Vegetation diversity of feeding plant of Tapanuli Orangutan (*Pongo tapanuliensis*) in the land of other uses around the Batang Toru Forest Area, North Sumatera

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Abstract. The Tapanuli orangutan (*Pongo tapanuliensis*) is an endemic species found in the Batang Toru ecosystem. The population of Tapanuli orangutan is divided into two main regions (west and east blocks), and also a small population in the natural reserve. Its status based on the IUCN red list is classified as "Critically Endangered". It is necessary to identify the diversity and abundance of forage vegetation for Tapanuli orangutan using vegetation analysis especially in other zones of Batang Toru forest area. All is related to the importance and urgency of Orangutan habitat protection. This research aimed to estimate the availability of forage sources of Orangutans particularly outside the protection area. It shows a total diversity index (H ′) of 4.62, which means that the level of diversity is high. Consequently, protection efforts outside the conservation area are really needed to support Batang Toru ecosystem from land conversion threat that may cause negative impact on the sustainability of Orangutan habitat itself.

1. Introduction

The Sumatran Orangutan (*Pongo abelii Lesson*) is an endemic animal whose natural distribution is only left in Aceh and North Sumatra Provinces, with conservation status as critically endangered animals. Since 2017 a new orangutan species in Batang Toru Forest Ecosystem was declared as Tapanuli Orangutan species (*Pongo tapanuliensis*). The existence of orangutans in Batang Toru in the South of Lake Toba has been frequently in the news due to the excitement geneleveld by the discovery and the immediate threat posed to the new species by the development of a hydrodam to geneleveld electricity [1].

The Tapanuli Orangutan population is located in two main areas of Batang Toru forest (West and East Blocks), and also a small population in the Nature Reserve of Dolok Sibual - Buali closed to the southeast of the west block. It’s in the list of critically endangered species based on the IUCN red list [2]. Currently the Batang Toru ecosystem covers 150,000 hectares and become the last habitat for the Tapanuli Orangutan and the total extent of its distribution covers 102,300 ha [3,4]. The didtribution of Tapanuli orangutan roughly 85% is under some form of protection status, but 15% is land for other uses [2]. Conservation action should be taken to protect orangutans by doing all rational actions and wisely [5].
Habitat of Tapanuli orangutan is being decline due to the converting forests into plantations, agriculture community settlements and other developments. This research is locatedata in the land of other uses (APL: Area Penggunaan Lain) where modelevelly has a function as a connection between the West block of Batang Toru and Sibual-Buali Nature Reserve. It aims to identify and collect data the diversity of the Tapanuli orangutan feeding plant that probably could be use as consideration in term of conservation effort and development in this area.

2. Methods

2.1. Study site
This research was conducted for three months in Huraba Village, Marancar District, Batang Toru Forest area, South Tapanuli Regency, North Sumatra. The tools used in this study are digital cameras, GPS (Global Positioning System), compasses, gauges, plastic straps, stationery, marker tapes and PC (Personal Computer).

2.2. Procedure on data collection
Field orientation was done as a first step to determine the plot position. The location chosen in the land of other uses area of Batang Toru forest represents the area where it’s estimated many types of plants as sources of orangutan’s food. Primary data was collected from individual of seedlings, saplings, poles and trees. The plot size based on vegetation level are: a) seedling plot (2m x 2m); b) sapling plot (5m x 5m); c) pole plot (10m x 10m) and d) tree plot (20m x 20m) [6]. Each of it was collected including number of individuals, height and diameter. Distribution point of the Tapanuli orangutan was noted as well as the names of plant species from the local community. The method used in vegetation analysis is the checkered line method. In the analysis of vegetation there are 10 path locations. Each path has a length of 1 km. Each path is made systematically with a total of 6 plots.

