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Diversity and biomass of tree species in Tambrauw, West Papua, Indonesia

IYAN ROBIANSYAH
Center for Plant Conservation, Bogor Botanic Gardens, Indonesian Institute of Sciences. Jl. Ir. H.Juanda 13, Bogor 16003, West Java, Indonesia.
Tel./fax.: +62-251-8322187, email: iyan.robiansyah@lipi.go.id

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Abstract. *Robiansyah I. 2018. Diversity and biomass of tree species in Tambrauw, West Papua, Indonesia. Biodiversitas 19: 377-386.* In spite of its high diversity and endemism, New Guinea is still one of the least explored regions on the globe. Flora information for the island as a whole is low compared to other areas in Malesia, and for Indonesian Province of Papua and West Papua it is much lower than for Papua New Guinea. To add more information and data on the flora of the West Papua Province, a vegetation analysis was conducted in Fef (442-509 m) and Bamusbama (757-914 m) Subdistricts, Tambrauw District, West Papua, Indonesia. Six and four plots of 30x30 m were placed in Fef and Bamusbama, respectively, to assess and compare the diversity and biomass of trees with diameter at breast height ≥ 10 cm. A total of 457 stems and ca. 86 tree species were identified. Fef accommodated higher species number (70) than Bamusbama (42). Meliaceae and Myrtaceae were the most important families in Fef and Bamusbama, respectively, while *Castanopsis acuminatissima* was the most important species in both subdistricts.The species diversity, richness, and evenness in Fef was higher than in Bamusbama. For tree biomass, the estimated value in Bamusbama (383.8 ton/ha) was much higher than in Fef (224.7 ton/ha). The results of the present study may serve as a baseline information for sustainable forest management and conservation of the region.

Keywords: Biomass, Papua, tree diversity, Tambrauw, vegetation analysis

INTRODUCTION

New Guinea is one of the global centers of plant diversity and harbors between 15,000-20,00 species, of which about 70-80% are endemic (Davis et al. 1995). It politically comprises both Papua New Guinea and Indonesian Province of Papua and West Papua. In spite of its high diversity and endemism, New Guinea is still one of the least explored areas on the globe (Mittermeier et al. 2003). Flora information for the island as a whole is low compared to other areas in Malesia, and for Indonesian Province of Papua and West Papua, it is much lower than for Papua New Guinea (Conn 1994). For West Papua Province, previous botanical explorations have been conducted in Arfak mountains (Gibbs 1917), Manokwari (Kuswandi et al. 1993), Ayawasi area (Polak 2000), Bomberai peninsula (Burnett et al. 2003; Sambas et al. 2003), Raja Ampat Islands (Takeuchi 2003), and mangrove forest of the Bintuni Reserve (Wikramanayake 2002) and Waigeo Island (Suhardjono 2013). Further studies on flora diversity in West Papua Province are crucially needed as deforestation rate of 22.300 ha/year (MoFE 2015) threatened the forests and plant diversity in this area.

West Papua Province has developed its sustainable development vision, and planned to become one of conservation provinces in Indonesia. By practicing sustainable development practices, the province aims to maintain its forest cover while pursuing economic development. As forest has a critical role in slowing or even halting climate change, this conservation province policy will help mitigating the impact of climate change in national and global level. The effectiveness of forest to absorb carbon dioxide, however, is positively correlated with plant diversity (Midgley et al. 2010), and has to be supported by frequent monitoring of ground check on plant biomass of the forest. Thus study on biomass estimation within the forest of West Papua Province is needed as it will serve as a baseline information for future studies.

As part of LIPI Bioresources Expedition, a vegetation analysis has been conducted in Fef and Bamusbama Subdistrict, Tambrauw District, West Papua Province on 14-28 April 2016. Vegetation analysis is a method to study species composition and structure of a plant community. The method is an important tool in land classification (Damman 1979), conservation management of endangered plants (Cropper 1993) and animals (Deutschlander and Bredenkamp 1999), and conservation management of soil and water (Maridi et al. 2014). It also plays a crucial role as a baseline data for helping plant species and community to adapt to future climate change (Palmate et al. 2017). Thus, in addition to add more information on flora diversity of Tambrauw, the results of this vegetation analysis may serve as basic information for sustainable forest management and conservation of the region.

The present publication will present the results of the vegetation analysis, and will be focused on the observation of species and stem density, important species and family, alpha and beta diversity of tree species in both subdistricts, and aboveground biomass of all living trees. It aims to analyze and compare the tree species, diversity, and biomass in the two subdistricts.

