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Species richness of trees in disturbed habitats within a protected area and its implications for conservation: The case of Mt. Apo Natural Park, Mindanao Island, Philippines

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Abstract. *Zapanta BR, Achondo MJMM, Raganas AFM, Camino FA, Delima, AGD, Mantiquilla JA, Puentespina, RP, Salvaña FRP. 2019. Species richness of trees in disturbed habitats within a protected area and its implications for conservation: The case of Mt. Apo Natural Park, Mindanao Island, Philippines. Biodiversitas 20: 2081-2091.* In order to improve forest management, it is fundamental to develop baseline information on species distribution i.e., richness and presence of endemic and threatened species in varying conditions of environmental degradation. In the Philippines, there is a growing number of studies which provided important information on pristine habitats (e.g. primary forest), however, there is a scarcity of studies on disturbed habitats. Here, we present baseline information on the tree species diversity in disturbed habitats like those portions converted to agricultural lands planted with fruit trees and other commercial crops within Mt. Apo National Park. A total of 136 tree species including a single gymnosperm was identified within the study sites. Of the species identified, the dominant families included Moraceae, Euphorbiaceae, Fabaceae, Meliaceae, Lauraceae, Myrtaceae, Arecaceae, Dipterocarpaceae, and Verbenaceae. Nineteen species were considered endemic including the Mindanao endemic, *Lindera apoensis*. Within this number, 47% are considered threatened on their range and four species viz. *Parashorea malaanonan*, *Shorea contorta*, and *Shorea negrosensis* are Critically Endangered with decreasing population records. The results of this current study suggest that disturbed habitats in Mt. Apo Natural Park still harbor endemic and threatened species, which are ecologically and economically important. Establishing a list of tree species in the area provides important information needed for the restoration of some disturbed areas which are abandoned by locals. The presence of endemic and threatened species also indicates that conservation, protection, and forest management efforts should be extended and allocated towards disturbed areas in the national park.

Keywords: Conservation, degraded ecosystem, distribution, species richness, trees

INTRODUCTION

Deforestation is among the important threats to biodiversity and the drivers of species extinction in tropical Southeast Asia (Hughes et al. 2017a,b) and the deforestation happens at an alarming rate in many lowland tropical rainforests particularly in the Asian tropics (Turner and Corlett 1996). The creation of protected area (PA) is fundamental to protect remaining pristine areas and is essential in developing future climate policies due to rewards from global payments to safeguard natural forest covers (Joppa and Pfaff 2011). However, protecting protected areas is costly and underfunded therefore many biologically important areas remain under protected (Corlett and Primack 2008). In Southeast Asia, the Philippines archipelago holds many important and rich protected areas, which harbor unique flora and fauna and many are endemic in the country (Posa et al. 2008; Salvaña and Gruezo 2018). The Philippine floras including trees dominate the forested areas of the country with an estimated of around 10,000-14,000 plant species which constitutes 5% of the world's flora (Barcelona et al. 2013). Many of these species, for example, *Pterocarpus indicus* (in local name called Narra), *Shorea contorta* (White Lauan), and *Vatica* spp. (Narigs) are dominant species in lowland forests and economically important for timber industry in the Philippines (Rojo and Aragones 1997; McGinley 2013; Salvaña et al. 2018)

However, the country is also experiencing rapid deforestation rate with present estimates of remaining forest range from 25% to less than 20% (Suarez and Sajise 2010; Apan et al. 2017). This current alarming rate is driven by unprecedented deforestation and forest resource extraction, conversion of natural lowland forest to agricultural lands for cash crops, i.e., large areas have been converted to high valued crops, such as rubber and oil palm, and infrastructure development (Brown and Diesmos 2009). In Mindanao Island, the southern part of the Philippines, embeds a diverse natural forest yet experiencing environmental pressures as the potential

expansion of oil palm and rubber plantation are projected in the region (Philippine Department of Agriculture Annual Report, 2013) coupled with other anthropogenic threats such as wildlife hunting and poaching (Tanalgo 2017). There have been several studies in the region on the floristic composition in protected areas, however, these studies focused on pristine areas and less on disturbed areas (Arances et al. 2004; Amoroso and Aspiras 2011; Amoroso et al. 2012, 2013), which are equally important when developing spatial-conservation priorities (Bryan et al. 2011). This current study aims to provide information on tree species richness and composition in defined disturbed areas in the lowlands of Mt. Apo National Park (MANP), Mindanao Island, the Philippines, with the hope to provide insights on the status relevant to present and future management of the protected area.

