammal species, and 16 percent of its bird species. The majority of these species are found in the country's forests (Sukara 2014). Indonesia is a mega-diverse country, its special insular nature along with the high number of endemic species vs. a high number of threatened species (von Rintelen et al. 2017). Based on IUCN data (www.iucnredlist.org), the number of threatened plants in Indonesia is increasing every year. In 2014 there were 408 species (IUCN 2014), 437 species in 2018 (IUCN 2018), 519 species in 2019 (IUCN 2019), and 619 species in 2020 (IUCN 2020). This condition is very worrying for the existence of Indonesian plants, because these plants will be increasingly threatened or become extinct if in the near or very near future there is no meaningful protection and rescue.

The most important conservation activity for plant diversity is *in-situ* conservation. However, the condition of plants in natural habitats often gets serious threats such as habitat destruction and exploitation so that plants become threatened and even extinct. Budiharta et al. (2011) reported that intrinsic biological factors and habitat loss are the most significant general threats and over-exploitation has also contributed considerably to species endangerment. Laurance et al. (2014) argued that agricultural development could trigger the loss of biodiversity through land-use change. Deforestation, is one of the highest rates of primary forest loss in the Indonesian forest. Austin et al. (2019) reported that oil palm plantations were the largest driver of deforestation over the 2001-2016 period, resulting in 23% of deforestation nationwide, The expansion of timber and other large-scale plantations together resulted in 21% of national deforestation. The expansion of small-scale agriculture and small scale mixed plantations together resulted in 22% of national deforestation. They estimate that the area impacted by logging roads was just over 350,000 ha during 2001-2016, suggesting that the total area degraded by logging activities could have been as high as 1,750,000 hectares. In Kalimantan, oil palm plantations were the dominant driver of deforestation from 2005 to 2013. Forest conversion to grassland/shrubland was also an important driver of forest loss in Kalimantan, more than two-thirds of the area of national forest to grassland conversion in 2016 occurred in Kalimantan.

The support of *ex-situ* plant conservation organizations such as botanical gardens is urgently needed to save plants from the threat of extinction, because the botanical gardens carry out exploration/expeditions, collection, propagation, and cultivation. (Heywood 2011; Dosmann and Groove 2012; Krishnan and Novy 2016) The results of plant propagation will be returned to their natural habitat. For this reason, the combination of *in-situ* and *ex-situ* conservation (integrated conservation) is the most ideal strategy to save plant species from extinction (IUCN/SSC

2014; Schwartz et al 2017; Mc Gowan 2017; Mounce et al 2017). This activity is in line with GSPC target 8 which states ‘At least 75 percent of threatened plant species in *ex-situ* collections, preferably in the country of origin, and at least 20% available for recovery and restoration programs’.

Kalimantan is known as an island that has a wealth of plants (Komara et al. 2016; Sofiah et al. 2018). Kinarum Protected Forest in Tabalong District was chosen as the location of the research because according to information from the Forest Service of South Kalimantan Province, the condition of the forest is still good, although this area was once a production forest in the era of 1970 to 1990, so it's thought to have lost a lot of species. However, based on local community information, there are still a number of commercial and threatened plant species. such as meranti (*Shorea* spp.), ulin (*Eusideroxylon zwageri*), sindur (*Sindora wallichii*), and jelutung (*Dyera costulata*) as well as fruit plants such as durian (*Durio* spp.) and langsat (*Baccaurea* spp.). Epiphytic plants such as orchids can still be found in forested areas, while other plants such as rattan are still used by the community as matting (Heriyadi 2016). Adjacent to the protected forest area there is an area developed as the Kinarum rafting ecotourism area and also some areas that have been converted into plantations by the community, this will threaten the existence of the remaining rare plants. In some forest areas such as Kinarum PF there is currently serious pressure on the presence of species directly, including emerging threats from invasive species, diseases, overharvest, habitat alteration and climate change (Mc Gowan 2017; Mounce et al. 2017; Chen and Sun 2018) or logging (Toma et al. 2017). Illegal logging in the production and protected forest areas around Riam Kinarum poses a serious threat to the sustainability of the plant species in Kinarum PF. The impact of environmental losses arising from the practice of illegal logging currently has been very well perceived by the people who live inside and outside of the Tabalong District (Basuki et al. 2013). Raes et al. (2009) stated that 56% of Kalimantan's protected lowland forests have been lost between 1985 and 2001, and forest degradation continues today.

Based on the information and facts mentioned above, the hypothesis of this study is that many plants are threatened even though diversity of plant species in Kinarum PF is expected to be low. Remaining plants, especially rare or threatened species, must be immediately saved both *in-situ* and *ex-situ*. The botanical garden is obliged to conserve endangered plants so it is necessary to know the exact data of the existence of these plant species in Kinarum PF. The structure and composition of plants in Kinarum PF is also very important to be known by the area manager in order to make a proper conservation effort. Pamoengkas et al. (2019) stated that information about the conditions of residual stands is important and urgently required for conservation efforts.

The purpose of this research is to determine the current conditions of the structure and composition of plants in Kinarum PF and to inventory the existence of threatened and or endemic plants. The results of this research are expected to be one of the references for future conservation efforts in the region, both *in-situ* and *ex-situ*.

MATERIALS AND METHODS

Research area

The research was conducted on 5-10 September 2017 at the Jaing Forest Management Resort part of the Tabalong Production Forest Management Unit (KPHP), precisely at Kinarum PF which covers 6,382 ha (Heriyadi 2016). This forest area is 1.6 km from the village of Kinarum, Upau Sub-district, Tabalong District, South Kalimantan Province, Indonesia. Jaing Forest Management Resort, covering the entire forest area of Murung Pudak Sub-district and part of Upau Sub-district's forest area with an area of 21,573 ha consisting of 6,382 ha of protected forest and 15,191 ha of production forest.

Figure 1. Research area in Kinarum Protected Forest, Upau Sub-district, Tabalong District, South Kalimantan Province, Indonesia. ▨ Kinarum PF

The Kinarum PF region is administratively a part of the Kinarum Village, Upau Sub-district, Tabalong District, South Kalimantan Province (Figure 1). The area is in the Tabalong watershed area which is drained by two main rivers namely the Kinarum river and the Jaing river.

The research location is at an altitude of 150-280 m above sea level, located in geographical coordinate points of 02 04 "90.70" S and 115 65 "43.9" E. This location is part of the northern hills of the Meratus Mountains series. Topographic conditions are generally sloping with a slope ranging from 5% to 85%. Soil types, in general, are red yellow podsolic complex, laterite, lithosol, and latosol. The degree of soil acidity is 5.6-6.5 and soil moisture is 45-70%. According to Heriyadi (2006), the climate of this tropical forest area has an air temperature of 29^o-31^o C and humidity of 68-93%, rainfall of 1,544 mm/year with 117 days of rainy days. In general, Tabalong has the highest rainfall in December (636 mm) and the lowest rainfall occurs in September (50 mm).

This research area is a secondary forest that was 40-50 years ago managed as a forest concession area. This area is part of secondary dryland forests that were once heavily overgrown by species from Dipterocarpaceae, Moraceae, and Meliaceae. Some fruits and rattan are non-timber forest products that are still consumed by the community until now.

Sampling and data

To obtain data on the composition and structure of vegetation in the Kinarum PF area, it has been carried out through vegetation analysis activities using the track plot method. Three transect lines were made of 100 m each with 5 observation plots measuring 20 x 20 m^2 per lane. The distance between the transect lines is 100 m. Each observation plot is further divided into observational sub-plots based on the growth stages. The objects in this research were all plant species found in the observation plot. Vegetation inventory has been carried out on sample plots that are suitable for the growth stage of 20 x 20 m^2 for tree, 10 x 10 m^2 for pole, 5 x 5 m^2 for sapling, and 2 x 2 m^2 for seedlings and or undergrowth. Each individual plant found in the entire plot was measured stem diameter at breast height (dbh) using a tape diameter, then classified whether it included trees, poles, or sapling. This dbh size is used as the basis for calculating the basal area for trees and poles. Meanwhile, specimens that have stem diameters of less than 10 cm (sapling and seedling) only count the number of individuals of each species in each sub-plot. The area of the research is 0.6 ha or 0.01% of the total protected area. Nicholson (in Edwin et al. 2017) stated that the sampling area ranging from 0.6−1.5 ha in Borneo rainforest has already been represented.