MATERIALS AND METHODS

Study area

The present study was conducted in Fef and Bamusbama Subdistrict, Tambrauw District, West Papua Province, Indonesia (Figure 1). Tambrauw District is located in the upper part of bird's head peninsula between 132°00' and 133°00' East and 0°15' and 1°00' South. It has altitude between 0 to 3000 m above sea level with the highest point at the top of Mount Kwoka. The climate is wet tropical and classified as Af type according to Köppen climate classification (Dam and Wong 1998). The relative air humidity is about 85-86% with minimum and maximum temperature of 23 and 31°C, respectively. The average precipitation is 3076 mm/year and number of day per year with precipitation is between 210-260 (BPS West Papua Province 2015). Most of areas in Tambrauw have eutrudepts soil type (40%) followed by dystrudepts (37%) and haprendolls (16%). Other soil types that can be found are endoaquepts, hapludalfs, udifluvents, and udipsamments (BPS Sorong District 2014). Known as a conservation district, more than 80% of Tambrauw areas are in form of conservation and protected forest (Fatem and Asem 2015).

Figure 1. Location of research plots (red dots) in Fef and Bamusbama Subdistricts, Tambrauw District, West Papua Province, Indonesia

Vegetation sampling

The research plots in Fef and Bamusbama Subdistrict were laid between an altitude of 442-509 m and 757-914 m above sea level (asl), respectively. A total of six and four plots of 30x30 m^2 were placed at the respected study sites with a minimum distance between plots of 300 m. Due to the low accessibility of the forest, local tribal law restriction, and regional security issue, the plots were placed not far from the nearest villages in both study sites. Thus to get a close representation of natural vegetation in both subdistricts, sites with low human disturbances were selected for establishing the plots. Within each plot, trees with diameter at breast height (dbh) $\geq$ 10 cm were measured for dbh and identified by an expert (Dwi Narko; Purwodadi Botanic Garden, East Java, Indonesia) in the field to genus level, or to species level where possible. To ease tree measurement and identification, the initial plot was divided into nine 10x10 m^2 subplots. Vouchers were collected for unidentified species and deposited in Herbarium Bogoriense of Research Center for Biology, Indonesian Institute of Sciences (LIPI), Cibinong, Bogor, West Java, Indonesia for identification.

Data analysis

As the size of the sampled area between sites was different, species-area and individual-area curves were calculated to compare species richness and stem number per site, respectively. Importance value index (IVI) was determined for all family and species, and calculated as the sum of relative frequency, density, and dominance (Ellenberg and Mueller-Dombois 1974). To assess the alpha diversity of the study sites, three diversity indexes were calculated, and they were Shannon-Wiener index (H) (Shannon 2001), Margalef richness index (M) (Margalef 1958) and Pielou evenness index (E) (Pielou 1966). All the indexes were calculated for each plot, subdistrict and all plots combined. For beta diversity, it was evaluated using Sorensen and Bray-Curtis similarity index (Magurran 2013) to see the differences in species composition and abundance between Fef dan Bamusbama Subdistrict. Furthermore, above ground biomass of live trees in the study sites was estimated using the equation developed by Ketterings et al. (2001) and then extrapolated into per hectare biomass. Wood density of each species required by the equation was obtained from Three Functional Attributes and Ecological Database (http://db.worldagroforestry.org/).

RESULTS AND DISCUSSION

Species and stem density

From a total plot area of 0.9 ha, the present study found 457 stems and identified at least 86 tree species from 67 genera and 32 families (Table 1). There were 30 tree species (26.7%) which were identified up to genus level and one unidentified tree due to lack of morphological features. The plots in the present study are less species-rich compared to previous plot-based studies in Sarawak (223, 214 species/ha) (Proctor et al. 1983), Sumatra (184 species/ha) (Kartawinata et al. 2003), Kalimantan (205 species/ha) (Sheil et al. 2010), Sulawesi (150 species/ha) (Kessler et al. 2005) and other areas in New Guinea (184, 181, 152, 145 species/ha) (Paijmans 1970). The species number of the plots is only higher when compared with 70 species/ha of Mount Gede Pangrango, West Java (Helmi et al. 2009). For the stem density, the result of the present study is still within the range of Malesia's Lowland rainforest of 350-800 trees/ha (dbh $\geq$ 10) (Kartawinata 1990).

Fef (442-509 m asl) accommodated ca. 70 tree species assigned to 30 families. A lower species number was found in Bamusbama (757-914 m asl) with ca. 42 tree species out of 24 families. Although the sampled area between the two subdistricts was different, the difference in species number was not an artifact. Species-area curves (Figure 2.A) showed that at 0.36 ha, species number in Fef was already higher than in Bamusbama. Fef also harbored higher stem number (265) compared to Bamusbama (191). Individual-area curves (Figure 2.B), however, showed that the difference in stem number was mainly due to unequal sampled areas. If the curve was extrapolated, stem number in Bamusbama would be similar with Fef. The decrease in number of species when moving from lower elevation (Fef) towards higher elevation (Bamusbama) is in accordance with the result from the study in sub-montane and lower montane forest in Central Sulawesi (Culmsee and Pitopang 2009) and the Mount Kinabalu altitudinal transect study (Aiba and Kitayama 1999). Several factors, such as the available area at each elevation, resource availability, ecophysiological barrier, and anthropogenic activities, might underlie the pattern (Hua 2004).

