BUKTI KORESPONDENSI ARTIKEL

Murdjoko A, Ungirwalu A, Mardiyadi Z, Tokede MJ, Djitmau DA & Benu NMH (2021) Floristic Composition of Buah Hitam Habitats in Lowland Tropical Mixed Forest of West Papua, Indonesia. Floresta e Ambiente 28.

Berikut adalah proses pengiriman artikel, proses, komentar reviewer, perbaikan dan korespondensi dengan pihak editor jurnal yang dilakukan oleh penulis korespondensi seperti di bawah ini:

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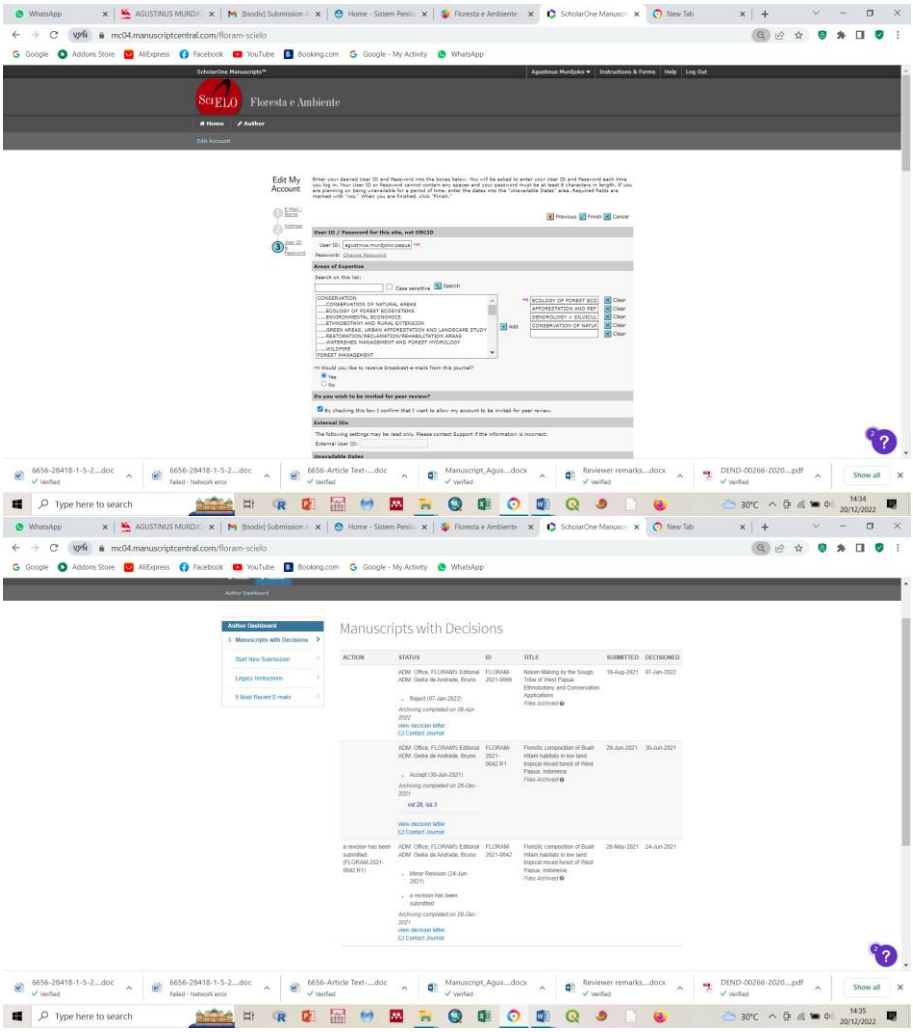
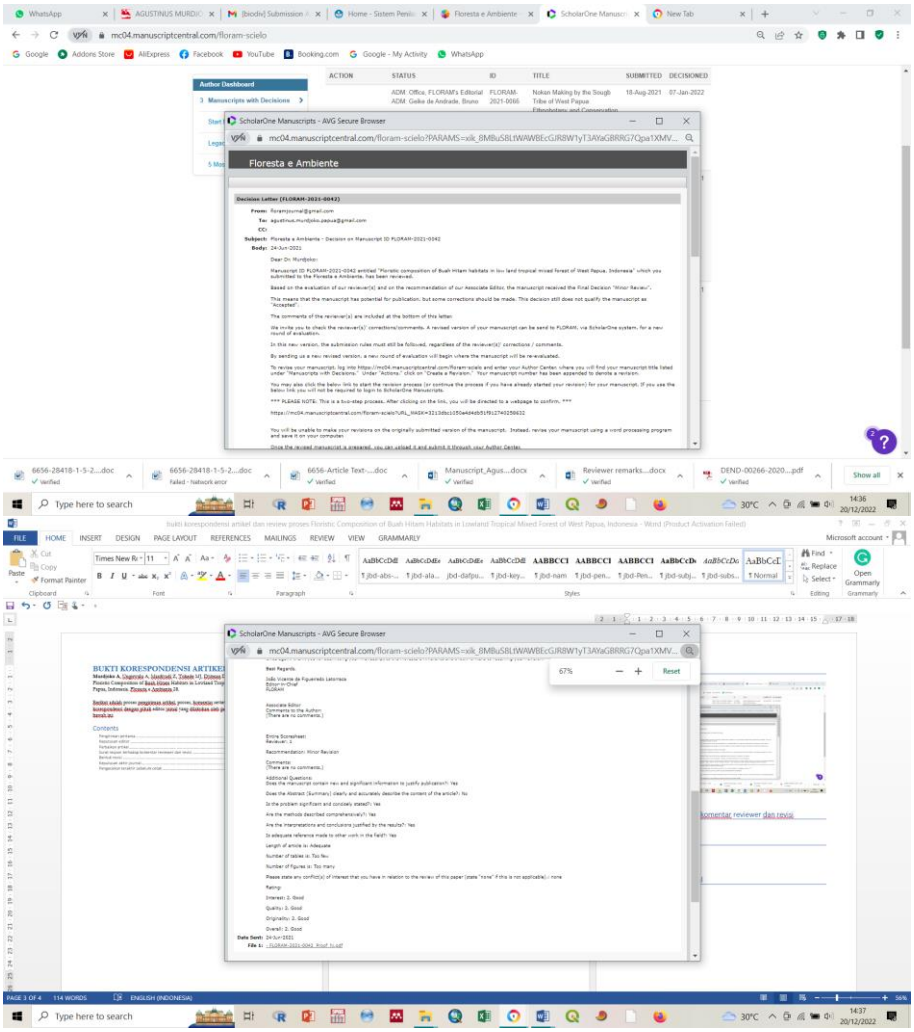
Pengiriman pertama



