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Tree species composition, richness and diversity of the Mount Matutum protected landscape (MMPL), Philippines

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Abstract

Forest trees assemblage and distribution were assessed through Plot Method across disturbed and undisturbed habitat gradients (500-1712 masl) representing lowland, montane and mossy forests of Mount Matutum Protected Landscape (MMPL). Species diversity through composition, richness and distribution along with endemism and conservation status was also determined. 1349 stems (≥10 cm DBH) were recorded; resolved into 45 families, 82 groups and 129 species - primarily dominated by genus *Ficus* of the Moraceae family. Disturbed lowland forest is mostly represented by *Piper aborescens, Artocarpus blancoi,* and *Mimusops elengi*; whereas undisturbed lowland forest is dominated by *Trema orientalis, Dendrocnide orbicularis* and *Ficus ulmifolia*. *Securinega flexuosa* dominates both disturbed and undisturbed montane forest. Meanwhile, *Dacrycarpus imbricatus* covers 80% of mossy forest disturbed and undisturbed areas. Disturbed and undisturbed montane forests (1323-1372 masl) demonstrate the most species-rich area. Species diversity index is highest in the disturbed montane forest (0.96) and lowest in undisturbed lowland forest (0.85). Two critically endangered and 16 vulnerable species were identified - of which 5 are Philippine endemics indicating that an efficient biodiversity conservation measure must continuously be undertaken in MMPL.

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Introduction

Tree species diversity is a key to total forest biodiversity as trees supply the resources and habitat for almost all other forest species (Ozcelik *et al.,* 2008). Forest lands harbor species-rich diversity, with tropical and sub-tropical forests being among the highly productive ecosystems on Earth that significantly interact with global and biogeochemical cycles, and regulate climate both at the regional and global scale (Ozcelik *et al.,* 2008; Barrufol *et al.,* 2013). However, these forests are under colossal human intervention (Reddy and Ugle, 2008). Trees in the forests have been logged for construction and shifting cultivation purposes (Aerts and Honnay, 2011). Such anthropogenic disturbances continually impair the quality of these forest ecosystems - with increasing human population in the nearby communities being directly related to the rise of encroachment in the forest (Wei and Jiang, 2012). Biodiversity loss brought about by human encroachment in the forest jeopardizes forest ecosystem functioning and its ability to provide ecosystem services (Aerts and Honnay, 2011). It is, therefore, imperative that understanding and managing forest ecosystems require the monitoring of tree diversity and forest structure (Motz *et al.,* 2010).

Mt. Matutum, a tropical forest in the SOCSARGEN region of the Philippines (6°22.00'N and 125° 5.00'E), is a center of biological diversity that provides crucial ecosystem services in its surrounding area. It forms the catchment and headwaters of major river systems such as the Silway-Klinan and Buayan which empty into the Sarangani Bay; and supplies 25% of the agro-industrial water requirements of the said region (Umehara, 2009).

Mt. Matutum has been a subject of many research and conservation initiatives from various organizations and academic institutions since its declaration as a protected landscape in March 1995 under Republic Act 1183. Data as to its tree diversity and composition is however very few and fragmented, and most remain unpublished. Hence, there is a need to look constantly into the state of biodiversity in forests ecosystems like Mt. Matutum. In doing so, coupling effects of altitude and human disturbance on tree diversity in the Mount Matutum Protected Landscape (MMPL) was addressed in this current investigation.

Disturbed areas have well-established trails likely developed and accessed for eco-tourism activities, and where agro-ecosystems dominate (Gao *et al.,* 2009). Meanwhile, undisturbed areas are unexplored and associated with unmanaged sites marked by a lesser degree of human-led disturbance (Gao *et al.,* 2009). Thus, the latter being expected to have higher species diversity than the former.

Altitude, on the other hand, has been regarded as a major factor affecting biodiversity in an area. Three models have been presented as to the extent of species richness across elevations: 1.) increasing diversity with increasing altitude, 2) humpback variation and 3) decreasing diversity with higher elevation (Desalegn and Beierkuhnlein, 2010). In this study, altitude has been designated to represent different forest types- lowland, mid-montane and mossy forests of MMPL. Gao *et al.,* (2009) consider that plant diversity, as well as landscape pattern, is closely related to altitude and human disturbance in mountain regions. As such, an assessment that will take into account altitude and disturbance likely presents a more concrete picture of the diversity of the region or area of interest.

