Diversity of vegetation in three cover types of forest at Mappi District, Papua

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Abstract. Diversity of vegetation in three cover types of forest, Mappi, Papua. Mappi District, located in southern part of Papua, is one area that has a unique forest area especially in biodiversity species of flora. The aim of this study is to know the types of vegetation and their potential. Observations were made using 9 plots, 20 x 20 m² in size of each plot; as tree (DBH [Diameter at Breast Height] ≥ 20 cm), 10 x 10 m² in size; as pole (10 ≤ DBH <20 cm), 5 x 5 m²; as sapling (DBH <10 cm) and 2 x 2 m²; as seedling. All vegetation in the plot are inventoried according to their growth rate. The location of the observation is based on land covers, namely swamp, secondary dryland and primary dryland forests. The results showed that the ecosystem in the swamp forest is located on the banks of the river with vegetation cover varying up to the mainland, such as Pandanus tectorius, Stenoclaena palustris, Cerbera manghas, where the species S. palustris is the species that mostly covers the forest floor. In the secondary forest, the vegetation types were consisted of Tristaniopsis ferruginea, Canarium denticulatum, Rhodamnia cinerea, Aporosa sp. and Palaquium sp. While in the primary dryland forests had stands of several species with high canopy and the forest floor covered by thin litter as lowland forest ecosystems, such as Santiria apiculata, S. laevigata, Cryptocarya crassimervia, Fagraea racemosa, Gonystylus macrophyllus, Vatica rassak and Prunus arboarea.

1. Introduction

Papua is one of the tropical forest areas in Indonesia which has the most complete vegetation in the world and a very high diversity of flora, as well as the largest area of forest resources remaining in Indonesia in tropical forests [1, 2]. Mappi District, located in southern part of Papua, is one area that has a unique forest area, but the tree cover for 19 years (2001-2018) decreased by 59,000 ha [3]. The reduced area of land cover and/or forest area due to land use by the community in a nomadic way, so it will have an impact on the existence of biodiversity species, especially flora.

In Mappi District, there are 17 rare vegetation types, namely shrubs, swamp shrubs, primary dryland forests, secondary dryland forests, primary mangrove forests, secondary mangrove forests, primary swamp forests, secondary swamp forests, plantation forests, dry land agriculture, mixed dryland agriculture, bush, savanna, swamp, plantation, open land and water body [4, 5]. Swamp forest is a typical ecosystem of southern Papua, especially in Mappi District, because the ecosystem is influenced by the monsoon climate. During the wet season the forest floor will be submerged in water, while in the dry season some species of vegetation will adapt to forest fires.
Merupakan tipe hutan yang umum ditemukan di Papua yang mempunyai kanopi yang agak terbuka tetapi lebat [5].

Unlike the other islands in Indonesia, forest area conditions in Papua are still protected. In the Biodiversity Action Plan for Indonesia, forest cover in Papua is estimated at more than 90% [6], 1993, or forest cover reaches 75-80% [7]. A little information of vegetation types from Mappi District, as well as the rapid rate of deforestation. Therefore, the purpose of this study is to provide information on the types of vegetation and their potential in Mappi Regency. This is important in addition to completing information about the species of flora in the Bogoriense Herbarium and also as an effort to conserve the area by using an adaptive species.

2. Methodology
2.1. Study site
The research area located at Assue Sub-District, Mappi District, Papua, Indonesia, situated at 5°51'7.24" S and 139°9'15.67" S, as shown in figure 1. To reach the site, it required ten hours of the main city of Mappi by car with not-paved and muddy road condition. The area includes tropical lowland evergreen rain forest and heath forest as well as several areas of shifting cultivation fallow of various ages.

The sampling plots are ca. 0-100 m asl and soil has dominated by gleisol type followed by cambisol and podsolic types [8]. Slope conditions are mostly flat (0-8%). Annual rainfall average is 4,023 mm during 2013-2017, with the wet months within a year, except August and September, and climate type was A with Q value reaching 5.26% or lower than 14.3% [9]. Also the location is being in the Eilanden watershed.

2.2. Data Collection
The characteristics of different stages of vegetation of growth were obtained by species composition, tree structure, tree volume and tree biomass. In nine plots, each 20m x 20m or 0.36 ha plot was set up in representative areas of vegetation. All vegetation in the plot were inventoried, recorded and identified according to growth rate, such trees, poles, saplings and seedlings. Unidentified vouchers in the field were transported to the Herbarium Bogoriense of Research Center for Biology, LIPI, Cibinong, West Java.