Keputusan editor



Keputusan adalah revisi minor

Surat respon terhadap komentar reviewer dan revisi

Manokwari, 29 June 2021
Dear Editor of *Floresta e Ambiente* Journal,

We would like to thank for giving the useful comments to improve this manuscript. Here, we have corrected as reviewer suggestions, and then we responded each comment as follows:

- **Abstract** has been edited to show the method and finding. However, we cannot give the detail method as the limit of Abstract must be at least 150 words.
- The use of conjunctions (adverb) were reduced as suggestion. We applied the different adverb.
- In **study area**, we added the map as shown in Figure 1 and information regarding elevation as abiotic condition.
- We changed "Shannon-Wiener index (H') and Pielou's evenness (J')" in the **Data Analysis** and **Figure 3**.
- In the **Results**, we have corrected as reviewer suggestions.
- We have added label for the abscissa refers to the horizontal (x) axis as Habitat type in **Figure 3**, **7**, and **9**.
- In **3.2. Ecological group forming in Buah Hitam habitat**, we added the description below subsection.
- We added information in **Figure 5** as "**Dendrogram of tree species using similarity index (%). The ten species between dashed red lines have the same group as Buah Hitam in the three habitats. The abbreviations for species are displayed in Table 1 (Tree Species and Acronym).**"
- In the **Figure 6**, we added the unit of dependent and independent variables. We also edited the sentences below the **Figure 6.**
- We have edited sentence by rewriting below **Figure 7**.
- We edited discussion as suggestion and added some related references.
- We added "**The authors declare no conflict of interest.**"

We hope that those improvements could increase the quality of manuscript. We wish to get opportunity for publication in *Floresta e Ambiente* Journal.

On behalf of the authors
Best regards,

Agustinus Murdjoko

Structural floristic of *Buah Hitam* habitats in low land tropical mixed forest of West Papua, Indonesia

Abstract

The biotic factors in tropical lowland forests, especially vegetation, are essential for the sustainable management of forest products. Furthermore, this investigation focused on trees as the important structure in the floristic diversity of *Buah Hitam* habitats and tree communities, as the scientific information on this species are largely unknown. The data used was collected from the habitats of *Buah Hitam* in *Wondama* Bay, West Papua, Indonesia, and the data of the tree species were obtained from primary forest, secondary, and the garden. The 26 plots were located purposively on transects of 9 plots in primary forest, 9 plots in secondary forest, and 8 plots in the garden. The species richness and diversity was higher in the primary forest than that in the secondary and garden. The tree communities indicated that the primary forest formed tree species while the secondary and garden showed the similarity in the tree species. The *Buah Hitam* grew dominantly in three habitats with mixed tree species in the three habitats. Since the local people have been using it as part of their life with traditional concepts, the consensual programs by the government and people should be set particularly in conservation and sustainable management for the three habitats.

Keywords: Bird's Head Peninsula, Dendrogram, *Haplolobus*, tree community, PAleontological STatistics

Introduction

Understanding the ecological and phytogeographical factors influencing the distribution of diversity in certain area is imperative. Therefore, this study focused on tropical forest, as it exhibits hyperdiversity under topographical conditions. Furthermore, the lowland tropical rainforests constitute of high biodiversity in terms of the composition of faunal and floral species. The biodiversity produces some benefits such as the production of timber and non-timber. Therefore, the local community as a social factor has been part of the forest, because they have lived and utilized the forest for generations. Most of these practices are based on their local knowledge, which takes into account the sustainability of the forest as a natural resource. By using the method, they have developed a traditional concepts of local knowledge for generations. Subsequently, it is part of the interaction between people and forests, in which their livelihood depends on the forest as a natural resource. Recently, the area in the lowland tropical rainforests is mainly threatened by disturbance, in particular by anthropogenic factors, mainly due to socio-economic development and implemented by the government through empowerment programs, especially in developing countries.

Papua is part of the rainforest that contains widespread tropical ecosystems, from coastal to alpine areas. The local communities have frequently interacted with forest for centuries leading to the development of their knowledge. Non-wood forest products are one of the forest services necessary for their survival, such as nutritional needs, ornamental purposes, etc. The Buah Hitam is a non-wood forest product that has benefited the local Wandamen ethnic groups in particular, living in the part of the eastern part the Bird's Head Peninsula in Wondama Bay. Furthermore, it is taxonomically described as a species of the genus *Haplolobus for which* the accepted name of Latin botanical names can be debated. Therefore, the *Haplolobus* sp was described because the specific morphological characters differed from the accepted species, such as *Haplolobus floribundus* (K.Schum.) and H.J.Lam *Haplolobus monticola* Husson. Then, the *Buah Hitam* was referred to as this species. Furthermore, the traditional use of *Buah Hitam* has shown the local knowledge of ethno-techno-conservation concepts by ethnic Wandamen. This concept is one of examples of the

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application of sustainable management by local communities in tropical rainforest. Therefore, it is necessary to study the habitat of *Buah Hitam* by using ecological approach, with little knowledge of the Buah Hitam ecological habitat.