2.3. Data analysis
Data was analyzed to determine the density, relative density, dominance, relative dominance, relative frequency and frequency as well as the Importance Value Index (IVI) using the formula of Dombois and Ellenberg (1974). The diversity of species in a forest area can be described by the Shannon-Wiener Index. According to [7], the greater the $H'$ in a community, the more diverse types within the community. The value of $H' = 0$ can occur if only one species in one sample (sample) and $H'$ are maximum if all species have the same number of individuals and this shows the abundance of perfectly distributed. The formula of Shannon Diversity Index - Wiener ($H'$) [8] is:
\[ H = - \sum p_i \log p_i \]  

(1)

with:

\[ p_i = \frac{n_i}{N} \]  

(2)

- \( H \) = Diversity Index of Shannon-Wiener
- \( n_i \) = Importance Value Index one kinds or Individuals amount
- \( N \) = The amount of Importance Value Index from all species or all species of Individual amount

Parameter Index Shannon - Wiener:
- \( H' < 1.5 \) low diversity
- \( 1.5 = H' = 3.5 \) middle diversity
- \( H' > 3.5 \) high diversity

3. Results and discussion

3.1. Structure and composition of vegetation

Plant species was collected from 10 observation paths with total number of 132 species, consisting of all levels of vegetation growth seedlings, saplings, poles and trees. Vegetation analysis results show the structure and composition of vegetation at the study site such as in Table 1.

| Track | Seedlings | Saplings | Poles | Trees |
|-------|-----------|----------|-------|-------|
| 1     | 10        | 13       | 9     | 7     |
| 2     | 15        | 13       | 11    | 10    |
| 3     | 7         | 12       | 12    | 12    |
| 4     | 20        | 18       | 12    | 11    |
| 5     | 12        | 21       | 11    | 17    |
| 6     | 6         | 8        | 4     | 5     |
| 7     | 6         | 19       | 14    | 13    |
| 8     | 0         | 4        | 6     | 12    |
| 9     | 2         | 9        | 7     | 8     |
| 10    | 5         | 16       | 17    | 13    |

The highest vegetation composition is in track 4 with a total individual species of 62 within forest community as secondary forest type. In other conditions the lowest vegetation composition is in track 8 with a total of 22 individual species within a dry land type which formerly as an area of mixed-bush scrub farming. It can be said that track 4 is dominated by a very diverse plant species so that at each level of vegetation over seedlings, saplings, poles and trees are different. Whereas on track 8 is dominated by types of cultivation plants.

Vegetation analysis is carried out to determine the structure and composition of vegetation, so that plant species can be identified along the path and how many plant species are at each vegetation level. [9,10] stated that the process of regeneration and growth of saplings of several species of trees must sometimes start from the formation of gaps or canopy openings. The secondary forest types found in track 4 has a high number of individual species, especially at seedling and sapling growth levels. It can be interpreted that the regeneration of the vegetation level in track 4 will continue to exist, where the
seedling and sapling level vegetation will now turn into trees in the future along with the gap of light entering the canopy. [11] said that population dynamics and tree dominance are influenced by mortality, growth and regeneration processes. There are many types of trees that are unable to grow and develop under the auspices of the parent tree.

3.2. Plant diversity in the land of other uses

The Shannon-Wiener diversity index value illustrates the richness of plant species at the study site. Diversity index value depends on the variation in the number of species and the number of individuals of each species found. The greater the number of species and variations in the number of individuals of each species, the greater diversity of an ecosystem. [6,12] stated that the index value of species diversity is influenced by the number of plant species and the number of individual species found in a vegetation community.

Based on the resulting species diversity index value as shown in Table 2, track 10 is the path of the highest level of species diversity with a shanon-wiener index value of 4.91 and the lowest shannon-wiener index value found on track 6 (2.87).

There are differences in values in tracks 2 and 5 where H’ on track 5 is smaller than H’ on track 2, whereas the value of the number of species and total individuals on track 5 is greater than track 2. This difference in value can be influenced by the number of individuals of each type. In accordance with the statement of [9,13] which states that the level of diversity of tree species can also be seen from the number of individuals in each species. The smaller the number of individuals in each species, the higher the diversity of species.

[14] stated that sometimes plant species richness is positively correlated with plant species diversity, but environmental conditions along the research pathway are heterogeneous, so that a decrease in plant species richness can be accompanied by increased diversity. This is very possible because the number of individuals on each track varies greatly. If all types of plants have the same number of individuals in each observation path, evenness will be maximum and homogeneous.

The phenomenon of individuals having evenness in numbers is very rare in nature, because each species has the ability to adapt and tolerance. Besides that, environmental conditions in nature are very complex and varied. [15] suggested that other factors that determine the presence of a plant or plant community include not only physical and chemical conditions, but also animals and humans that have a large influence on plants.