Trees were defined as having a DBH (Diameter at Breast Height) equal or greater than 20 cm, poles with 10 ≤ DBH < 20 cm, saplings with DBH ranging from 1 to lower than 10 cm and seedlings with
DBH less than 1 cm. Tree measurement were in size 20m x 20m, for poles in size 10m x 10m plot, for saplings in size 5m x 5m and for seedlings in size 2m x 2m. Importance Value Index (IVI) is used to figure out dominance of a species in a community [10]. The calculation equation of IVI, as follows:

- **Density (D; N ha⁻¹)**
  \[ \text{Density} (D) = \frac{\text{Number of individuals}}{\text{Unit area in plot}} \]

- **Relative Density (RD; %)**
  \[ \text{Relative Density} (RD) = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100\% \]

- **Frequency (F)**
  \[ \text{Frequency} (F) = \frac{\text{Points occupied of a given species}}{\text{Distribution a species in plot}} \]

- **Relative Frequency (RF; %)**
  \[ \text{Relative Frequency} (RF) = \frac{\text{Frequency of a given species}}{\text{Frequency of all species}} \times 100\% \]

- **Dominance (Dm; m² ha⁻¹)**
  \[ \text{Dominance} (Dm) = \frac{\text{Basal area of a species}}{\text{Total basal area of a species per unit area}} \]

- **Relative Dominance (RDm; %)**
  \[ \text{Relative Dominance} (RDm) = \frac{\text{Dominance of a species}}{\text{Dominance of all species}} \times 100\% \]

- **Important Value Index (IVI)**
  \[ \text{IVI} = \text{RD} + \text{RF} + \text{RDm} \]

Furthermore, the volume and potential stand / biomass of trees were estimated using the equation [11] and then converted into per hectare biomass.

3. **Result and Discussion**
Observation of flora biodiversity at the study site was based on land cover using nine observation plots, consisting of several land covers, namely swamp forest, secondary dryland forest and primary dryland forest. Swamp forest are generally bordered by rivers filled with species of blade grass (rumput pisau), Pandanus and fern species located alongside the river, while the secondary and primary dryland forests located distance from the river's edge are filled with standing stands to be larger than 100 cm in diameter.

3.1. *Swamp Forest*
At the tree level, at the research location located in the function of the area in the form of a Production Forest, there are a number of trees diameter > 20 cm growing sporadically. Ecosystems in swamp forests are located after shrub vegetation as riparian ecosystems on river banks with vegetation cover varying up to the mainland, such as *Pandanus tectorius*, *Stenoclaena palustris*, *Cerbera manghas*, where *S. palustris* is a species that mostly covers forest floor. In some locations in the swamp forest there is a stretch of *Eucalyptus papuana* with a diameter of approx. 20 to 30 cm. In the sampling plot consisted of six tree species, the density of 200 trees ha⁻¹ and the basal area (BA) reached 15.91 m² ha⁻¹, the commonly found species that was sago (*Metroxylon sagu*) which grew naturally and had the highest IVI reaching 81.19, as shown in table 1. The diameter of the tree ranges from 21 to 40 cm and the height of the bole length between 8 to 17 m.

| No | Species Name    | Family    | RDM² | RD%  | RF%  | IVI% |
|----|----------------|-----------|------|------|------|------|
| 1  | *Metroxylon sagu* | Arecaceae | 40.12| 12.50| 28.57| 81.19|
| 2  | *Ficus septica*  | Moraceae  | 20.34| 31.25| 14.29| 65.88|

*Table 1. List of stand species in swamp forest at tree level according to Importance Value Index (IVI)*
3 Alstonia pneumatophora Apocynaceae 12.86 25.00 14.29 52.14
4 Campnosperma brevipetiolatum Anacardiaceae 10.43 12.50 14.29 37.22
5 Melaleuca leucadendra Myrtaceae 9.11 12.50 14.29 35.90
6 Hevea brasiliensis Euphorbiaceae 7.14 6.25 14.29 27.67

*RDm (Relative Dominance); *RDm (Relative Density); *RF (Relative Frequency); *d (Important Value Index)

The large number of sago stands shows the location is a permanent shallow swamp forest and regularly gets a supply of fresh water. The amount of *Metroxylon sagu* stand is also influenced by the community who cut down the trees in the lowland mixed forest for the purpose of firewood and building materials, so that the logged areas will be filled with sago and will inhibit the growing of other trees, such as *Terminalia copelandii*, *Garcinia dulcis* and *Myristica* sp., and *Calophyllum papuana* [12]. Swamp forests are abundant in the lowlands along the southern coast of Papua. Campnosperma which are the dominant forest tree species can reach a height of 30-35 m. A similar finding in swamp forest is generally overgrown by sago (*Metroxylon sagu*) and pandan (*Pandanus* spp.) [5] [12].