Ethnic Wandamen grouped the habitats of *Buah Hitam* in this area, generally in lowland location. Then, the location was divided into three groups based on the information, which are primary forest, secondary forest, and garden. All habitats are characterized by high density of vegetation particularly trees as the main structure. Therefore, the environmental condition was different among the habitats, presumably effecting the species guild of tree, species composition, and structure. Furthermore, the ecological process was hypothesized in the three habitats of *Buah Hitam* varies. Subsequently, this investigation focused mostly on tree species comprising the habitat of *Buah Hitam* in Wondama Bay. Therefore, the tree structure of floristic diversity, tree species richness and tree community remained scientifically unknown. Moreover, an understanding of the species composition and species guilds in forest ecosystems is essential in order to set up suitable programs for sustainable forest management.

The specific objectives of this research were to, (1) investigate the species richness and diversity of trees in *Buah Hitam* habitats, and (2) study the tree communities formed by tree species. The results can be used to support scientific information of non-timber forest product management in tropical rainforest and direct conservation program based on traditional concept since the forest is part of the customary forest of ethnic Wandamen.

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Methods

Study Area

This study was conducted in the eastern part of Bird's Head Peninsula and the locations were selected by considering the activity of the local community in utilizing the *Buah Hitam*. Therefore, the four areas were selected to place the plots and they were administratively located in four districts of the Teluk Wondama Regency .viz Wasior (Rado, 2°40'18.06"S, 134°30'17.33"E), Wondiboi (Kaibi, 2°48'14.19"S, 134°31'59.08"E), Rasiey (Tandia, 2°50'32.28"S, 134°32'31.27"E), and Duari (Sobey, 2°32'42.18"S, 134°28'50.97"E). The four locations of the study area were mainly in lowland forest and close to the sea in western and northern parts while the southern part was the coastal area of Teluk Wondama Regency (Two districts: Kuri and Idoor) and eastern part of Wondiwoi Mountains (Nature Reserve). The study area was divided ecologically into three habitats of *Buah Hitam* namely primary forest, secondary forest, and the garden. The primary forest was the characteristic of old-growth forest where anthropogenic intervention was infrequent. The secondary forest was re-growth forest resulting from fallow swidden whilst garden was the location nearby home with vegetation area formed by utilizing the useful plant grow naturally or artificially without agricultural treatments. The information regarding the *Buah Hitam* Habitats was obtained by applying the Snowball sampling during an interview with local people. The locations were predominantly inhabited by ethnic group of Wandamen consisting of subethnic groups namely Wamesa, Kuri, Miere, Mairasi/Toro, Ambumi, and Dusner (Ungirwalu et al. 2018). They have been utilizing *Buah Hitam* as part of their life for generations in which they also apply the local wisdom as part of traditionally sustainable management of *Buah Hitam*. Most of the local people depends on natural resources for their livelihood, as used by the traditional farmers in swidden (Ungirwalu et al. 2017).

The locations are mainly characterized by tropical mixed forest with a large number of families and species of vegetation, of which tree species were the main structure (Ungirwalu 2019; Murdjoko et al. 2021). Alluvial soil was the major species at the sites, with raw organic material ranging from 1.1 % to 2.33 % (C-organic), cation exchange capacity (CEC) was around 5.23-11.56

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meq/100g, nitrogen (N-total) was from 0.12-0.19 %, and Soil pH was about 4.51-6.14 (Ungirwalu et al. 2018). The climate data of mean temperature and mean humidity were 26.4ºC (23.3 ºC and 31.2 ºC, minimal and maximum) and 86.4 % (64.4 % and 97.6 %, minimal and maximum), respectively (Badan Pusat Statistik Kota Teluk Wondama 2019).

Sampling and vegetation observation

26 samples of the plots, which consists of 9 plots in primary forest, 9 plots in secondary, and 8 plots in garden were placed. The distribution of plots based on locations were Wasior (2 plots for each primary forest, secondary forest, and garden), Wondiwoi (2 plots for each primary forest, secondary forest, and garden), Rasiey (3 plots for each primary forest and secondary forest, 2 plots in garden), and Duari (2 plots for each primary forest, secondary forest, and garden). The plot size was 20 m x 20 m for tree data with diameter above 20 cm and there were three subplots inside main plot to collect data of pole as categorized with diameter between 10-20 cm (10 m x 10 m), plot with size 5 m x 5 m was used for the collection of sapling as categorized with height taller than 1.5 m, and plot with size 2 m x 2 m was used for the collection of seedling as categorized with the height less than 1.5 m. The plots were set purposively with minimal distance at least 100 m in habitat of *Buah Hitam* in primary forest, secondary, and garden. The data was collected in the form of taxonomic information (family and species), the number of individuals, and diameter (cm). The species and family were obtained from voucher identified in Herbarium Papuaense of "Balai Penelitian dan Pengembangan Lingkungan Hidup dan Kehutanan (BP2LHK) Manokwari" and Herbarium Manokwariense (MAN) Pusat Penelitian Keanekaragaman Hayati Universitas Papua (PPKH-UNIPA), Manokwari. The scientific names of tree were based on The Plant List (TPL) (http://www.theplantlist.org) and Taxonomic Backbone of the World Flora Online (WFO) (www.worldfloraonline.org).