MATERIALS AND METHODS

Study sites

The study was conducted from dry months of May 2015 to wet months of October 2015 in selected disturbed habitats within Mt. Apo Natural Park. MANP is a mountainous landscape with 2,954 meters above sea level as its highest peak. The protected landscape covers 54, 974.87 hectares. The park falls under the jurisdiction of two provinces, Davao del Sur and North Cotabato. The total land area is divided into different classification: (i) Closed Canopy Forest- 12,604 ha; (ii) Open Canopy Forest- 13,460 ha; and (iii) brushland/cultivated area-37, 898 ha. Larger areas including buffer zones are converted into agricultural lands. With a fertile volcanic soil rich in minerals, it can support higher yield of agricultural crops. In addition, precipitation occurs at any time of the year wherein there is no definite dry and wet season. Thirty-nine communities are residing within the protected area which is primarily composed of different indigenous tribes. Most of these individuals have farm-based livelihood. The declaration of MANP as a protected area of the Philippines under National Integrated Protected Areas System-Republic Act No. 9237 was on 2003. Perhaps, these communities are already present in the area and there are small scale agricultural activities. Though the existing law has been enforced, the conversion of forest into agricultural lands continuously occur which threatens different species of flora and fauna.

Five sampling sites (Figure 1) were strategically selected based on the visual indicators of degradation or disturbance (i.e., proximity to settlement, openness of canopy cover, and presence of agricultural crops). The sampling sites include Sitio Tibolo, Centro and Lower Tudaya, Lower Pogpog, Sitio Colan and Sitio Balabag.

Plant collection, identification, and assessment of conservation status

A modified line transect method was used in the sampling of tree species. A line transect with length of 2000 m was established from a starting point to a possible endpoint (Madulid 1989). The transect line was established in areas wherein sampling is feasible and has the capacity to provide the most accurate data. Sampling techniques included 2000 m transect walks conducted with multiple recorders (described by Madulid 1989). Inventory of trees within the study area involved a method of opportunistic identification of existing trees within 5m on both sides of the transect line (Agduma et al. 2011). On-site identification of tree species which includes its local name, family and scientific name up to the lowest order of possible taxa was done together with field botanist. Also, the occurrence of an individual species was recorded several times depending on its location along the transect line. Photographs of selected tree species were also taken for documentation. The transect was traversed back and forth in order to check for possible missed trees. Any herbarium vouchers are taken to confirm the species name.

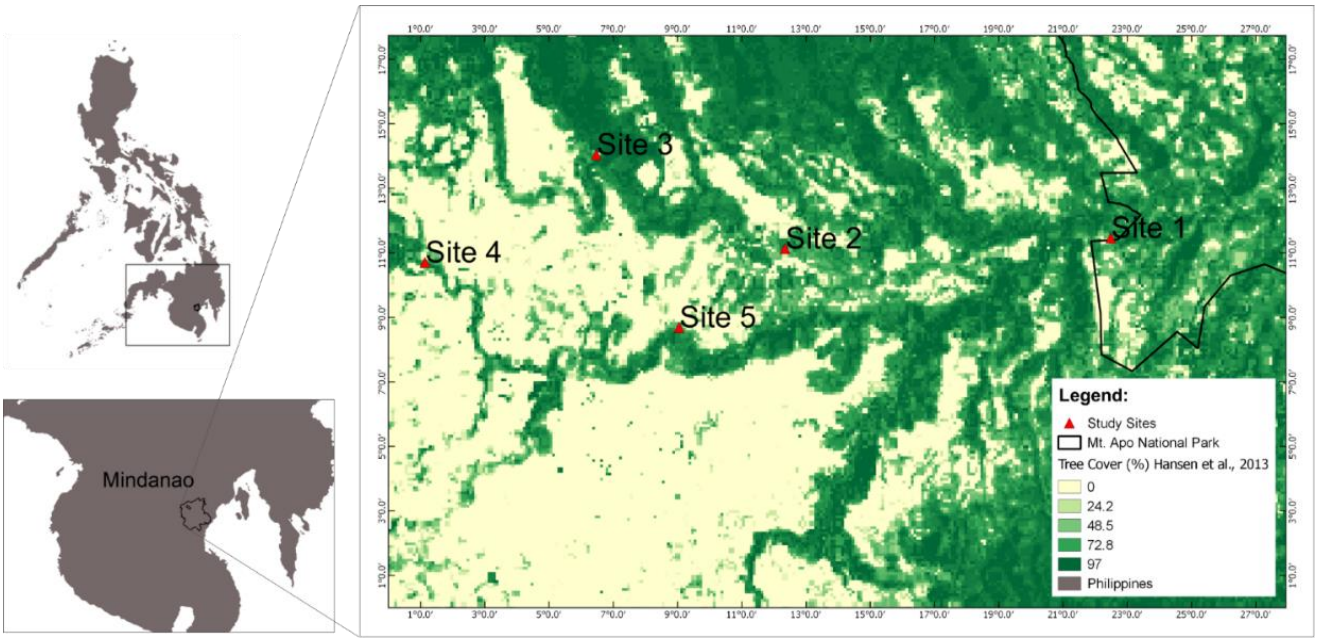

Figure 1. Map showing the five sampling sites within the disturbed habitats of Mt. Apo Natural Park, Davao del Sur, Philippines