The species of *C. brevipetiolatum* and *C. papuana* is often used by the Yachai tribe in Mappi District as material for making boat, but the currently wood has been reduced [13]. Those species was observed outside the sampling plot. Potential stands, except sago, are dominated by *Ficus septica* with a stand volume reaching 72.19 m³ ha⁻¹ and biomass reaching 122.78 Mg ha⁻¹, as listed in table 2.

| No | Species Name         | Family   | Volume (m³ ha⁻¹) | Biomass (Mg ha⁻¹) |
|----|----------------------|----------|------------------|-------------------|
| 1  | *Ficus septica*      | Moraceae | 25.86            | 70.92             |
| 2  | Alstonia pneumatophora | Apocynaceae  | 19.11            | 13.99             |
| 3  | Campnosperma brevipetiolatum | Anacardiaceae | 13.94            | 11.96             |
| 4  | Melaleuca leucadendra | Myrtaceae | 9.31             | 15.78             |
| 5  | Hevea brasiliensis   | Euphorbiaceae | 3.97            | 10.12             |
|    | Total                |          | 72.19            | 122.78            |

The poles level, vegetation cover is somewhat different from the tree level consisting of seven species. The density and BA were 213 trees ha⁻¹ and 31.13 m² ha⁻¹, respectively. The main constituent plant species are kayu susu (*Alstonia pneumatophora*) which is the dominant species compared to other species that grow clumpy, followed by *Ficus septica*, *Melaleuca leucadendra* and *Campnosperms brevipetiolatum* which grow solitary, with a range of diameter stands from 11 to 18 cm. Stand species at pole level based on IVI clearly shown in table 3.

| No | Species Name         | Family   | Rdm⁷ | RD₉ | RF₉ | IVI⁷ |
|----|----------------------|----------|------|-----|-----|------|
| 1  | *Alstonia pneumatophora* | Apocynaceae  | 35.74 | 35.29 | 14.29 | 85.32 |
| 2  | *Ficus septica*      | Moraceae | 20.47 | 17.65 | 14.29 | 52.41 |
| 3  | *Melaleuca leucadendra* | Myrtaceae | 19.97 | 17.65 | 14.29 | 51.90 |
The potential stands regarding to tree volume and biomass, respectively, reached 24.86 m³ ha⁻¹ and 19.39 Mg ha⁻¹ (table 4).

Table 4. Stand potencies in swamp forest at pole level according to their volume and biomass

| No | Species Name        | Family       | Volume (m³ ha⁻¹) | Biomasa (Mg ha⁻¹) |
|----|---------------------|--------------|------------------|-------------------|
| 1  | Alstonia pneumatophora | Apocynaceae  | 10.58            | 7.34              |
| 2  | Ficus septica       | Moraceae     | 7.16             | 4.09              |
| 3  | Melaleuca leucadendra | Myrtaceae    | 3.06             | 4.25              |
| 4  | Campnosperma brevipetiolatum | Anacardiaceae | 2.01             | 1.46              |
| 5  | Syzygium plumeum    | Myrtaceae    | 1.66             | 1.40              |
| 6  | Rhodamnia cinerea   | Myrtaceae    | 0.40             | 0.86              |
|    | **Total**           |              | **24.86**        | **19.39**         |

The sapling density reaches 600 ha⁻¹ trees with plant species such as Rhodamnia cinerea and Garcinia dulcis. While the seedling density was 31,250 ha⁻¹, consisting of rumput pisau (*Eleocharis dulcis*), pinang (*Areca catechu*), terantang (*Campnosperma brevipetiolatum*) and kayu susu (*A. pneumatophora*). The stand condition of the swamp forest is presented in figure 2.

![Figure 2. Location of swamp forest](image-url)

Some species that characterize swamp forests are the presence of standing species of terantang (*C. brevipetiolatum*), kayu susu (*A. pneumatophora*) and *G. dulcis*. Total potential stands at tree and pole levels in swamp forests are quite high than the average the potential stand was 20 m³ ha⁻¹ (personal comm.), indicating the study sites in swamp forests are still productive forest. In contrast, the potential swamp forests is a bit lower than the potential of swamp forests in swamp forests of sago [6].
The similar finding of the estimated stand potential at the study site is lower than the stand potential in Jayapura Natural Forest with moderate to dense density, ranging from 265-387 Mg ha\(^{-1}\) [14], and the potential of forest resources from the national forest inventory plot in Papua reaches 146 Mg ha\(^{-1}\) [15]. Regarding the vegetation conditions in the sampling plot could be indicated as mixed swamp forest, while outside the sampling plot there are swamp forest on a wide area with certain species, such as sago swamp forest, Melaleuca swamp forest and Eucalyptus swamp forest. The species found at the study site are the characters of swamp forest that have varying canopy in the upper layer and lower canopy, and there are often black pools of water along the land [16-17].