The level of Shannon-wiener species diversity in each pathway has the same high category in [16] research in the toru forest area, he stated that the Shannon-Wiener diversity index (H’ ) found in the three habitat types each has a value 3.65 hill-montana transitional forest formations (FHHM), 3.22 Peat forest formations (FHG) and 4.42 Dipterocarpaceae forest formations (FHDA).

| Track | Number of species | Individual Total | H | Hmax | Equitability Index (E) |
|-------|-------------------|------------------|---|------|------------------------|
| 1     | 26                | 110              | 3.74 | 4.7  | 0.79                   |
| 2     | 31                | 83               | 4.47 | 4.95 | 0.90                   |
| 3     | 25                | 155              | 3.28 | 4.64 | 0.70                   |
| 4     | 40                | 115              | 4.54 | 5.32 | 0.85                   |
| 5     | 39                | 144              | 4.06 | 5.29 | 0.76                   |
| 6     | 15                | 79               | 2.87 | 3.90 | 0.73                   |
| 7     | 30                | 68               | 4.63 | 4.90 | 0.94                   |
| 8     | 15                | 53               | 3.11 | 3.90 | 0.79                   |
| 9     | 11                | 72               | 2.95 | 3.45 | 0.85                   |
| 10    | 35                | 67               | 4.91 | 5.12 | 0.95                   |

Table 2. The value of the diversity index of each path
3.3. Diversity of orangutan feeding plants in the land of other uses

From the 10 pathways analyzed and identified, there are several vegetation types of Tapanuli Orangutan feeding species. Index value of diversity of feed tree species can be seen in Table 3.

| No | Latin Name | Track | Total individu | -log2 pi | H | H max | Part of Eaten |
|----|------------|-------|----------------|----------|---|-------|--------------|
| 1  | Mangifera foetida | 2     | 2              | 0.006    | 7.219 | 0.048 | 5.20 | Fruit |
| 2  | Arenga pinnata | 6, 7, 8, 10 | 17            | 0.057    | 4.131 | 0.235 | Fruit |
| 3  | Ficus benjamina | 7     | 3              | 0.010    | 6.634 | 0.066 | Fruit |
| 4  | Artocarpus integer | 8, 9 | 7              | 0.023    | 5.411 | 0.127 | Fruit |
| 5  | Theobroma cacao | 6, 8 | 6              | 0.020    | 5.634 | 0.113 | Fruit |
| 6  | Spondias dulcis | 5     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 7  | Ficus auriculata | 1     | 1              | 0.003    | 8.219 | 0.027 | Fruit |
| 8  | Durio zibethinus | 2, 4, 6, 8, 9 | 42          | 0.140    | 2.826 | 0.398 | Fruit |
| 9  | Archidendron bubalinum | 6, 7, 10 | 10          | 0.033    | 4.897 | 0.164 | Fruit |
| 10 | Podocarpus neriifolius | 3    | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 11 | Macaranga lowii | 8, 10 | 6              | 0.020    | 5.634 | 0.113 | Fruit |
| 12 | Quercus sp. | 1     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 13 | Syzigium acuminitisimum | 10  | 13             | 0.043    | 4.518 | 0.197 | Fruit |
| 14 | Archidendron pauciflorum | 2, 8 | 5             | 0.016    | 5.897 | 0.098 | Fruit |
| 15 | Garcinia nigrolineata | 1, 4 | 4             | 0.013    | 6.219 | 0.083 | Fruit |
| 16 | Cocos nucifera | 8     | 12             | 0.040    | 4.634 | 0.186 | Fruit |
| 17 | Aidia densiflora | 1, 3, 5, 6, 9 | 29          | 0.097    | 3.361 | 0.327 | Fruit |
| 18 | Mangifera indica | 8     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 19 | Garcinia mangostana | 8     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 20 | Pomelia pinnata | 4, 5, 7, 10 | 21           | 0.070    | 3.826 | 0.269 | Fruit |
| 21 | Artocarpus teysmanni | 8, 9 | 4             | 0.013    | 6.219 | 0.083 | Fruit |
| 22 | Ficus crassiramea | 5     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 23 | Parkia javanica | 2, 10 | 7              | 0.023    | 5.411 | 0.127 | Fruit |
| 24 | Kandelia candal | 9     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 25 | Nephelium lapaceum | 2, 4, 5 | 8            | 0.026    | 5.219 | 0.140 | Fruit |
| 26 | Solanum mutabile | 2, 5 | 5             | 0.016    | 5.897 | 0.098 | Fruit |
| 27 | Solanum torvum | 7     | 2              | 0.006    | 7.219 | 0.048 | Fruit |
| 28 | Calamus manan | 7, 10 | 5             | 0.016    | 5.897 | 0.098 | Fruit |
| 29 | Flaoourtin rukam | 1, 6 | 8             | 0.026    | 5.219 | 0.140 | Fruit |
| 30 | Salacca zalacca | 8, 9 | 9             | 0.030    | 5.049 | 0.152 | Fruit |
| 31 | Macaranga gigantea | 7, 10 | 14            | 0.046    | 4.411 | 0.207 | Fruit |
| 32 | Begonia isoptera | 6, 7, 10 | 14          | 0.046    | 4.411 | 0.207 | Fruit |
| 33 | Etlingera elatior | 1, 6, 7 | 6            | 0.020    | 5.634 | 0.113 | Topmost |
| 34 | Korthalsia flagelaris | 7, 8, 9 | 9            | 0.030    | 5.049 | 0.152 | Topmost |
| 35 | Manihot esculenta | 8, 9 | 4             | 0.013    | 6.219 | 0.083 | Fruit |
| 36 | Artocarpus elasticus | 1, 4, 6, 10 | 11          | 0.036    | 4.759 | 0.175 | Fruit |

