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Vegetation structure of Sumatran Orangutan (*Pongo abelii*) habitat in North Sumatra, Indonesia

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Abstract. *Zaitunah A, Samsuri, Ras S. 2021. Vegetation structure of Sumatran Orangutan* (Pongo abelii) *habitat in North Sumatra, Indonesia. Biodiversitas 22: 633-639.* Gunung Leuser National Park forest in the Bukit Lawang section is the habitat of Sumatran Orangutan *(Pongo abelii).* There have been reports of the orangutans visiting the village. As some tree species are required for their sustenance to provide nests and food, there is a need to study species diversity availability in their habitat. Thus, the aim of the research was to analyze the composition and structure of the area's vegetation-this was done for the forestand mixed plantation. The sampling for the measurement of tree parameters was conducted using the line strip method. The strips (width 50 m, length 250 m) were constituted by a sub-plot measuring for seedling, pole, sapling, and trees. Within the sampling area, 181 species were found. Species within Dipterocarpaceae showed higher important value index (IVI) compared to other species in all layers. *Shorea parviflora* and *Shorea ovalis* were among the species with higher IVI in all the layers. The presence of species of Dipterocarpaceae and other species preferred by orangutans will support their quality of life. Therefore, orangutans prefer staying in the forest to entering the garden. Thus, it is concluded that their entry into the mixed gardens is related to the garden's proximity to the forest. Conservation efforts are needed to minimize the conflict between man and orangutan in the surrounding area.

Keywords: Bukit Lawang, orangutan habitat, *Pongo abelii*, vegetation composition

INTRODUCTION

Pongo abelii, or Sumatran orangutan, is one of the great apes that lives in Asia, while three of its relatives, e.g., gorillas, chimpanzees, and bonobos, live in Africa. *P. abelii* is one of the endemic species of Sumatra and has a smaller population compared to that in Kalimantan. Orangutans can live in primary forests, from the lowland to the highland areas. A significant reduction in the population of *P. abelii* is due to high levels of habitat conversion and fragmentation and illegal killing. Forest loss data indicate that key Sumatran orangutan forest habitat area (i.e., below 500 m asl) reduced by 60% between 1985 and 2007 (Wich et al. 2008, 2011). A decrease in their habitat due to logging, encroachment, and road expansion poses a serious threat to orangutans (Kuswanda 2007). Deforestation and forest degradation leads to the loss of nest trees and fruit trees as food (Marshall et al. 2009). This can cause a change in the behavior of orangutans, especially in their diet, with increased consumption of leaves and cambium (Knott 1998). Vegetation structures with a high diversity of fruit tree species in the orangutan habitat can comprise a habitat that is part of the forest ecosystem (Nayasilana 2015). Differences in fig-or fruit-eating patterns can affect the social behavior of the orangutan group (Sugardjito 2009). According to the International Union for Conservation of Nature and Natural Resources (IUCN), the Sumatran orangutan conservation status is critically endangered (Singleton et al. 2017). Therefore, priority needs to be given to protect and maintain the quality of the habitat.

Forest cover is an essential factor in determining the quality of wildlife habitat. The opening up of forest areas is one of the biggest threats to the environment, because it affects the forest ecosystem (Ceballos et al. 2015). During 1980-1990, Indonesia's forests were reduced by conversion to agricultural land, plantations and settlements, forest fires, and unsustainable forest exploitation practices (Directorate General Forest Protection and Nature Conservation 2007). Forest damage, which reached 56.6 million ha at the rate of 1.8-2.8 million hectares per year, caused by both human and natural factors, has affected wildlife habitat, including that of the Sumatran orangutan.

Gunung Leuser National Park is one of the orangutan habitats in Sumatra Island. MacKinnon (2000) noted that Sumatra Island is home to around 9,000-10,000 plant species, 3,000-4,000 of which are concentrated in Gunung Leuser National Park. The species are as follows-Dipterocarpaceae (*Shorea* and *Dryobalanops*), Myristicaceae, Eurphobiaceae, Sapotaceae, Meliaceae, Moraceae, and Oleaceae. The wildlife habitat in the Gunung Leuser National Park area has been fragmented by various human activities (Supriatna et al. 2020), thus becoming a major threat to wildlife survival. According to the Ministry of Forestry (2010), parts of the Gunung Leuser National Park have been fragmented by oil palm plantations.