3.2. Secondary dryland forest

Location of in secondary dryland forest have more tree species than in swamp forests, this can be influenced by forest conditions that are less affected by tides and the accessibility and use of wood by the community only on certain species. Although the observed stand species is a transition between swamp forest and terrestrial forest, which is a lowland forest ecosystem, such as the species of *Tristaniopsis ferruginea*, *Canarium denticulatum*, *Rhodamnia cinerea*, *Aporosa* sp. and *Palaquium* sp. In the observation plot, the tree level consists of 17 tree species with the density of 200 trees ha\(^{-1}\) and the BA reaching 23.16 m\(^2\) ha\(^{-1}\), also diameter ranging from 20 to 105 cm. In contrast, the density and BA of secondary dryland forest in Papua was, respectively, 938 trees ha\(^{-1}\) dan 19.10 m\(^2\) ha\(^{-1}\) [15]. The main species in the secondary dryland forest was *T. ferruginea* based on IVI reaching 66.30, the highest IVI value of the species larger than 30 indicating the *T. Ferruginea* can perform as a balance species in the secondary dryland forest ecosystem. List of stand species in secondary dryland forest a clearly shown in table 5. The potential stands are dominated by *T. ferruginea* with a stand volume of 72.71 m\(^3\) ha\(^{-1}\) out of a total stand volume of 175.52 m\(^3\) ha\(^{-1}\) and biomass reaching 244.78 Mg ha\(^{-1}\), as shown table 6.

**Table 5.** List of stand species in secondary dryland forest at tree level according to Importance Value Index (IVI)

| No | Species Name          | Family     | RDm³ | RD² | RF | IVI² |
|----|-----------------------|------------|------|-----|----|------|
| 1  | *Tristaniopsis ferruginea* | Myrtaceae  | 49.25 | 12.50 | 4.55 | 66.30 |
| 2  | *Lithocarpus vinkii*  | Fagaceae   | 4.83  | 15.63 | 9.09 | 29.55 |
| 3  | *Gluta renghas*       | Anacardiaceae | 5.80  | 9.38  | 13.64 | 28.82 |
| 4  | *Prunus arborea*      | Rosaceae   | 6.33  | 9.38  | 9.09  | 24.79 |
| 5  | *Santiria apiculata*  | Burseraceae | 7.67  | 6.25  | 9.09  | 23.01 |
| 6  | *Canarium denticulatum* | Burseraceae | 8.98  | 9.38  | 4.55  | 22.90 |
| 7  | *Campnosperma brevipetiolatum* | Anacardiaceae | 3.02  | 6.25  | 4.55  | 13.81 |
| 8  | *Rhodamnia cinerea*   | Myrtaceae  | 2.86  | 3.13  | 4.55  | 10.53 |
| 9  | *Pentaspadon motleyi* | Anacardiaceae | 2.10  | 3.13  | 4.55  | 9.77  |
| 10 | *Aporosa* sp.         | Euphorbiaceae | 1.78  | 3.13  | 4.55  | 9.45  |
| 11 | *Horsfieldia irya*    | Myristicaceae | 1.43  | 3.13  | 4.55  | 9.10  |
| 12 | *Gironniera hirta*    | Cannabaceae | 1.21  | 3.13  | 4.55  | 8.88  |
| 13 | *Diospyros* sp.       | Ebenaceae  | 1.10  | 3.13  | 4.55  | 8.77  |
| 14 | *Gonystylus macrophyllus* | Thymelaceae | 0.94  | 3.13  | 4.55  | 8.61  |
| 15 | *Gordonia papuana*    | Theaceae   | 0.93  | 3.13  | 4.55  | 8.60  |
| 16 | *Garcinia dulcis*     | Clusiaceae | 0.89  | 3.13  | 4.55  | 8.56  |
| 17 | *Palaquium* sp.       | Sapotaceae | 0.87  | 3.13  | 4.55  | 8.54  |
Table 6. Stand potencies in secondary dryland forest at tree level according to their volume and biomass

| No | Species Name             | Family     | Volume (m³ ha⁻¹) | Biomass (Mg ha⁻¹) |
|----|--------------------------|------------|------------------|-------------------|
| 1  | *Tristaniopsis ferruginea* | Myrtaceae  | 72.71            | 140.82            |
| 2  | *Canarium denticulatum*   | Burseraceae| 20.74            | 20.36             |
| 3  | *Santiria apiculata*      | Burseraceae| 19.50            | 17.64             |
| 4  | *Prunus arborea*          | Rosaceae   | 15.18            | 13.42             |
| 5  | *Lithocarpus vinkii*      | Fagaceae   | 10.38            | 8.41              |
| 6  | *Gluta rengas*            | Anacardiaceae| 9.23       | 11.49             |
| 7  | *Campnosperma brevipetiolatum* | Anacardiaceae | 6.03       | 5.82              |
| 8  | *Rhodanmia cinerea*       | Myrtaceae  | 5.09             | 6.07              |
| 9  | *Gordonia papuana*        | Theaceae   | 2.55             | 1.60              |
| 10 | *Diospyros sp.*           | Ebenaceae  | 2.50             | 1.96              |
| 11 | *Pentaspadon motleyi*     | Anacardiaceae| 2.05       | 4.22              |
| 12 | *Palaquium sp.*           | Sapotaceae | 1.98             | 1.49              |
| 13 | *Garcinia dulcis*         | Clusiaceae | 1.73             | 1.53              |
| 14 | *Gonystylus macrophyllus* | Thymelaceae| 1.52             | 1.62              |
| 15 | *Horsfeldia irya*         | Myristicaceae| 1.51        | 2.68              |
| 16 | *Aporosa sp.*             | Euphorbiaceae| 1.45        | 3.47              |
| 17 | *Gironniera hirta*        | Cannabaceae| 1.37             | 2.20              |
|    | **Total**                |            | 175.52           | 244.78            |

