International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Habitat Characteristic of *Pongo pygmaeus morio* in Prevab Area, Kutai National Park, Borneo, Indonesia

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Abstract

The population of Bornean Orangutan now isolated in many habitat fragments. Prevab area in the Kutai National Park (Prevab KNP) is one of the few important natural habitats of Pongo pygmaeus morio remaining in East Kalimantan. Botanical assessments such as floristic composition, forest structure, and food sources availability studies are essential in view of their value in understanding the extent of the forest as an orangutan habitat and ecosystems. In this study, we investigate tree species composition, structure of forest stand, and distribution of orangutan food trees in the Prevab KNP. This study was carried out in the Prevab area (Orangutan Research Station in the Kutai National Park), East Kutai, East Kalimantan from October 2013 to September 2014. The structure data collection used the botanical plot of 0.6 ha and 1 ha for tree species composition. We were determined the number, total height, diameter of breast high, height of clear bole, the height of maximum crown width, and the crown width of all tree species.

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Food trees were determined based on the direct observation, the information of community and staff of national parks, observed the after-eating signs of the orangutan, and the works of literature study.

Important Value Index is the pattern of calculation used to decide the dominant vegetation ecologically in the study area. The structure of forest stand was described in the form of architecture profile (horizontal and vertical). The food trees describe in the form of distribution map. Tree species (dbh ≥5 cm) found in the botanical plot represented at least 148 species, 85 genera, and 43 families. The study plots are dominated by *Cananga odorata*. The trees density with ≥5 cm dbh was 864 trees/ha, the average dbh of ±16 cm, the total basal area of ±28.68 m^2/ha. They vary greatly in species and dimension. There were 5 layers of the canopy in Prevab KNP. The food trees density was ±376 trees/ha, at least 376 food trees/ha, the number of trees wich producing fruit or flower every month less than 6%. 65% of the total number of trees with dbh ≥10 cm is the potential food resources for the orangutan. The Prevab KNP is the good habitat for orangutan if seen from the aspect of either structure, vegetation composition, or food resources. The combination of these three factors may have increased the habitat quality for orangutans in the Prevab KNP.

Keywords: Orangutan; Forest structure; Species composition; Food trees.

1. Introduction

Tropical forests receive high radiative energy, playing a significant role in the global carbon budget [1, 2, 3, 4]. According to [5], deforestation and forest degradation in primary tropical forests, which are of high biodiversity value, continue at an alarming rate: around 6 million hectares per year. Forest biodiversity is being lost at an alarming rate up to 100 animal and plant species are lost every day in tropical forests [5]. Tropical forests in Southeast Asia represent about 11% of the world's tropical forests in terms of area [6], they have the highest relative deforestation rate in tropical areas [3, 7, 8, 9]. According to [6] research, 30 percent of global forest cover has been cleared, while another 20 percent has been degraded. Most of the rest has been fragmented, leaving only about 15 percent intact.

Indonesia's forests are home to thousands of plant and animal species, and 50-60 million Indonesians depend directly on the forests for their livelihoods [6]. The forests of Borneo and Sumatra are some of the most biologically diverse habitats on Earth, possessing staggeringly high numbers of unique plant and animal species [5]. Charles Darwin described the forests of Borneo as "one great luxuriant hothouse made by nature for herself," they are home to more than 200 species of mammals, including elephants, orangutans, clouded leopards and rhinoceros, more than 350 bird species, 150 reptile and amphibian species, and a staggering 10,000 plant species [5].

Bornean Orangutans now occur in fragmented and isolated populations, they are most abundant in lowland forest below 500 m above sea level [10, 11]. Deforestation caused the loss of at least 39% of Bornean's orangutan habitat within the orangutan's range over the 1992-2002 period [12]. Habitat protection for orangutan (*Pongo* spp.) in Borneo Island and Sumatera has become an important goal of forest management in Indonesia [11]. Prevab Area, Kutai National Park is one of the few important natural habitats of the Bornean orangutan remaining in East Kalimantan. The Prevab area severe burns twice, namely in 1982/1983 and 1997/1998 [13]. Botanical assessments such as floristic composition and structure studies are essential in view of their value in understanding the extent of plant biodiversity in forest ecosystems. In this study, We investigate tree species composition, structure of forest stand, and distribution of orangutan food trees in the Prevab Area of the Kutai National Park.