Data analysis

Tree species richness and diversity

The tree vegetation in the primary forest, secondary, and garden were compared by applying the sample rarefaction (Mao's tau) by setting a matrix of presence-absence data abundance. Therefore, the species accumulation curve was performed to describe the species number in three habitats over the number of individuals (Colwell et al. 2004). The shannon-Wiener index (H') and Pielou's evenness (J') were implemented to analyze the species richness and evenness. The Species abundance curve or Whittaker plot in primary forest was applied to analyze the dominant families and the tree species. The abundance of individuals based on families and tree species was in vertical axis with rank of families and species in descending order in horizontal axis.

Tree community

The tree species were grouped by executing Dendrogram and discussing the tree species growing along with *Buah Hitam*. The graphs of individuals of tree species against diameter class (cm) were employed by dividing into 7 diameter classes with interval of 10 cm. To depict statistically the relationship between tree density and *Buah Hitam* density, the linear regression was computed with the correlation, then 95 % of confidence interval in the regression graph was calculated and shown. The multivariate analysis of Correspondence Analysis (CA) was instigated to examine the tree communities by considering the plots of three habitats in two axes in on the graph of CA. The vertical structure of the three habitats was displayed through comparing the density proportion of seedlings, saplings, poles, and trees in the graphs.

The data was analyzed by operating the (PAleontological STatistics) software version 4.03 as a freeware data analyzer (Hammer et al. 2001).

Results

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Taxonomic richness and diversity in three types of *Buah Hitam* habitat

The data were enumerated from 9, 9, and 8 plots in primary forest, secondary, and garden respectively. The data were described as 1003 individuals of vegetation, 33 families, and 83 species of trees. The individuals distributed in primary forest, secondary, and garden were 345, 381, and 277 respectively. The highest distribution of taxonomic group for family was in the secondary forest (26 families), followed by families in the primary forest (24 families), and the lowest number of families was in the garden (16 families). There was a decrease in species number from primary forest (53 species), secondary forest (47 species), and garden (25 species) (Figure 2 on the left side). The Sample rarefaction (Mao's tau) showed the number of species growth (Taxa S using 95 % confidence) with the increase in the number of individuals (Specimens) in three habitats of *Buah Hitam* (Figure 1). The three species curves displayed the non-linear model in which the growth started early and predictably reached plateau as optimal species number during the data collection. This investigation focused on tree species as a structural vegetation of *Buah Hitam* habitat in the three locations.

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Figure 1. Number of species against number of individuals (specimens) using Sample rarefaction (Mao's tau) in primary forest (PF) and secondary forest (SF), and Garden (G). The confidence intervals for three species curve were 95 percent.

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The species richness of the tree vegetation in the tree locations was defined by means of Shannon wiener index (H'), while the species evenness was expressed as Pielou's evenness index (J') shown in Figure 2 on the right side. The tree species richness displayed the decrease between locations of primary forest and secondary and then there was a gradual increase in garden but lower than the primary forest.

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Figure 2. Species and individual number (left) as well as Shannon wiener index (H') and Pielou's evenness index (J') (right) in primary forest (PF) and secondary forest (SF), and Garden (G). The bar charts use the primary axis (left scale) and the line charts use the secondary axis (right scale).

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Figure 3. Ranking of the species abundance curve or Whittaker plot in primary forest (a) and secondary forest (b), and Garden (c). The family rank is displayed in primary forest (d) and secondary forest (e), and Garden (f). Y-axis (Abundance) is the relative abundance and X-axis (Rank) is the species and family rank.

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Species density was ranked in three habitats in ascending order, as shown in Figure 3. The *Haplolobus monticola* was was the dominant species in the three habitats with variation of density. The dominant family in the three habitats were *Burseraceae* based on the number of individuals and species (Figure 3). The highest density was in the secondary forest in which the dominant species were more or less than 120 individuals. The dominant species in the garden was about 65 individuals, and the dominant species in the primary forest was approximately 45 individuals. The dominance of families and tree species in three habitats has been shown for ten families and species, the composition of which varies between the three locations, as shown in Figure 3 below for the dominant family and above the dominant species. The five dominant families in primary forest were *Burseraceae*, *Sapindaceae*, *Myristicaceae*, *Meliaceae*, and *Moraceae*. The top five families in the secondary forest were *Burseraceae*, *Moraceae*, *Meliaceae*, *Sapindaceae*, and *Lamiaceae*. The garden was dominantly presented by families of *Burseraceae*, *Sapindaceae*, *Meliaceae*, *Anacardiaceae*, and *Lamiaceae*. The five dominant species in primary forest were *Haplolobus monticola* Husson, *Artocarpus integer* (Thunb.) Merr, *Lansium domesticum* Corrêa, *Litsea* timoriana Span and Myristica fatua Houtt. The secondary forest were mainly presented by *Haplolobus monticola* Husson, *Artocarpus altilis* (Parkinson

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ex F.A.Zorn) Fosberg, *Lansium domesticum* Corrêa, *Artocarpus heterophyllus* Lam., and *Mangifera indica* L. whilst the species of *Haplolobus monticola* Husson, *Lansium domesticum* Corrêa, *Mangifera indica* L., *Nephelium lappaceum* L., and *Syzygium malaccense* (L.) Merr. & L.M.Perry grew predominantly in the garden. The analysis of dominant families and species showed different results in three habitats of Buah Hitam. Furthermore, the three habitats were compared in order to illustrate the structural vegetation of tree species as part of the biotic elements in ecological condition. This study focused mainly on tree species as the main factor behind the creation of the three types of forest as habitat of *Buah Hitam*, particularly the lowland tropical forest.

Ecological group forming in *Buah Hitam* habitat

Figure 4. Dendrogram of tree species using similarity index (%).

Table 1. List of tree species (83) and family (33) in primary forest (PF) and secondary forest (SF), and Garden (G) with number represented as density.

