Tree diversity and community characteristics in Panas, Eco-cultural Park, Davao del Norte, Philippines

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Abstract. The Philippines is known as a biodiversity hotspot. Years of careless deforestation for raw products have left the country severely depleted in forest resources. This study assessed tree diversity in Panas Eco-cultural Park, New Corella, Davao del Norte, Philippines. The following data were generated: tree species identification, rank abundance, relative density, relative frequency, relative dominance and importance value. A total of 420 individuals representing 47 species from 28 families were documented. Three species are critically endangered (6.38%), seven are vulnerable (14.89%), and seven are known as Philippine endemics (14.89%). The most abundant species was *Swietenia macrophylla*. The species *Pterocarpus indicus* ranked highest for relative dominance and importance value. All species had some form of economic or ecological value. The presence of endemic and endangered species necessitates urgent conservation measures. Cooperation between the local government unit, community and researchers will aid in the sustainable conservation and management of Panas Eco-cultural Park.
Key Words: tree species richness, tree species dominance, tree population structure, *Swietenia macrophylla, Pterocarpus indicus*.

Introduction. Tropical forests produce 40 percent of the world's oxygen and stabilize world climate by sending their stored heat and humidity into the Earth's colder temperate zones. They also store and recycle rain which in turn can prevent flood, drought and erosion of the soil. And though the total land area covered by all moist forest types account for only 7 percent of the Earth's total land surface, they are still home to 50 percent of all known species of living organisms (Mazzaro 2016). Forests play a significant role in the carbon cycle by absorbing one-third of recent anthropogenic emissions of carbon into the atmosphere in recent years. However, deforestation, particularly in the tropics, has already contributed to one-fifth of annual anthropogenic carbon emissions (Percy et al 2003). Countries can suffer from the adverse ecological backlash of low forest coverage and unevenly distributed forest resources. These problems include accelerated grassland degradation, frequent occurrence of droughts and floods, enlargement of desertification areas and severe soil erosion and loss of water. Loss of forest ecosystems can change climatic conditions which may influence more frequent forest fires, increased occurrence of pests and disease and through loss of habitat, the subsequent loss of biodiversity as well (Zhiqiang 2002; Lasco et al 2008).

The Philippines is an archipelagic country made up of 7,107 islands. It is considered to be one of the 17 mega biodiversity countries in the world due to its geographical isolation, high species endemism and diverse range of habitats. It ranks fifth in the global scale for number of plant species where five percent of the world's flora also naturally occurs (Garcia et al 2013). The unique topography of the country makes it possible for various vegetation types to flourish (Fernando et al 2008a). As such, the Philippines is home to a large array of unique flora and fauna (Philippine Statistics Authority 2000). Davao del Norte is a province of Region XI in the Philippine island of Mindanao. It has both Type II and Type IV climate characterized by no dry season with pronounced rainfall from November to January and evenly distributed rainfall throughout the year with no distinct dry or wet season, respectively (DENR 2014). It has a total land area of 19,671.83 km^2 (DENR 2014). The total land area of Davao del Norte is 35% dedicated to agricultural use where they grow rice, corn and fruit trees among other crops though the province also cuts down timber for log production (Department of Agrarian Reform-Policy and Strategic Research Service 2006; Philippine Forestry Statistics 2015). The total forest cover of Davao del Norte reaches a total area of 53,189 ha in both forestland, alienable and disposable land under the Philippine Forestry Statistics (2015).

Species diversity is an easily interpretable indicator of biological biodiversity. It is usually determined using the Shannon-Wiener Index by Shannon & Wiener (1949) and has been used many times since its inception, calculating species diversity in ecosystems for fauna and flora in both temperate and tropical settings. Likewise, the index of dominance by Simpson (1949) is used to determine the probability that two randomly chosen individuals belong to different species (Morris et al 2014). These two indices are usually used together as to gain a clearer picture of an ecosystem's biotic structure (Tripathi et al 2004; Thakur & Khare 2006; Sharma et al 2009). Species frequency, defined as the number of times a plant species occurs in a given number of quadrats or plots, is used to compare plant communities, detect changes in vegetation composition over time and quantify or describe the distribution of species in a selected community (University of Idaho College of Natural Resources 2015). To tally the total data obtained from these approaches in measuring ecosystem structure, the importance value index (IVI) is used. The IVI is the sum of the relative density, relative frequency and relative dominance. This gives an overall estimate of the influence of importance of a plant species in the community (Yeakley 2010).