The information on the composition and structure of forest vegetation is highly important for understanding the wildlife habitat condition, especially for the Sumatran orangutan. Orangutans depend on trees for their nests and

food. Studies relating to the orangutan have covered distribution of their population (Voigt et al. 2018), population trends (Santika et al. 2017), future human response, landcover change response (Struebig et al. 2015; Wich et al. 2016), and habitat disturbance effect (Ancrenaz et al. 2015; Sapari et al. 2019; Spehar and Rayadin 2017). Pandong et al. (2019) pointed out that deforestation of orangutan habitat had triggered their movement to find food sources that may not be suitable for their habitat. Most observations of nests or signs of feeding are within 50 m of forest areas (Ancrenaz et al. 2015). The forest canopy buffers reduce the extreme effect of temperature changes and solar radiation (Hardwick et al. 2015) and provide orangutans a place to stay and nest. Bukit Lawang is one of the Sumatran orangutan's habitats and also an ecotourism area, in which a former orangutan rehabilitation station was officially closed in 1997. The area is located in the Bukit Lawang section of Gunung Leuser National Park and the surrounding area of Bahorok Sub-district, Langkat District, North Sumatra Province, Indonesia. This research was conducted to find out the vegetation composition and structure of Sumatran Orangutan habitat in Bukit Lawang section and the Sub-district of Bahorok. This information would be a valuable resource in determining the scale of priority in protecting and improving the habitat condition of orangutan.

MATERIALS AND METHODS

This research was conducted in the habitat area of Sumatran orangutan in Bukit Lawang section of Gunung Leuser National Park, and surrounding areas in Sub-district of Bahorok, Langkat Distrik, North Sumatra Province, Indonesia (Figure 1). Vegetation analysis was also conducted in a mixed garden near the section. Bukit Lawang is located at the coordinates of 98°07′12,0″E and 03°32′45,2″N.

Data processing was carried out at the Forest Management Laboratory, Faculty of Forestry, University of Sumatera Utara, Medan, Indonesia.

Primary data was obtained by direct observation in the field. Saplings were within 1.5 m height and <7 cm in diameter. Poles were young trees ranging in diameter from 7 cm to <20 cm in diameter. Trees were mature trees> 20 cm in diameter. The data were measured by sampling using the line strip method with a width of 50 meters and a length of 250 meters (area of 6,250 m^2). Each strip was made of a sub-plot measuring 6 m ×6 m for the seedling, 12.5 m ×12.5 m for the sapling, 25 m ×25 m for the pole, and 50 m ×50 m for the tree. There were 45 plots in the study area located in Bukit Lawang, mixed garden near the boundary, and in Bahorok Sub-district area. Importance Value Index (IVI) was calculated based on data of density, frequency, and dominance of each species. Relative density is a comparison of the density of any species to the density of all species. Relative frequency is the comparison of the frequency of each species to the frequencies of all species. Relative dominancy is the comparison of the dominancy of a species to the dominancy of all species. Calculation of IVI was carried out with the formula (Mueller-Dombois and Elenberg 1974; Pamoengkas et al. 2017):

$$Relative\ density\ (RD) = \frac{density\ per\ ha\ of\ a\ species}{total\ number\ of\ density\ all\ species} \times 100\ \%$$

$$Relative\ frequency\ (RF) = \frac{frequency\ of\ a\ species}{total\ number\ of\ frequency\ all\ species} \times 100\ \%$$

$$Relative\ dominance\ (RDm) = \frac{dominance\ of\ a\ species}{total\ dominance\ of\ all\ species} \times 100\ \%$$