Important taxa

Species with the highest IVI value in Fef were *Castanopsis acuminatissima*, closely followed by *Cryptocarya* sp., *Baccaurea* sp., *Vatica rassak*, and *Dysoxylum parasiticum* (Table S1). Similarly, species with the highest IVI value in Bamusbama was *C. acuminatissima* and followed at some distance by *Decaspermum* sp., *Intsia bijuga*, *Aglaia sapindina* and *Elaeocarpus coloides* (Table S2). In both subdistricts, *C. acuminatissima* was the most important species with respected IVI value of 18.29% and 53.84%. These results indicate that forests in Fef and Bamusbama can be categorized as lower montane forest. Paijmans (1976) and Robbins (1971) argue that in New Guinea, *C. acuminatissima* usually is the most dominant species of primary and secondary lower montane forest at elevation of 500-2300 m asl.

In family level, a total of eight families were present in Fef but absent in Bamusbama, and they were Annonaceae, Cardiopteridaceae, Chrysobalanaceae, Dilleniaceae, Gentianaceae, Phyllanthaceae, Sapindaceae, and Tetramelaceae. In contrast, only Araucariaceae and Flacourtiaceae were present in Bamusbama but absent in Fef. The highest number of species was found in Myrtaceae (9 species), Lauraceae (8 species), Phyllanthaceae (6

Table 1. List of species found in Fef and Bamusbama Subdistrict, Tambrauw District, West Papua Province, Indonesia

Family/species	Fef	Bamusbama
Anacardiaceae		
Buchanania amboinensis Miq.	+	
Campnosperma brevipetiolatum Volk.	+	
Semecarpus L.f. sp.		+
Annonaceae		
Mitrephora Hook.f. & Thomson sp.	+	
Polyalthia Blume sp.	+	
Apocynaceae		
Alstonia macrophylla Wall. ex G.Don	+	
Alstonia scholaris (L.) R. Br.		+
Tabernaemontana aurantiaca Gaudich.	+	
Araucariaceae		
Agathis labillardierei Warb.		+
Burseraceae		
Canarium L. sp.	+	+
Canarium L. sp2		+
Haplolobus floribundus (K.Schum.) H.J.Lam	+	
Santiria Blume sp.		+
Cardiopteridaceae		
Gonocaryum Miq. sp.	+	
Celastraceae		
Lophopetalum Wight ex Arn. sp.	+	+
Chrysobalanaceae	+	
Clusiaceae		
Calophyllum L. sp.		+
Garcinia hollrungii Lauterb.	+	
Combretaceae		
Terminalia kaernbacchii Warb.	+	+
Dilleniaceae		
Dillenia auriculata Martelli	+	
Dipterocarpaceae		
Hopea iriana Slooten	+	
Vatica rassak Blume	+	+
Ebenaceae		
Diospyros cauliflora Blume.	+	+
Diospyros pulchra Bakh.	+	
Elaeocarpaceae		
Elaeocarpus albiflorus Knuth		+
Elaeocarpus coloides Schltr.	+	+
Euphorbiaceae		
Blumeodendron borneense Pax & K.Hoffm.		+
Endospermum moluccanum (Teijsm. & Binn.) Kurz	+	
Macaranga polyadenia Pax & K.Hoffm.	+	+
Pimelodendron amboinicum Hassk.	+	
Fagaceae		
Castanopsis acuminatissima (Blume) A.DC.	+	+
Lithocarpus brassii Soepadmo	+	
Flacourtiaceae		
Ryparosa calotricha Mildbr.		+
Gentianaceae		
Fagraea elliptica Roxb.	+	
Icacinaceae		
Stemonurus Blume sp.	+	+
Lamiaceae		
Teijsmanniodendron bogoriense Koord.	+	+
Lauraceae		
Beilschmiedia Nees sp.	+	
Cinnamomum culilawan Blume.		+
Cryptocarya bullata Kosterm.	+	
Cryptocarya R.Br. sp.	+	+
*Litsea*Lam. sp.		
Litsea tuberculata Boerl.	+	
Neolitsea (Benth. & Hook.f.) Merr. sp.		+
Phoebe Nees sp.	+	
Lecythidaceae		
Barringtonia J.R.Forst. & G.Forst. sp.	+	+
Leguminosae		
Archidendron F.Muell. sp.	+	
Intsia bijuga (Colebr.) Kuntze		+
Maniltoa Scheff. sp.		+
Malvaceae		
Kleinhovia hospita L.	+	
Sterculia L. sp.	+	+
Meliaceae		
Aglaia sapindina (F.Muell.) Harms	+	+
Aglaia subminutiflora C.DC.		+
Dysoxylum parasiticum (Osbeck) Kosterm.	+	+
Dysoxylum Blume sp2	+	+
Dysoxylum Blume sp3	+	
Lansium parasiticum (Osbeck) K.C.Sahni & Bennet	+	
Moraceae		
Antiaris toxicaria Lesch.	+	
Artocarpus altilis (Parkinson ex F.A.Zorn) Fosberg	+	+
Ficus callophylla Blume	+	
Ficus fistulosa Reinw. ex Blume	+	
Myristicaceae		
Knema Lour. sp.	+	+
Myristica concinna J.Sinclair	+	
Myristica schumanniana Warb.	+	
Myristica Gronov. sp.	+	+
Myristica Gronov. sp2	+	+
Myristica Gronov. sp3	+	+
Myrtaceae		
Decaspermum J.R.Forst. & G.Forst. sp.		+
Rhodomyrtus elegans (Blume) A.J.Scott	+	
Syzygium acuminatissimum (Blume) DC.	+	
Syzygium brevicymum (Diels) Merr. & L.M.Perry	+	+
Syzygium longipes Merr. & L.M.Perry	+	+
Syzygium salicifolium (Wight) J.Graham	+	+
Syzygium sorongense (T.G.Hartley & Craven) Craven & Biffin.	+	
Syzygium R.Br. ex Gaertn. sp.	+	
Syzygium tierneyanum (F.Muell.) T.G.Hartley & L.M.Perry	+	
Phyllanthaceae		
Aporosa praegrandifolia (S.Moore) Schot	+	
Baccaurea racemosa (Reinw. ex Blume) Müll. Arg.	+	
Baccaurea Lour. sp.	+	
Bridelia insulana Hance.	+	
Cleistanthus Hook.f. ex Planch. sp.	+	
Glochidion novoguineense K.Schum.	+	
Sapindaceae		
Allophylus cobbe (L.) Raeusch.	+	
Guioa Cav. sp.	+	
Sapotaceae		
Manilkara Adans. sp.	+	+
Palaquium pseudocalophyllum H.J.Lam		+
Pouteria Aubl. sp.	+	
Tetramelaceae		
Octomeles sumatrana Miq.	+	
Unidentified		
Unidentified297		+