Material and Method

Study site. Data were collected from three plots in Panas, Eco-Cultural Park, New Corella, Davao del Norte, Philippines (Figure 1) from August to December 2017.

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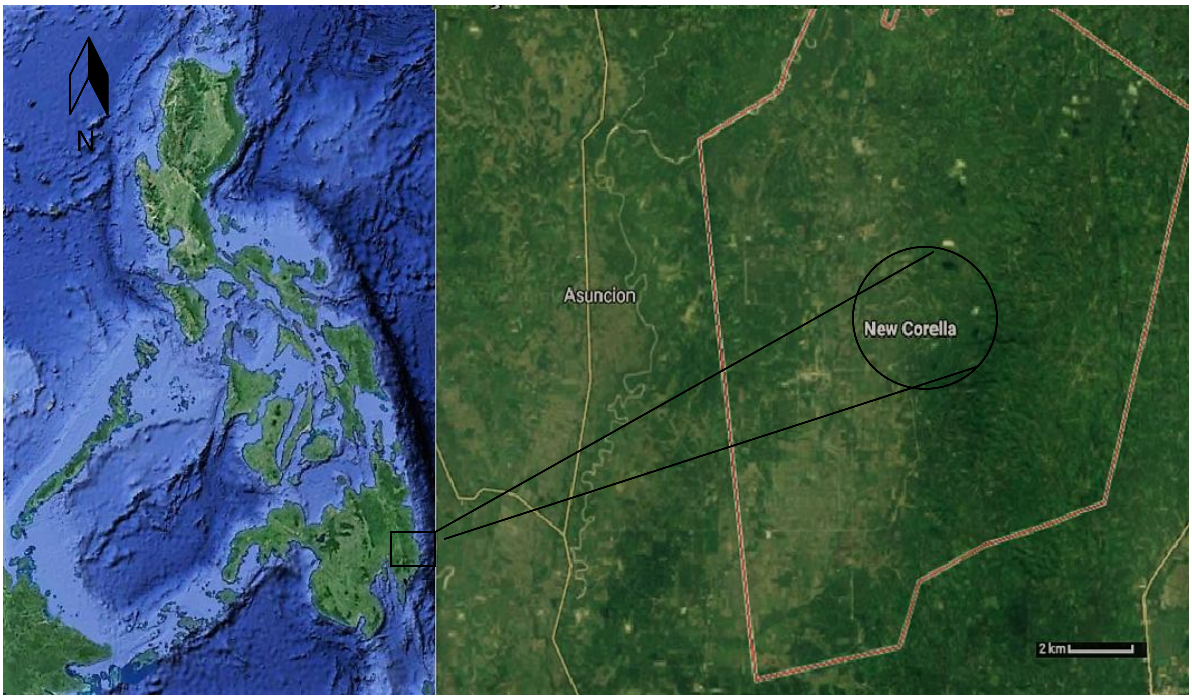

Figure 1. Satellite map showing New Corella, Davao del Norte, Philippines, 07°36'21N; 125°50'53E (Google Earth 2017).

The site was located approximately 200 to 700 m above sea level with site coordinates of 07°35’39.74’N and 125°51’4.76’E. With the presence of waterfalls, the site was considered a riparian environment, having steep slopes and lush undergrowth beneath the sparse canopy cover of the forest with the forest floor thinly covered by leaf litter. Three, one-km transect lines were established. The transect lines were situated on different elevations to allow for analysis of vegetation types on different elevation levels. There were no other criteria used to determine where transects were established other than elevation increases along its length. With the presence of waterfalls, the site is considered a riparian environment, having steep slopes and lush undergrowth beneath the sparse canopy cover of the forest with the forest floor thinly covered by leaf litter.