$$Important\ Value\ Index\ (IVI)_{tree} = RD + RF + RDm$$

$$Important\ Value\ Index\ (IVI)_{seedling,sapling} = RD + RF$$

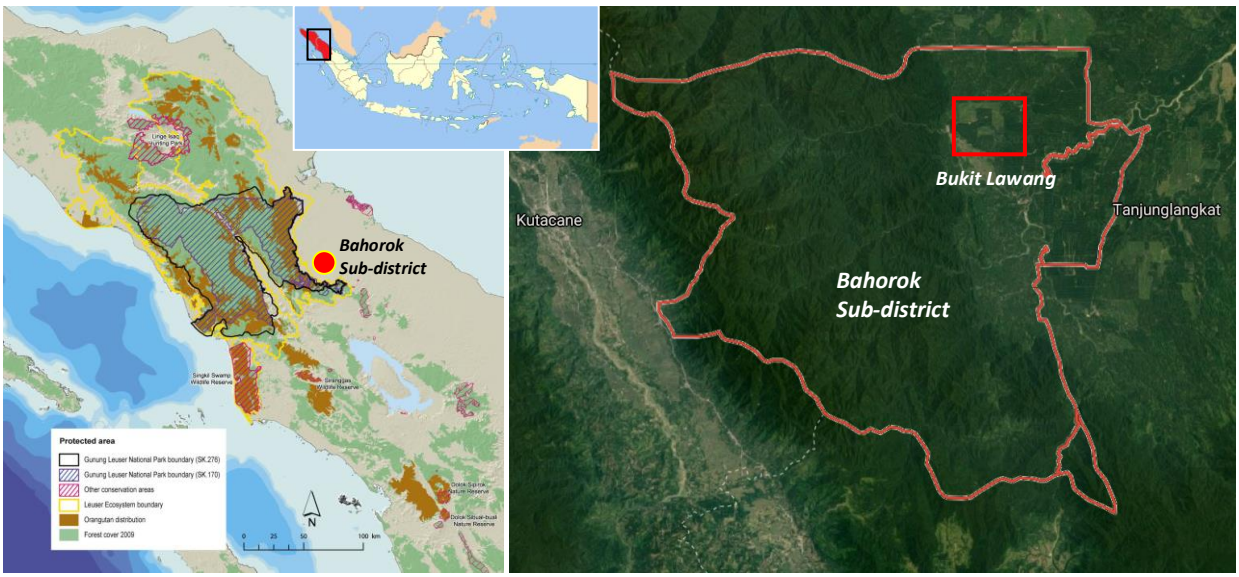

Figure 1. Research location map in Bukit Lawang section of Gunung Leuser National Park, and surrounding areas of Bahorok Sub-district, Langkat Distrik, North Sumatra Province, Indonesia

RESULTS AND DISCUSSION

Vegetation structure in Gunung Leuser National Park, Bukit Lawang Section

One hundred and eighty-one (181) species at all stages of growth were found in the sampling areas. The research shows the dominant existence of the Dipterocarpaceae species, confirming the finding of Aulia (2018), who stated that the most dominant vegetation in the Gunung Leuser National Park Bukit Lawang Section is the Dipterocarpaceae family, namely *Shorea parviflora.* This is quite different from the dominant species found in the remaining natural forest in the area, eg., *Pterospermum subpeltatum, Pometia pinnata, Nephelium lappaceum* (Samsuri et al. 2019). Dipterocarpaceae also exists in degraded and fragmented forests in Batang Toru as an orangutan habitat (Samsuri et al. 2014). The natural forests of the Besitang watershed located in the area have *Pterospermum javanicum* with the highest IVI. *Shorea* sp, *Octomeles sumatrana,* and *Pometia pin*ata are also found (Hasibuan 2019).

Dipterocarpaceae is a pantropical tree family that has spread throughout Asia, including Indonesia. Rachmat et al. (2020) aver that the existence of the Dipterocarps species is threatened due to illegal logging, forest degradation, and land conversion. Supriatna et al. (2017) mentioned the extent of deforestation in the provinces of Sumatra between 2000 and 2012 varied from 3.74% to 49.85%. During that time six species lost 50% or more of their forest habitat. The leading causes of deforestation are logging, followed by fire and/or conversion to plantations.

The existence of the orangutan, who consume part of certain tree species, can help spread the species; there is a relationship of mutualism between the two. If the remaining natural forest is maintained, it will contribute significantly to protecting the Sumatra orangutan and other species (Burivalova et al. 2020). Meanwhile, competition between existing plants, in this case, is related to the climate and minerals needed. Microclimatic conditions and minerals will support the growth and development of a tree species, making it superior and proliferative in an area (Robert and Lean 2007).