The classification of growth stages in this research is: (i) Seedlings: dbh < 3 and height ≤1.5 m, (ii) Sapling: 3≤ dbh <10 cm, (iii) Pole: dbh 10-20 cm, and (iv) Tree: dbh > 20 cm.

Some plant species were identified directly on the plots, while for some others identification could not be made on the plots and depended on making herbarium specimens. The herbarium specimens were then identified by reference to voucher specimens held by Herbarium Bogoriense as well as the herbarium and living plant collections in Bogor Botanic Gardens. The scientific names of plants adopted were those already in use within The Plant List.

Data analysis

Important value index

Data analysis using Microsoft Excel 2010 and QGIS 2.14.1-Essen. Relative Density (RD), Relative Frequency (RF), Relative Dominance (RD.), and Importance Value Indices (IVI) were calculated and analyzed according to the Dumbois-Muller and Ellenberg formula (1974). Basal area (m^2) is the area occupied by a cross-section of stem at breast height (1.3 m) = [3.14 x $(dbh/2)^2$]. Absolute values so obtained may be transcribed to relative values:

$$\text{Relative density (\%)} = \frac{\text{No. of individuals of a species}}{\text{Total no. of individuals in sample}} \times 100$$

$$\text{Relative dominance (\%)} = \frac{\text{Basal area of a species}}{\text{Total basal area in sample}} \times 100$$

$$\text{Relative frequency (\%)} = \frac{\text{Sampling units containing a species}}{\text{Sum of all frequencies}} \times 100$$

Importance Value Index (IVI) for a species is the sum of its relative density, relative dominance, and relative frequency. The IVI values have been helped to understand the ecological significance of the species in community structure (Premavani et al. 2014).

Diversity index and dominance species

Shannon's Diversity Index (H') was calculated to quantify the vegetation structure (Magurran 1988):

H:-Σ (ni/N) log (ni/N)
ni : number of individuals of the i species
N : total number of individuals of all species

The index was calculated for each of the four growth stages (seedling, sapling, pole, and tree). Diversity criteria according to Barbour et al. (1987), vegetation has a high level of diversity if the Diversity Index H '> 3. While categorized as moderate if the value of H '= 1-3, and said to be low if the value of H '<1.

The abundance of a species was analyzed using the species abundance index (e) (Odum and Barrett 2004),

e = H/(Log s)

Where:
e : Species Abundance Index: (e value: 0-1; 1 : all species are abundant)
H : Index of species diversity
s : Number of species

Dominance in a community and plant regeneration stage were analyzed using the Dominance Index (Ds) (Odum and Barrett 2004), Ds = (ni/N) ²

Where:
Ds : Domination Index
ni : importance value of the-i species
N : total importance

On the basis of ecological dominance (Ds) in a community the species are grouped into three categories (Krebs 1999): (i) 0.00 < Ds < 0.30 = low dominance, (ii) 0.30 < Ds < 0.60 = intermediate dominance, and (iii) 0.60 < Ds < 1.00 = high dominance.

Conservation status

Determining species conservation status is based on data from the International Union for the Conservation of Nature and Natural Resources (IUCN) available on its official website, i.e. http: //www.iucnredlist.org/search. A plant is declared as threatened species if it has been entered into the International Union for the Conservation of Nature and Natural Resources (IUCN) category which is Critically Endangered (CR), Endangered (EN), or Vulnerable (VU). Meanwhile, species declared as endemic plants in Kalimantan refer to the Kalimantan Endemic Flora book (Sidiyasa 2015) and as protected plants nationally refer to the Minister of Environment and Forestry of the Republic of Indonesia Regulation No. 20 of 2018 concerning Protected plant and animal species and Republic of Indonesia Government Regulation No. 7 of 1999 concerning Preservation of plant and animal species

RESULTS AND DISCUSSION

Structure and composition

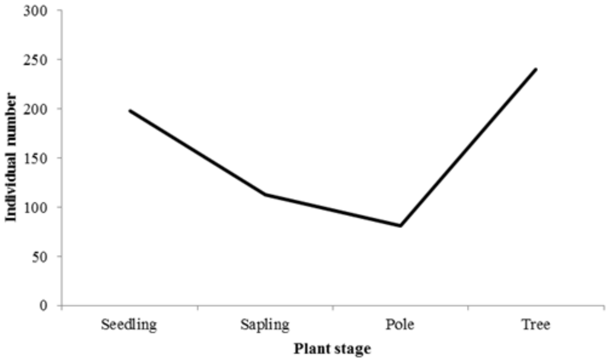
Based on the results of the inventory, 632 specimens have been obtained which are included in 121 species, 87 genera, and 44 families (Table 1). This shows that Kinarum PF is inhabited by many plant species so that it can be stated that the condition of Kinarum PF in terms of plant species richness is quite good with the diversity index value obtained more than one. The 632 specimens were divided into four growth stages, namely 240 tree stages (67 species, 48 genera, 24 families), 81 pole stages (35 species, 28 genera, 17 families), 113 sapling stages (48 species, 39 genera, 23 families), and 198 stages of seedlings or undergrowth (35 species, 33 genera, 26 families). All plant species found can be seen in Table S1.

The structure of vegetation in Kinarum PF is generally seen in Figure 2. Figure 2.A shows the structure of vegetation when all types of plant habitus are included, while Figure 2.B. is a vegetation structure only for tree habitus types. Figure 2.A. looks like U-shaped while picture 2.B. looks closer to the letter J. Both structures are viewed from the aspect of regeneration is not good, because the number of young plants is smaller than the number of tree stages. This structure is quite risky if growth disturbance occurs at the tree stage and stunted growth of young plants either due to natural factors or human and animal factors. A good vegetation structure to ensure the continuity of plant regeneration in forest areas is inverted J-shaped. Inverted J-shaped patterns have shown good reproduction and potential recruitment of the species (Todou et al. 2018).

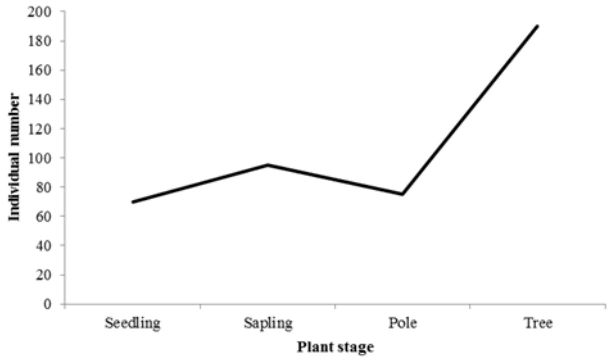
Although the number of trees appears to be more than other stages of growth, some species actually originate from pioneer species such as *Macaranga* spp, *Malotus* spp. and *Ficus* spp. *Macaranga* is a fast-growing pioneer species that may regenerate from seed banks which are abundant in the forest floor in the rain forests (Sadili and Kartawinata 2016). *Macaranga* spp. are also quite abundant although not many seedlings were planted (Komara et al. 2016). Thus there is still hope for continuity of regeneration for tree-type habitus even if it only comes from a pioneer species. Unfortunately, these pioneer species will not grow as large as primary wood plants. At the species level, big sized trees from *Dryobalanops* and other Dipterocarpaceae with small numbers of individuals presented higher values of IVI than pioneer species which had a larger number of individuals with smaller sized DBH.