Forest structure analysis. Each tree species was identified through their characteristic features such as arrangement of leaves, leaf structure, leaf shape, leaf margin, leaf tips, leaf bases, leaf venation, flower structure, inflorescence, fruit type and fruit shape (Jensen 1999). Additional literature for species identification and partial valuation for potential use values include the manual on the “Properties and Uses of lesser-used Species of Philippine Timbers” by Bello & Mosteiro (1997) and by the “Vascular Plant Species Inventory of a Philippine Lowland Rain Forest and Its Conservation Value” by Langenberger (2006). The conservation status of these species was determined using IUCN (2017) and Fernando et al (2008b). Assistance was also provided by licensed Forester Brian Pototan in identifying species of trees in the site.

Parameters used to analyze the vegetation included population density, frequency, dominance, relative density, relative frequency, relative dominance, and importance value (Cañizares & Seronay 2016). Density is determined by the number of tree species in a given plot. Relative density is the density of one tree species as a percentage of total tree density obtained from the plots. Frequency is the total number of times a certain species is documented within a plot. Relative frequency is the percentage that one tree species represents out of total plant frequency (Fidellibus & Mac Aller 1993). Dominance is the total basal are of a given species per unit area within a community. Likewise, relative dominance is the dominance of one species representing a percentage of total dominance (Brower et al 1998):

$$\text{Relative Density} = \left(\frac{\frac{\text{TSTT}}{\text{TPA}}}{\text{TD}}\right) * 100 \qquad [1]$$

$$\text{Relative Frequency} = \left(\frac{\text{TSPT}}{\text{TPF}}\right) * 100 \qquad [2]$$

$$\text{Relative Dominance} = \left(\frac{\frac{\text{TASTP}}{\text{TPA}}}{\text{TBA}}\right) * 100 \qquad [3]$$

$$\text{Importance Value} = \left(\frac{\text{Rde}+\text{RF}+\text{RDo}}{3}\right) \qquad [4]$$

where: TSTT = total number of individuals of a species throughout three transects;
TPA = total plot area;
TD = total density;
TSPT = total number of times species is present in three plots;
TPF = total plot frequency;
TASTP = total area of a species throughout three plots;
TPA = total plot area;
TBA = total basal area;
Rde = relative density;
RF = relative frequency;

RDo = relative dominance.

Statistical analysis. The Paleontological Statistical Software Package (PAST) was used to statistically analyze the data collected. PAST was used to calculate in situ relative abundance, species richness, Shannon-Wiener diversity index and evenness (Hammer et al 2001).

Results

***Species abundance and conservation status**.* Canopy tree species reaching 15-30 m high while emergent trees reaching 60 m in height were found in the study site. The Park is also the site of a watershed rehabilitation project. The tallest of the emergent trees observed in the site, *Ceiba pentandra*, attained a height of 45 m tall. Emergent trees recorded were 30 m to 45 m tall such as *Acacia mangium.* These were the only two emergent tree species observed accounting for 0.94% of all species in the site. Canopy trees included *Swietenia macrophylla*, *Cananga odorata*, *Pterocarpus indicus*, *Cratoxylum sumatranum*, *Terminalia foetidissima*, *Nauclea orientalis*, *Palaquium luzoniense*, *Polyscias nodosa*, *Melanolepis multiglandulosa*, *Gmelina arborea*, *Alstonia scholaris*, *Hopea malibato*, *Pterospermum obliquum*, *Artocarpus sericicarpus*, *Duabanga moluccana*, *Prunus grisea*, *Sterculia* sp., *Pometia pinnata*. So, eighteen of the documented species are canopy trees (8.46%).