Based on Table 1, the most dominant species were *Shorea ovalis* with IVI of 6.06. *S. parvifolia*, which in the tree, pole, and seedling stage, was at the top of the ten dominant competing species. The lowest IVI in the seedling stage was *S. parvifolia*, with an IVI of 2.88. *Podocarpus imbricatus* still showed its consistency by being within the ten most dominant species in the seedling phase, after previously being a new species entering ten dominant species in the sapling stage. Figure 2 shows that the highest density in the seedling stage is of Dipterocarpaceae, followed by Lauraceae, Euphorbiaceae, and others.

Table 2 reveals the dominant species in sapling as *S. parvifolia* with an IVI of 4.63. In the case of *S. parvifolia*, it dominates not only in the tree and pole but also in the sapling. Nevertheless, some species experience significant changes in the sapling stage, such as the *Hopea odorata* species, with an IVI of 2.34. *Polyalthia lateriflora*, which are within ten species that dominate in the tree and pole layers, are not included in the ten species that dominate in the sapling stage. Figure 3 shows that the highest density in sapling layer is among Dipterocarpaceae, followed by Euphorbiaceae, Lauraceae, and others.

The ten species with high IVI values were 7.84. *S. parvifolia* (7.84) was found to be the highest IVI, while the lowest was *Shorea* sp. with an IVI of 3.58 (Table 3). There are four species of the genus *Shorea*, equivalent to 40%, which are included in the ten main species in the pole. While the species with the lowest IVI of 3.58 are *Shorea* sp., which are also of the genus *Shorea*, and *Polyalthia lateriflora* with an IVI of 4.16. This shows that the competition between species in the pole was won by the genus *Shorea*. According to Syafei (1990), plant species dominance is influenced by the existing environmental factors, which in turn are influenced by minimum, maximum and optimum conditions. Lack of environmental factor support will inhibit the growth and development of a plant species. Figure 4 shows that the highest density in pole layer is among Euphorbiaceae, followed by Dipterocarpaceae, Lauraceae, and others. The highest IVI value is 7.31, belonging to *S. parvifolia*, while the lowest is *Endospermum diadenum* with an IVI of 3.36 (Table 4). There were three species of *Shorea*. Figure 5 shows that the highest density in tree layer is among Dipterocarpaceae, followed by Euphorbiaceae, Lauraceae, and others.