Table 1. Location and description of study sites

Location	Coordinates	Description
Study site 1. Sitio Tibolo, Sta. Cruz, Davao del Sur	06º57.693'N,125º22.676'E (636-768 masl)	The area was classified as an early secondary growth forest. Some parts were cultivated with fruit-bearing trees. Canopy epiphytes and vines were moderately abundant. Ground cover and understory plants were moderately abundant. Fallen logs and exposed rocks were common in the area. Mosses were identified as rare. Humus cover and leaf litter were thin to moderately thick with depth ranging from 1-4 cm.
Study site 2. Centro and Lower Tudaya, Sta.Cruz, Davao del Sur (Site 2)	6°57'38.02"N, 125°20'51.01"E (833 masl)	The area was classified as an agroforest consisting of cultivated land areas. Cultivated plants include fruit-bearing trees and shrubs where Coffea spp. (Coffee) and Hevea brasiliensis (Rubber) were abundant in the area. Emergent trees are present with heights ranging from 25-30m. A flat to rolling terrain was observed. Canopy epiphytes such as orchids, Anyema and Pterocybium were moderately abundant. Understory and ground cover plants which include *Anamirta* (Ligtang), *Setaria* (Ayas-as), *Schismatoglottis* (Pihau) and *Piper aduncum* (Buyo Buyo Buyo-buyo Palo Verde) were also moderately abundant in the area. Fallen logs and exposed rocks were common in the areas near the cultivated lands and the Sibulan River. Humus and leaf litter was thin to moderate with depths ranging from 1 to 3 cm. Human settlements, some crop plantation (Banana and other fruits) were also noted as an ongoing anthropogenic disturbance.
Study site 3. Lower Pogpog, Sta. Cruz, Davao del Sur	6°57'55.04"N, 125°19'35.10"E (1060 masl)	It was classified as an early secondary growth forest which suggests that a previous disturbance occurred in the area. Also, a few parts of the area were cultivated land which consists of *Daucus carota* (Carrot). Emergent trees included species from the family Meliaceae, Moraceae, and Dipterocarpaceae. Understory plants such as the *Iresene herbstii* (Blood leaf), *Schismatoglottis latifolia* (Pihau) and *Piper betle* (Betel) dominated the area and occurred in high densities. Also, grasses such as *Saccharum spontaneum* (Talahib), *Dinochloa* sp. (Bikal) and ferns such as *Osmunda banksifolia* (Osmunda) were widespread along the area. Canopy epiphytes from the family Orchidaceae were moderately common. Exposed rocks were commonly found near the river systems and fallen logs were found only on cultivated areas. Moss density was determined to be moderate to common and was mostly found on exposed surface of rocks. Clearing of trees and human settlements were also noted to be present on cultivated land.
Study site 4. Sitio Colan, Sta. Cruz, Davao del Sur.	6°57'33.59' N, 125°18'49.96' E (1165-1250 masl)	Most parts of the area were categorized as an early secondary growth forest which indicates regrowth of plants after a major disturbance due to anthropogenic activities. Other parts of the area were cultivated into an agroforest which consists of *Musa* spp. (banana) and *Coffea* spp. (coffee). Emergent trees included dipterocarps and trees from the family Moraceae. Canopy epiphytes and vines were rarely observed while understory and ground cover plants were common in the area. Mosses were observed in moderate numbers and were found on large boulders of exposed rocks and ground cover within moist areas. Leaf litter and humus cover were significantly thicker on cultivated land or agroforest than the early secondary growth forest. This suggests that logging activities were done prior to cultivation. Soil was commonly loamy and changed into some rocky substrates as it progressed near the power plant. On-site disturbances included shifting cultivation: temporary cultivation of land, after its usage, is abandoned by owners to revert the land back to its natural vegetation, and weeding, or the removal of unwanted plants.
Study site 5. Sitio Balabag, Sta. Cruz, Davao del Sur	6°57'11.64" N, 125°20'15.42" E (987 to 1050 m asl)	The area was classified as an early secondary growth forest which is mostly part of a riparian environment. Emergent trees belonged to the family Moraceae and Sapindaceae. Canopy epiphytes, vines, understory plants and ground cover plants were moderately abundant. Also, *Piper betle* (betel) was highly abundant and widely spread on the area. Exposed rocks and fallen logs were abundant near the river system. Mosses were also moderately abundant and are commonly found at the surfaces of the rocks and logs. Soil parent material was composed of sand.

The identification of tree species was verified according to Kubitzki and Kadereit (2003) and other digital databases e.g., International Plant Names Index, Co's Digital Flora of the Philippines (www.philippineplants.org) and The Plant List (www.theplantlist.org). Consequently, the identified tree's conservation status (Least Concerned, Near-Threatened, Vulnerable, Endangered, and Critically Endangered) was determined using the database of IUCN Red List (2016) for Threatened Species and the preliminary assessment of Threatened Plants in the Philippines by Fernando et al. (2008). The species composition and the similarity among species across different sites were also assessed using Bray-Curtis single-link cluster analysis performed using Biodiversity Pro 2.0 software (McAleece et al. 1997).