This study sought to identify the following: 1) species composition, richness and distribution, 2) Similarity and Simpson's diversity indices, and 3) endemism and conservation status of trees species between disturbed and undisturbed sites across lowland, montane and mossy forests of Mount Matutum Protected Landscape (MMPL), Philippines.

Materials and methods

Study sites

Field reconnaissance and secondary data gathering were conducted to determine two (2) major sites: the disturbed and undisturbed areas in MMPL. The disturbed sites were at Sitio Glandang, Barangay Kablon, Tupi, South Cotabato (A1=6°22'10.98"N:125°4'8.71"E;A3=6°21'1.00"N:125° 3'35.40"E;A5=6°21'19.00"N:125°4'8.00"E).

Undisturbed sites were at Sitio Kawit, Barangay Maligo, Polomolok, South Cotabato (A2=6°20'40.10"N:125°6'3.80"E;A4=6°21'15.70"N:125°5'39.60"E;A6=6°21'21.70"N:125°5'8.40"E) (Fig. 1-4).

In each site, three sampling areas were established representative of varying altitude and forest vegetation types namely: lowland dipterocarp (below 1000 masl), montane (1000 to 1500 masl) and mossy (> 1500 masl) forests.

Sampling method

A total of (8) plots spaced 20 meters apart were established along a 2-km transect belt in each sampling area. Trees within the 20 × 20m nested plot were assessed and identified on site taking into account the diameter at breast height (DBH), height (H), crown diameter (CD) and crown height (CH). Geographical coordinates were taken per sampling plot while individual trees in each plot were subjected to geo - tagging to evaluate the extent of its distribution and become a basis for monitoring activities in the future. Species within the sampling plots were photographed, and representative samples were collected, pressed and mounted as herbarium vouchers.

Conservation status of tree species

Conservation status of identified tree species was determined using the Redlist Database of the International Union for the Conservation of Nature (IUCN) 2013 v 3.1 and the National List of Threatened Philippine Plants by Fernando *et al.* (2008).

Data analysis

Species richness and diversity indices were analyzed through MS-Excel and MS-DOS Qbasic Programs, respectively. Species richness is the simplest measure of biodiversity, counting the number of different species in the area. Moreover, parameters for measuring tree species diversity include Basal Coverage (BC), Relative Density (RD), Relative Frequency (RF), Relative Coverage (RC), Species Importance Value (SIV), Similarity Index (SI) and Simpson's diversity index.

Density = Total no. of individuals.

Relative Density (RD) = (density/total no. of individuals of all species) ×100.

Frequency = no. of transects the species appeared

Relative Frequency (RF) = (Frequency/Total frequency of all species) × 100.

Coverage = Area covered by species/ total area.

Relative Coverage (RC) = (Coverage/Total coverage of all species) × 100.

Species Importance Value (SIV) = Relative Abundance + Relative frequency

Distribution was evaluated based on RF values while dominance was presented through SIVs. Sorensen and Jackards similarity indices present the comparison in terms of composition and abundance of the disturbed and undisturbed sites. Overall diversity was further determined through Simpson's diversity index.

Results and discussion

Species composition and distribution

A total of 129 species of trees representing 82 groups and 45 families were noted in the lowland, montane and mossy forests in MMPL. From these, 100 trees species were observed in the disturbed areas while 91 tree species were found in the undisturbed areas.

Family Moraceae was observed to have the greatest number (17) of tree species composed largely of Ficus group. Families composed of > 5 tree species were Sapotaceae, Myrtaceae, Meliaceae, Laureacea, and Euphorbiaceae. The most represented families in the disturbed areas of MMPL are Moraceae (15), Lauraceae (8) and Myrtaceae (7). The same families dominates the undisturbed areas: Moraceae (13), Lauraceae (7) and Myrtaceae (6) (Table 1).

Table 1. Top ten families with their respective species number in undisturbed and disturbed areas of MMPL.