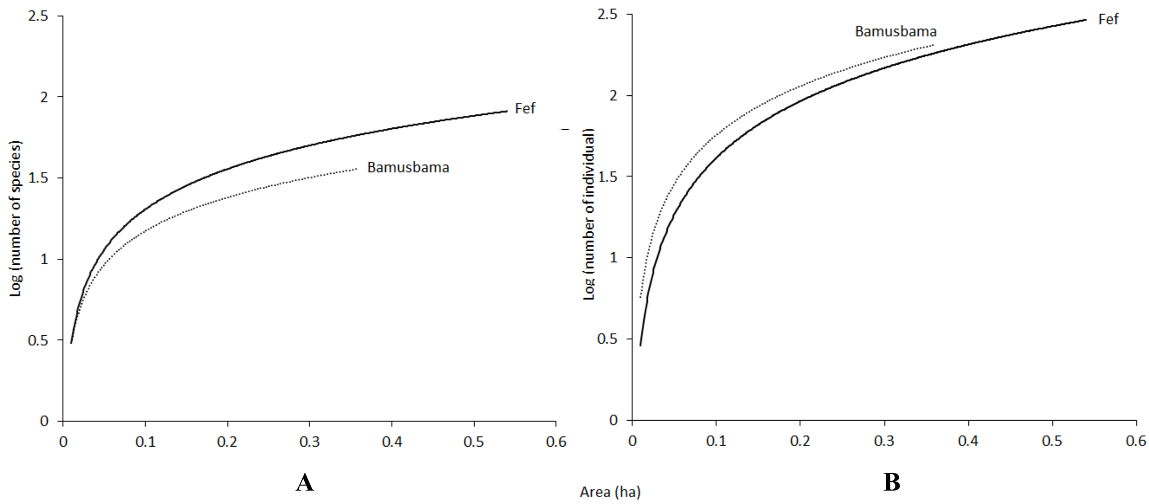

Figure 2. Species-area (A) and individual-area curves (B) for Fef and Bamusbama Subdistrict, Tambrauw District, West Papua Province, Indonesia