In the pole level, vegetation cover is slightly different from the tree level consisting of seven species of trees. The density and BA were respectively 144 trees ha⁻¹ and 2.39 m² ha⁻¹. The main constituent tree species are *Lithocarpus vinkii*, that is the dominant species, followed by other species such as *Canarium denticulatum*, *Gordonia excelsa* and *Diospyros* sp. A range of stand diameter was 11 to 19 cm. List tree species at pole level based on IVI was shown in table 7. Potential stands based on volume and biomass, respectively reached 20.07 m³ ha⁻¹ and 15.41 Mg ha⁻¹, shown in table 8. The sapling density reached 3,000 trees ha⁻¹ with the species of stands based on IVI dominated by *G. dulcis* followed by *Lithocarpus vinkii, Pittosporum ramiflorum* and *Gordonia papuana* (table 9).

Table 7. List of stand species in secondary dryland forest at pole level according to Important Value Index (IVI)

| No | Species Name          | Family   | RDmᵃ | RDᵇ | RFᶜ  | IVIᵈ |
|----|-----------------------|----------|------|-----|------|------|
| 1  | *Lithocarpus vinkii*  | Fagaceae | 37.96| 34.78| 18.75| 91.49|
| 2  | *Canarium denticulatum* | Burseraceae| 15.90| 17.39| 18.75| 52.04|
| 3  | *Gordonia papuana*    | Theaceae | 11.02| 13.04| 12.50| 36.56|
| 4  | *Diospyros sp.*       | Ebenaceae| 7.65 | 8.70 | 12.50| 28.84|
| 5  | *Tristaniopsis ferruginea* | Myrtaceae | 7.82 | 4.35 | 6.25 | 18.42|
| 6  | *Garcinia dulcis*     | Clusiaceae| 6.89 | 4.35 | 6.25 | 17.49|
| 7  | *Gironniera hirta*    | Cannabaceae| 3.48 | 4.35 | 6.25 | 14.07|
| 8  | *Callophyllum papuana* | Clusiaceae| 3.16 | 4.35 | 6.25 | 13.76|
| 9  | *Pandanus tectorius*  | Pandanaceae| 3.16 | 4.35 | 6.25 | 13.76|
Table 8. Stand potencies in secondary dryland forest at pole level according to their volume and biomass

| No | Species Name         | Family    | Volume (m$^3$ ha$^{-1}$) | Biomasa (Mg ha$^{-1}$) |
|----|----------------------|-----------|--------------------------|------------------------|
| 1  | Lithocarpus vinkii   | Fagaceae  | 8.18                     | 6.20                   |
| 2  | Canarium denticulatum| Burseraceae| 3.36                     | 2.44                   |
| 3  | Gordonia papuana     | Theaceae  | 2.03                     | 1.67                   |
| 4  | Tristaniopsis ferruginea| Myrtaceae | 1.96                     | 1.36                   |
| 5  | Diospyros sp.        | Ebenaceae | 1.64                     | 1.18                   |
| 6  | Garcinia cf. dulcis  | Clusiaceae| 1.38                     | 1.17                   |
| 7  | Baccaurea nanihu  | Euphorbiaceae| 0.53                     | 0.43                   |
| 8  | Callophyllum soulattri | Clusiaceae| 0.53                     | 0.46                   |
| 9  | Gironniera hirta     | Cannabaceae| 0.46                     | 0.52                   |

|       |                      |           | 20.07 | 15.41 |

Table 9. List of stand species in secondary dryland forest at sapling level according to Important Value Index (IVI)