Table 1. Recapitulation of species and number of specimens found at each vegetation growth stages

Growth stage	Quantity			
	Species	Genus	Family	Specimen
Tree	67	48	24	240
Pole	35	28	17	81
Sapling	48	39	23	113
Seedling/undergrowth	35	33	26	198
Total	121	87	44	632



A



B

Figure 2. Vegetation structure of Kinarum Protected Forest. A. Vegetation structure for all habitus type, B. Vegetation structure for only tree habitus

There are eight plant species found at all stages of growth, namely *Aidia racemosa*, *Antidesma montanum, Artocarpus lanceifolius, Dehaasia turfosa. Diplospora malaccense*, *Dryobalanops lanceolata, Ficus serrata,* and *Xanthophyllum vitellinum*. In general, the eight plant species showed good regeneration in Kinarum PF. A plant species is said to have good regeneration if it is present at all stages of growth (Zulkarnaen et al. 2015). However, when viewed based on the number of individuals at each stage of growth it would seem that for their survival, in general, these species are not ideal. From Figure 3, we can see an example of the structure of four plant species in which three of them are species belonging to the Least concern (LC) plant category according to the IUCN red list. Three LC categories, namely *Aida racemosa, Antidesma montanum* and *Dryobalanops lanceolata* have less than ideal structures compared to *Diplospora malaccense* structures. *Aida racemosa* has a structure close to the letter L which means it is better than the two other LC species. *Antidesma montanum* has a structure that tends to form zigzag while *Dryobalanops lanceolata* has a structure shaped J. *Dryobalanops lanceolata* has a high risk for failure to regenerate properly due to the relatively small number of tillers compared to the number of stages of the tree. If these small tillers are stunted while large trees are harvested illegally, the risk of extinction of *D. lanceolata* in Kinarum PF is very high. The relatively ideal potential for species survival is actually demonstrated by *Diplospora malaccense* whose structure leads to an inverted J shape indicating good regeneration (Astbha et al. 2019; Todou et al. 2018).

The number of species found for each family can be seen as shown in Figure 4. Families represented by 10 or more species in sequence are Lauraceae (13 species), followed by Moraceae (11 species), and Rubiaceae (10 species). Differences in species numbers are due to differences in tolerance to habitat factors such as slope, altitude, soil characteristics, and species distribution. Each species has different tolerance levels that can grow or live in a particular environment (Edwin et al. 2017). Topographical habitat plays an important role in structuring tree species. Relative elevation and slope convexity are the most important variables for predicting the presence or absence of a species. Soil type is another factor that is frequently associated with topography and can control tree distribution. This indicates that the three families have a high tolerance and adaptation to environmental factors in Kinarum PF. The Lauraceae is one of the largest and important families of trees and shrubs throughout tropical and subtropical forests (Julia et al. 2009). In the mountains of South East Asia, Lauraceae species appear over a wide altitudinal range (Sri-Ngernyuang 2003). The Lauraceae also are of major ecological and economic importance in Southeast Asia as they comprise a major part of many forests in the region (de Kok 2017). The second-highest number of species found is Moraceae. Rahmah et al. (2015) found something similar in Bukit Dua Belas National Park. They found Moraceae was the richest family (11 sp) that *Ficus fistulosa* had the highest density (24 trees/ha). Moraceae has many species that can grow in various habitats such as *Ficus* spp and *Artocarpus* spp. Lauraceae and Moraceae were also found as families with dominant species in the study of Edwin et al. (2017) in Wehea Protected Forest, Kutai, East Kalimantan. While Ling and Yulia (2012) in their research in Semenggoh Arboretum, Sarawak, stated that Moraceae is the third dominant family after Myristicaceae and Sapotaceae. In third place, Kinarum PF is represented by Rubiaceae which has many species. Rubiaceae is the fourth family in number of species in the Angiosperms after Orchidaceae, Asteraceae, and Leguminosae. The Rubiaceae is a cosmopolitan family, predominantly pantropical, and with a small portion of species of extratropical distribution (Delprete and Jardim 2012).

The highest number of specimens in Kinarum PF by family is Rubiaceae (91 specimens). Rubiaceae is well represented at all layers of tropical vegetation, with all kinds of habits, as herbs, shrubs, lianas, and from small trees to tall canopy trees, and all dimensions (Delprete and Jardim 2012). When viewed based on the strata, the highest number of specimens at the tree stage is Euphorbiaceae (46 specimens). Research by Kessler et al. (2005) in Napu Valley show similar results for dominant plant families based on their strata, stating that Euphorbiaceae, Rubiaceae, and Myristicaceae were the most common forest tree families in the forest gardens. Euphorbiaceae was also the dominant family in the secondary forest. In Kinarum PF, Euphorbiaceae becomes the dominant family because it is represented by many pioneer species from *Macaranga* and *Malotus*. Meanwhile, for the pole stage, the highest number of specimens was Moraceae (18 specimens), for the sapling stage was Rubiaceae (29 specimens), and for the seedling stage was Tectariaceae (87 specimens). As has been said above that Rubiacea and Moraceae are two species-rich and cosmopolitan families, this is also shown by the results of Almulqu et al. (2018) on Mount Mutis for Moraceae and in Napu Valley Forest, Lore Lindu (Kessler et al. 2005) for Rubiaceae. For seedlings or undergrowth, the family of ferns dominates Kinarum PF. Tectariaceae is the dominant family represented by the genus Tectaria followed by other ferns of Schizaeaceae namely *Lygodium circinnatum*. *Tectaria* is the largest fern genera, comprising 150-210 mostly tropical species (Zhang et al. 2017). Even in Kalimantan, the root of *Tectaria* is used by the Tomun Dayak tribe as one of the traditional medicines (Santoso et al. 2018). Meanwhile, *L. circinatum* is widely used as handicraft materials for household tools and traditional Dayak bags.

The highest number of specimens by species is at the tree stage is *Dryobalanops lanceolata* (18 specimens), at the pole stage is *Dehaasia turfosa* (10 specimens), at the sapling stage is *Memecylon oleifolium* (10 specimens), and at the seedling stage is *Tectaria incisa* (87 specimens). *Dryobalanops lanceolata* is widespread and common, but outside the protected areas the species is threatened by habitat loss and conversion, driven by the expansion of agriculture in Borneo (Bodos et al. 2019). *Dryobalanops lanceolata* was an endemic plant of Kalimantan but common and widespread growing in the Kinarum forest area. However, *D. lanceolata* is one of the plant species from the Dipterocarpaceae family which has several medicinal purposes such as mouth ulcers, abscesses, boils, and cold sores (Kuspradini et al. 2018). Meanwhile, Sidiyasa (2015) noted *D. turfosa* as one of the endemic plants of Kalimantan. *Dehaasia turfosa* in secondary forests usually present as a pre-disturbance remnant tree (http: //www.asianplant.net). At the sapling stage, *M. oleifolium* was obtained as the plant with the highest number of specimens. Although *M. oleifolium* is not included in Kalimantan endemic plants such as *D. lanceolata* and *D. tufosa*, in the Singapore flora checklist this species is stated as a critically endangered plant (Chong et al. 2009). Furthermore, *T. incisa* is an undergrowth which dominates the Kinarum PF region. This species is a common fern group found in Kalimantan and even Komara et al. (2016) found also in the coal mining area in Kutai, East Kalimantan.

Important Value Index (IVI)

In this research, the largest IVI at the tree stage was *Dryobalanops lanceolata* (IVI = 46.36), at the pole stage was *Dehaasia turfosa* (IVI = 32.99), at the sapling stage was *Diplospora malaccensis* (IVI = 13.30) and at the stages, seedlings are *Tectaria incisa* (IVI = 63.29). Kinarum PF is dominated by *D. lanceolata* trees because this species has a greater diameter, density, and frequency compared to other species. This dominance shows the high adaptability of the species to its habitat. Krebs (1994) stated that the success of each species to occupy an area is influenced by its ability to adapt optimally to all physical environmental factors (temperature, light, soil structure, humidity, etc.), biotic factors (interactions between species, competition, parasitism, and etc.), and chemical factors which include the availability of water, oxygen, pH, nutrients in the soil and others that interact with each other. In the observation area, *D. lanceolata* is found in relatively open areas and high light intensity. Tirkaamiana et al. (2019) said that *D. lanceolata* is tolerant to the availability of sunlight, they can be easily established in open planting areas that have high temperatures.

However, in this study seedling and sapling of *D. lanceolata* are difficult to find. According to Itoh et al. (1995), this is possible because about 60-70% of the scattered seeds will die. A majority of dead seedlings were killed by fallen branches or were found standing with wilted leaves, probably due to water stress. Tree seedling survival can be reduced due to drier conditions (Ismail et al. 2014). In addition according to Granados et al. (2017), Dipterocarp seeds germinate very rapidly or else perish; delayed germination and seed banks are unknown. Herbivory by invertebrates or pathogenic infection after germinated seeds may have contributed to overall mortality in the forest. IVI at the highest pole stage is occupied by *Dehaasia turfosa* which is a Kalimantan endemic plant. This species grows scattered in pamah forests and peat swamps. The analysis showed that *D. turfosa* has a higher density and frequency value than other species in Kinarum PF. Furthermore, the highest IVI for the sapling stage was obtained by *Diplospora malaccensis*.