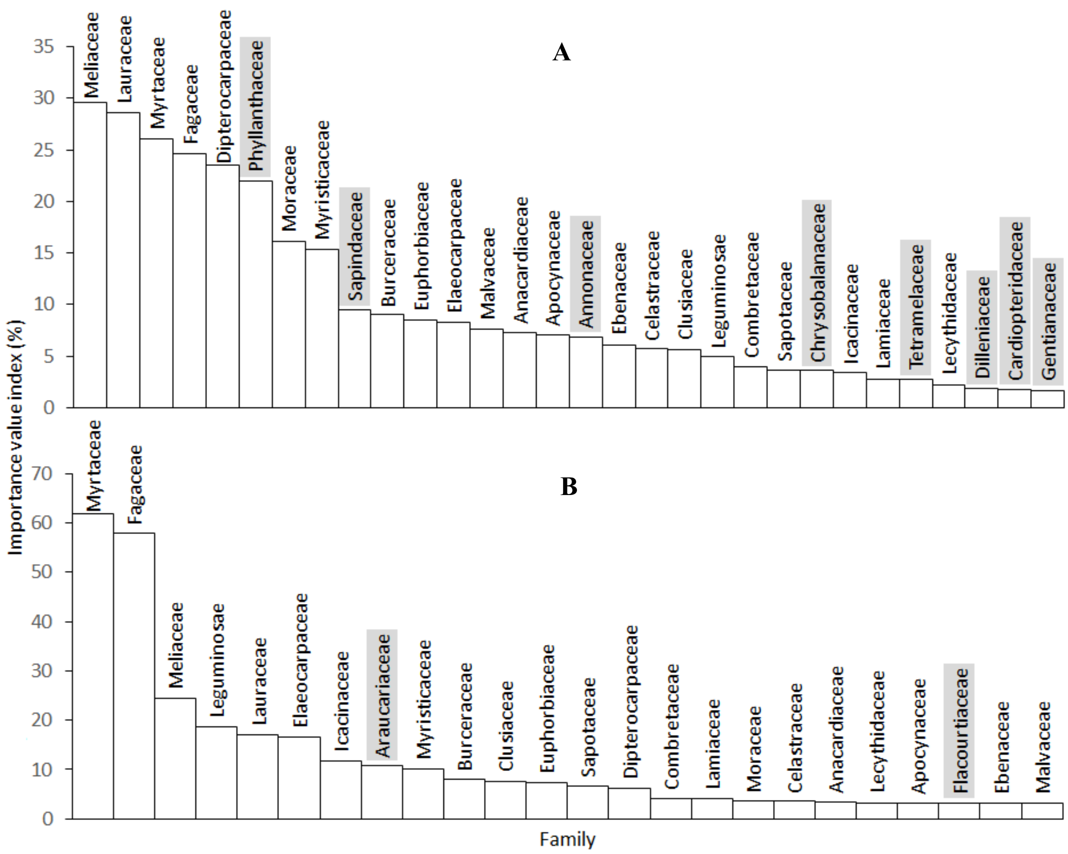

Figure 3. Importance value index of tree families in Fef (A) and Bamusbama (B) Subdistricts, Tambrauw District, West Papua Province, Indonesia based on their relative density, frequency, and dominancy. Families unique to each site were written in grey background

species), Meliaceae (6 species), and Myristicaceae (6 species) (Table 1). There were 11 families (34.4%) that were represented by only one species. When looking at IVI values, Meliaceae, Lauraceae, Myrtaceae, and Fagaceae (2 species) were the most important families in both subdistricts (Figure 3). In Bamusbama, the IVI value of the last two families was much higher and dominant compared to the others. Dipterocarpaceae (2 species) in Fef and Leguminosae (3 species) in Bamusbama also included the five most important families although they were represented by only a few species. In general, the most important families pattern found in the present study are similar with of the study by Polak (2000) at Ayawasi Area, Sorong District, West Papua Province. The five most important families in the present study are among the ten families with the highest IVI value.

Alpha and beta diversity

The overall tree species diversity, richness, and evenness across the study sites was high with H, M and E of 3.74, 14.37 and 0.83, respectively (Table 2). Although there was variability between plots, Table 2 showed Fef generally had a higher species diversity (H=3.77), richness (M=12.72) and evenness (E=0.88) compared to Bamusbama (H=2.9, M=8, and E=0.77). High dominance of *C. acuminatissima* and *Decaspermum* sp. is the main cause of low tree diversity in Bamusbama. Combined relative density (42.4%) and dominance (50.7%) of both species are significantly higher than other species, leading to very high IVI value of these species and suppression of other trees presence (Table S2).

Comparison between the two subdistricts using Sorensen (0.44) and Bray-Curtis similarity index (0.35) revealed that Fef and Bamusbama had low similarity in term of species composition and abundance. This low similarity may due to the elevational difference between the two study sites, which cause in shifting of species composition and abundance. Table 1 showed that there were 44 and 16 species unique to Fef and Bamusbama, respectively, and only 26 (30%) species shared between both subdistricts.

Tree diameter classes and biomass

The pattern of dbh classes of the tree species in Fef and Bamusbama showed an inverted J-shaped distribution (Figure 4), an indication of forest dominated by young trees. More than 70% of trees in both subdistricts had dbh ≤30 cm. There were only a few trees with dbh more than 70 cm. The biggest tree in term of dbh in Fef and Bamusbama was *Ficus callophylla* (85 cm) and *Intsia bijuga* (110 cm), respectively. This pattern indicates a good potential for reproduction and recruitment of the forests.

Total biomass estimated from all tree species found in the study sites was 288.3 ton/ha, which is within the range of the previously published estimates for New Guinea forests, 118-493 ton/ha (Bryan et al. 2010). For comparison with other islands, the estimated value is much lower compared to the biomass of the tree at Sebulu, East Kalimantan (509 ton/ha) (Yamakura et al. 1986), and Ulu Gadut Foret, West Sumatra (482.75 ton/ha) (Suwardi et al. 2013), but still higher when compared to of Siberut Island Nature Reserve, West Sumatra (131.92 ton/ha) (Bismark et al. 2016) and Kintamani, Bali (233.87 ton/ha) (Sujarwo and Darma 2011).