| No | Species Name        | Family    | RDM | RD$^b$ | RF$^c$ | IVI$^d$ |
|----|---------------------|-----------|-----|-------|-------|--------|
| 1  | Garcinia dulcis     | Clusiaceae| 15.91| 20.00  | 14.29 | 50.20  |
| 2  | Lithocarpus vinkii  | Fagaceae  | 20.90| 13.33  | 9.52  | 43.76  |
| 3  | Pittosporum ramiformum | Pittosporaceae | 12.42| 10.00  | 4.76  | 27.18  |
| 4  | Gordonia papuana    | Theaceae  | 5.83 | 10.00  | 9.52  | 25.35  |
| 5  | Elaeocarpus sp.     | Elaeocarpaceae| 7.74| 6.67   | 9.52  | 23.94  |
| 6  | Rhodamnia cinerea   | Myrtaceae | 5.92 | 3.33   | 4.76  | 14.01  |
| 7  | Gluta renghas       | Anacardiaceae| 1.60| 6.67   | 4.76  | 13.03  |
| 8  | Diospyros sp.       | Ebenaceae | 4.68 | 3.33   | 4.76  | 12.77  |
| 9  | Diospyros ulo       | Ebenaceae | 4.68 | 3.33   | 4.76  | 12.77  |
| 10 | Hevea brasiliensis | Euphorbiaceae| 4.68| 3.33   | 4.76  | 12.77  |
| 11 | Syzygium sp.        | Myrtaceae | 4.68 | 3.33   | 4.76  | 12.77  |
| 12 | Gironniera hirta    | Cannabaceae| 3.58| 3.33   | 4.76  | 11.68  |
| 13 | Pterandra azurrea   | Melastomataceae| 3.18| 3.33   | 4.76  | 11.28  |
| 14 | Callophyllum papuana| Clusiaceae| 3.09| 3.33   | 4.76  | 11.18  |
| 15 | Gonystylus macrophyllus | Thymelaceae | 0.66| 3.33   | 4.76  | 8.75   |
| 16 | Santiria apiculata  | Burseraceae| 0.46| 3.33   | 4.76  | 8.55   |

While the density of seedling is 45,625 trees ha$^{-1}$, consisting of *Rhodamnia cinerea* and *G. dulcis*. The potential of stands at tree and pole levels in secondary dryland forests is quite high, each level has a potential larger than 20 m$^3$ ha$^{-1}$, indicates that the location of the study on secondary dryland forests is still productive forest.

There are several stands that are used as boat-making materials by the community such as *Canarium denticulatum* and *Gordonia papuana*, but only a few of these stands are still found [13]. The estimation of stand potential at the study site is higher than the stand potential in Jayapura natural forest which reaches 186 Mg ha$^{-1}$ [14], and the potential of forest resources from the national forest inventory plot in...
Papua reaches 180 Mg ha\(^{-1}\) [15]. An overview of secondary dryland forest conditions is presented in figure 3.

3.3. Primary Dryland Forest

Primary dryland forest have several tree species, some of which are also found in secondary dryland forests. Stand species, in this area, had high canopy and forest floor covered by thin litter are characterized of lowland forest ecosystems. Some of found species were *Santiria apiculata*, *S. laevigata*, *Cryptocarya crassinervia*, *Fagraea racemosa*, *Gonystylus macrophyllus*, *Vatica rassak* and *Prunus arborea*. Primary dryland forest in Papua dicirikan oleh vegetasi yang tinggi dan komposisi floranya sangat kaya [16]. In the sampling plot for tree level consists of 25 tree species, the density of 256 trees ha\(^{-1}\) and BA reaches 42.98 m\(^2\) ha\(^{-1}\), with a diameter larger than previous two forest types, ranging from 20 to 122 cm. In contrast, the density reached 1,000 trees ha\(^{-1}\) dan BA reached 23.26 m\(^2\) ha\(^{-1}\) in primary dryland forest of Papua [15]. Important species in primary dryland forest are mohobi (*Santiria laevigata*) and sonokeling (*Dalbergia rostrata*) based on IVI, respectively, reaching 41.57 and 32.38 (table 10). The highest IVI value of the both species indicating the mohobi and sonokeling can perform as a balance species in the primary dryland forest ecosystem.

Table 10. List of stand species in primary dryland forest at tree level according to Important Value Index (IVI)

| No | Species Name       | Family         | RDm | RD  | RF  | IVI  |
|----|--------------------|----------------|-----|-----|-----|------|
| 1  | *Santiria apiculata* | Burseraceae    | 15.80 | 14.00 | 11.76 | 41.57 |
| 2  | *Dalbergia rostrata* | Fabaceae       | 23.44 | 6.00  | 2.94  | 32.38 |
| 3  | *Cryptocarya crassinervia* | Lauraceae | 17.67 | 4.00  | 2.94  | 24.61 |
| 4  | *Fagraea racemosa* | Loganiaceae    | 6.75  | 6.00  | 5.88  | 18.64 |
| 5  | *Gonystylus macrophyllus* | Thymelaceae | 3.69  | 8.00  | 5.88  | 17.58 |
| 6  | *Diospyros sp.* | Ebenaceae      | 1.87  | 6.00  | 8.82  | 16.69 |
| 7  | *Tristaniopsis ferruginea* | Myrtaceae | 4.14  | 6.00  | 5.88  | 16.02 |
| 8  | *Santiria laevigata* | Burseraceae    | 3.95  | 8.00  | 2.94  | 14.89 |
| 9  | *Semecarpus sp.* | Icacinaceae    | 1.86  | 4.00  | 5.88  | 11.74 |
| 10 | *Callophyllum papuana* | Clusiaceae    | 4.24  | 4.00  | 2.94  | 11.19 |
The similar finding was shown in both *S. laevigata* and *D. rostrata* species, in the potential of volume and biomass of the total stand volume of 401.49 m$^3$ ha$^{-1}$ and biomass reaching 476.59 Mg ha$^{-1}$, presented in table 11. Potential stands of this study was higher than lowland tropical forests [5].