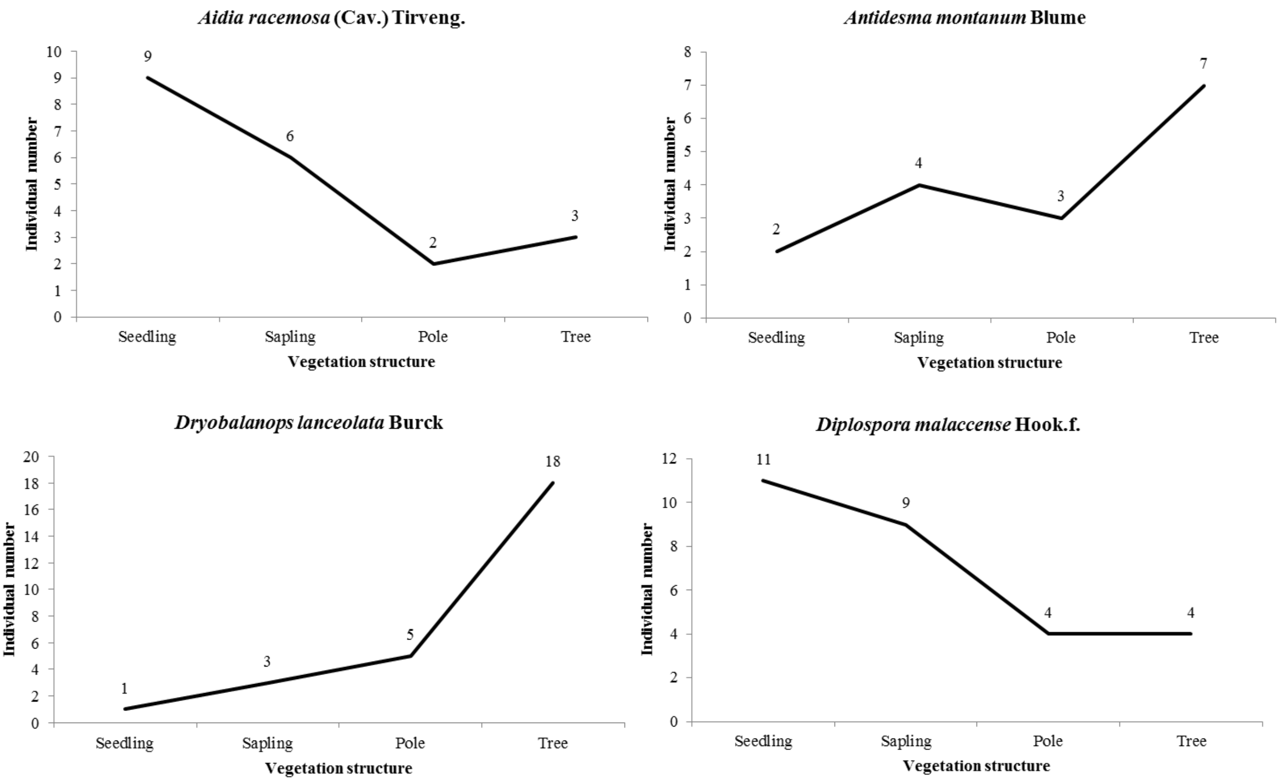


Figure 3. Four types of vegetation structure from sampling species

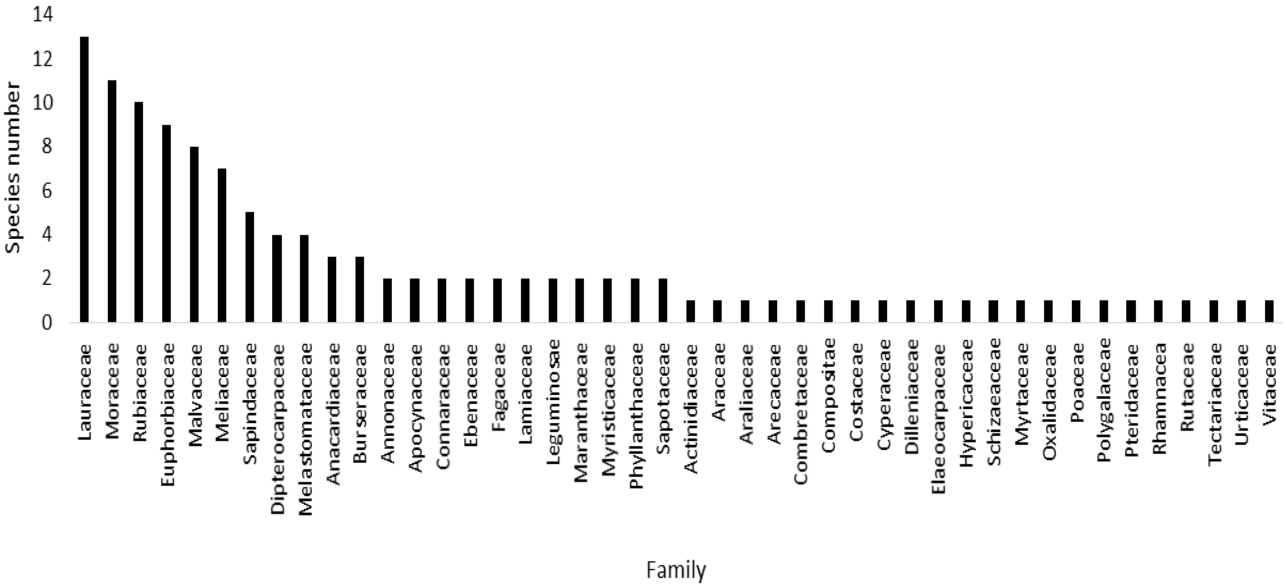


Figure 4. Family composition in the research area

Sadeghi et al. (2014) reported that *D. malaccensis* also gave the highest importance index value for species and families in Ulu Muda Forest Reserve, Kedah, Peninsular Malaysia. The notable point was that rich successional families such as Euphorbiaceae and Rubiacea were ranked in the first and second levels of value, respectively. Meanwhile, *Tectaria incisa* occupies the highest IVI position for the seedling or undergrowth stage. Besides the higher density and frequency values compared to other species, this species is indeed widely distributed in almost all regions. This is very possible because *Tectaria* is one of the largest fern genera, it has been estimated to contain ca. 210 mostly tropical species (Zhang and Zhang 2017), one of which is *T. incisa* which is invasive plants.

Importance Value Index (IVI) is a quantitative parameter used to express the degree of dominance of a species in a community. Species with the greatest IVI is the most dominant species, or the ruling species (Pamoengkas et al. 2018). Based on the results of vegetation analysis, the dominant plant species obtained at each stage of growth are as follows.

Tree stage

There are five species of plants that dominate at the tree stage (Table 2), namely *Dryobalanops lanceolata* with an IVI value of 46.36%, *Macaranga bancana* (21.15%), *Macaranga gigantea* (20.29%), *Beilschmiedia kunstleri* (19.92%), and *Ficus serrata* (15.67%). *Dryobalanops lanceolata* and *Beilschmiedia kunstleri* belong to the group of plants in the LC category (IUCN 2020). All the *Beilschmiedia* species of Borneo are trees, ranging in height from 8-40 m. *Beilschmiedia kunstleri* grows in Primary or secondary dipterocarp forest, submontane mossy forest, heath forest or kerangas forest, on mostly sandy soils, sometimes brown soils, black soils, ultrabasic or limestone. Altitude 10-800 m, rarely up to 1300 m (Nishida. 2008). This is in accordance with the conditions at Kinarum PF which is at an altitude of 280 m with sandy soils brown to yellowish-brown. The other three species come from *Macaranga* spp. and *Ficus* which are a group of pioneer plants that individually can be found in large numbers but generally have small diameter stems. *Macaranga* spp., important indicators for the old secondary forest (Susanto et al. 2016) while *Ficus* spp. are keystone tree species in tropical forest ecosystems (Kuaraksa et al. 2012) and in which some of them are pioneers in dry habitats (Lee et al. 2013).