RESULTS AND DISCUSSION

Tree species composition across sites

Tree species were identified in disturbed habitats within Mt. Apo Natural Park. We recorded a total of 136 tree species representing 101 genera belongs to 37 families. Angiosperms dominated the area comprising of 135 different tree species while only one representative tree species were recorded for Gymnosperm (Podocarpaceae, *Dacrycarpus imbricatus*) (Table 2).

At the family level, the most abundant taxa included Moraceae (30 species; 20%), Euphorbiaceae (15 species; 10%); Fabaceae (13 species, 9%); Meliaceae (7 species; 5%); Lauraceae (6 species; 4%); Arecaceae and Myrtaceae (5 species; 3%) and Verbenaceae with 4 species (2%). The remaining 26 tree families were represented by less than 5 species (Figure 2).

Among sites surveyed, site 3 had the highest species richness (n=75) followed by site 2 (n=73 species), site 4 (n=66), site 5 (n=59) and site 1 (n=57) (Figure 3). Furthermore, Bray-Curtis distance-based analysis showed a 54.9 % similarity in terms of composition in all sites. Between site 1 and 2 and between site 4 and 5 are shown to be similar in terms of species composition with values of 63.3% and 63.2% respectively. Site 3 on the other hand, is quite unique in terms of species composition as compared to sites 1 (51.7 %) and 2 (55.0 %) (Figure 6).

Threatened tree species

Of 139 tree species recorded at the study sites, 19 (13%) were classified as threatened according to IUCN criteria and Fernando (et al. 2008) (Figures 4-5). This is slightly lower compared to the assessment conducted by Gregorio et al. (2009) on trees in Southern Mindanao (n=23, 20%). Of the 19 threatened trees, 15 were categorized as Vulnerable and 4 as Critically Endangered. Among these threatened species, 9 were considered as Philippine endemic.

Vulnerable tree species included *Artocarpus blancoi* (Antipolo), *Cinnamomum mercadoi* (Kalingag), *Cryptocarya ampla* (Bagarilao), *Dillenia philippinensis* (Katmon), *Dracontomelon dao* (Dao), *Ficus ulmifolia* (Isis), *Lithocarpus bennettii* (Pangnan), *Macaranga bicolor* (Hamindang), *Macaranga grandifolia* (Takip-asin), *Palaquium philippense* (Malakmalak), *Pterocarpus indicus* (Smooth Narra), *P. indicus* forma *echinatus* (Prickly Narra), *Securinega flexuosa* (Anislag) and *Vitex parviflora* (Molave).

Of 19 threatened species, the majority of these species were found in site 3 (n=13) (Fig. 5) wherein 4 species were classified as Critically Endangered and three of which belong to family Dipterocarpaceae, namely *Parashorea malaanonan* (Bagtikan), *Shorea contorta* (White Lauan) and *Shorea negrosensis* (Red Lauan).

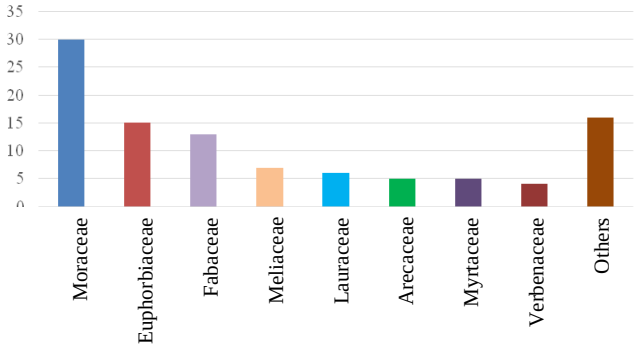

Figure 2. Abundance of trees per family

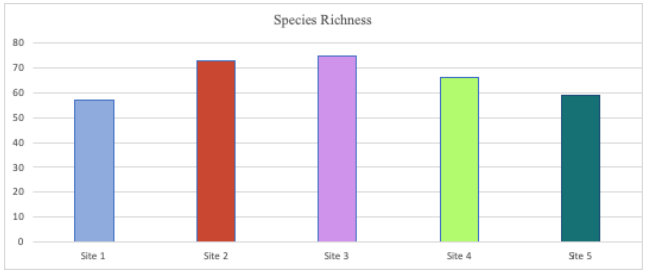

Figure 3. Species richness of trees at the five sampling sites

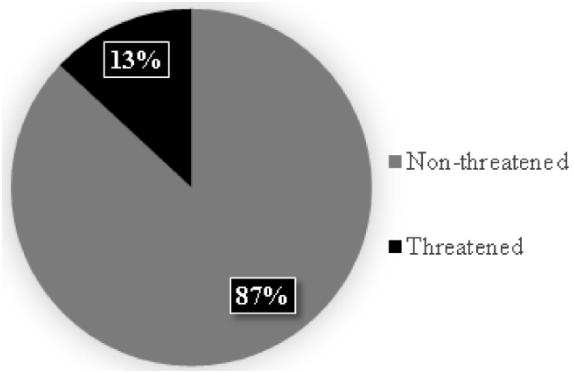

Figure 4. Percent of threatened tree species recorded at the disturbed habitats of Mt. Apo Natural Park, Davao del Sur.