FAMILY	No. of species	
	Undisturbed	Disturbed
Moraceae	13	15
Lauraceae	7	8
Myrtaceae	6	7
Euphorbiaceae	5	7
Sapotaceae	5	6
Meliaceae	4	5
Rutaceae	4	3
Fagaceae	3	3
Melastomataceae	3	4
Annonaceae	2	2

Phytosociological data (Tables 2.1) presents three (3) species, *Piper aborescens, Artocarpus blancoi,* and *Mimusops elengi* inhabiting the disturbed area of lowland forest of high density. However, *Mimusops elengi,* though populous is not widespread based on its relative frequency (1.464) while *Piper aborescens* and *Artocarpus blancoi* appear to be widely distributed in the area with relative frequencies of 6.532 and 2.815 respectively. On the other hand, seven (7) tree species did not present high number of individuals but are relatively widespread in the area namely; *Ficus linearifolia* (RF=4.279), *Ficus minahassae* (RF=4.279), *Macaranga bicolor* (RF=4.279), *Polyscias nodosa* (RF=4.279), *Berrya cordifolia* (RF=6.532), *Erythrina subumbrans* (RF=6.532), and *Pterocymbium tinctorium* (RF=4.279). In the lowland forest of the undisturbed area, *Trema orientalis, Dendrocnide orbicularis,* and *Ficus ulmifolia* present the most number of individuals and are the most widely distributed based on their relative frequencies (Table 2.2).

Table 2.1. Phytosociological Data in the Disturbed Area-Lowland Forest.

Scientific name	No. of plots present	BC	RD	RF	RC	SIV
Pterocymbium tinctorium	3	7.535	11.356	4.279	41.431	57.066
Erythrina subumbrans	4	6.725	3.155	6.532	36.977	46.663
Piper arborescens	4	0.000	22.713	6.532	0.000	29.244
Artocarpus blancoi	2	0.000	13.565	2.815	0.000	16.380
Mimusops elengi	1	0.000	12.618	1.464	0.000	14.082
Ficus linearifolia	3	0.393	5.363	4.279	2.159	11.801
Ficus minahassae	3	0.884	1.262	4.279	4.858	10.399
Berrya cordifolia.	4	0.000	2.839	6.532	0.000	9.371
Shorea astylosa.	2	0.000	4.732	2.815	0.000	7.547
Macaranga bicolor	3	0.221	1.893	4.279	1.215	7.387

In the montane forest, one (1) species, the *Securinega flexuosa*, locally known as Anislag has a high number of individuals and widely distributed both in the disturbed and undisturbed areas of MMPL. This species is known to be native in tropical rainforests and is known for its superb wood quality and high water storage and retention capacity. Its presence in Mt. Matutum is advantageous as it does not only have high economic value but is also a defense in landscape destruction activities. Moreover, this native tree has been one of the ten (10) timber species recommended for rainforestation or smallholder forestry in Leyte, Philippines in the effort to rehabilitate and restore degraded areas (Mangaoang and Pasa, 2003) (Table 2.3-2.4).

Table 2.2. Phytosociological Data in the Undisturbed Area-Lowland Forest.

Scientific name	No. of plots present	BC	RD	RF	RC	IV
Trema orientalis	3	11.585	25.000	12.881	31.548	69.430
Ficus ulmifolia	4	5.326	20.000	19.661	14.504	54.165
Dendrocnide orbicularis	4	3.545	22.500	19.661	9.654	51.815
Ficus balete	1	15.340	5.000	4.407	41.774	51.181
Ficus congesta	3	0.245	7.500	12.881	0.668	21.050
Ficus linearifolia	2	0.091	5.000	8.475	0.247	13.721
Ficus minahassae	1	0.393	5.000	4.407	1.069	10.476
Macaranga grandifolia	1	0.098	2.500	4.407	0.267	7.174
Berrya cordifolia	1	0.098	2.500	4.407	0.267	7.174
Ficus botryocarpa	1	0.000	2.500	4.407	0.000	6.907

Table 2.3. Phytosociological Data in the Undisturbed Area-Montane Forest.

Scientific name	No. of plots present	BC	RD	RF	RC	SIV
Dacrycarpus imbricatus	5	155.046	2.265	3.309	47.669	53.243
Lithocarpus sulitii	7	46.690	6.472	4.622	14.355	25.449
Palaquium philippense	8	26.170	4.207	5.252	8.046	17.505
Securinega flexuosa	7	6.401	10.356	4.622	1.968	16.946
Dendrocnide meyeniana	8	2.327	9.385	5.252	0.715	15.353
Decaspermum fruiticusom	7	15.451	5.178	4.622	4.751	14.550
Micromelum compressum	6	13.849	4.531	3.939	4.258	12.728
Syzygium bordenii	6	12.428	4.854	3.939	3.821	12.614
Phoebe sterculioides	7	0.434	5.502	4.622	0.134	10.257
Canarium asperum	6	0.437	5.502	3.939	0.134	9.575