If the calculation was separated for each Subdistrict, tree biomass in Bamusbama (383.8 ton/ha) was much higher than in Fef (224.7 ton/ha). This result is not in line with the global elevational trend of decreasing aboveground biomass. In the majority of cases, the tree biomass decrease with increasing of elevation (Weaver and Murphy 1990; Lieberman et al. 1996; Raich et al. 1997; Aiba and Kitayama 1999; Kitayama and Aiba 2002; Wang et al. 2003; Moser et al. 2008).The exceptionality result of the present study may be attributed to the high dominance of Fagacea species (*C. acuminatissima*) in Bamusbama. Study by Culmsee et al. (2010) suggests an elevational biomass decrease in sites with low/no presence of Fagaceae, but relatively high biomass in montane forests with moderate to high abundance of this family.

In conclusion, forests in the study sites are still in good condition as shown by the inverted J-shaped distribution of dbh classes. Although the stem density is still within the range of Malesia's Lowland rainforest, the total species number found in Fef and Bamusbama is generally lower compared to of other forests in Indonesia. In both subdistricts, *C. acuminatissima* is the most dominant species in term of IVI value, while Meliaceae, Lauraceae, Myrtaceae, Fagaceae, Dipterocarpaceae, and Leguminosae are the most important families. The diversity indexes show Bamusbama has lower tree diversity, richness, and evenness than Fef. This mainly due to high dominance of *C. acuminatissima* and *Decaspermum* sp. in Bamusbama. Furthermore, Fef and Bamusbama had low similarity in term of species composition and abundance. There are only 30% species shared between both subdistricts. Concerning aboveground biomass of living trees, the estimated value in the present study is within the range of the previously published estimates for New Guinea forests. *C. acuminatissima* is suggested to play an important role in term of biomass production and stocking. All the results presented in the present study may serve as a basis for more sustainable forest management and conservation of the region.

Table 2. Shannon-Wiener index (H), Margalef richness index (M) and Pielou evenness index (E) of tree species in Fef and Bamusbama Subdistrict, Tambrauw District, West Papua Province, Indonesia for each plot (Fef 1-6 and Bamusbama 1-4), district and all plots combined (total)

Location	H	M	E
Fef 1	2.83	5.58	0.93
Fef 2	1.87	2.78	0.75
Fef 3	3.12	7.23	0.93
Fef 4	2.59	5.02	0.87
Fef 5	2.90	5.52	0.94
Fef 6	2.48	4.31	0.87
Bamusbama 1	1.44	1.51	0.74
Bamusbama 2	2.27	3.29	0.86
Bamusbama 3	1.10	2.02	0.50
Bamusbama 4	3.09	6.52	0.97
Fef	3.77	12.72	0.88
Bamusbama	2.90	8.00	0.77
Total	3.74	14.37	0.83

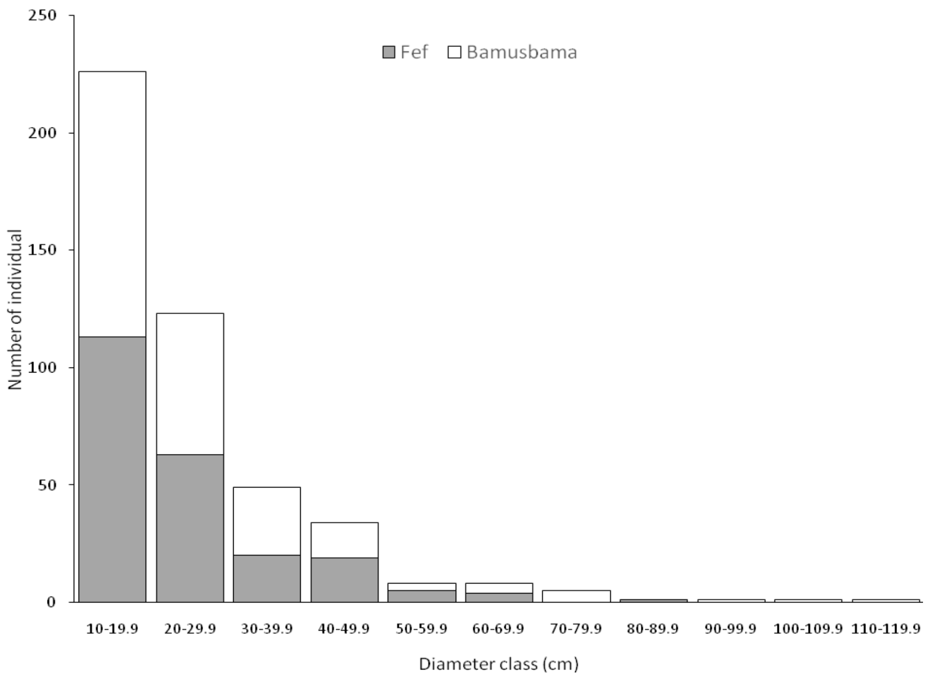

Figure 4. Diameter classes of tree species found in Fef and Bamusbama Subdistrict, Tambrauw District, West Papua Province, Indonesia