Table 2. Identified tree species recorded at disturbed habitats within Mt. Apo Natural Park, Davao del Sur, the Philippines

Scientific name	Local name	Family	Distribution	Conservation Status	Sites				
					1	2	3	4	5
Acacia mangium Willd	Mangium	Fabaceae	Widespread	NL[1], NL[2]			✓	✓	✓
Acer laurinum Hassk.	Philippine Maple	Aceraceae	Southeast Asia	NL[1], NL[2]	✓	✓	✓	✓	
Adonidia merrillii Becc.	Manila Palm	Arecaceae	No Record	EN[1], NL[2]	✓	✓		✓	✓
Aglaia edulis (Roxb.) Wall.	Malasaging	Meliaceae	Asia Endemic	VU[1], LC[2]			✓		✓
Albizia saponaria (Lour.) Blume ex. Miq. var. *saponaria*	Salinkugi	Fabaceae	Southeast Asia	NL[1], NL[2]		✓			
Alchornea rugosa (Lour.) Muell.-Arg.	Aguioui	Euphorbiaceae	Widespread	NL[1], NL[2]					✓
Alstonia scholaris (L.) R. Br.	Dita	Apocynaceae	Widespread	NL[1], LC[2]	✓	✓	✓	✓	
Anisoptera thurifera (Blanco) Blume	Palosapis	Dipterocarpaceae	Philippines, Sulawesi, Moluccas (Morotai, Halmahera, Bačan, Obi, Aru Is.) and New Guinea	NL[1], NL[2]	✓	✓			
Annona muricata L.	Guyabano	Annonaceae	Widespread	NL[1], NL[2]		✓			
Antidesma ghaesembilla Gaertn. var. *ghaesembilla*	Binayuyu	Euphorbiaceae	Widespread	NL[1], NL[2]			✓		
Aralia sp.	Malakapaya	Araliaceae				✓			
Areca catechu L.	Betel nut	Arecaceae	Widespread	NL[1], NL[2]		✓			
Artocarpus altilis Blanco	Breadfruit	Moraceae	Widespread	NL[1], NL[2]	✓	✓		✓	
Artocarpus blancoi (Elmer) Merr.	Antipolo	Moraceae	Philippine-Endemic	NL[1], VU[2]	✓		✓		✓
Artocarpus heterophyllus Lam	Jackfruit	Moraceae	Widespread	NL[1], NL[2]		✓	✓	✓	✓
Artocarpus odoratissimus Blanco	Marang banguhan	Moraceae	Widespread	NL[1], NL[2]		✓	✓	✓	
Artocarpus ovatus Blanco	Anubing	Moraceae	Southeast Asia	NL[1], NL[2]				✓	✓
Astrocaryum standleyanum L. H. Bailey	Black Palm	Arecaceae	Tropical Asia	NL[1], NL[2]	✓	✓			
Astronia apoensis Elm.	Astronia	Melastomataceae	Philippine-Endemic	NL[1], NL[2]		✓	✓	✓	
Breynia vitis-idaea (Burm.f.) C.E.C.Fisch.	Matang-hipon	Phyllanthaceae	India- Malaysia -China	NL[1], NL[2]	✓	✓	✓		✓
Bridelia glauca Blume	Balitahan	Euphorbiaceae	Widespread	NL[1], NL[2]			✓		✓
Burserea graveolens (Kunth) Triana & Planch.	Palosanto	Burseraceae	Widespread	NL[1], NL[2]			✓	✓	
Calliandra calothyrsus Meissn.	Calliandra	Fabaceae	Widespread	NL[1], NL[2]	✓	✓	✓	✓	✓
Callicarpa magna Schauer.	Atimla	Verbenaceae	Southeastern Asia	NL[1], NL[2]			✓	✓	
Calophyllum blancoi Pl. & Tr.	Bitaog	Clusiaceae	Asia Endemic	NL[1], NL[2]			✓		
Calophyllum inophyllum L.	Malatalisay	Calophyllaceae	Widespread	NL[1], LC[2]		✓			
Canarium hirsutum Willd.	Dulitan	Burseraceae	Southeastern Asia	NL[1], NL[2]	✓				✓
Caryota rumphiana Mart.	Fishtail palm	Arecaceae	Philippine-Endemic	NL[1], NL[2]	✓	✓			
Casuarina equisetifolia L.	Agoho	Casuarinaceae	Widespread	NL[1], NL[2]	✓	✓	✓		
Chrysophyllum oliviforme L.	Caimiticello	Sapotaceae	Widespread	NL[1], NL[2]	✓				