2. Method

2.1. Study Area

This study was carried out in the Prevab Orangutan Research Station of the Kutai National Park (Prevab KNP), East Kutai Regency, East Kalimantan Province, Borneo (see Figure 1). Data were collected from October 2013 to September 2014.

Figure 1: Location of Prevab Study Area in Kutai National Park

2.2. Data Collection

Variables which is used to describe characteristics of orangutan habitat in Prevab KNP consist of trees species composition with the diameter at breast height/dbh ≥5 cm, the vertical and horizontal structure of forest stand, and distribution of orangutan food trees.

The trees composition data collection used two botanical plot of 0.4 ha (200 m x 20 m) and one botanical plot of 0.2 ha (100 m x 20 m). Each plot was subdivided into 20 m x 20 m quadrat for easy sampling of trees (dbh ≥5 cm). Thus, we used the total botanical plot of 1 ha and quadrats of trees were 25 quadrats. We have recorded the species, number, and dbh of all trees (dbh ≥5 cm) for each quadrat.

The structure data collection used a botanical plot of 0.6 ha (100 m x 60 m). Sample plots were developed purposively. We were determined the number, total height (h), dbh, height of clear bole (hcb), the height of maximum crown width (hmcw), and the crown width of all tree species in each quadrat [14]. Crown diameter is measured in two perpendicular directions. Crown projection diameter is first measured along maximum crown width axis and then perpendicularly to this first direction. The average is used for crown width. The radius projection of crown measured with eight radiuses to get a more accurate prediction of crown width. Tree parameters to be measured can be seen in Figure 2.

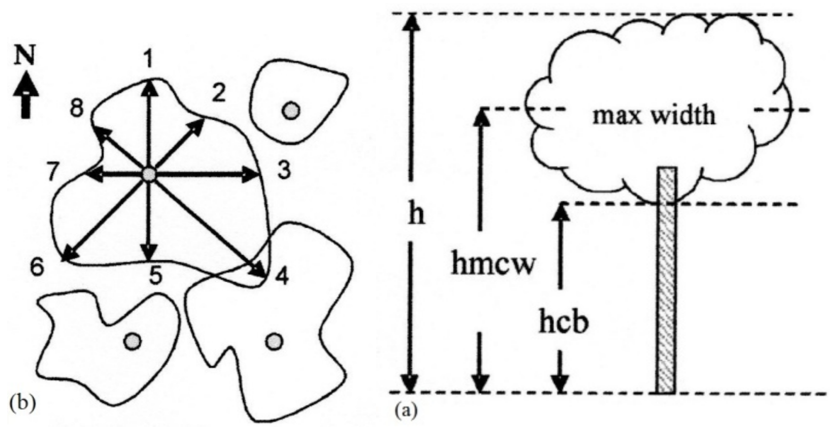


Figure 2: (a) Height measurement and (b) crown radius measurement [14]

Data of orangutan food trees and its distribution were collected based on the existence of orangutan food trees. Food trees were determined based on the direct observation, the information of community and staff of national parks, observed the after-eating signs of the orangutan, and the works of literature study. We noted all the food trees in the area a female orangutan home range called Labu, determined the species, and recorded its geographic positions with a global positioning system (GPS). Food category consists of fruits, flowers, barks, or leaf of the food tree.

2.3. Data Analysis

Tree species composition. We determined species composition of the trees based on measurements DBH in each quadrat. We considered multiple-stemmed plants as single individuals for the calculation of stem density and summed the basal area of all trees for the calculation of basal area (m^2/ha). For each species, we calculated relative abundance (RA, %) as the number of individuals of that species/total number of individuals, relative basal area (RBA, %) as the basal area of that species/total basal area, and relative frequency (RF, %) as the number of quadrats with that species/total number of quadrats. Important Value Index (IVI) is the pattern of calculation used to determine the dominant vegetation ecologically in the study area. It is the result of RA, RBA, and RF [15].