Dendrogram analysis was performed in order to group the species trees based on position on the sites. The tree species were distributed in primary and secondary forest forming the mixed species while the garden site tends to have more planted vegetation. The formation of tree community here is focused on the tree species growing around *Buah Hitam* species. The acronyms of tree species were shown in Table 1. The result showed that ten species had the strong relation with *Buah Hitam* namely *Artocarpus heterophyllus* Lam., *Citrus* sp, *Sterculia schliebenii* Mildbr., *Clerodendrum* sp, *Artocarpus altilis* (Parkinson ex F.A.Zorn) Fosberg, *Premna corymbosa* Rottler & Willd., *Lansium domesticum* Corrêa, *Mangifera indica* L., *Nephelium lappaceum* L., and *Pometia pinnata* J.R. Forst. & G. Forst.

Figure 5. The destruction of individuals of tree species against diameter class (cm) in three habitats of *Buah Hitam* (a). Distribution of *Buah Hitam* individuals based on diameter class (cm) (b).

The individuals of tree species showed the reverse J-shaped model in the tree habitats of *Buah Hitam* as displayed in Figure 5a. The individuals of tree species were distributed from small diameter to more or less 60 – 69 cm, unless for individuals in the garden in this class diameter, which was missing. In general, the three habitats provided an abundant number of small trees typified by having small diameters particularly less than 10 cm. The stock of the small trees can be used to indicate the regeneration of trees in three habitat in which the process of regeneration is suitable for all tree species. In contrast, the distribution of individuals of *Buah Hitam* in the three habitats did not follow the reverse J-shaped model, but there was the availability of *Buah Hitam* in almost class diameter except the diameter larger than 50 in garden habitat. The regeneration of *Buah Hitam* was running well as the number of individuals of small and larger was available even though the number of individuals was not abundantly distributed (Figure 5b).

Figure 6. The correlation between tree density (n.ha^{-1}) denoted by x and the density of Buah Hitam denoted by y (n.ha^{-1}) was described as linear model with equation y = 0.0988x + 6.1845 and coefficient of determination (R^2) = 0.3908. The 95% confidence limits (blue lines) for the average (red line) are shown in graph.

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The regression and correlation analysis was implemented in order to figure out the relationship between tree density (independent variable) and *Buah Hitam* density (dependent variable) (as pictured in Figure 6). The equation model was described linearly as y = 0.0988x + 6.1845, where the indicated y was a dependent variable and x was the symbol for the independent variable. The contribution of tree density to the number of *Buah Hitam* density was explained statistically using a coefficient of determination (R^2), in which about 40 % of distribution of *Buah Hitam* density was expressed by tree density in the three habitats. Furthermore, 95 % of confidence interval was applied to the linear regression as shown when the blue lines explained the upper and lower limit.

Figure 7. Correspondence Analysis (CA) of plot distribution in primary forest (**x**) and secondary forest (□), and Garden (●) to show pattern of tree communities.

The Correspondence Analysis was computed to describe the tree communities form in the habitat of Buah Merah as illustrated in Figure 7. The plots of primary forests seems to be distributed by creating groups unless one plot joining another group, while the plots of secondary forest and garden tends to constitute a group except for one plot of the garden. The first axis (Axis 1) explained 13.9 % of variation in this model while the second axis (Axis 2) described 9.94 % of variation of this model.

Figure 7. Density proportion of seedlings, saplings, poles, and trees in primary forest (PF) and secondary forest (SF), and Garden (G).

The structure of tree species under three habitats can be explained by specifying the density ratio. Then, the distribution of tree species in the three habitats was described by seedlings, saplings, poles, and trees as shown in Figure 7. The number of seedlings was highest in secondary forest and the lowest number of seedlings was present in primary forest. The saplings were abundantly in primary forest followed by garden and secondary forest, respectively. The larger individuals were described using poles and tree, as the number of both seems to be more or less similar among the three habitats.

Discussion

Density of individuals and floristical composition affect the habitat of *Buah Hitam*

The species composition of the trees in the habitats of Buah Hitam varies in the primary forest, in the secondary forest and in the garden. The primary forest here is characterized as a mixed tropical forest with many species. This biotic state in the primary forest was similar to that of the secondary forest, especially the composition of the tree species, while the garden contains fewer tree species compared to the two forests. The secondary forest is a result from the swidden activity where the rotation of agriculture was not studied intensively and the cycle is unclear during traditional crops. The ex-field of crops were normally left recovering itself during post-swidden. Therefore, the composition of species differed from the primary forest by the decreasing number of tree species. Subsequently, the garden was created through the establishment of a settlement in an area that previously functioned as secondary forest and the local communities have been living there for generations. Gardening is about gathering useful plants, but they have spent some time planting the vegetation extensively while making a living from the forest and other natural resources. Therefore, there has been some composition of tree species growing in the garden.

The density of tree species in all three habitats formed an abundance of small individuals as a dynamic population process in the tropical forest. Regardless of the species compositing, the regeneration of tree species in three habitats of Buah Merah was successfully established during

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the natural process. The vertical structure relationship in the three habitats of Buah Merah includes seedlings, trees, poles and trees, where small individuals (seedlings and trees) were mostly larger than larger individuals (poles and trees).