A total of 420 individuals belonging to 47 species distributed over 28 families were documented. Family Moraceae was the most represented with 60 individuals followed by family Meliaceae with 47 individuals, Sapindaceae with 37 individuals, Sapotaceae with 32 individuals. Families Euphorbiaceae, Lamiaceae and Sterculiaceae are each represented with 27 individuals, followed by Fabaceae with 21 individuals, Dipterocarpaceae and Tiliaceae are each represented with 20 individuals. Family Annonaceae is represented with 17 individuals. Then, Rubiaceae was documented with 16 individuals, followed by Sonneraticeae with 11 individuals and Guttiferae with 9 individuals. Both the families Anacardiaceae and Combretaceae are represented by 7 individuals, Araliaceae, Myrtaceae and Rosaceae are represented with 6 individuals each. Boraginaceae and Rutaceae are each represented with 3 individuals each. Apocynaceae, Bombaceae, Melastomataceae and Oxalidaceae are represented by 2 individuals each and the least represented families are Casuarinaceae, Lauraceae and Urticaceae with one individual representing each family. There were also seven endemic species (14.89%) documented, namely *Hopea malibato*, *Shorea contorta*, *Shorea polysperma*, *Ficus fiskei*, *Palaquium luzoniense*, *Pterospermum obliquum* and *Diplodiscus paniculatus*. Assessment of the conservation status of the documented species revealed that nine of the species (19.15%) recorded are threatened according to IUCN (2017). These include three critically endangered species; *Hopea malibato*, *Shorea contorta*, and *Shorea polysperma* and seven vulnerable species, *Pterocarpus indicus*, *Vitex parviflora*, *Artocarpus blancoi*, *Prunus grisea*, *Palaquium luzoniense, Diplodiscus paniculatus* and the introduced, *Swietenia macrophylla.* The three species found in greatest number include *Pometia pinnata, Ficus aurea* and *Swietenia macrophylla* (Table 1).

Table 1

Rank abundance and conservation status of tree species in Panas Eco-cultural Park, Davao Oriental, Philippines

Family	*Species*	*Rank abundance*	*Conservation status*
Anacardiaceae	*Dracontomelon dao* (Blanco) Merr. & Rolfe	6	Not assessed
	Spondias pinnata J.R.Forst. & G.Forst.	1	Not assessed
Annonaceae	*Cananga odorata* (Lam.) Hook. f. & Thomson	17	Not assessed
Apocynaceae	*Alstonia scholaris* (L.) R. Br.	2	Least concern