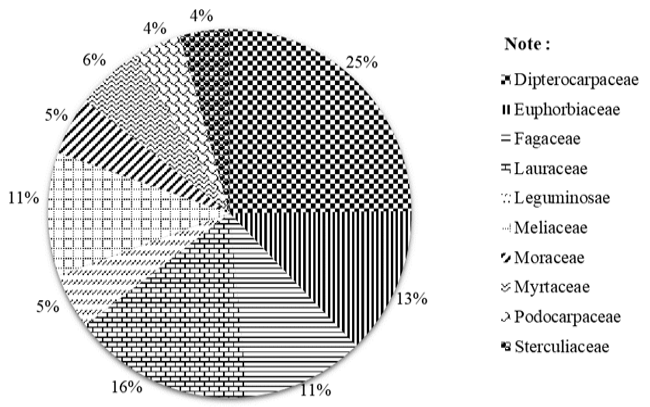

Figure 2. Family with the highest density in seedling

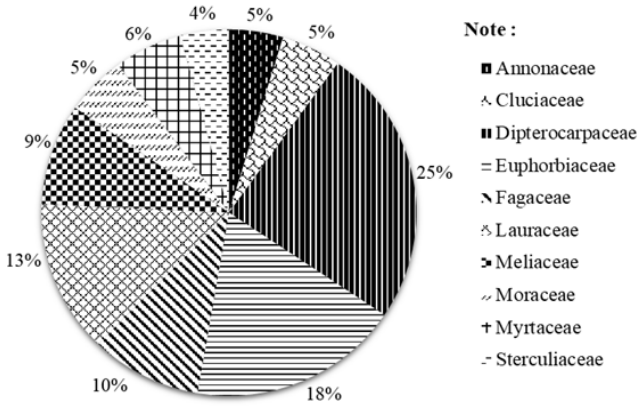

Figure 3. Family with the highest density in sapling

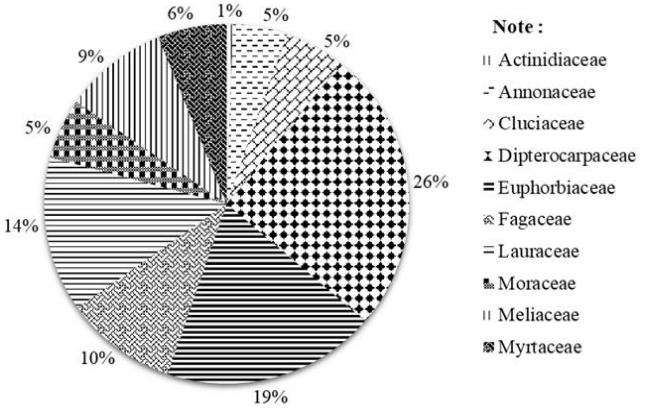

Figure 4. Family with highest density in pole

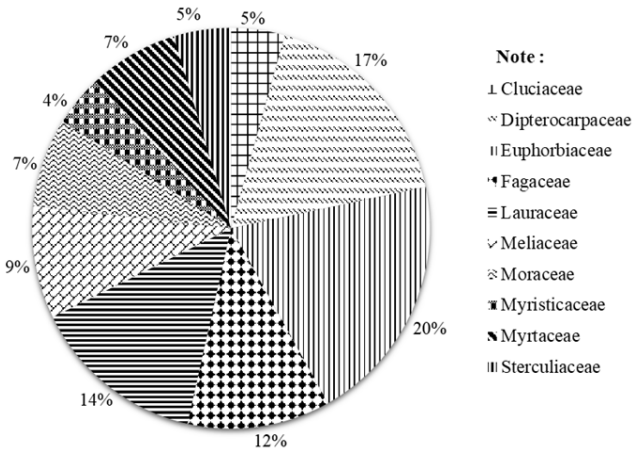

Figure 5. Diagram of a family with the highest tree density

Table 1. Ten species with high IVI in the seedling stage

Species	Individual number	RD (%)	RF (%)	IVI
Shorea ovalis	188	5.10	0.96	6.06
Actinodaphne angustifolia	188	1.00	4.57	5.57
Aglaia argentea	150	4.03	0.96	4.99
Shorea leprosula	112	3.36	0.97	4.33
Hopea odorata	117	3.17	0.96	4.14
Podocarpus imbricatus	153	2.84	0.95	3.78
Aglaia sp	37	2.91	0.84	3.74
Archidendron ellipticum	72	2.37	0.96	3.33
Lithocarpus gracilis	73	2.29	0.97	3.26
Shorea parvifolia	50	1.92	0.97	2.88

Table 2. Ten main species of saplings

Species	Individual number	RD (%)	RF (%)	IVI
Shorea parvifolia	267	4.01	0.62	4.63
Aglaia sp.	219	3.28	0.62	3.90
Litsea firma	200	3.00	0.62	3.62
Shorea ovalis	170	2.55	0.62	3.17
Shorea leprosula	167	2.51	0.62	3.13
Podocarpus imbricatus	153	2.29	0.62	2.91
Aglaia argentea	128	2.06	0.62	2.67
Archidendron ellipticum	120	1.92	0.62	2.54
Actinodaphne angustifolia	107	1.85	0.62	2.47
Hopea odorata	77	1.72	0.62	2.34

Table 3. The ten main species at pole

Species	Individual number	RD (%)	RF (%)	RBA (%)	IVI
Shorea parvifolia	112	5.34	1.09	1.42	7.84
Shorea leprosula	62	2.98	1.08	0.85	4.91
Litsea firma	48	2.40	1.06	1.38	4.84
Aglaia sp.	43	2.18	1.08	1.39	4.65
Hopea odorata	43	2.42	1.08	0.98	4.48
Polyalthia sumatrana	23	2.07	1.09	1.26	4.42
Actinodaphne angustifolia	34	2.18	1.07	1.10	4.35
Shorea ovalis	38	2.08	1.10	1.15	4.33
Polyalthia lateriflora	20	2.00	1.07	1.09	4.16
Shorea sp.	16	1.81	1.04	0.72	3.58