Ecological condition in forming tree communities

The individuals of *Buah Hitam* have strong relationship with other tree species in which the ten species were mostly present along with *Buah Hitam* (Figure 4). The dendrogram was executed to see how many species had heterospecific associations forming the tree community. The six species, namely *Artocarpus heterophyllus*, *Citrus* sp, *Sterculia schliebenii*, *Clerodendrum* sp, *Artocarpus altilis*, and *Premna corymbosa* mostly grow in the secondary forest and garden. The formation of the Buah Hitam tree community was mainly a result of human activity, while the Buah Hitam seed was used less when it was used in the ethnobotanical process, which left the number of seeds on the ground, especially in the secondary forest and garden. This was a part of traditional activity including the *Buah Hitam* utilization. Besides, the reproductive season of this species is annual, and therefore the availability of *Buah Hitam* has met the local people's need particularly as nutrient supply. This maybe the reason that the correlation between tree density and *Buah Hitam* density was about 39 % where the increase of tree density positively affects the density of *Buah Hitam*. It was therefore imperative to explain that the tree community of *Buah Hitam* habitas formed generaly two groups viz. mainly primary forest and both secondary forest with garden (Figure 7).

The regeneration of Buah Hitam was mainly influenced by anthropogenic factors, especially in secondary forests and gardens. Therefore, the number of Buah Hitam individuals with a diameter of less than 30 cm in the secondary forest and garden compared to those in the primary forest are shown in Figure 5b. The *Buah Hitam* in primary forest regenerated naturally for decades and is therefore the less number of small individuals. Therefore, the regeneration process depends on natural dynamic as seed dispersal was predictably conducted by bats or other wildlife. Some of the seeds have been moved away from the parent trees creating a negative-conspecific association. Based on observation and interview that the *Buah Hitam* was frequently taken by bats as food, the locals used traditional pest control known as apiaimi and kabareru, which was part of the ethno-techno protection concept in the area. The traditional pest control was mostly conducted in secondary forest where the distance from their home was taken into consideration. Only a few have implemented the traditional pest control in primary forest by having specific reason such as the abundance of harvestable fruits from trees. In the garden, the *Buah Hitam* trees rarely experienced pest activity such as bats. Consequently, the *Buah Hitam* tress in primary forest functioned as food supply for wildlife.

Strategies of sustainable management acquired from traditional conservation concept

The habitat of Buah Hitam can be used to develop traditional protection concepts, especially in the primary forest. The majority of the local population continues to believe that the dynamics are limiting natural resources in order to preserve the forest ecosystem. This research revealed that the primary forest has been reserved as natural place and the local people have utilized the part of secondary forest as a result of shifting cultivation. Although their livelihood fully depends on natural forest, they only worked in secondary forest and garden as swidden agriculture, as their ancestors carried out in a similar field. However, an extensive research regarding swidden and conservation are less known, but the swidden has been conducted for generations in this area. Therefore, this research suggested that the traditional concept of conservation should be considered by the government to view development on a conservation basis, as formally stated in the declaration. Involving the local community in regional development is mandatory in order to acquire the traditional concept that supports the sustainable management of natural resources, especially forests. The government has reviewed the Mount Wondiwoy nature reserve, but on the

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edge of the nature reserve, consideration should be given to the case where the government is required to establish a forest based on local knowledge as consensus programs. In brief, by delineating the forest area to create traditional zones, this can be the possible program for conservation particularly *in-situ* conservation programs, and conduct the regular monitoring of species in this area particularly vegetation.

Acknowledgments

This research is part of the "Penelitian Terapan Unggulan Perguruan Tinggi RISTEKDIKTI 2021". The authors expresses profound gratitude to Teluk Wondama Regency, Fakultas Kehutanan Universitas Papua, kepada Balitbangda Provinsi Papua Barat, and Kepala Biro Administrasi Pembangunan Provinsi Papua Barat for permit, field guide, supporting. We are extremely grateful to anonymous reviewer(s) for improving this work.

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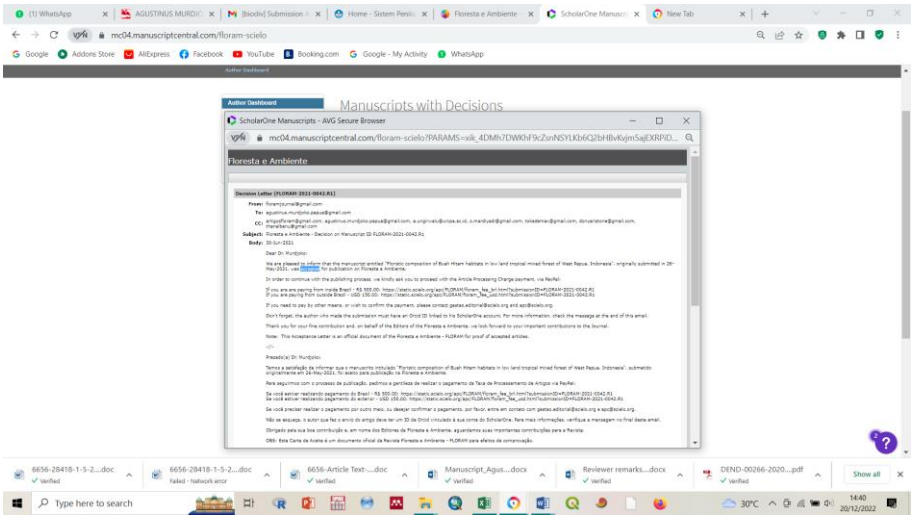