Araliaceae	*Polyscias nodosa* (Blume) Seem	6	Not assessed
Bombaceae	*Ceiba pentandra* (L.) Gaertn.	2	Not assessed
Boraginaceae	*Cordia dichotoma* G. Forst.	3	Not assessed
Casuarinaceae	*Casuarina nodiflora* Thunb.	1	Not assessed
Combretaceae	*Terminalia foeditisma* Griff.	7	Not assessed
Dipterocarpaceae	*Hopea malibato* Foxw.	3	Critically endangered; Philippine endemic
	Shorea contorta Vidal	15	Critically endangered; Philippine endemic
	Shorea polysperma (Blanco) Merr.	2	Critically endangered, Philippine endemic
Euphorbiaceae	*Macaranga tanarius* (L.) Müll. Arg.	2	Not assessed
	Macaranga mappa (L.) Müll. Arg.	6	Not assessed
	Melanolepis multiglandulosa (Reinw. Ex Blume) Rchb. & Zoll.	19	Not assessed
Fabaceae	*Pterocarpus indicus* Willd.	14	Vulnerable
	Acacia mangium Willd.	1	Not assessed
	Wallaceodendron celebicum (C. B. Rob.) Merr.	6	Not assessed
Guttiferae	*Cratoxylum sumatranum* (Jack) Blume	9	Not assessed
Lamiaceae	*Vitex parviflora* A. Juss.	3	Vulnerable
	Gmelina arborea Roxb. ex Sm.	24	Not assessed
Lauraceae	*Laura* sp.	1	Data deficient
Melastomataceae	*Melastomata* sp.	2	Not assessed
Meliaceae	*Toona calantas* Merr. & Rolfe	3	Data deficient
	Dysoxylum gaudichaudianum (A. Juss.) Miq.	3	Least concern
	Aglaia ilanosiana (C.) DC.	5	Not assessed
	Swietenia macrophylla King	36	Vulnerable
Moraceae	*Artocarpus blancoi* (Elmer)	6	Vulnerable
	Artocarpus sericicarpus F. M. Jarett	7	Not assessed
	Ficus aurea Nutt.	33	Not assessed
	Ficus elastica Roxb. ex Hornem.	1	Not assessd
	Ficus fiskei Elmer	5	Not assessed; Philippine endemic
	Ficus minahassae (Teijsm. & Vriese) Miq.	5	Not assessed
	Ficus septica Burm. f.	3	Not assessed
Myrtaceae	*Syzygium polycephaloides*	6	Not assessed
Oxalidaceae	*Averrhoa bilimbi* L.	2	Not assessed
Rosaceae	*Prunus grisea* (Blume ex Müll. Berol.) Kalkman	6	Vulnerable
Rubiaceae	*Nauclea orientalis* (L.) L.	16	Not assessed
Rutaceae	*Melicope triphylla* (Lam. Merr.)	3	Not assessed
Sapindaceae	*Pometia pinnata* J. R. Forst. & G. Forst.	33	Not assessed
	Nephelium sp.	4	Not assessd
Sapotaceae	*Palaquium luzoniense* (Fern.-Vill.) Vidal	32	Vulnerable; Philippine endemic
Sonneraticeae	*Duabanga moluccana* Blume	11	Not assessed
Sterculiaceae	*Pterospermum obliquum* Blanco	7	Philippine endemic
	Sterculia sp.	20	Not assessed
Tiliaceae	*Diplodiscus paniculatus* Turcz.	20	Vulnerable; Philippine endemic
Urticaceae	*Laportea meyeniana* (Walp.) Chew	1	Not assessed