**Table 11.** Stand potencies in primary dryland forest at tree level according to their volume and biomass

| Species                        | Family          | Volume | Biomass | Volume | Biomass |
|-------------------------------|-----------------|--------|---------|--------|---------|
| Lithocarpus vinkii            | Fagaceae        | 1.84   | 4.00    | 2.94   | 8.78    |
| Chionanthus sp.               | Oleaceae        | 1.44   | 4.00    | 2.94   | 8.38    |
| Vatica rassak                 | Dipterocarpaceae| 3.09   | 2.00    | 2.94   | 8.03    |
| Syzygium plumeum              | Myrtaceae       | 1.69   | 2.00    | 2.94   | 6.63    |
| Pouteria firma                | Sapotaceae      | 1.19   | 2.00    | 2.94   | 6.13    |
| Pitsporum ramiflorum          | Pittosporaceae  | 1.08   | 2.00    | 2.94   | 6.03    |
| Aglaia parviflora            | Meliaceae       | 1.02   | 2.00    | 2.94   | 5.96    |
| Beilschmiedia sp.             | Lauraceae       | 0.90   | 2.00    | 2.94   | 5.84    |
| Canarium denticulatum         | Burseraceae     | 0.86   | 2.00    | 2.94   | 5.81    |
| Teijsmanniodendron sp.        | Verbenaceae     | 0.70   | 2.00    | 2.94   | 5.64    |
| Baccaurea nanhua              | Euphorbiaceae   | 0.63   | 2.00    | 2.94   | 5.57    |
| Elaeocarpus petiolaris        | Elaeocarpaceae  | 0.62   | 2.00    | 2.94   | 5.56    |
| Horsfieldia irya              | Myristicaceae   | 0.54   | 2.00    | 2.94   | 5.48    |
| Medinilla versteegii          | Melastomataceae | 0.49   | 2.00    | 2.94   | 5.44    |
| Prunus arborea                | Rosaceae        | 0.47   | 2.00    | 2.94   | 5.41    |
The level of poles, vegetation cover is relatively different from the tree level consisting of seven species of plants, the density of 194 trees ha\(^{-1}\) and LBD reaching 38.44 m\(^2\) ha\(^{-1}\). The main constituent tree species are *Diospyros* sp. That is the dominant species followed by other species of *Horsfieldia irya*, *Santiria apiculata* and *Syzygium plumeum*, with a range of stem diameters from 10 to 19 cm. Plant species at pole level based on IVI (table 12). The potential stands according to tree volume and biomass, respectively were 27.78 m\(^3\) ha\(^{-1}\) and 26.14 Mg ha\(^{-1}\), shown in table 13.

Table 12. List of stand species in primary dryland forest at pole level according to Importance Value Index (IVI)

| No | Species Name         | Family       | RDm\(^a\) | RD\(^b\) | RF\(^c\) | IVI\(^d\) |
|----|----------------------|--------------|-----------|----------|----------|----------|
| 1  | *Diospyros* sp.      | Ebenaceae    | 23.20     | 22.58    | 15.00    | 60.78    |
| 2  | *Horsfieldia irya*   | Myristicaceae| 14.30     | 16.13    | 10.00    | 40.43    |
| 3  | *Santiria apiculata* | Burseraceae  | 13.59     | 12.90    | 10.00    | 36.50    |
| 4  | *Syzygium plumeum*   | Myrtaceae    | 8.53      | 6.45     | 10.00    | 24.98    |
| 5  | *Santiria laevigata* | Burseraceae  | 6.02      | 6.45     | 5.00     | 17.47    |
Table 13. Stand potencies in primary dryland forest at sapling according to their volume and biomass