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Table S1. Importance value index (IVI) of tree species in Fef District based on their relative density (RD), frequency (RF) and dominance (RDm)

Species	RD (%)	RF (%)	RDm (%)	IVI (%)
Castanopsis acuminatissima (Blume) A.DC.	6.77	0.83	10.70	18.29
Cryptocarya R.Br. sp.	6.77	2.48	8.31	17.56
Baccaurea Lour. sp.	7.52	4.13	4.25	15.90
Vatica rassak Blume	6.02	2.48	5.89	14.39
Dysoxylum parasiticum (Osbeck) Kosterm.	3.76	3.31	7.01	14.07
Baccaurea racemosa (Reinw. ex Blume) Müll.Arg.	5.26	3.31	4.78	13.35
Myristica Gronov. sp.	2.63	4.13	3.65	10.41
Syzygium salicifolium (Wight) J.Graham	4.14	3.31	2.67	10.11
*Hopea iriana*Slooten Dyer	5.26	0.83	2.53	8.62
Syzygium brevicymum (Diels) Merr. & L.M.Perry	2.26	1.65	4.23	8.14
*Elaeocarpus coloides*Schltr.	2.63	1.65	3.14	7.43
Artocarpus altilis (Parkinson ex F.A.Zorn) Fosberg	2.26	1.65	3.31	7.22
Litsea Lam. sp.	1.88	3.31	1.52	6.71
Pimelodendron amboinicum Hassk.	1.88	2.48	1.72	6.08
Ficus callophylla Blume	0.75	0.83	4.46	6.04
Allophylus cobbe (L.) Raeusch.	1.13	2.48	1.97	5.58
Campnosperma brevipetiolatum Volk.	1.13	2.48	1.90	5.50
*Lithocarpus brassii*Soepadmo	0.75	1.65	2.64	5.05
Haplolobus floribundus (K.Schum.) H.J.Lam	1.88	1.65	1.38	4.92
Lophopetalum Wight ex Arn. sp.	1.50	1.65	1.68	4.84
Diospyros cauliflora Blume.	1.50	1.65	1.54	4.69
Garcinia hollrungii Lauterb.	1.13	2.48	0.74	4.34
Polyalthia Blume sp.	1.50	1.65	1.14	4.29
Archidendron F.Muell. sp.	1.50	1.65	0.90	4.06
Alstonia macrophylla Wall. ex G.Don.	1.13	1.65	1.22	4.00
Canarium L. sp.	0.75	1.65	1.24	3.65
Kleinhovia hospita L.	1.50	0.83	1.15	3.48
Syzygium acuminatissimum (Blume) DC.	1.50	1.65	0.27	3.43
Guioa Cav. sp.	1.13	0.83	1.46	3.41
Chrysobalanaceae	0.75	0.83	1.61	3.19
*Terminalia kaernbacchii*Warb.	0.75	1.65	0.68	3.09
Stemonorus Blume sp.	1.50	0.83	0.63	2.96
Dysoxylum Blume sp2	0.75	1.65	0.40	2.80
Sterculia L. sp.	0.75	1.65	0.40	2.80
Aglaia sapindina (F.Muell.) Harms	0.75	1.65	0.23	2.63
Syzygium R.Br. ex Gaertn. sp.	0.75	1.65	0.17	2.57
Litsea tuberculata Boerl.	0.75	0.83	0.79	2.37
Teijsmanniodendron bogoriense Koord.	0.75	0.83	0.73	2.31
Octomeles sumatrana Miq.	0.38	0.83	1.10	2.30
Aporosa praegrandifolia (S.Moore) Schot	0.75	0.83	0.58	2.16
*Cryptocarya bullata*Kosterm.	0.75	0.83	0.39	1.97
Barringtonia J.R.Forst. &G.Forst. sp.	0.75	0.83	0.19	1.77
Tabernaemontana aurantiaca Gaudich. sp.	0.75	0.83	0.15	1.73
Ficus fistulosa Reinw. ex Blume	0.75	0.83	0.12	1.70
Rhodomyrtus elegans (Blume) A.J.Scott	0.75	0.83	0.12	1.70
Bridelia insulana Hance.	0.38	0.83	0.47	1.67
Antiaris toxicaria Lesch.	0.38	0.83	0.31	1.51
Myristica schumanniana Warb.	0.38	0.83	0.29	1.49
Syzygium longipes Merr. &L.M.Perry	0.38	0.83	0.28	1.48
Glochidion novoguineense K.Schum.	0.38	0.83	0.25	1.45
Macaranga polyadenia Pax&K.Hoffm.	0.38	0.83	0.23	1.43
Pouteria Aubl. sp.	0.38	0.83	0.23	1.43
Dillenia auriculata Martelli	0.38	0.83	0.21	1.41
Myristica Gronov sp2	0.38	0.83	0.19	1.39
Beilschmiedia Nees sp.	0.38	0.83	0.18	1.38
Syzygium tierneyanum (F.Muell.) T.G.Hartley&L.M.Perry	0.38	0.83	0.15	1.35
Diospyros pulchra Bakh.	0.38	0.83	0.13	1.34
Endospermum moluccanum (Teijsm. &Binn.) Kurz	0.38	0.83	0.13	1.34
Gonocaryum Miq. sp.	0.38	0.83	0.13	1.34
Knema Lour. sp.	0.38	0.83	0.13	1.34
Phoebe Nees sp.	0.38	0.83	0.13	1.34
Myristica concinna J.Sinclair	0.38	0.83	0.13	1.34