Dominance, frequency and importance value. *Pterocarpus indicus* ranked highest for both relative dominance (12.9773) and importance value (6.9641888). Commonly called 'narra', *P. indicus* is endemic in the tropical and subtropical regions in Southeast Asia (Combalicer et al 2011). Meanwhile, *Gmelina arborea* was highest in relative frequency. Though not ranking highest in the all measures of community characteristics, *P. indicus*, still ranked highest in importance value due to its relatively high measure for dominance and density in transect 2 (Figure 2). The log-normal distribution pattern of the abundance curve indicates the heterogenous nature of the forest community (Figure 3).

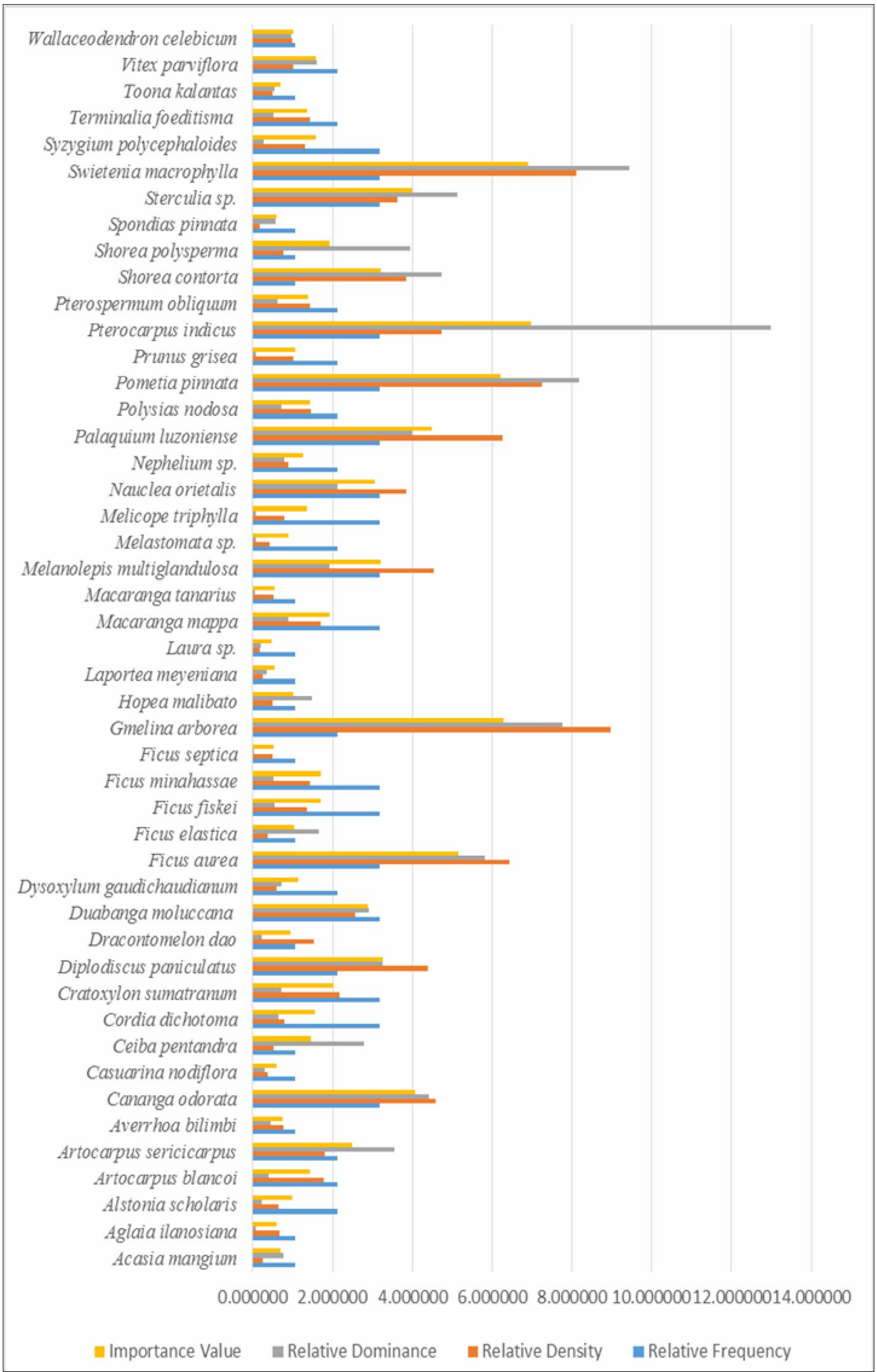

Figure 2. Attributes of tree species in Panas Eco Cultural Park, Davao Oriental, Philippines.