Pole stage

There are five plant species that dominate at the pole stage (Table 3), namely *Dehaasia turfosa* with IVI 32.99%, *Sterculia lanceolata* (23.86%) *Dryobalanops lanceolata* (20.52%), *Ficus consociata* (20.44), and *Ficus uncinata* (15.76). *Sterculia lanceolata* grows in undisturbed to slightly disturbed (open sites) mixed dipterocarp and sub-montane forests up to 1000 m altitude. *S.lanceolata* is commonly found on hillsides and plays a predominant position in Kinarum PF. The same phenomenon is also found in the waterfalls of Curug Sewu, Kendal by Sunarmi et al. (2018). Meanwhile *Ficus* spp. still dominates at this stage which indicates that this pioneer species is quite adaptive in the Kinarum PF region. One species of which is *F. uncinata* according to Sidiyasa (2015), including endemic Bornean plants. Research by Widiyatno et al. (2017) in Tanjung Paku, Central Kalimantan, precisely shows *Ficus* spp. as the dominant plant at the seedling stage.

Sapling stage

There are three plant species at the sapling stage which have IVI ≥ 10%, namely *Diplospora malaccensis* with IVI = 13.30%, *Memecylon oleifolium* (11.52%), and *Aidia* *racemosa* (10.64%) (Table 4). *Aidia racemosa* is included in the LC category (IUCN 2020) because this species is widely used by people directly from their habitat. This plant was brought into light recently due to the ability of its roots and leaves to relieve body aches and tiredness. It is now being marketed locally as a tea or tonic for energy and overall body strength. In addition to this, it was also traditionally known to be able to cure gastric pains (Goh et al. 2017)

Seedling stage/undergrowth

Table 5. shows the two species that occupy the highest IVI for seedlings or undergrowth, namely *Tectaria incisa* (63.29%) and *Lygodium circinatum* (13.12%). Both of these species are groups of ferns that are quite invasive and cosmopolitan so that they control the secondary forest floor. *L. circinatum* is very common in Indonesia's secondary forests while *T. incisa* is found in certain regions. Neo et al. (2014) reported that *Tectaria incisa* has been found in Bukit Batok Nature Park and Lentor Forest.

Table 2. Dominant plants at the tree stage

Species	Total individual	Ba (m^2/ha)	RDo (%)	D (N/ha)	RD (%)	F	RF (%)	IVI (%)
Dryobalanops lanceolata Burck	18	41.20	32.24	30.00	7.50	0.60	6.62	46.36
Macaranga bancana (Miq.) Müll. Arg.	17	11.40	8.92	28.33	7.08	0.47	5.15	21.15
Macaranga gigantea (Rchb.f. & Zoll.) Müll. Arg.	15	13.24	10.36	25.00	6.25	0.33	3.68	20.29
Beilschmiedia kunstleri Gamble	17	11.70	9.16	28.33	7.08	0.33	3.68	19.92
Ficus serrata L.	14	6.94	5.43	23.33	5.83	0.40	4.41	15.67

Table 3. Dominant plants at the pole stage

Species	Total individual	Ba (m^2/ha)	RDo (%)	D (N/ha)	RD (%)	F	RF (%)	IVI (%)
Dehaasia turfosa Kosterm.	10	0.08	12.80	16.67	12.35	0.27	7.84	32.99
Sterculia lanceolata Cav.	7	0.06	9.33	11.67	8.64	0.20	5.88	23.86
Dryobalanops lanceolata Burck	5	0.04	6.51	8.33	6.17	0.27	7.84	20.52
Ficus consociata Blume	6	0.04	7.15	10.00	7.41	0.20	5.88	20.44
Ficus uncinata (King) Becc.	5	0.03	5.66	8.33	6.17	0.13	3.92	15.76

Table 4. Dominant plants at the sapling stage

Species	Total individual	D (N/ha)	RD (%)	F	RF (%)	IVI (%)
Diplospora malaccensis Hook.f.	9	15.00	7.96	0.27	5.33	13.30
Memecylon oleifolium Blume	10	16.67	8.85	0.13	2.67	11.52
Aidia racemosa (Cav.) Tirveng.	6	10.00	5.31	0.27	5.33	10.64

Table 5. Dominant plants at the seedling stage/undergrowth

Species	Total individual	D (N/ha)	RD (%)	F	RF (%)	IVI (%)
Tectaria incisa Cav.	87	145.00	43.94	0.80	19.35	63.29
Lygodium circinatum (Burm. f.) Sw.	10	16.67	5.05	0.33	8.06	13.12

Table 6. Index of dominance. diversity. abundance. and density of vegetation species at the growth stage in Kinarum PF

Uraian	Tree	Pole	Sapling	Seedling
Dominance index (C)	0.051	0.046	0.030	0.120
Diversity index (H)	1.504	1.443	1.605	1.259
Index of abundance (*e*)	1.047	0.558	0.616	0.836
Density (specimen/ha)	400	135	188.33	330

Based on the analysis of vegetation, dominance index, diversity index, index of abundance, and species density have been obtained at each stage of tree, pole, sapling and seedling growth (Table 6). Dominance index (C) is used to determine the level of dominance of a species in a forest area. In the Simpson index, there are several criteria in determining the value of the dominance index. C = 0 is low dominance, meaning that there are no species that dominate other species while C = 1 is high dominance, meaning that there are species that dominate other species (Krebs 1999). Based on the dominance index, it can be determined the form of concentration of dominant vegetation species in a stand. The results of the calculation of the dominance index indicate the value of C at each stage of growth is almost 0 (Table 6), meaning that in this forest in general no one species dominates the other species. The nearly zero values correspond to low diversity or more homogeneous plant ecosystems (Karyati et al. 2013). When viewed at each stage of growth are as follows *Dryobalanops lanceolata* occupies a dominant position at the tree stage with a value of C = 0.024, *Dehaasia turfosa* at the pole stage with a value of C = 0.012, *Diplospora malaccensis* at the sapling stage with a value of C = 0.004), and *Tectaria Incisa* with a value of C = 0.100. Dominant species are species that can utilize the environment they occupy more efficiently than other species in the same place. The ability of a species to influence and control over a community is by a large number of species, the size, and control of the space, reflected in the value of its dominance.

Diversity index (H) is a description of the level of species diversity within a community that can be used to express the relationship of species abundance in the community. According to Pamoengkas et al. (2018), species diversity can also be used to express community structure and measure community stability. The results of the analysis showed that the index of species diversity at the sapling stage was 1.605. This value is higher than the index value at the tree (1.5), pole (1.4), and seedling stages (1.3). This value is indeed still smaller than the results of research in other Kalimantan lowland forests. The results of the study by Pamoengkas et al. 2019 in the production forest on logged-over forest areas in Central Kalimantan, shows the average index at all stages has values > 3. Similarly the results of Sofiah et al. (2018) in the Besiq Bermai East Kalimantan forest, the forest area was a primary forest that started undergoing degradation and becoming a secondary forest, which shows a value of H > 3. However, Godoong (2016) stated that the Shannon index decreases with increasing dbh in both lowland and hill dipterocarp forests. Based on Odum and Barrett (2004) criteria, Kinarum PF is classified as moderate forest (1 < H < 3). The H index value in Kinarum PF does not differ greatly from the results of Godoong's research (2016) in selectively logged forest of Sabah which shows the value of H < 2 for plants that have dbh above 20 cm and in dryland forest, Kendawangan Nature Reserve has a value of H only 2.7 (Purwaningsih and Kartawinata 2018).

In general, the results of the species abundance index calculation can be said that for all stages of growth the results are uniform. This is indicated by the value of e which is not much different for each stage of trees, poles, saplings, and seedlings, each of which is 1.0, 0.6, 0.6, and 0.8. These results indicate that the Kinarum PF condition can carry out succession well.

Meanwhile, the results of the analysis show that tree density is generally higher than other stages. The pole stage has the lowest density value compared to the sapling and seedling stages. Conditions with such structures cause the regeneration of unstable forest vegetation. Pole density which is very far from the density of the tree is very risky to maintain the continuation of certain tree generations if there is a disruption to growth in the sapling and pole stages. Some species that are community characteristics in this area are indicated by their high density or a large number of individuals compared to other species, ie at the tree stage is *D. lanceolata* at 30 individuals/ha, while the pole stage is *Dehaasia turfosa* (16.67 individuals/ha), the sapling stage is *Diplospora malaccensis* (15 individuals /ha), and the seedling or undergrowth stage is *Tectaria incisa* (145 individuals/ha). The difference in density values of each species is due to differences in reproductive ability, distribution, and adaptability to the environment. Furthermore, the vegetation with the most extensive distribution capability (highest frequency value) at this research location is the tree stage is *Dryobalanops lanceolata*, the pole stage is *Dehaasia turfosa* and *Dryobalanops lanceolata*, the sapling stage is *Diplospora malaccensis, Aidia racemosa,* and *Sterculia coccinea*, while the seedling stage is *Tectaria incisa*. This shows that Kinarum PF's habitat characteristics are quite in accordance with the characteristics of the plant, so that the plant is able to adapt well. These species are the species with the highest frequency value at each stage of their growth, which indicates the best spreadability compared to other species. Frequency is used as a parameter of vegetation that can show the distribution or distribution of plant species in ecosystems.