Stand Structure. The architecture profile analysis is used to obtain the description the forest structure as a vertical and horizontal profile. The structure of forest stand was described in the form of architecture profile by projecting the result of height and crown radius measurement of the trees. The parameters derived from measurement were processed by using the Software SExI-FS (Spatially Explicit Individual-Based Forest

Simulator), 2.1.0 version [14].

Distribution of food Tree. The food trees distribution in the study area describes in the form of distribution map. Coordinates of food trees were processed by using the Software ArcGIS, 10.1. version.

3. Result

3.1. Tree species composition

Tree species (dbh ≥5 cm) found in the botanical plot represented minimum 148 species, 85 genera, and 43 families. *Cananga*, *Paranephelium*, *Alangium, Ficus, Chisocheton*, and *Aglaia* were top six genera dominated that's area. They have IVI ≥10 % (Tabel 1). *Ficus* is important food sources for orangutan (Leighton, 1993). We found minimal 10 species *Ficus* during our study in the Prevab KNP.

Table 1: Ecological dominance ranking genera with IVI ≥5 % of trees in Prevab KNP (n=866) within the 1-hectare plot in decreasing order of IVI

Genera	Family	D	F	BA	IVI
Cananga	Annonaceae	127	18	3.62	31.44
Paranephelium	Sapindaceae	53	14	1.941	16.12
Alangium	Alangiaceae	66	18	0.92	14.99
Ficus	Moraceae	52	28	0.64	14.68
Chisocheton	Meliaceae	21	10	2.60	13.80
Aglaia	Meliaceae	38	23	1.11	13.55
Croton	Euphorbiaceae	29	15	0.85	9.76
Dillenia	Dilleniaceae	29	16	0.76	9.70
Melicope	Rutaceae	40	13	0.55	9.53
Dracontomelon	Anacardiaceae	15	10	1.51	9.31
Nephelium	Sapindaceae	18	10	1.18	8.49
Litsea	Lauraceae	25	17	0.44	8.32
Eusideroxylon	Lauraceae	12	7	1.47	8.13
Sphaerocoryne	Annonaceae	22	14	0.38	7.08
Macaranga	Euphorbiaceae	22	15	0.22	6.77
Clerodendrum	Verbenaceae	22	5	0.76	6.36
Pterospermum	Sterculiaceae	7	5	1.24	6.29
Oroxylum	Bignoniaceae	12	8	0.62	5.39
Syzygium	Myrtaceae	12	11	0.36	5.17
Alseodaphne	Meliaceae	13	11	0.32	5.16
Monocarpia	Lauraceae	15	10	0.28	5.03

Sixty three of the 84 genera in the Prevab KNP had IVI <5 %.

The study plots are dominated by kenanga (*Cananga odorata*). Kenanga has the highest density (127 trees/ha), the biggest basal area (3.62 m^2/ha), and the most prevalent distribution (18 quadrats from total 25 quadrats). Summary of botanical analysis of trees (dbh ≥5 cm) in Prevab KNP with IVI ≥2 % is presented in Table 2. One hundred and five species of the 148 species in the Prevab KNP had IVI <2%. *C. odorata* was the most dominant in this study. *C. odorata* is a small to large forest tree to 40 m tall and about 45 cm in diameter with a straight stem [17]. *C. odorata* is 35 m tall and commonly grows in secondary forest and primary forest edges [18].

The research results showed that the orangutan habitat was rich of tree species. A long history has allowed the high diversity of plants that thrive in wet forests [19]. Research about tree species composition in Prevab KNP has never been done before, the results show that species composition are not exactly the same. [20] found there are 98 species from 38 families in that area, while [21] found there are 74 species from 39 families.

Some species of trees are found in the botanical plot in this study, is not found in other studies research plots, eg *Spondias mombin, Morinda citrifolia, Sindora leiocarpa, baccaurea sumatrana*, etc. In 1 ha of lowland forests of Borneo may grow as much as 240 different species of trees and 1 ha more nearby may add half the amount of these species, no two hectares that have exactly the same kind of composition, many species found only once in a spacious plot [19].

3.2. Forest structure

Thoroughly, the trees density with ≥5 cm dbh in Prevab KNP was 864 trees/ha, the average dbh of ±16 cm, the total basal area of ±28.68 m^2/ha. They vary greatly in species and dimension (dbh, height and canopy diameter).