Manilkara Adans. sp.	0.38	0.83	0.13	1.33
Dysoxylum Blume sp3	0.38	0.83	0.12	1.32
Cleistanthus Hook.f. ex Planch. sp.	0.38	0.83	0.10	1.30
Myristica Gronov. sp3	0.38	0.83	0.08	1.28
Mitrephora sp.	0.38	0.83	0.08	1.28
Buchanania amboinensis Miq.nania sp.	0.38	0.83	0.06	1.26
Syzygium sorongense (T.G.Hartley& Craven) Craven &Biffin.	0.38	0.83	0.06	1.26
Lansium parasiticum (Osbeck) K.C.Sahni& Bennet	0.38	0.83	0.05	1.26
Fagraea elliptica Roxb.	0.38	0.83	0.05	1.25

Table S2. Importance value index (IVI) of tree species in Bamusbama Subdistrict based on their relative density (RD), frequency (RF) and dominance (RDm)

Species	RD (%)	RF (%)	RDm (%)	IVI (%)
Castanopsis acuminatissima (Blume) A.DC.	27.23	3.64	22.98	53.84
Decaspermum J.R.Forst. &G.Forst. sp.	15.18	5.45	27.76	48.40
Intsia bijuga (Colebr.) Kuntze	1.57	1.82	13.82	17.21
Aglaia sapindina (F.Muell.) Harms	4.19	5.45	1.80	11.44
*Elaeocarpus coloides*Schltr.	3.66	5.45	2.20	11.32
*Agathis labillardierei*Warb.	1.57	1.82	6.74	10.13
Litsea Lam. sp.	4.19	3.64	1.90	9.73
Syzygium salicifolium (Wight) J.Graham	5.24	1.82	1.61	8.66
Stemonurus Blume sp.	4.19	1.82	2.62	8.63
Dysoxylum parasiticum (Osbeck) Kosterm.	2.09	3.64	2.85	8.58
Syzygium brevicymum (Diels) Merr. &L.M.Perry	4.19	1.82	1.30	7.31
Calophyllum L. sp.	2.09	3.64	0.52	6.25
Vatica rassak Blume	2.62	1.82	1.08	5.52
Canarium L. sp.	1.05	3.64	0.66	5.34
Palaquium pseudocalophyllum H.J.Lam	1.57	1.82	1.66	5.04
Myristica Gronov. sp.	1.05	3.64	0.22	4.91
Dysoxylum Blume sp2	1.05	1.82	0.71	3.58
Myristica Gronov. sp3	1.05	1.82	0.64	3.51
Terminalia kaernbacchii Warb.	1.05	1.82	0.64	3.50
Aglaia subminutiflora C.DC.	0.52	1.82	1.08	3.43
Myristica Gronov. sp2	1.05	1.82	0.49	3.36
Blumeodendron borneense Pax&K.Hoffm.	1.05	1.82	0.47	3.33
*Teijsmanniodendron bogoriense*Koord.	0.52	1.82	0.98	3.32
Cinnamomum culilawan Blume. sp.	1.05	1.82	0.38	3.24
Cryptocarya R.Br. sp.	1.05	1.82	0.34	3.20
Syzygium longipes Merr. &L.M.Perry	1.05	1.82	0.32	3.19
Artocarpus altilis (Parkinson ex F.A.Zorn) Fosberg	0.52	1.82	0.59	2.93
Lophopetalum sp.	0.52	1.82	0.55	2.89
Manilkara Adans. sp.	0.52	1.82	0.42	2.76
Semecarpus L.f. sp.	0.52	1.82	0.42	2.76
Unidentified297	0.52	1.82	0.32	2.67
Barringtonia J.R.Forst. &G.Forst. sp.	0.52	1.82	0.25	2.59
Alstonia scholaris (L.) R. Br.	0.52	1.82	0.22	2.56
Maniltoa Scheff. sp.	0.52	1.82	0.22	2.56
Ryparosa calotricha Mildbr.	0.52	1.82	0.22	2.56
Canarium L. sp2	0.52	1.82	0.19	2.53
Macaranga polyadenia Pax&K.Hoffm.	0.52	1.82	0.18	2.52
Elaeocarpus albiflorus Knuth	0.52	1.82	0.16	2.50
Neolitsea (Benth. &Hook.f.) Merr. sp.	0.52	1.82	0.16	2.50
Santiria Blume sp.	0.52	1.82	0.11	2.45
Diospyros cauliflora Blume.	0.52	1.82	0.10	2.44
Sterculia L. sp.	0.52	1.82	0.07	2.42
Knema Lour. sp.	0.52	1.82	0.07	2.41