Field observations as shown in Table 3 noted that there were 36 species of orangutan feed plants with a species diversity index (H') of 4.62 and a Hmax of 5.20 which could be categorized as very high [14]. The total number of individual feed tree species found in the study location was 300, which was
dominated by species: Durian (*Durio zibethinus*), Coffee (*Aidia densiflora*), Matoa (*Pometia pinnata*), Sapot (*Macaranga gigantea*) and Sanduduk (*Begonia isoptera*).

In the diversity of Tapanuli Orangutan food species, the total diversity index ($H'$) of 4.62 means that the level of diversity is very high. This is consistent with the statement [8], if $H' < 1.5 = \text{low level of diversity}$, $1.5 = H' = 3.5 = \text{moderate level of diversity}$, and $H' > 3.5 = \text{high level of diversity}$. The difference in diversity values is in line with changes in species composition and uniqueness of the characteristics of ecosystems contained in the APL Area (Other Use Areas). The greater the number of species, the higher the diversity or vice versa if the value is small, the community is dominated by fewer species [17].

One of the formation of forest types is due to differences in adaptation of each type of plant, as well as competition between plants that have a high shade area and plants that are under shade, resulting in a struggle for sunlight and nutrients in the soil. This causes plants that are in the shade does not fully get light for photosynthesis and in general this type of forest is secondary forest. In accordance with the statement of [18], low diversity is present in communities in secondary forest areas, such as areas mixed with plantation plant communities, and nutrient-poor soils. Meanwhile high diversity is found in areas with optimum environment. According to [6], high species diversity indicates that a community has a high complexity, because the interactions that occur within the community are very high. According to [19], if the value of a low diversity index indicates that there is a very high ecological pressure, either from biotic factors (competition between individual plants at each level) or abiotic factors. The high ecological pressure causes not all types of plants to survive in an environment.

4. Conclusions

The number of plants in the study site are 132 species with 36 species of them are feeding plants of Tapanuli orangutan. Shannon Wiener species diversity index for Tapanuli Orangutan food plant has a value of 4.62 which means that the level of diversity is high. The status of land as an area for other uses must give attention to the aspect of balancing in its utilization in order to maintain the value and benefits of area. The biggest challenge in using this land is synchronizing the interests of humans and wildlife so that they can live co-existence.

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Acknowledgements

The author would like to thank the parties who have helped this research activity so that it can run smoothly. Special thanks to the Sumatra Utara Natural Resources Conservation Agency (BKSDA) who has provided input on research and the Yayasan Orangutan Sumatera Lestari - Orangutan Information Center (YOSL - OIC) which is willing to provide material and moral support to USU students in assisting orangutan research studies.