Most of the trees in the botanical plot had ≤20 cm dbh (±77.78%), while trees with dbh >20 cm there were only ±22.22%. The largest dbh recorded for *Paranephelium* sp. was 117 cm and *Eusideroxylon zwageri* was 108 cm. The distribution of dbh of all trees in the sample plots can be seen in Figure 3.

In the present study, the diameter class distribution pattern of trees with DBH ≥5 cm was negative exponential, wich showed the trend is 'reverse J-shaped' or 'L-shape' [22]. The frequency of trees in this DBH size class is large, from 5 cm and gradually decreases relatively to DBH class increasing. That is typical of natural regeneration and it is one of the characteristics of pristine forest in Kalimantan. The condition is common in the tropical forests, the structure of Sungai Wain Forest and Long Mamay Forest in East Bornean also showed the same trend [23, 24]. Actually, the reverse J-shape or L-shape suggesting a balanced mature forests or forest [25].

The height of trees with dbh ≥5 cm in Prevab KNP was around 1-40 m with the average height of ±10.5 m. The trees were in the height class of 5.1-10 m had the higher percentage (38.35%), and next, the trees were in the height class of 10.1-15 m (29.52%). Trees with heights 4-20 m (C layers) were in bigger percentage (86.14%). Trees between 1 and 4 m (D layers) height made up 8.43%. Trees with heights 20-30 m (B layers) made up 4.82% whereas individuals greater than 30 m (A layers) was only 0.6%. Vertical structure of the forest stand in Prevab KNP can be seen in Figure 4.

Table 2: Ecological dominance ranking 43 species with IVI ≥2 % of 148 species of trees in Prevab KNP (n=866) within the 1 hectare plot in decreasing order of IVI

Species	Family	D	F	BA	IVI
Cananga odorata	Annonaceae	127	18	3.62	31.44
Paranephelium sp.	Sapindaceae	39	9	1.82	12.94
Croton argyratus	Euphorbiaceae	29	15	0.85	9.76
Dracontomelon dao	Anacardiaceae	15	10	1.51	9.31
Chisocheton sp.	Meliaceae	17	7	1.61	9.19
Alangium ridleyi	Alangiaceae	37	10	0.50	8.33
Eusideroxylon zwageri	Lauraceae	12	7	1.47	8.13
Ficus indica	Moraceae	28	8	0.34	6.25
Pterospermum diversifolium	Sterculiaceae	6	4	1.24	5.93
Nephelium hamulatum	Sapindaceae	13	6	0.83	5.78
Melicope latifolia	Rutaceae	24	7	0.36	5.63
Dillenia exelsa	Dilleniaceae	17	10	0.38	5.61
Oroxylum indicum	Bignoniaceae	12	8	0.62	5.39
Clerodendrum adenophysum	Verbenaceae	19	4	0.60	5.21
Chisocheton macrophylla	Meliaceae	4	3	0.99	4.61
Polyalthia verugenia	Annonaceae	15	8	0.27	4.51
Alangium sp.	Alangiaceae	19	6	0.21	4.30
Monocarpia euneura	Annonaceae	12	8	0.25	4.09
Endospermum diadenum	Euphorbiaceae	10	5	0.50	4.04
Vitex pinnata	Verbenaceae	6	5	0.61	3.97
Melicope sp.	Rutaceae	16	6	0.19	3.90
Walsura pinnata	Meliaceae	15	7	0.14	3.82
Dillenia siberiana	Dilleniaceae	11	5	0.38	3.74
Aglaia sp.1	Meliaceae	11	6	0.31	3.72
Actinodaphne borneensis	Lauraceae	7	6	0.33	3.32
Paranephelium xestophyillum	Sapindaceae	14	5	0.12	3.18
Nauclea officinalis	Rubiaceae	8	6	0.24	3.13
Aglaia tomentosa	Meliaceae	7	5	0.33	3.11
Artocarpus elasticus	Moraceae	5	3	0.52	3.07
Elmerillia tsiampacca	Magnoliaceae	1	1	0.77	3.03
Aglaia dookoo	Meliaceae	8	4	0.32	2.98
Ficus ribes	Moraceae	8	7	0.09	2.86
Litsea cylindrocarpa	Lauraceae	11	6	0.05	2.84
Macaranga personii	Euphorbiaceae	9	6	0.12	2.82
Diospyros borneensis	Ebenaceae	8	4	0.23	2.66
Ficus sp.	Moraceae	8	6	0.09	2.62