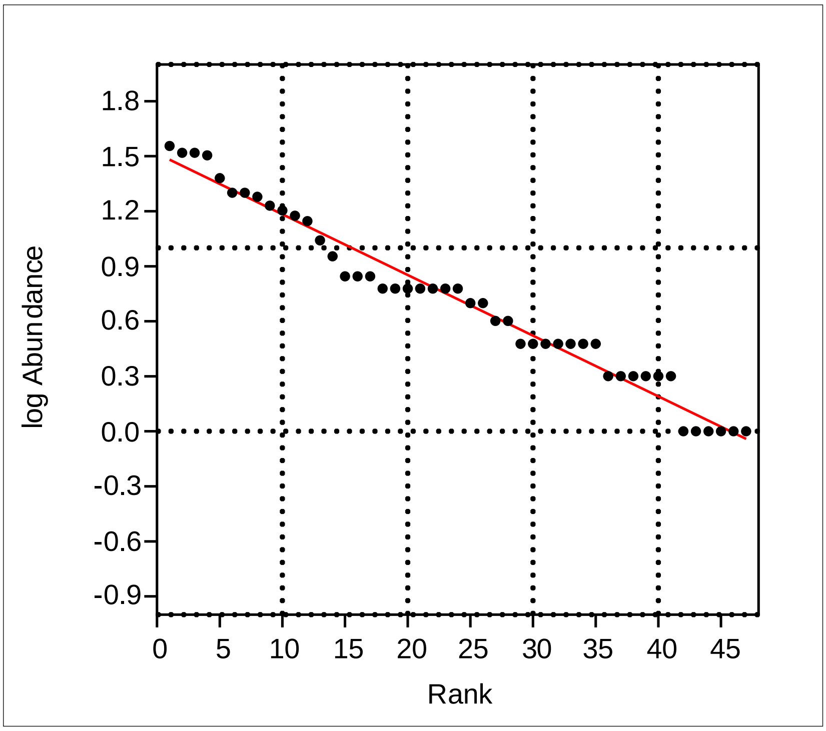

Figure 3. Abundance of tree species in Panas Eco Cultural Park, Davao del Norte, Philippines.

Discussion. The lowland forests of the Philippines are known to be dominated by dipterocarps. This comprises about 94% of the timber volume of the country (Langenberger 2006). *Shorea* sp. is common in the island of Mindanao. *Hopea malibato* is also common but occurs in a much lower altitude (Langerberger 2006).

Artocarpus blancoi is a species that originated from Southeast Asia (Rodolfo et al 2016). Studies also reported that fig species including *Ficus fiskei* were cultivated locally in the Philippines. It is a native small tree distributed throughout thickets and forests and moist localities at low and medium altitudes. It is endemic to the Philippines and is locally known as 'upling gubat' or 'isis' (Santiago & Balidoy 2015). Other endemic species recorded in this current study area include *Palaquium luzoniense* which is locally known as 'nato', *Pterospermum obliquum* and *Diplodiscus paniculatus.* The destruction of the tropical forests due to illegal logging may have caused the deterioration of species of Family Dipterocarpaceae mentioned previously (Rana et al 2009).

With regard to species conservation status, *P. indicus* is considered vulnerable (IUCN 2017) and was included in the priority list of species for conservation and reforestation in the Philippines. This is because of its limited potential to be an invasive species in native plant communities, adaptation to stress, fast growth, ease in reproduction and economic importance (Thomson 2006; ERDB 2012). IUCN also categorized *Artocarpus blancoi* as vulnerable (Agduma et al 2011). *Vitex parviflora* is known as a slow-growing timber with regard to its performance in rain forest plantations. Change in species loss was reported largely due to harvesting decisions of people. Wen et al (2008) reported the *Prunus grisea* is a low-growing tree (10-15 meters tall) and thus, light may just usually penetrate the undergrowth. It is also an economically significant species with its use as an ornamental or timber source. *Palaquium luzoniense*, also noted in this current study, was previously reported growing on low and middle slopes (Malaki et al 2018).

Threats to forest tree species recorded include illegal cutting for housing construction, firewood, charcoal making, and mine timbers. Slash and burn (*kaingin*) and conversion of forest lands to other uses, wildlife hunting, and collection of wild plants are most prevalent. *Diplodiscus paniculatus*, commonly called 'barorbo', is a tree nut that grows widely in the forests but at the rate of forest exploitation, genetic resources conservation of these species begin to vanish (Sotto & Coronel 1994). The species *S. macrophylla* itself is an invasive non-native species and as such, its prevalence poses a threat to biodiversity management and conservation.

Ethnobotanical assessment of tree species. In this study, species of trees valued for the light construction material that they provide are *Artocarpus blancoi*, *Palaquium luzoniense*, *Shorea contorta.* The species of tree that provide good to high quality timber are *Diplodiscus paniculatus*, *Hopea malibato*, *Pterocarpus indicus*, *Pterospermum obliquum*, *Shorea polysperma*, *Vitex parviflora.* The tree species *Artocarpus blancoi*, *Ficus fiskei*, *Hopea malibato*, *Pterocarpus indicus*, *Vitex parviflora*, also have bioactive compounds that have chemical and medicinal properties.