Most of the tree species in the montane forest with a high number of individuals also appear to be widely distributed. In the disturbed site, *Securinega flexuosa* and *Dendrocnide meyeniana* rank first and second, respectively in terms of Frequency and at the same time widely distributed. *Palaquium philippense* moreover did not present a high number of individuals but is widely distributed with reference to its relative frequency (RF) values. Aside from *Securinega flexuosa* two other species, the *Gymnostoma rumphianum* and *Syzygium calubcob* present a high number of individuals and wide distribution in the undisturbed site of montane forest. Meanwhile, *Neolitsea vidalii* was observed to be widely distributed in the area though the number of individual stands was far lower than the ones previously mentioned (Table 2.3-2.4).

Table 2.4. Phytosociological Data in the Disturbed Area-Montane Forest.

Scientific name	No. of plots present	BC	RD	RF	RC	SIV
Securinega flexuosa	8	3.098	18.069	5.230	7.467	30.767
Ficus balete	3	10.701	1.238	1.987	25.794	29.019
Gymnostoma rumphianum	5	5.276	11.386	3.295	12.718	27.399
Dacrycarpus imbricatus	4	9.210	1.238	3.033	22.200	26.471
Syzygium calubcob	7	0.356	11.634	4.603	0.858	17.094
Glochidion canescens	7	2.191	3.960	4.603	5.281	13.844
Neolitsea vidalii	8	0.445	5.198	5.230	1.074	11.502
Lithocarpus sundaicus	5	1.129	5.446	3.295	2.722	11.463
Decaspermum fruiticusom	3	0.436	6.436	1.987	1.051	9.474
Micromelum compressum	6	0.362	3.218	3.923	0.872	8.012

The mossy forest of Mt. Matutum showed that *Dacrycarpus imbricatus*, locally known as Igem, has the highest number of individuals and the most widely distributed in both the disturbed and undisturbed areas (Table 2.5-2.6). It is also the most abundant tree species covering approximately 81% of the in the mossy forest. Igem is said to be a distinguishing feature of MMPL where stands could have DBH greater than 200 cm. Local communities have associated this tree to be indigenous in the area claiming its existence for hundreds of years.

Table 2.5. Phytosociological Data in the Undisturbed Area-Mossy Forest.

Scientific name	No. of plots present	BC	RD	RF	RC	SIV
Dacrycarpus imbricatus	8	38.933	20.134	8.203	80.730	109.068
Memecylon ovatum	4	3.324	4.027	4.758	6.893	15.678
Pistacia chinensis	5	0.324	8.725	5.168	0.673	14.566
Neolitsea vidalii	6	0.000	7.383	6.153	0.000	13.535
Terminalia microcarpa	4	1.869	2.685	4.758	3.875	11.317
Toona calantas	5	0.000	6.040	5.168	0.000	11.208
Securinega flexuosa	5	0.739	3.356	5.168	1.531	10.055
Syzygium subcaudatum	4	0.206	4.698	4.758	0.428	9.884
Decaspermum fruiticusom	4	0.526	4.027	4.758	1.091	9.876
Syzygium bordenii	4	0.041	3.356	4.758	0.086	8.200

Species richness

It has been observed that the greatest number of species can be found at the montane forests (1323-1372 masl) for both the disturbed and undisturbed areas. Further, it is revealed that at higher elevations (> 1500 masl), the number of species decreases. The same trend has been presented in a study of plant diversity in Mt. Shennongjia, China where species richness peaks at middle elevations between 900-1500 masl primarily at 1200 masl (Wei *et al.*, 2010). (Fig. 5.)

A hump-shape variation is observed in this study where the peak in species richness occurs at mid-altitude. This hump-shape variation is referred to as "mid-altitude bulge" or "mid-domain effect" where species richness is at its peak in middle elevations. Tu *et al.* (2010) accounts this high species richness in middle elevations due to increasing overlap of species ranges toward the centre of domain. Further Tu *et al.* (2010) perceived that this trend has been observed in tropical and sub-tropical mountain ecosystems and supported by increasing body of literature.