Aglaia odorata	Meliaceae	9	5	0.10	2.55
Litsea garciae	Lauraceae	5	4	0.26	2.42
Syzygium liniatum	Myrtaceae	4	4	0.28	2.36
Alangium kurzii	Alangiaceae	10	2	0.21	2.36
Koordersiodendron pinnatum	Anacardiaceae	3	1	0.49	2.27
Octomeles sumatrana	Datiscaceae	1	1	0.53	2.19
Planchonia valida	Myrtaceae	4	3	0.25	2.01

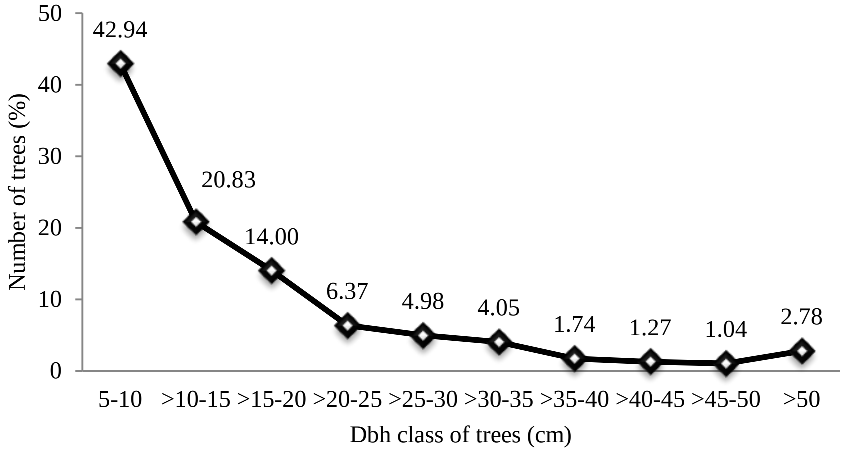
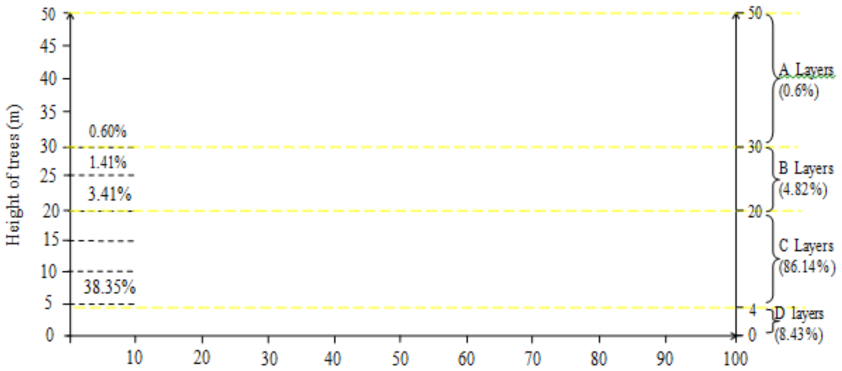


Figure 3: The distribution dbh of trees within the 1 hectare plot in the Prevab KNP (N=866)



Length of sample plot (m)

There were 5 layers of the canopy in Prevab KNP, i.e., A (>30 m), B (20-30 m), C (4-20 m), D (1-4 m), and E (0-1 m) layers (Soerianegara and Indrawan 1998). Generally, tree density in relation to the vertical structure of the forest decreased with increasing height of canopy layers. The number of trees in the understorey layer was far higher than the number of trees in the upper strata (lower canopy, upper canopy, and emergent layers) in Prevab KNP. Stratification is easily recognizable in the forest canopy forests and profile diagrams (but more often not easy). However, the concept of stratification provides several benefits, especially when we consider the use of forests by animals [19].