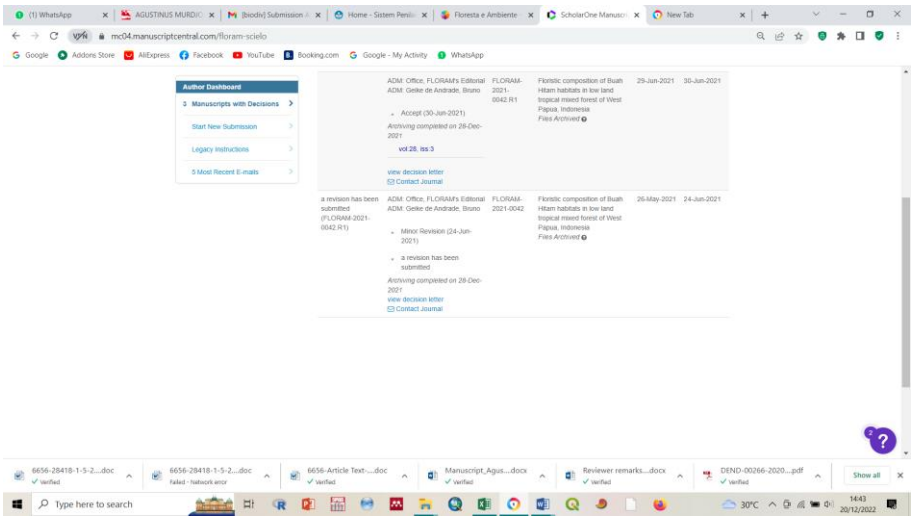
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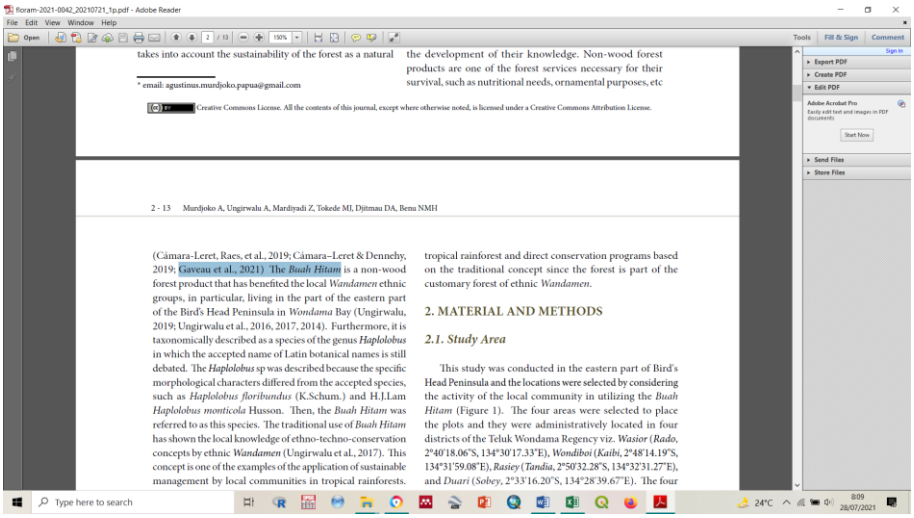

takes into account the sustainability of the forest as a natural

the development of their knowledge. Non-wood forest products are one of the forest services necessary for their survival, such as nutritional needs, ornamental purposes, etc

* email: agustinus.murdjoko.papua@gmail.com

(Câmara-Leret, Raes, et al., 2019; Câmara–Leret & Dennehy, 2019; Gaveau et al., 2021) The *Buah Hitam* is a non-wood forest product that has benefited the local *Wandamen* ethnic groups, in particular, living in the part of the eastern part of the Bird's Head Peninsula in *Wondama* Bay (Ungirwalu, 2019; Ungirwalu et al., 2016, 2017, 2014). Furthermore, it is taxonomically described as a species of the genus *Haplolobus* in which the accepted name of Latin botanical names is still debated. The *Haplolobus* sp was described because the specific morphological characters differed from the accepted species, such as *Haplolobus floribundus* (K.Schum.) and H.J.Lam *Haplolobus monticola* Husson. Then, the *Buah Hitam* was referred to as this species. The traditional use of *Buah Hitam* has shown the local knowledge of ethno-techno-conservation concepts by ethnic *Wandamen* (Ungirwalu et al., 2017). This concept is one of the examples of the application of sustainable management by local communities in tropical rainforests. tropical rainforest and direct conservation programs based on the traditional concept since the forest is part of the customary forest of ethnic *Wandamen*.

2. MATERIAL AND METHODS

2.1. Study Area

This study was conducted in the eastern part of Bird's Head Peninsula and the locations were selected by considering the activity of the local community in utilizing the *Buah Hitam* (Figure 1). The four areas were selected to place the plots and they were administratively located in four districts of the Teluk Wondama Regency viz. *Wasior* (*Rado*, 2°40'18.06"S, 134°30'17.33"E), *Wondiboi* (*Kaibi*, 2°48'14.19"S, 134°31'59.08"E), *Rasiey* (*Tandia*, 2°50'32.28"S, 134°32'31.27"E), and *Duari* (*Sobey*, 2°33'16.20"S, 134°28'39.67"E). The four

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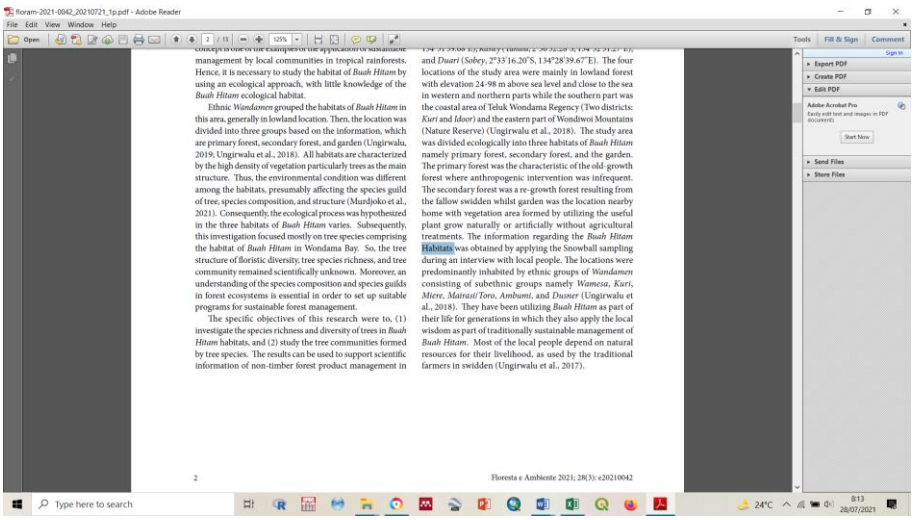

management by local communities in tropical rainforests. Hence, it is necessary to study the habitat of *Buah Hitam* by using an ecological approach, with little knowledge of the *Buah Hitam* ecological habitat.