While it can be inferred that disturbed areas would have lesser number of species, results of this study showed the opposite in the lowland area. Here, the disturbed area appears to be more species-rich than the undisturbed. This may likely be explained by intermediate-disturbance hypothesis (IDH) of Connell (1978) where disturbances of intermediate frequency may present more species-rich areas. Townsend *et al.* (1997) further explains that richness should be highest at intermediate levels of disturbance because of both rapid colonizers and more competitive species can co-occur unlike that in the extremes. The same has also been shown by Svensson *et al.* (2007) where maximum diversity regarding species richness was generated at an intermediate frequency of disturbance.

Table 2.6. Phytosociological Data in the Disturbed Area-Mossy Forest.

Scientific name	No. of plots present	BC	RD	RF	RC	SIV
Dacrycarpus imbricatus	8	18.914	24.615	15.015	67.301	106.931
Lithocarpus sulitii	5	5.191	15.385	9.459	18.471	43.315
Syzygium bordenii	7	1.353	20.000	13.213	4.815	38.029
Syzygium mimicum	5	0.000	6.923	9.459	0.000	16.383
Cinnamomum mercadoi	4	0.000	4.615	8.709	0.000	13.324
Securinega flexuosa	3	1.216	3.077	5.706	4.326	13.109
Clethra pulgarensis	3	0.000	5.385	5.706	0.000	11.090
Neolitsea vidalii	3	0.080	2.308	5.706	0.284	8.297
Calophyllum blancoi	2	0.000	3.846	3.754	0.000	7.600
Ficus septica	2	0.362	2.308	3.754	1.288	7.350

Table 3. 1. Similarity index in disturbed and undisturbed Communities.

Forest Type	Disturbed			Undisturbed		
	Lowland	Montane	Mossy	Lowland	Montane	Mossy
Lowland	-	29	11	-	27	0
Montane	29	-	38	27	-	37
Mossy	11	38	-	0	37	-

Further, it has been observed that some portion of the undisturbed area in the lowland forest show secondary growth characteristic as the understory growth appears to be more frequent than trees. This area may have undergone previous clearings as evidenced by the presence of *Aglaia ilanosiana* saplings that are typical species found in a succession area. As such, even if the undisturbed area is expectedly an undisturbed site, current findings show the same conditions as the disturbed site of lowland forest. Landscape changes in the lowland have been linked to a strong human disturbance in the lowlands marked by fragmented areas and a variety of farmlands (Gao *et al.,* 2009).

Table 3.2. Similarity index between disturbed and undisturbed communities.

Disturbed	Undisturbed		
	Lowland	Montane	Mossy
Lowland	24		
Montane		57	
Mossy			48

Similarly in the mossy area, the richness of trees in the disturbed appears to be higher than the undisturbed. Variation may likely result from a wide range of factors such as climate, geographical position and the amount of rainfall, among others. A disturbance along this elevation appears to be insignificant as human activities weakened in high altitudes (Gao *et al.,* 2009).

Species diversity

Simpson's Index of Diversity (SID) showed the highest diversity in the mid-montane forest (0.95) while the least was indexed in the lowland forest (0.78) of the undisturbed site (Fig. 6). Across all forest types, it can be gleaned that undisturbed areas appear to be more diverse than the disturbed. This pattern is likely expected except in the lowland area where disturbed sites appear to be more diverse than the undisturbed sites. Some authors perceived that disturbed or managed areas may present greater diversity than the unmanaged or undisturbed areas which have only encountered an intermediate frequency of disturbance. Meanwhile, the montane and mossy forest in the high altitude could less likely account variation in diversity to anthropogenic activities as they are weakened in high altitudes (Gao *et al.,* 2009). Nonetheless, overall diversity measure based on Simpson's index still appears to be high in both the disturbed and undisturbed areas. However, with the observed local threats in the area such as small-scale slash and burn activities as well as the prevalence of invasive or alien species, such a high diversity may be threatened in the long run if there are no sustainable wildlife and forest conservation measures being undertaken.

Table 4. Conservation Status of Tree Floral species based on local and international standard.