Cinchona pubescens Vahl.	Quinine	Rubiaceae	Widespread	NL[1], NL[2]			✓	✓	✓
Cinnamomum mercadoi Vidal	Kalingag	Lauraceae	Philippine-Endemic	VU[1], VU[2]	✓		✓		
Citrus maxima (Burm. f.) Osbeck	Pomelo	Rutaceae	Widespread	NL[1], NL[2]		✓			
Cocos nucifera L.	Coconut	Arecaceae	Tropical Countries	NL[1], NL[2]	✓	✓			
Colona serratifolia Cav.	Anilao	Malvaceae	Widespread	NL[1], NL[2]			✓	✓	✓
Commersonia bartramina (L.) Merr.	Suyapao	Malvaceae	Widespread	NL[1], NL[2]	✓	✓	✓	✓	✓
Cordia dichotoma G. Forster	Anonang	Boraginaceae	Widespread	NL[1], NL[2]			✓	✓	
Cratoxylum formosum (Jack) Dyer var. *formosum*	Salinggogon	Clusiaceae	Asia Endemic	NL[1], LC[2]				✓	
Croton leiophyllus uell.-Arg.var.*leiophyllus*	Taguang-uak	Euphorbiaceae	Widespread	NL[1], NL[2]				✓	
Cryptocarya ampla Merr.	Bagarilao	Lauraceae	Asia	VU[1], VU[2]			✓	✓	✓
Cryptocarya cagayanensis Merr.	Cryptocarya	Lauraceae	Philippines (Luzon), New Guinea, Moluccas, Sulawesi, Borneo	NL[1], NL[2]			✓		
Dacrycarpus imbricatus (Blume) de Laub.	Igem	Podocarpaceae	Southeast Asia	NL[1], LC[2]		✓			
Dendrocnide luzonensis (Wedd.) Chew	Lipa	Urticaceae	Tropical Asia	NL[1], NL[2]		✓			
Dendrocnide meyeniana (Walt.) Chew	Lipang Kalabaw	Urticaceae	Philippines, Taiwan	NL[1], NL[2]		✓	✓		
Dillenia philippinensis Rolfe.	Katmon	Dilleniaceae	Philippine Endemic	LC[1], VU[2]				✓	✓
Dracontomelon dao (L.) Blume.	Dao	Anacardiaceae	Widespread	VU[1], VU[2]	✓	✓	✓	✓	
Duabanga moluccana Blume	Loktob	Lythraceae	Asia endemic	NL[1], NL[2]	✓	✓	✓		✓
Durio zibethinus Murr.	Durian	Malvaceae	Widespread	NL[1], NL[2]	✓	✓	✓		
Dysoxylon arborescens (Blume) Miq.	Kalimutain	Meliaceae	Widespread	NL[1], LC[2]					✓
Dysoxylum gaudichaudianum (A. Juss.) Miq.	Igiu	Meliaceae	Widespread	NL[1], NL[2]		✓	✓	✓	✓
Engelhardtia serrata Bl.	Bolas	Juglandaceae	Southeastern Asia	NL[1], LC[2]	✓		✓		
Erythrina subumbrans (Hassk.)Merr.	Rarang	Fabaceae	Asia	NL[1], NL[2]	✓	✓		✓	✓
Ficus balete Merr.	Balete	Moraceae	Philippine-endemic	NL[1], NL[2]		✓	✓	✓	✓
Ficus binnendykii Miq. var. *coriacea* Comer	Baleteng-liitan	Moraceae	Southeastern-Asia	NL[1], NL[2]				✓	
Ficus botryocarpa Miq.	Basikong Kalauang	Moraceae	Widespread	NL[1], NL[2]	✓				
Ficus callosa Willd.	Kalukoi	Moraceae	Widespread	NL[1], NL[2]	✓	✓	✓		
Ficus congesta var. congesta Roxb.	Malatibig	Moraceae	Widespread	NL[1], NL[2]	✓	✓	✓		✓
Ficus cumingii var. *cumingii*	Is-is-liitan	Moraceae	Taiwan, Philippines, Borneo, Palawan, Sulawesi	NL[1], NL[2]			✓		
Ficus heteropleura Blume	Opling-Buntotan	Moraceae	Southeastern Asia	NL[1], NL[2]	✓	✓		✓	✓
Ficus heteropoda Miq.	Alangas	Moraceae	Widespread	NL[1], NL[2]				✓	✓
Ficus irisana Elmer var. *irisana*	Aplas	Moraceae	Taiwan, India, Philippines	NL[1], NL[2]		✓	✓		✓
Ficus latsonii Elmer	Tangisang layugan	Moraceae	Philippine-endemic	NL[1], NL[2]	✓	✓	✓	✓	✓
Ficus magnoliifolia Blume	Kanapai	Moraceae	China, Taiwan	NL[1], NL[2]	✓	✓			
Ficus minahassae (Teijsm. & de Vr.) Miq.	Hagimit	Moraceae	Widespread	NL[1], NL[2]	✓	✓	✓	✓	✓
Ficus nervosa pubinervis (Bl.) C. C. Berg	Dungo	Moraceae	Southeastern Asia	NL[1], NL[2]					✓
Ficus nota (Blco.) Merr.	Tibig	Moraceae	Widespread	NL[1], NL[2]	✓	✓	✓		✓