Table 4. The ten main tree species with high IVI

Species	Individual number	RD (%)	RF (%)	RBA (%)	IVI
Shorea parvifolia	123	5,53	1,04	0,75	7,31
Castanopsis tungurut	30	4,92	1,08	0,70	6,71
Shorea leprosula	72	3,23	1,04	0,79	5,06
Litsea firma	53	2,38	1,04	1,05	4,46
Aglaia sp.	49	2,22	1,04	0,90	4,14
Hopea odorata	49	2,20	1,04	0,76	4,00
Shorea ovalis	44	1,97	1,04	0,85	3,86
Actinodaphne angustifolia	38	1,96	1,05	0,59	3,59
Polyalthia lateriflora	21	1,74	1,03	0,81	3,59
Endospermum diadenum	26	1,74	1,04	0,58	3,36

The dominance of a plant species indicates it's having a more extensive range of environments compared to other types. Hence, with a wide range of tolerance to environmental factors, a plant species will have a wide distribution. Figure 3 shows the diagram of poles' distribution within the family with the highest density. The finding is similar to family species in the primary and secondary forests of Ketambe, where Moraceaeare the most numerous species, in addition to other families of Euphorbiaceae, Lauraceae, Clusiaceae, and Meliaceae (Nayasilana et al. 2015). Priatna et al. (2006) found that the most important families of GLNP were Dipterocarpaceae with IVI by 52.0, followed by Euphorbiaceae with IVI by 51.8. The most prevalent species was *Shorea kunstleri* (Dipterocarpaceae) with IVI by 24.4, followed by *Macaranga diepenhorstii* (Euphorbiaceae) with IVI by 12.4. Amelia et al. (2019) found three Dipterocarpaceae species in Sekundur, namely *Parashorea lucida*, *Shorea johorensis*, and *Hopea dryobalanoides*.

According to Montagnini and Jordan (2005), the dominant species in a phase of tree growth do not dominate in other phases due to competition with other plants causes the dominant species or other plants are less able to compete. Besides, these species are less able to defend themselves and adapt to natural conditions, thus ensuring that the species does not develop. Besides, the absence of

species in other phases is caused by natural factors such as natural disasters, erosion, flooding, or human activities such as encroachment in the forest area. There is one new species that is within the ten dominant species, *Podocarpus imbricatus*, with RD of 2.29%, RF of 0.62%, and IVI of 2.91. *P. imbricatus* is not within the ten most dominant species in the tree and pole layer.

There is a significant difference between the species dominating the tree, the pole, the sapling stages, and the seedling layer. According to Odum (1996), the competition will increase the competitiveness to sustain life, and the strong species will win and suppress others. The losing species have a low growth rate and development, resulting in low density. Each plant has minimum, maximum and optimum conditions for the existing environmental factors. At the minimum, a species will grow but not develop to the same extent as under the maximum condition. They will only be able to grow differently. Figure 5 shows a family distribution seedling layer. Samsuri et al. (2019) found dominant species originating from the Dipterocarpaceae family in Besitang watershed forest landscape in GLNP. Likewise, in areas bordering (edge forest) community cultivation areas, there are many orangutan food sources, namely palm shoots and fruit trees (Hasibuan et al. 2019).

Orangutan also needs a tree for nesting, apart from the source of food. Onrizal (2019) states that Dipterocarpaceae was recorded as the most favored tree family to build a nest. There are 14 species as preferences of nesting trees that should be selected to be planted to restore the degraded habitat.

Forest conversion has a negative impact on orangutan. The conversion to oil palm negatively affects orangutan population, leading to reduced densities (Seaman et al. 2019). Provision of alternate types of food sources for dwellers in natural forests can reduce the potential for conflict between orangutans and humans (Freund et al. 2017, Santika et al. 2017). The carrying capacity of orangutans' habitat has to be increased by planting food species through reforestation activities and restoration of the remaining degraded forest landscape (Samsuri et al. 2014). As Sherman et al (2020) mentioned the need to improve management practices in unprotected habitats, including small forest patches distributed across agricultural landscapes to protect orangutans.

The vegetation of mixed garden in the border areas between Bukit Lawang section and Bahorok Sub-district

Orangutans are moving around in their home range to look for food sources and build a tree nest. Even so, orangutan will remain in an area as long as the food is abundant. The vegetation analysis was also conducted in mixed gardens located around the Bukit Lawang section's border. The area is part of the administrative area of the Bahorok Sub-district. According to the owner of a mixed garden in the study site, orangutan had entered their gardens for a certain period of time. The local community confirmed that orangutan entered their gardens to eat and rest. Food sources in the mixed garden are abundant to attract the orangutan. Table 5 shows six species of trees found in mixed gardens owned by local people that are often entered by an orangutan. Morrison (2002) mentioned that habitat could link the presence of species, populations, or individuals (animals or plants) with a physical area and biological characteristics.