Artocarpus blancoi is known to be useful as light material for construction of boats by the *Mansaka* people of Mindanao (Abrams 1961). This species has also been found with very mild insect repellent properties against mosquitoes (Obico & Ragragio 2014). Other uses as documented show that the leaves of *A. blancoi* can be consumed for nutrition (Ragragio et al 2013). *Diplodiscus paniculatus* is used as construction material and can provide soil erosion control and sediment retention on the substrate it grows on (Visayas State University-Institute of Tropical Ecology 2010). *Ficus fiskei* has been found to act as an antioxidant and pro-oxidant that can neutralize oxidative stress by regulating the production of reactive oxygen and nitrogen species. This in turn, if applied properly, can maintain human health (Santiago & Balidoy 2015). *Hopea malibato*, though described as slow to grow, is a source of high quality timber. The tree itself can mitigate damage from soil erosion by acting as a windbreak, protecting its surrounding substrate (Visayas State University-Institute of Tropical Ecology 2010). Microbial activity from certain compounds such as oligostilbenes have very mild HIV-inhibitory activity and exhibit cytotoxic properties against host cells in antiviral assays (Dai et al 1998). *Palaquium luzoniense*is highly valued for both the latex that can be derived from it which can be in turn used to manufacture latex-based items and for the timber that it possesses (Visayas State University-Institute of Tropical Ecology 2010; Ragasa et al 2015). *Pterocarpus indicus* is known for the high-quality timber it possesses mainly used for the production of furniture. Trees of this species are also excellent at enhancing the soil fertility through nitrogen fixation (Visayas State University-Institute of Tropical Ecology 2010). Additionally, heartwood extracts of *P. indicus* were shown to possess anti-fungal properties while other parts of the tree such as bark, leaves and roots showed a wide range of antibacterial activity (Pilotti et al 1995; Khan & Omoloso 2003). *P. indicus* has also been shown to be able to remediate soil that has been contaminated by chemical compounds, particularly those containing the element chromium (Mangkoedihardjo et al 2008). *Pterospermum obliquum*, although a source of good quality timber, has more ecological value as it stabilizes riverbanks, help substrate retain their sediment content and thus help control soil erosion (Visayas State University-Institute of Tropical Ecology 2010).

Shorea contorta provides good quality wood that can be used for light construction, including boat keels. It also acts as a shade tree for the growth of abaca plants. *S. polysperma* also provides good quality wood and can serve as a windbreak and minimize soil erosion (Visayas State University-Institute of Tropical Ecology 2010). *Vitex parviflora* is highly favored for the high quality wood it has that can be used for constructing houses and furniture. It is also useful for preventing soil erosion and improving sediment retention (Visayas State University-Institute of Tropical Ecology 2010). Known medicinal uses of *V. parviflora* include using an infusion from its wood to induce vomiting to expel poison and decoction from its bark to treat diarrhea (Ragasa et al 2003). Other bioactive compounds have been found in the leaves of *V. parviflora* which have antioxidant properties. In addition, leaf, stem and root methanolic crude extracts of this tree have been recorded to have antibacterial activities against *Staphylococcus aureus* (Panti et al 2014; Tantengco et al 2016).

Conclusions. The study site, Panas Eco-Park, consisted of very diverse tree species. A total of 47 species distributed on 28 families were present in the area. Family Moraceae is one of the most species-rich families of trees found at an elevation below 500 m. Two genera of this family, *Artocarpus* and *Ficus,* that were found in the study site are known to be excellent sources of fruit. They are rich sources of nutrition for insects, birds and animals. The subsequent seed dispersal by these animals aided the members of family Moraceae to propagate in the site.

Despite the relatively small number of endemic and vulnerable species present in the site, conservation measures should not be overlooked. All species found in situ have at least some form of medicinal, constructional and nutritional value that can be derived from them. Cooperation between the stakeholders (local government unit, villagers, and researchers) could sustain conservation efforts and livelihoods for years to come.

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