Ficus odorata (Blanco) Merr.	Pakiling	Moraceae	Philippine-endemic	NL[1], NL[2]		✓			
Ficus pseudopalma Blco.	Niogniogan	Moraceae	Philippine-endemic	NL[1], NL[2]	✓				
Ficus ruficaulis Merr.	Tabgun	Moraceae	Widespread	NL[1], NL[2]	✓				
Ficus septica Blume.f.	Hawili	Moraceae	Widespread	NL[1], NL[2]		✓	✓	✓	✓
Ficus sp.	Ficus	Moraceae	Asia				✓		
Gmelina arborea Roxb.	Yemane	Verbenaceae	Widespread	NL[1], NL[2]			✓		
Gymnacranthera farquhariana (Hook F. & Th.) Warb	Anuping	Myristicaceae	Widespread	NL[1], NL[2]				✓	
Gymnostoma rumphianum (Miq.) L.A.S. Johnson	Agoho Del Monte	Casuarinaceae	Widespread	NL[1], NL[2]	✓		✓	✓	✓
Homalanthus populifolius Graham.	Bleeding Heart Tree	Euphorbiaceae	Widespread	NL[1], NL[2]		✓	✓		
Homalanthus populneus (Geisel.) Pax var. *laevis* (Blanco) Merr	Malabalante	Euphorbiaceae	Widespread	NL[1], NL[2]	✓		✓	✓	✓
Homalanthus populneus (Geiseler.) Pax var. *populneus*	Balante	Euphorbiaceae	Thailand to Malesia	NL[1], NL[2]	✓	✓	✓	✓	✓
Horsfieldia costulata (Miq.) Warb.	Yabnob	Myristicaceae	Widespread	NL[1], NL[2]			✓		
Kleinhovia hospita L.	Tan-ag	Sterculiaceae	Asia	NL[1], NL[2]				✓	
Lansium domesticum Corr.	Lanzones	Meliaceae	Southeastern Asia	NL[1], NL[2]	✓	✓		✓	✓
Leucaena leucocephala (Lam.) de Wit	Ipil-ipil	Fabaceae	Widespread	NL[1], NL[2]	✓	✓	✓	✓	✓
Leucaena pulverulenta (Schldl.) Benth.	Giant Ipil-ipil	Fabaceae	Widespread	NL[1], NL[2]	✓				✓
Leucosyke capitellata (Poir.) Wedd.	Alagasi	Urticaceae	Asia	NL[1], NL[2]	✓	✓	✓		✓
Lindera apoensis Elmer	Sarirab	Lauraceae	Mindanao endemic	NL[1], NL[2]			✓	✓	✓
Lithocarpus bennettii (Blco.) Rehd.	Pangnan	Fagaceae	Philippine-endemic	LC/LR[1], VU[2]				✓	✓
Lithocarpus sp.	Ulayane	Fagaceae	Widespread			✓			
Litsea perrottetii (Blume) F. -Vill.	Marang	Lauraceae	Taiwan and Philippines	NL[1], NL[2]			✓	✓	✓
Macaranga bicolor Muell.-Arg.	Hamindang	Euphorbiaceae	Philippine-endemic	NL[1], VU[2]		✓		✓	✓
Macaranga grandifolia (Blco.) Merr.	Takip-asin	Euphorbiaceae	Widespread	NL[1], VU[2]	✓	✓	✓	✓	✓
Macaranga tanarius (Blco.) Merr.	Binunga	Euphorbiaceae	Asia	NL[1], NL[2]	✓	✓		✓	✓
Mallotus mollissimus (Geiseler) Airy Shaw	Hinalumo	Euphorbiaceae	Malesia to E. Queensland	NL[1], NL[2]			✓	✓	
Mallotus pallidus (Airy Shaw) Airy Shaw	Banato	Euphorbiaceae	Southeastern Asia	NL[1], NL[2]			✓		
Mallotus philippinensis Muell. Arg	Banato	Euphorbiaceae	Widespread	NL[1], NL[2]				✓	✓
Mangifera indica L.	Mango	Anacardiaceae	Southeastern Asia	NL[1], DD[2]	✓	✓			
Melanolepis multiglandulosa (Reinw. ex Blume) Reichb. & Zoll.	Alim	Euphorbiaceae	Widespread	NL[1], NL[2]	✓		✓		
Neonauclea formicaria (Elmer) Merr.	Himbabalud	Rubiaceae	Philippine-endemic	NL[1], NL[2]	✓	✓	✓	✓	✓
Neonauclea media (Havil.) Merr.	Uisak	Rubiaceae	Philippine-endemic	NL[1], NL[2]	✓	✓		✓	✓
Nephelium lappaceum L.	Rambutan	Sapindaceae	Southeast Asia	NL[1], LC[2]		✓			✓
Palaquium philippense (Perr.) C.B.Rob.	Malakmalak	Sapotaceae	Widespread	VU[1], VU[2]				✓	
Haplostichanthus lanceolata (Vidal) Heusden	Anolang	Annonaceae	Widespread	NL[1], NL[2]				✓	✓
Parashorea malaanonan (Blanco) Merrill	Bagtikan	Dipterocarpaceae	Malaysia (Sabah, Sarawak); Philippines	NL[1], CR[2]			✓	✓	✓