| No | Species Name       | Family            | Volume (m³ ha⁻¹) | Biomasa (Mg ha⁻¹) |
|----|--------------------|-------------------|------------------|-------------------|
| 1  | Diospyros sp.      | Ebenaceae         | 7.17             | 6.12              |
| 2  | Horsfieldia irya   | Myristicaceae     | 4.18             | 3.67              |
| 3  | Santiria apiculata | Burseraceae       | 3.99             | 3.59              |
| 4  | Syzygium plumeum   | Myrtaceae         | 1.74             | 2.32              |
| 5  | Vatica rassak      | Dipterocarpaceae  | 1.65             | 1.26              |
| 6  | Prunus arborea     | Rosaceae          | 1.23             | 1.02              |
| 7  | Santiria laevigata | Burseraceae       | 1.20             | 1.55              |
| 8  | Diospyros ulo      | Ebenaceae         | 1.17             | 0.84              |
| 9  | Polyalthia glauca  | Annonaceae        | 1.13             | 1.01              |
| 10 | Syzygium synaptoneurum | Myrtaceae     | 1.08             | 1.08              |
| 11 | Fagraea racemosa   | Loganiaceae       | 0.89             | 0.69              |
| 12 | Pouteria firma     | Sapotaceae        | 0.82             | 0.76              |
| 13 | Canarium denticulatum | Burseraceae     | 0.60             | 0.54              |
| 14 | Garcinia valetoniana | Clusiaceae     | 0.50             | 0.80              |
| 15 | Gironniera hirta   | Cannabaceae       | 0.43             | 0.90              |

A total of 17 tree species at the sapling level with a density of 2,500 trees ha⁻¹ with a species of stands based on IVI dominated by Gonystylus macrophyllus followed by Elaeocarpus petiolatus and Lithocarpus vinkii (table 14). While, the seedling density was 31,875 trees ha⁻¹, commonly found species of Santiria apiculata and Diospyros sp.

Table 14. List of stand species in primary dryland forest at sapling according to Importance Value Index (IVI)

| No  | Species Name            | Family      | RDm  | RDb  | RF  | IVI  |
|-----|-------------------------|-------------|------|------|-----|------|
| 1   | Gonystylus macrophyllus | Thymelaceae | 17.92| 8.00 | 5.00| 30.92|
| 2   | Elaeocarpus petiolatus  | Elaeocarpaceae | 17.05| 8.00 | 5.00| 30.05|
| 3   | Lithocarpus vinkii      | Fagaceae    | 7.64 | 8.00 | 10.00| 25.64|
| 4   | Pouteria firma          | Sapotaceae  | 9.89 | 8.00 | 5.00| 22.89|
| 5   | Chionanthus sp.         | Oleaceae    | 4.26 | 8.00 | 10.00| 22.26|
6 Santiria apiculata Burseraceae 8.56 8.00 5.00 21.56
7 Prunus arborea Rosaceae 2.47 8.00 10.00 20.47
8 Baccaurea nanhua Euphorbiaceae 10.01 4.00 5.00 19.01
9 Santiria laevigata Burseraceae 2.47 8.00 5.00 15.47
10 Gironniera hirta Cannabaceae 5.22 4.00 5.00 14.22
11 Evodia sp. Rutaceae 5.22 4.00 5.00 14.22
12 Diospyros sp. Ebenaceae 3.88 4.00 5.00 12.88
13 Aglaia lawii Meliaceae 1.98 4.00 5.00 10.98
14 Macaranga triloba Euphorbiaceae 1.11 4.00 5.00 10.11
15 Vatica rassak Dipterocarpaceae 1.11 4.00 5.00 10.11
16 Garcainia valetoniana Clusiaceae 0.71 4.00 5.00 9.71
17 Fagraea racemosa Loganiaceae 0.49 4.00 5.00 9.49

A similar finding to swamp and secondary dryland forests, the potential stands at tree and pole levels in primary dryland forests are quite high, each of which has a potential level of > 20 m$^3$ ha$^{-1}$, this shows that the research location with land cover in the form of primary land forest is categorized as productive forest.

There are several of stands that are used as boat-making and building materials by the community such as Canarium denticulatum, Vatica rassak and Syzygium sp., But only a few of these stands are found at the district location [13]. Furthermore, the estimation of stand potential at the study site is higher than the stand potential in Jayapura natural forest 119 Mg ha$^{-1}$ [14], and the potential of forest resources from the national forest inventory plot in Papua reaches 239 Mg ha$^{-1}$ [15]. The condition of primary dryland forests is presented in figure 4.

![Figure 4. Location of primary dryland forest](image)

High biodiversity and its potential of stands on swamp, secondary dryland and primary dryland forests showed that the study area has not significant disturbance, although in some locations there has been land clearing by the community and generally located close the river for settlement. The high
potential of the stand also at the study site affects the ability of the ecosystem to store high carbon and as an indication that Papua in general as a conservation area.

**Conclusion**

The highest density and basal area, reaching 256 trees ha\(^{-1}\) and 42.98 m\(^2\) ha\(^{-1}\), was found in primary dryland forest, and was followed by secondary dryland forest (200 trees ha\(^{-1}\) and the 23.16 m\(^2\) ha\(^{-1}\)) and swamp forest (200 trees ha\(^{-1}\) and the 23.16 m\(^2\) ha\(^{-1}\)). There were different main species of the different cover types. A high potential in stands on the secondary dryland and primary dryland forests showed that the study area had a high productive forest.

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