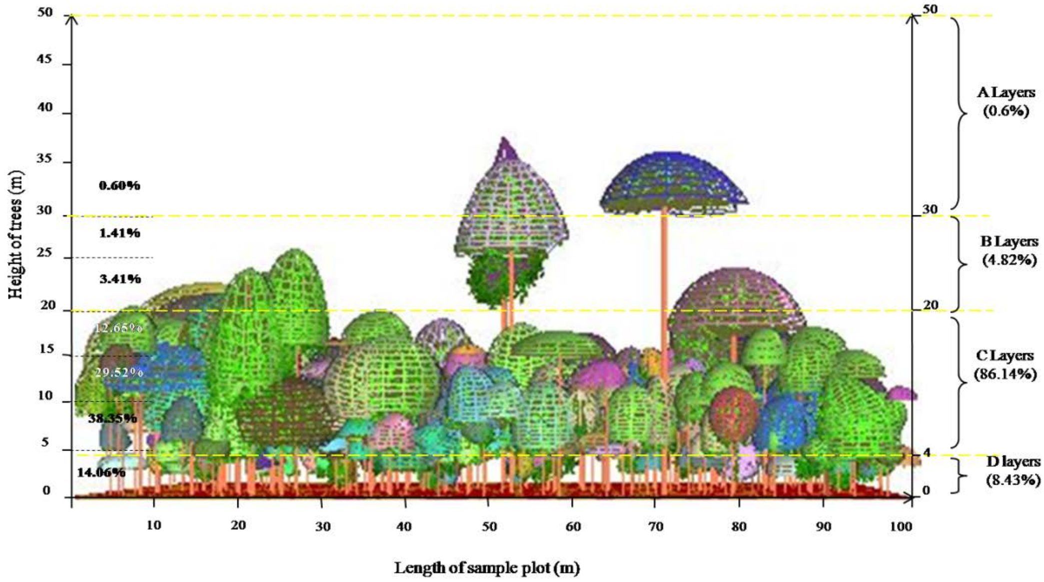


Figure 4: Vertical profile of forest stand in Prevab KNP (n = 498 trees)

Canopy diameter from trees with dbh ≥5 cm in the Prevab KNP was around 0.5-38.5 m with the average canopy diameter of ±7.25 m. Trees with canopy diameter small were the most. Trees with canopy diameter of <5 m were 33.97%, 5.1-10 m were 46.15%, 10.1-15 m were 14.74%, 15.1-20 m were 3.42%, 20.1-25 m were 1.07%. The stand contained trees had canopy diameter wide (≥25 m), it's around ±0.64% of the number of trees. Figure 5 presents a horizontal structure of the forest stand.