Species official common name	Scientific name	Different conservation status		Endemicity
		IUCN 2013.2	Fernando et. al (2008)	
Malatapai	*Alangium longiflorum*	VU Alc	VU Alc	NE
Lanotan	*Mitrephora lanotan*	VU A1cd	VU Alc	NE
Katmon / Katmon-bayani	*Dillenia philippinensis*	VU A1d	OWS LR/lc	NE
Nabol	*Elaeocarpus gigantifolius*	VU D2	OTS LR/nt	NE
Hamindang	*Macaranga bicolor*	VU A1cd		NE
Anislag	*Securinega flexuosa*	VU A1cd	VU Alc	NE
Antipolo	*Artocarpus blancoi*	VU A1d		E
Isis	*Ficus ulmifolia.*	VU A1cd		E
Prickly Narra	*Pterocarpus indicus*	VU A1d	CR Alcd	NE
Kalingag	*Cinnamomum mercadoi*	VU A1d	VU Alc	NE
Puso-puso	*Neolitsea vidalii*	VU A1cd		NE
Takip-asin	*Macaranga grandifolia*	VU A1cd		NE
Malakmalak	*Palaquium philippense*	VU A1d	VU Alcd	E
Nato	*Palaquium luzoniense*	VU A1d	VU Alcd	NE
Magabuyo	*Celtis luzonica*	VU A1cd		NE
Molave	*Vitex parviflora*	VU A1cd	EN Alcd	NE
Yakal	*Shorea astylosa*	CR A1cd	CR Alcd	E
White Lauan	*Shorea contorta*	CR A1cd	VU Alcd	E
Kalantas	*Toona calantas*	DD	CR Alcd	NE
Kangko	*Aphanamixis polystachya*	LC	VU Alc	NE
Kuling manok	*Aglaia luzoniensis*	NT	OWS LR/lc	NE
Kalantas	*Toona calantas*	DD	CR Alcd	NE
Kangko	*Aphanamixis polystachya*	LC	VU Alc	NE
Kuling manok	*Aglaia luzoniensis*	NT	OWS LR/lc	NE
Makaasim	*Syzygium nitidum* Benth	NA	CR Alcd	NE
Katmon-kalabaw	*Dillenia reifferscheidia*	NA	VU Alc	NE

Similarity index

Highest similarity has been observed between montane and mossy forests in both the disturbed and undisturbed areas. Meanwhile, the least similarity was recorded for lowland and mossy in both areas. It is further observed that similarity values are quite low across forest types as they were far lower than 50%. Comparing the communities between disturbed and undisturbed communities, it can be observed that the lowlands have high dissimilarity while montane and mossy in both areas showed some degree of similarity at 57% and 48% respectively (Table 3.2).

Fig. 1. Philippine Map.

Endemism and conservation status

Concerning IUCN species redlist v. 2013.1 and the Threatened Philippine Plants by Fernando *et al.* (2008), a total of nineteen (19) trees has significant conservation status categorized either as Critically Endangered (Cr) or Vulnerable (Vu) (Table 4). Most of the trees species observed were classified as Vu while two (2) were found to be CR based on IUCN.

However, looking at the list by Fernando *et al.* (2008) some species fall under a different category from that of IUCN. For example, *Syzgium nitidum* and *Dillenia reifferscheidia* were not yet assessed (NA) based on IUCN but has been considered to be Cr and Vu respectively. According to IUCN (2013), CR species are facing a very high risk of extinction in the wild since at least 80% of its population declines over the last and is expected to continue at that rate in the next ten years.

Fig. 2. Mindanao Map.

Fig. 3. Map showing the relative position of Mt. Matutum in Southern Mindanao.

On the other hand, VU category is estimated to contain less than 10,000 mature individuals with a projected decline in population of at least 10% within ten years or 3 generations. Other tree species fall under Other Threatened Species (OTS) and Other Wildlife Species (OWS) categories. In this study one (1) tree species, *Eleaocarpus gigantifolius* locally known as Nabol is considered as OTS. Two (2) species were further classed as OWS namely; *Dillenia philippinensis* and *Aglaia luzoniensis*. OTS are said to be threatened from adverse factors such as overcollection and are most likely to be VU for while OWS species have the tendency to become threatened due to predation and destruction of habitats (Fernando *et al.,* 2008). It can be expected that many other tree species not categorized under IUCN are already threatened by habitat fragmentation. Langenberger *et al.* (2006) observes that IUCN red list seems to have a strong focus on well-known and economically important species as in the case of trees where only dipterocarps have been classified as critically endangered although many other tree species are found to be rarer in the study area.