Conservation status

The International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF) estimated that up to 60,000 higher plant species could become extinct or nearly extinct by the year 2050 (Subbaiyan et al. 2014). There are 2,732 species of Indonesian plants included in the IUCN conservation status category (2020), consisting of one species Extinct/EX, two species Extinct in the Wild/EW, 125 species Critically Endangered/CR, 179 species Endangered/EN, 315 species Vulnerable/VU, 1902 species Least Concern/LC, and 208 species Data Deficient/DD. The results of vegetation analysis, 42 species (34.7%) of 121 plant species found in Kinarum PF are included in the IUCN conservation status category (2020). This shows that 1.54% of the plant species included in the IUCN red list grow in this forest area.

The species included in the IUCN red list (Table 7) consist of eight species (6.6%) of threatened plants, 33 species (27.3%) LC, and one species (0.8%) DD. These plant species belonging to the family Meliaceae (5 species), which mostly come from the genus *Aglaia*. Sixty species of *Aglaia* can be found in Borneo, and 12 species are endemic (Trimanto and Sofiah 2018), some species are beginning to be rare and are found in Kinarum PF. Other threatened plants belong to Dipterocarpaceae, Malvaceae, Rubiaceae (each 4 species), Burseraceae, Lauraceae, Moraceae, Phyllanthaceae (each 3 species), Euphorbiaceae, Leguminosae (each 2 species), and Anacardiaceae, Combretaceae, Hypericaceae, Myristicaceae, Poaceae, Rhamnaceae (one species each). Eight threatened species are *Aglaia angustifolia, Artocarpus tamaran, Dracontomelon costatum, Durio dulcis, Durio kutejensis, Eusideroxylon zwageri, Myristica magnifica,* and *Shorea guiso*. Of the eight species that are threatened, based on the stage of its growth can be described as follows, three species are at the tree stage, one species is at the tree and pole stage, one species is at the tree, pole and sapling stage, and three other species, one is only at the pole stage, one at the sapling stage and another at the seedling stage (Table 7).

Thus there are five threatened plant species in the tree stage at Kinarum PF with an average density of 1.67-3.33 specimens/ha, namely *A. angustifolia, A. tamaran, E. zwageri, M. magnifica,* and *S. guiso* (Table 7). One of them is in the endangered category, *M. magnifica*. The species is a tree used as an important plant to cure various diseases, is used as an analgesic, depressant, and anti-inflammatory agent (Padmaja et al. 2019). One other species that have an endangered category is *D. costatum* which is at the sapling stage. Growth at the sapling stage has a greater disturbance risk than at the tree stage. In 1830 Korthals collected this species from Martapura (Ganesan and Middleton 2019). Furthermore, a decline in the population of *D. costatum* continues to occur because this species is one of the world's commercial trade logs (Mark et al. 2014) whose distribution is limited in Indonesia, Malaysia, and Brunei. According to Mark (2017) logging of primary forest plays a significant role in deforestation which results in the loss of several species of commercial timber plants. This is also supported by Upadhaya et al. (2014) which stated that in general trees that are in a rare and threatened category are caused by over-exploitation of tree species for timber. In addition to that, the highest rates of biodiversity in the world are found in tropical regions populated by developing countries, which do not have adequate technical and financial resources to manage all these species (Borokini 2014).

The IVI value of the eight threatened plant species as mentioned above is less than 10%, so it can be said that the plant is not dominating Kinarum PF. A species is considered to play a role if its IVI is ≥ 10% for the seedlings and saplings stage, whereas for poles and trees the stage is ≥ 15% (Pamoengkas et al. 2019). In total, the density of trees in this study site is 400 specimen/ha (Table 6). These results are not much different from the results of other studies such as Kartawinata et al. (2008) in lowland dipterocarp forest at Wanariset Samboja, East Kalimantan with a tree density of 557/ha; Sidiyasa (2009) in HL Sungai Wain, East Kalimantan, with a tree density of 532.50/ha; Haryadi (2017) in HL Telaga Kameloh, Central Kalimantan with a tree density of 502/ha, Sudrajat and Dwiputro (2019) in the Conservation Forest of the buffer zone of the Liquid Natural Gas Industry area, East Kalimantan, obtaining a tree density of 491.75 ind/ha, whereas, in Germplasm Preservation Areas, Central Kalimantan, Pamoengkas et al. (2019) only obtained 182.5/ha. The example for comparison of densities at each growth stage in the four Kalimantan forest areas with slightly different sampling sizes is as in Table 8 below. The average tree density is below 500/ ha and pole density below 700/ha, but very different results are found in the sapling and seedling stages. This shows Kinarum PF is very poor for its regeneration rate. This condition is certainly very worrying, especially for the survival of rare, endemic and threatened plant species.

While for each threatened species, the average density is 1.67-3.33/ha. Other researchers also found threatened species with low average densities such as *Shorea leprosula* in Berau, East Kalimantan (Saridan 2012), *Dryobalanops lanceolata* and *A. tamaran* each with only 2/ha in Forest conservation LNG, East Kalimantan (Sudrajat and Dwiputro 2019), and *D. kutejensis* found in very limited quantities in the Kaleka forests of Central Kalimantan (Rahu et al. 2013). However, the IUCN criteria for the CR category are if the adult tree density is 0.05 individuals/ha while for the EN and VU categories it has at least an adult tree density of 0.005 individuals/ha. The average density for *A. angustifolia, A. tamaran, E. zwageri, M. magnifica,* and *S. guiso* is more than 0.05 individuals /ha, so based on the above criteria these species in Kinarum PF are theoretically not threatened. The *D. costatum, D. dulcis,* and *D. kutejensis* which are not found in the tree stage might be threatened in the next few years. However, based on IVI values, all threatened plant species in Kinarum PF have a low IVI (IVI ≤ 2.46%), so the presence of these plants is feared to be threatened in the future. In general, plants with high IVI have better adaptability, competitive power, and reproductive capacity compared to other plants in one particular area. Conversely, a low IVI indicates that these species are very potential to be lost from the ecosystem if there is pressure due to very small numbers, low reproductive capacity, and narrow distribution in the ecosystem (Zulkarnain et al. 2015). In general, the eight species have an IVI of less than 10% and a dominance index close to 0 (nothing dominates), so it is feared that it will be threatened in the future.

Besides threatened plants, Kinarum PF is also inhabited by at least two species of plants that are protected under Minister of Environment and Forestry Regulation No.20 Th 2018 and Republic of Indonesia Government Regulation No. 7 of 1999, namely *E. zwageri* and *Koompassia excelsa.* Eleven species have been declared as Kalimantan endemic plant (Sidiyasa 2015) namely *A. tamaran, Dehaasia turfosa, Dryobalanops lanceolata, D. dulcis, D. kutejensis, Ficus uncinata, Nephelium cuspidatum, Pentace borneensis, Sarcotheca macrophylla, Shorea amplexicaulis*, and *Tristaniopsis whiteana*. Some of the threatened, endemic, or protected species mentioned above are also found in several similar research plots.