Ethnic *Wandamen* grouped the habitats of *Buah Hitam* in this area, generally in lowland location. Then, the location was divided into three groups based on the information, which are primary forest, secondary forest, and garden (Ungirwalu, 2019; Ungirwalu et al., 2018). All habitats are characterized by the high density of vegetation particularly trees as the main structure. Thus, the environmental condition was different among the habitats, presumably affecting the species guild of tree, species composition, and structure (Murdjoko et al., 2021). Consequently, the ecological process was hypothesized in the three habitats of *Buah Hitam* varies. Subsequently, this investigation focused mostly on tree species comprising the habitat of *Buah Hitam* in Wondama Bay. So, the tree structure of floristic diversity, tree species richness, and tree community remained scientifically unknown. Moreover, an understanding of the species composition and species guilds in forest ecosystems is essential in order to set up suitable programs for sustainable forest management.

The specific objectives of this research were to, (1) investigate the species richness and diversity of trees in *Buah Hitam* habitats, and (2) study the tree communities formed by tree species. The results can be used to support scientific information of non-timber forest product management in

and *Duari* (*Sobey*, 2°33'16.20"S, 134°28'39.67"E). The four locations of the study area were mainly in lowland forest with elevation 24-98 m above sea level and close to the sea in western and northern parts while the southern part was the coastal area of Teluk Wondama Regency (Two districts: *Kuri* and *Idoor*) and the eastern part of Wondiwoi Mountains (Nature Reserve) (Ungirwalu et al., 2018). The study area was divided ecologically into three habitats of *Buah Hitam* namely primary forest, secondary forest, and the garden. The primary forest was the characteristic of the old-growth forest where anthropogenic intervention was infrequent. The secondary forest was a re-growth forest resulting from the fallow swidden whilst garden was the location nearby home with vegetation area formed by utilizing the useful plant grow naturally or artificially without agricultural treatments. The information regarding the *Buah Hitam* Habitats was obtained by applying the Snowball sampling during an interview with local people. The locations were predominantly inhabited by ethnic groups of *Wandamen* consisting of subethnic groups namely *Wamesa*, *Kuri*, *Miere*, *Matrasi/Toro*, *Ambumi*, and *Dusner* (Ungirwalu et al., 2018). They have been utilizing *Buah Hitam* as part of their life for generations in which they also apply the local wisdom as part of traditionally sustainable management of *Buah Hitam*. Most of the local people depend on natural resources for their livelihood, as used by the traditional farmers in swidden (Ungirwalu et al., 2017).

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Should be : habitats (lower case)

Figure 1. The four locations of the research study on the main map (white boxes).

The locations are mainly characterized by tropical mixed forests with a large number of families and species of vegetation, of which tree species were the main structure (Murdjoko et al., 2021; Ungirwalu, 2019). Alluvial soil was the major species at the sites, with raw organic material ranging from 1.1 % to 2.33 % (C-organic), cation exchange capacity (CEC) was around 5.23-11.56 meq/100g, nitrogen (N-total) was from 0.12-0.19 % and Soil pH was about 4.51-6.14 (Ungirwalu et al., 2018). The climate data of mean temperature and mean humidity were 26.4°C (23.3 °C and 31.2 °C, minimal and maximum) and 86.4 % (64.4 % and 97.6 %, minimal and maximum), respectively (Badan Pusat Statistik Kota Teluk Wondama, 2019).

2.2. Sampling and vegetation observation

26 samples of the plots, which consists of 9 plots in primary forest, 9 plots in secondary, and 8 plots in the garden were placed. The distribution of plots based on locations were *Wasior* (2 plots for each primary forest, secondary forest, and garden), *Wondiwoi* (2 plots for each primary forest, secondary forest, and garden), *Rasiey* (3 plots for each primary forest, and secondary forest, 2 plots in garden), and *Duairi* (2 plots for each primary forest, secondary forest, and garden). The plot size was 20 m x 20 m for tree data with a diameter above 20 cm and there were three subplots inside the main plot to collect data of pole as categorized with diameter between 10-20 cm (10 m x 10 m), plot with size 5 m x 5 m was used for the collection of sapling as categorized with a height taller than 1.5 m, and plot with size 2 m x 2 m was used for the collection of seedling as categorized with the height less than 1.5 m. The plots were set purposively with a minimal distance of at least 100 m in the habitat of *Buah Hitam* in primary forest, secondary, and garden. The data was collected in the form of taxonomic information (family and species), the number of individuals, and diameter (cm). The species and family were obtained from voucher identified in Herbarium *Papuaense* of "*Balai Penelitian dan Pengembangan Lingkungan Hidup dan Kehutanan* (*BP2LHK*) Manokwari" and Herbarium *Manokwariense* (*MAN*) *Pusat Penelitian Keanekaragaman Hayati* Universitas Papua (PPKH-UNIPA), Manokwari. The scientific names of the tree were based on The Plant List (TPL) (http://www.theplantlist.org) and Taxonomic Backbone of the World Flora Online (WFO) (www.worldfloraonline.org).

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Those are the corrections. We hope that those could be changed.

On behalf of authors.
Best regards,

Agustinus Murdjoko