This shows that *Hevea brasiliensis* has the highest IVI of 140, followed by *Theobroma cacao* with IVI of 86.38 and *Mangifera indica* with the lowest IVI of 3.70. *H. brasiliensis* dominates mixed plantations because of its location within rubber plantations. Besides, the main commodities in the mixed gardens are *H. brasiliensis* and *T. cacao.* Initially, the mixed garden was a rubber plantation, but people took the initiative to plant other species that were also economically profitable. Figure 6 shows the species density in the mixed garden.

Plantations and mixed gardens are indeed not the natural habitats of Sumatran orangutan, but the geographical conditions and location are still included in the home range of orangutan. So, there are possibilities for the movement of orangutans from the forest to non-forest areas. In this case, the orangutan has entered the mixed garden several times in the vicinity of their natural habitat.

Table 5. Six commodity species in the mixed garden in the border of Bukit Lawang section and Bahorok sub-district, Indonesia

Species	Individual number	RD (%)	RF (%)	RBA (%)	IVI
Hevea brasiliensis	1,229	75.27	35	29.72	140
Theobroma cacao	221	12.73	35	38.65	86,38
Musa paradisiaca	182	15.05	30	32.11	51,45
Gnetum gnemon	12	9.83	25	23.61	3,89
Mangifera Indica	6	4.72	25	25.91	3,70
Cocos nucifera	18	3.68	25	25.88	14,55
		η̃			
	∑=1,668	=20.21	29.16	29.31	300

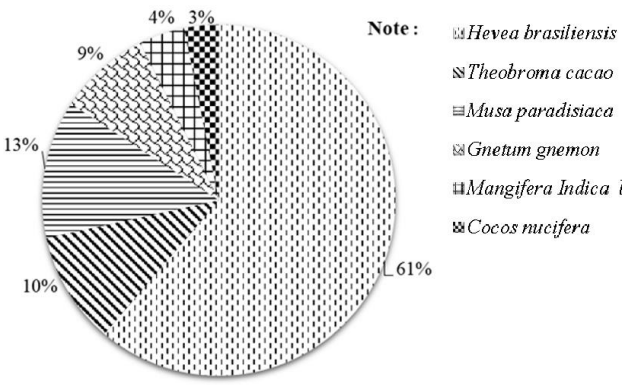

Figure 6. Species density in the mixed garden

Vegetation density and habitat of Sumatran orangutan *(Pongo abelii)* in Bukit Lawang section and Bahorok sub-district

Observation in the Bukit Lawang section revealed several orangutans are moving freely in the forest. In addition to their food source available in the forest, several orangutan old nests were also found, which indicates their liking for the forest. This can be confirmed by the discovery of a number of nest trees and several orangutan individuals at that location. Sofyan et al. (2013) mentioned activities of orangutan depends on the trees in their habitat. Orangutans move by swinging from branch to branch from one tree to another. Orangutans eat fruit, shoots, flowers, bark, leaves, and young branches found in the trees in their habitat.

Shorea parvifolia was the dominant species in the tree, pole, and sapling layers, while the dominant vegetation for the seedling layer was *Shorea ovalis*. The dominant vegetation families were Dipterocarpaceae and Euphorbiaceae in the tree layer. Clusiaceae and Dipterocarpaceae dominated in the pole layer, while Clusiaceae and Annonaceae dominated in the sapling layer. Dipterocarpaceae and Euphorbiaceae were also dominant in the seedling layer. As for mixed gardens, the dominant species were *Hevea brasiliensis*, *Theobroma cacao L.* and *Mangifera indica L.*

The finding of orangutans entering mixed gardens is related to the distance of the garden from the forest. The mixed gardens are in the vicinity of their natural habitat and still in their home range. The research concluded that the forest cover of Gunung Leuser National Park is still the ideal habitat of orangutans due to the maintenance of trees for their needs. The dominance of Dipterocarpaceae and other species preferred by orangutans will support their quality of life. Conservation efforts are needed to minimize the conflict between man and orangutan in the surrounding area.

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