Table 7. Species of threatened plants found in the research area (IUCN 2020)

Species	Family	IUCN category	Average density (specimen/ha)			
			Tree	Pole	Sapling	Under
Threatened category						
Aglaia angustifolia (Miq.) Miq.	Meliaceae	VU	1.67	-	-	-
Artocarpus tamaran Becc.	Moraceae	VU	1.67	-	-	-
Dracontomelon costatum Blume	Anacardiaceae	EN	-	-	1.67	-
Durio dulcis Becc.	Malvaceae	VU	-	-	-	1.67
Durio kutejensis (Hassk.) Becc.	Malvaceae	VU	-	1.67	-	-
Eusideroxylon zwageri Teijsm. & Binn.	Lauraceae	VU	3.33	1.67	-	-
Myristica magnifica Bedd.	Myristicaceae	EN	3.33	1.67	1.67	-
Shorea guiso Blume	Dipterocarpaceae	VU	1.67	-	-	-
LC category						
Aglaia elliptica (C.DC.) Blume	Meliaceae	LC	-	-	1.67	-
Aglaia grandis Korth. ex Miq.	Meliaceae	LC	1.67	-	-	-
Aglaia simplicifolia (Bedd.) Harms	Meliaceae	LC	1.67	-	-	-
Aidia racemosa (Cav.) Tirveng.	Rubiaceae	LC	5.00	3.33	10.00	15.00
Aleurites moluccanus (L.) Willd.	Euphorbiaceae	LC	1.67	-	-	-
Alphitonia excelsa (Fenzl) Reissek ex Benth.	Rhamnaceae	LC	1.67	-	-	-
Antidesma montanum Blume	Phyllanthaceae	LC	11.67	5.00	6.67	3.33
Antidesma stipulare Blume	Phyllanthaceae	LC	-	-	5.00	-
Archidendron ellipticum (Blanco) I.C. Nielsen	Leguminosae	LC	6.67	1.67	-	-
Artocarpus elasticus Reinw. ex Blume	Moraceae	LC	1.67	1.67	-	-
Beilschmiedia kunstleri Gamble	Lauraceae	LC	28.33	-	-	-
Bridelia tomentosa Blume	Phyllanthaceae	LC	-	-	1.67	-
Canarium asperum Benth.	Burseraceae	LC	-	-	-	1.67
Cratoxylum formosum (Jacq.) Benth. & Hook.f. ex Dyer	Hypericaceae	LC	-	-	-	1.67
Dacryodes incurvata (Engl.) H.J. Lam	Burseraceae	LC	1.67	-	-	-
Dryobalanops lanceolata Burck	Dipterocarpaceae	LC	30.00	8.33	5.00	1.67
Ficus variegata Blume	Moraceae	LC	1.67	1.67	-	1.67
Harpullia cupanioides Roxb.	Sapindaceae	LC	-	-	1.67	-
Koompassia excelsa (Becc.) Taub.	Leguminosae	LC	1.67	-	5.00	10.00
Leea indica (Burm. f.) Merr.	Vitaceae	LC	-	-	3.33	-
Mallotus philippensis (Lam.) Müll. Arg.	Euphorbiaceae	LC	1.67	-	-	-
Neonauclea calycina (Bartl. ex DC.) Merr.	Rubiaceae	LC	-	-	3.33	-
Neonauclea glabra (Roxb.) Bakh.f. & Ridsdale	Rubiaceae	LC	3.33	1.67	-	-
Neonauclea lanceolata (Blume) Merr.	Rubiaceae	LC	3.33	-	3.33	1.67
Palaquium obovatum (Griff.) Engl.	Sapotaceae	LC	5.00	-	-	-
Pennisetum purpureum Schumach.	Poaceae	LC	-	-	-	1.67
Santiria laevigata Blume	Burseraceae	LC	5.00	3.33	-	-
Scaphium macropodum (Miq.) Beumée ex K.Heyne	Malvaceae	LC	-	-	-	-
Shorea amplexicaulis P.S. Ashton	Dipterocarpaceae	LC	8.33	5.00	-	-
Shorea leprosula Miq.	Dipterocarpaceae	LC	3.33	1.67	-	-
Sterculia lanceolata Cav.	Malvaceae	LC	6.67	11.67	5.00	-
Terminalia foetidissima Griff.	Combretaceae	LC	-	-	1.67	-
Toona sureni (Blume) Merr.	Meliaceae	LC	1.67	-	-	-
DD category						
Cinnamomum porrectum (Roxb.) Kosterm.	Lauraceae	DD	1.67	-	-	-

Note: The categories used in table 7 are global IUCN categories, not the results of the author's own assessment. CR: Critically Endangered; EN: Endangered; VU: Vulnerable; LC: Least Concern; DD: Data Deficient

Table 8. Comparison of plant density for each stage of growth in four different forest areas

Location	Plot size (ha)	Density (specimen/ha)			
		Tree	Pole	Sapling	Seedling
Kinarum Protected Forest, South Kalimantan (*this research*)	0.6	400	135	188,33	330
Germplasm Preservation Areas, Central Kalimantan (Pamoengkas et al. 2019)	1	182.	325	1460	22875
Forest conservation LNG, East Kalimantan (Sudrajat & Dwiputro. 2019)	2	491	No data	3725	69218
Sentarum Lake National Park, West Kalimantan (Kusmana et al. 2009)	0.1	390	670	6010	No data

The following are a few examples: *Cratoxylum formosum* and *A. tamaran*, found in Semboja Lestari, East Kalimantan (Yassir and Arbainsyah 2014) and in Muara Kendawangan Nature Reserve, West Kalimantan (Purwaningsih and Kartawinata 2018); *Tristaniopsis whiteana* found in Muara Kendawangan Nature Reserve, West Kalimantan (Purwaningsih and Kartawinata 2018); *D. dulcis* and *D. kutejensis* found in Wanariset Semboja, East Kalimantan (Kartawinata et al. 2008); *S. guiso* found in Sebangau forest, Central Kalimantan (Mirmanto 2010); *Shorea leprosula* found in Besiq Bermai (Sofiah et al. 2018) and Semboja Lestari (Yassir and Arbainsyah 2014), East Kalimantan, while *E. zwageri* are found in some areas of East Kalimantan such as in Kutai National park (Haryati et al. 2011), Semboja Lestari (Yassir and Arbainsyah 2014), Wanariset Semboja (Kartawinata et al. 2008), HL Sungai Wain (Sidiyasa 2009), and Besiq Bermai (Sofiaht et al. 2018).

All of these species are assets of flora diversity in Kinarum PF which are feared that they will be threatened in the future if adequate conservation efforts are not conducted. Furthermore, Pamoengkas et al. (2018) stated that the loss of biological diversity threatens the sustainability and development of forests ecosystem in the future.

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Table S1. List of plants found in observation plots in Kinarum PF