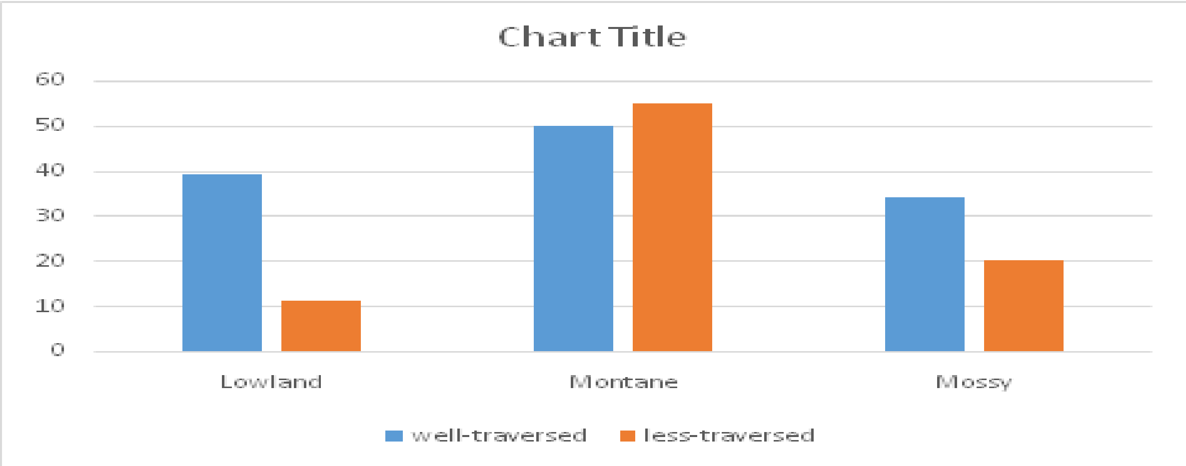

Fig. 5. Species Richness of Disturbed and Undisturbed Areas across Lowland, Mid-Montane and Mossy Forests of Mt. Matutum.

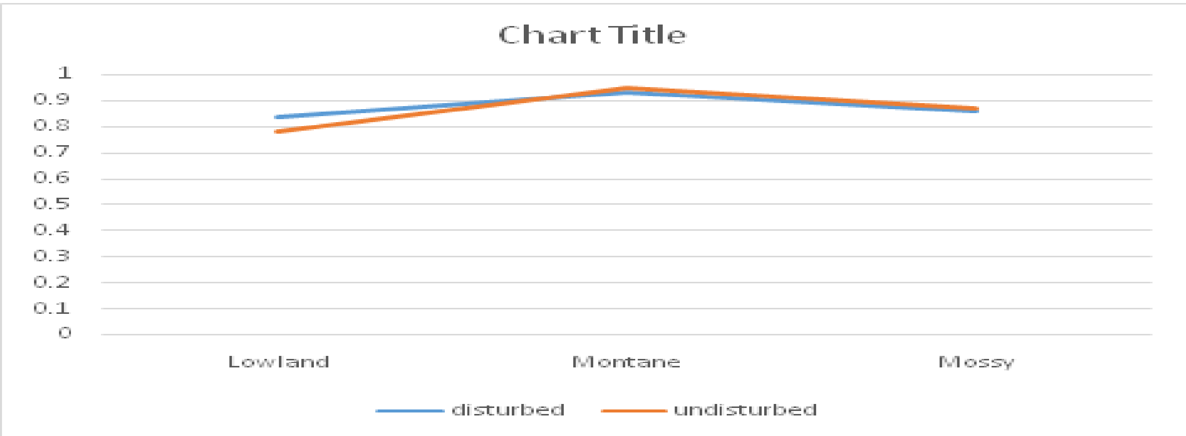

Fig. 6. Species Diversity Index across elevations.

Conclusion

The disturbed and undisturbed areas of MMPL showed a variety of tree species across elevations-lowland, montane, and mossy forest. It has been further shown that though expectedly undisturbed, the lowland forest in the undisturbed areas presented signs of disturbance owing to the low species richness compared to the disturbed area. Diversity showed high values particularly in the montane forests of MMPL in both the disturbed and undisturbed areas.

The presence of local threats and invasive species in the area indicates a potential threat to the sustainability of the MMPL. Moreover, since MMPL houses significant population of critically endangered and vulnerable trees, management of the landscape has to be intensified to ensure the balance of ecosystem's functioning and services.

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