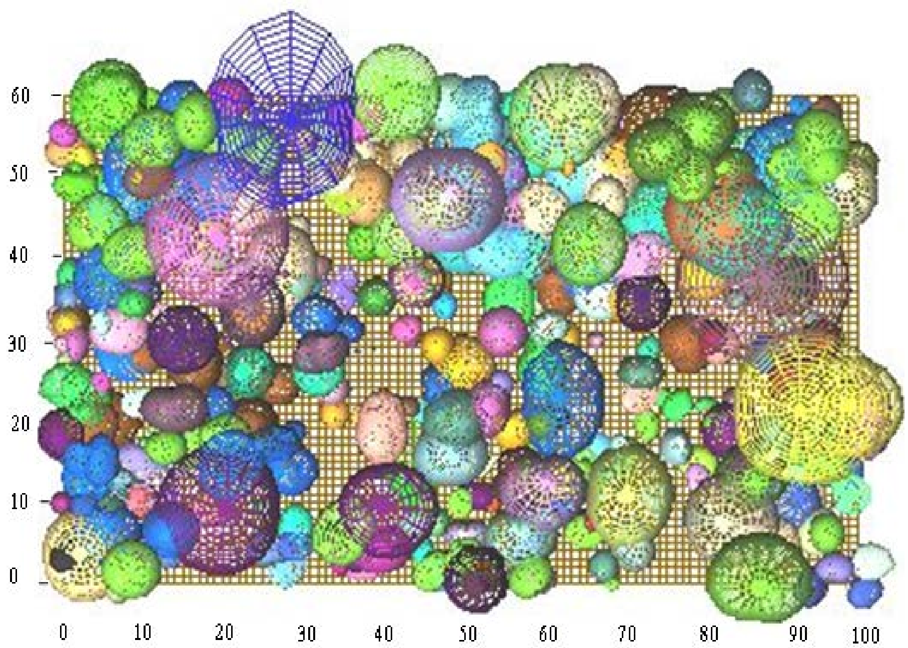


Figure 5: Horizontal profile of forest stand in Prevab KNP

3.3. Distribution of food tree

The food trees density in Prevab KNP was ±376 trees/ha, although in 1 ha there are at least 376 orangutan food trees, the number of trees wich producing fruit or flower every month less than 6%. Irregular fruiting season is the norm for wild fruit trees such as *Durio zibethinus*, *Nephelium* spp., *Garcinia* spp., *Lansium* spp., and *Baccaurea* spp. [27]. Production of flowers and fruit in the forest also is irregular, varied from species to another, even among the trees of the same species in different valleys [26]. In the alluvial swamp forests of Tanjung Puting, 54-60% of all tree dbh> 10 cm is a potential food source for orangutans, although only 8-17% of trees were old enough to provide significant amounts of fruit [28].

Orangutan food trees distributed almost around the home range areas, which reached 65% of the total number of trees with dbh ≥10 cm is the potential food resources for the orangutan. Previous studies showed that the orangutan can be eating many species, but some species still more favored than others and usually intensively fed on a relatively limited number of taxa [13, 29, 30]. Distribution of food trees wich produced fruit or flower around the home range of an adult female orangutan from October 2013 to September 2014 presented in Figure 6. The results of this study indicate that the forest of Prevab KNP was nearing the condition of the natural habitat of orangutans when seen from the structure, composition, and the availability of food resources. We used the research result at the orangutan research stations Mentoko in the Kutai National Park as a comparison because that's area has the same history with Prevab KNP. Although important fruit taxa had changed 15 years after 1997-1998 fires in Mentoko, the density of large trees had increased and densities of important food taxa had recovered or increased, pioneer food and fruit food trees remained relatively abundant [13]. Study on the foraging strategies of the orangutan in Mentoko showed no divergence from normal, diet and activity budgets had reverted to near pre-damage values [13]. Feeding behavior and reproductive behavior of animals closely related to the food availability and seasonal conditions. Fruits availability determined feeding behavior and foraging behavior of the primates, including the orangutan [27, 28, 31, 32].

Figure 6: Food tree distribution around the home range of an adult female orangutan (white polygon) in Prevab KNP. Food trees are marked with a red fruit ( )

4. Conclusion

The results of this study indicate that the forest of Prevab KNP was nearing the condition of the natural habitat of orangutans when seen from the structure, composition, and the availability of food resources.The Prevab KNP was rich of tree species, the forest canopy has 5 layers and continues, orangutan food trees distributed almost around the home range areas of the orangutan. The combination of these three factors may have increased the habitat quality for orangutans in the Prevab KNP. Forest structure gets quick recovery after burnt, but species composition might take several decades to recovery [32]. Finally, The Prevab KNP is important habitat for Pongo pygmaeus morio in East Borneo. Efforts to protect them from encroachment, fires, hunting, and other destructive activities should be carried out. The Prevab KNP is also important as a location for research related to forest succession, especially post-fire regeneration**.**

This study has several limitations, among others: we did not do analysis on woody lianas. An adequate lianas analysis methods until now has not existed. In the natural habitat, woody lianas were the important food resource for orangutans, woody lianas also were the important connecting equipment for the orangutan to move if the canopy of trees did not intersect each other (Richard 1952; Rijksen 1978). In the area of Mentoko and Prevab, Kutai National Park, the trees forming the C stratum mostly associated with epiphytic and liana (Ferisa 2014). It is important to find an effective lianas analysis methods to describe fully the role of woody lianas in shaping the structure of the forest as the orangutan habitat.

Acknowledgements

We are very grateful to The Kutai National Park (KNP), College of Agricultural (STIPER) Kutai Timur, Bogor Agricultural University, and provincial government East Kalimantan. We are also indebted to the individuals and organizations who provided logistical and organizational support in the field: STIPER Kutai Timur (Arbain, I.M. Ramadhan), field assistants at KNP (S. Nur Bani, Darim, Nala, Udin, Junudi). The research complied with Indonesian legal requirements and was approved by the relevant institutional committees of the nation of Indonesia.

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