Species name	Family	Conservation Status			
		IUCN Category (2020)	**National Protected plant**	**Endemic of Borneo**	***Ex-situ* conservation in BBG**
Actinodaphne gullavara (Buch.-Ham. ex Nees) M.R.Almeida	Lauraceae	-	-	-	-
Aglaia angustifolia (Miq.) Miq.	Meliaceae	VU	-	-	-
Aglaia elliptica (C.DC.) Blume	Meliaceae	LC	-	-	+
Aglaia grandis Korth. ex Miq.	Meliaceae	LC	-	-	+
Aglaia simplicifolia (Bedd.) Harms	Meliaceae	LC	-	-	+
Aidia racemosa (Cav.) Tirveng.	Rubiaceae	LC	-	-	-
Aleurites moluccanus (L.) Willd.	Euphorbiaceae	LC	-	-	+
Alphitonia excelsa (Fenzl) Reissek ex Benth.	Rhamnaceae	LC	-	-	-
Alstonia angustiloba Miq.	Apocynaceae	-	-	-	+
Antidesma montanum Blume	Phyllanthaceae	LC	-	-	+
Antidesma stipulare Blume	Phyllanthaceae	LC	-	-	+
Archidendron ellipticum (Blanco) I.C.Nielsen	Leguminosae	LC	-	-	+
Artocarpus elasticus Reinw. ex Blume	Moraceae	LC	-	-	+
Artocarpus integer (Thunb.) Merr.	Moraceae	-	-	-	+
Artocarpus lacucha Buch.-Ham.	Moraceae	-	-	-	+
Artocarpus lanceifolius Roxb.	Moraceae	-	-	-	-
Artocarpus tamaran Becc.	Moraceae	VU	-	+	+
Beilschmiedia kunstleri Gamble	Lauraceae	LC	-	-	+
Blumeodendron sp.	Lauraceae	-	-	-	-
Bridelia insulana Hance	Euphorbiaceae	-	-	-	+
Bridelia tomentosa Blume	Euphorbiaceae	LC	-	-	+
Buchanania arborescens (Blume) Blume	Anacardiaceae	-	-	-	+
Calathea zebrina (Sims) Lindl.	Marantaceae	-	-	-	+
Canarium asperum Benth.	Burseraceae	LC	-	-	+
Canthium glabrum Blume	Rubiaceae	-	-	-	-
Cheilocostus speciosus (J.Koenig) C.D.Specht	Costaceae	-	-	-	+
Cinnamomum porrectum (Roxb.) Kosterm.	Lauraceae	DD	-	-	+
Clausena excavata Burm.f.	Rutaceae	-	-	-	+
Connarus odoratus	Connaraceae	-	-	-	-
Cratoxylum formosum (Jacq.) Benth. & Hook.f. ex Dyer	Hypericaceae	LC	-	-	+
Cryptocarya ferrea Blume	Lauraceae	-	-	-	+
Cryptocarya strictifolia Kosterm.	Lauraceae	-	-	-	-
Dacryodes incurvata (Engl.) H.J.Lam	Burseraceae	LC	-	-	-
Daemonorops laciniata Furtado	Arecaceae	-	-	-	-
Dehaasia cuneata (Blume) Blume	Lauraceae	-	-	-	-
Dehaasia incrassata (Jack) Kosterm.	Lauraceae	-	-	-	+
Dehaasia turfosa Kosterm.	Lauraceae	-	-	+	-
Diospyros borneensis Hiern	Ebenaceae	-	-	-	+
Diospyros macrophylla Blume	Ebenaceae	-	-	-	+
Diplospora malaccense Hook. f.	Rubiaceae	-	-	-	+
Dracontomelon costatum Blume	Anacardiaceae	EN	-	-	-
Dryobalanops lanceolata Burck	Dipterocarpaceae	LC	-	+	+
Durio dulcis Becc.	Malvaceae	VU	-	+	+
Durio kutejensis (Hassk.) Becc.	Malvaceae	VU	-	+	+
Dysoxylum sp.	Meliaceae	-	-	-	-
Elaeocarpus stipularis Blume	Elaeocarpaceae	-	-	-	+
Elateriospermum tapos Blume	Euphorbiaceae	-	-	-	+
Endiandra sp.	Lauraceae	-	-	-	-
Eusideroxylon zwageri Teijsm. & Binn.	Lauraceae	VU	+	-	+
Ficus consociata Blume	Moraceae	-	-	-	+
Ficus ribes Reinw. ex Blume	Moraceae	-	-	-	-
Ficus serrata L.	Moraceae	-	-	-	-
Ficus sp.	Moraceae	-	-	-	-
Ficus uncinata (King) Becc.	Moraceae	-	-	+	-
Ficus variegata Blume	Moraceae.	LC	-	-	-
Gluta renghas L.	Anacardiaceae	-	-	-	+
Guioa diplopetala (Hassk.) Radlk.	Sapindaceae	-	-	-	+
Guioa pleuropteris (Blume) Radlk.	Sapindidanceae	-	-	-	+
Gymnacranthera forbesii (King) Warb.	Myristicaceae	-	-	-	+
Harpullia cupanioides Roxb.	Sapindaceae	LC	-	-	-
Koompassia excelsa (Becc.) Taub.	Leguminosae	LC	+	-	+

Lansium parasiticum (Osbeck) K.C.Sahni & Bennet	Meliaceae.	-	-	-	+
Leea indica (Burm. f.) Merr.	Vitaceae	LC	-	-	+
Leucosyke capitellata Wedd.	Urticaceae	-	-	-	-
Lithocarpus cyclophorus (Endl.) A.Camus	Fagaceae	-	-	-	-
Lithocarpus elegans (Blume) Hatus. ex Soepadmo	Fagaceae	-	-	-	-
Litsea garciae Vidal	Lauraceae	-	-	-	-
Litsea umbellata (Lour.) Merr.	Lauraceae	-	-	-	+
Lygodium circinatum (Burm. f.) Sw.	Lygodiaceae	-	-	-	+
Macaranga bancana (Miq.) Müll.Arg.	Euphorbiaceae	-	-	-	-
Macaranga gigantea (Rchb.f. & Zoll.) Müll.Arg.	Euphorbiaceae	-	-	-	+
Mallotus philippensis (Lam.) Müll.Arg.	Euphorbiaceae	LC	-	-	+
Memecylon acuminatissimum Blume	Melastomataceae	-	-	-	-
Memecylon edule Roxb.	Melastomataceae	-	-	-	+
Memecylon oleifolium Blume	Melastomataceae	-	-	-	-
Memecylon paniculatum Jack	Melastomataceae	-	-	-	+
Myristica magnifica Bedd.	Myristicaceae	EN	-	-	-
Neolamarckia cadamba (Roxb.) Bosser	Rubiaceae	-	-	-	-
Neolitsea cassiifolia Merr.	Lauraceae	-	-	-	+
Neonauclea calycina (Bartl. ex DC.) Merr.	Rubiaceae	LC	-	-	+
Neonauclea glabra (Roxb.) Bakh.f. & Ridsdale	Rubiaceae	LC	-	-	+
Neonauclea lanceolata (Blume) Merr.	Rubiaceae	LC	-	-	+
Nephelium cuspidatum Blume	Sapindaceae	-	-	+	+
Nephelium juglandifolium Blume	Sapindaceae	-	-	-	+
Palaquium obovatum (Griff.) Engl.	Sapotaceae	LC	-	-	+
Pennisetum purpureum Schumach.	Poaceae	LC	-	-	-
Pentace borneensis Pierre	Malvaceae	-	-	+	+
Peronema canescens Jack	Lamiaceae	-	-	-	+
Phyllanthus reticulatus Poir.	Rubiaceae	-	-	-	+
Pimeleodendron sp.	Euphorbiaceae	-	-	-	-
Polyalthia rumphii (Blume ex Hensch.) Merr.	Annonaceae	-	-	-	+
Polyscias nodosa (Blume) Seem.	Araliaceae	-	-	-	+
Pouteria multiflora (A.DC.) Eyma	Sapotaceae	-	-	-	-
Rauvolfia verticillata (Lour.) Baill.	Apocynaceae	-	-	-	+
Rhaphidophora hookeri Schott	Araceae	-	-	-	-
Roureopsis emarginata (Jack) Merr.	Connaraceae	-	-	-	+
Santiria laevigata Blume	Burseraceae	LC	-	-	+
Sarcotheca macrophylla Blume	Oxalidaceae	-	-	+	+
Saurauia sp.	Actinidiaceae	-	-	-	-
Scaphium macropodum (Miq.) Beumée ex K.Heyne	Malvaceae	LC	-	-	+
Scleria sumatrensis Retz.	Cyperaceae	-	-	-	-
Shorea amplexicaulis P.S.Ashton	Dipterocarpaceae	LC	-	+	-
Shorea guiso Blume	Dipterocarpaceae	VU	-	-	+
Shorea leprosula Miq.	Dipterocarpaceae	LC	-	-	+
Spermacoce alata Aubl.	Rubiaceae	-	-	-	-
Stachyphrynium placentarium (Lour.) Clausager & Borchs.	Maranthaceae	-	-	-	-
Sterculia coccinea Roxb.	Malvaceae	-	-	-	+
Sterculia lanceolata Cav.	Malvaceae	LC	-	-	+
Sterculia macrophylla Vent.	Malvaceae	-	-	-	+
Sterculia rubiginosa Zoll. ex Miq.	Malvaceae	-	-	-	+
Taenitis blechnoides (Willd.) Sw.	Pteridaceae	-	-	-	-
Tectaria incisa Cav.	Tectariaceae	-	-	-	-
Terminalia foetidissima Griff.	Combretaceae	LC	-	-	+
Tetracera scandens (L.) Merr.	Dilleniaceae	-	-	-	+
Timonius wallichianus (Korth.) Valeton	Rubiaceae	-	-	-	-
Toona sureni (Blume) Merr.	Meliacaeae	LC	-	-	+
Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	Myrtaceae	-	-	+	+
Uvaria schizocalyx Backer	Annonaceae	-	-	-	-
Vernonia arborea Buch.-Ham.	Compositae	-	-	-	-
Vitex altissima L.f	Lamiaceae	-	-	-	-
Xanthophyllum vitellinum (Blume) D.Dietr.	Polygalaceae	-	-	-	+

Note: CR: Critically Endangered; EN: Endangered; VU: Vulnerable; LC: Least Concern; DD: Data Deficient.