Parasponia rugosa Blume	Hanagdong	Cannabaceae	Southeast Asia	NL[1], NL[2]	✓		✓		
Persea americana Mill.	Avocado	Lauraceae	Widespread	NL[1], NL[2]		✓	✓		
Petersianthus quadrialatus (Merr.) Merr.	Tuog	Lecythidaceae	Tropical Asia	NL[1], NL[2]		✓			
Pipturus arborescens (Link) C.B. Rob	Dalunot	Urticaceae	Southeastern Asia	NL[1], NL[2]		✓	✓	✓	✓
Planchonella nitida (Blume) Dub.	Duklitan	Sapotaceae	Widespread	NL[1], NL[2]	✓	✓		✓	✓
Pongamia pinnata (L.) Merr.	Bani	Fabaceae	Widespread	NL[1], LC[2]			✓		
Polyscias nodosa (Blume) Seem	Malapapaya	Araliaceae	Widespread	NL[1], NL[2]	✓	✓	✓	✓	✓
Pometia pinnata Forst. & Forst.f.	Malugai	Sapindaceae	Asia	NL[1], NL[2]	✓	✓			✓
Psidium guajava L.	Guava	Myrtaceae	Widespread	NL[1], NL[2]		✓	✓	✓	
Pterocarpus indicus Willd.	Narra	Fabaceae	Widespread	CR[1], VU[2]	✓	✓	✓		
Pterocarpus indicus Willd. forma *echinatus* (Pers.) Rojo	Prickly Narra	Fabaceae	Widespread	CR[1], VU[2]				✓	
Pterospermum diversifolium Blume	Bayok	Sterculiaceae	Asia	NL[1], NL[2]				✓	
Samanea saman (Jacq.) Merr.	Rain Tree	Fabaceae	Widespread	NL[1], NL[2]			✓		
Sandoricum koetjape Blanco	Santol	Meliaceae	Southeast Asia	NL[1], NL[2]		✓			
Schefflera actinophylla (Endl.)Harms	Umbrella ree/aralia	Araliaceae	Widespread	NL[1], NL[2]			✓		
Securinega flexuosa (Muell. Arg.) Muell. Arg	Anislag	Euphorbiaceae	Widespread	VU[1], VU[2]			✓	✓	✓
Semecarpus philippinensis Engl.	Kamiring	Anacardiaceae	Philippine Endemic	NL[1], NL[2]			✓	✓	✓
Senna spectabilis (DC.) Irwin & Bameby	Antsuan-dilaw	Fabaceae	Widespread	NL[1], LC[2]	✓				
Shorea contorta Vidal	White Lauan	Dipterocarpaceae	Philippine-endemic	VU[1], CR[2]	✓	✓	✓	✓	
Shorea negrosensis Vidal	Red Lauan	Dipterocarpaceae	Philippine-endemic	VU[1], CR[2]	✓	✓	✓		✓
Spathodea campanulata Beauv.	African Tulip	Bignoniaceae	Widespread	NL[1], NL[2]	✓	✓	✓	✓	✓
Spondias mombin L.	Hog-plum	Anacardiaceae	Tropical Countries	NL[1], NL[2]		✓			
Streblus asper Lour.	Kalios	Moraceae	Widespread	NL[1], NL[2]	✓				
Swietenia macrophylla King	Large-leaf Mahogany	Meliaceae	Tropical Asia	NL[1], LC2		✓			
Sympetalandra densiflora (Elmer)	Malasantol	Fabaceae	Malesian Region	NL[1], NL[2]					✓
Syzygium bordenii (Merr.) Merr.	Malaruhat puti	Myrtaceae	Widespread	NL[1], NL[2]				✓	
Syzygium cumini (L.) Skeels	Black Plum	Myrtaceae	Widespread	NL[1], NL[2]				✓	
Syzygium polycephaloides (C. B. Rob.) Merr.	Lipote	Myrtaceae	Widespread	NL[1], NL[2]	✓		✓		
Syzygium samarangense (Blume) Merr. & L.M.	Makopa	Myrtaceae	Widespread	NL[1], NL[2]		✓	✓		
Tectona grandis L.*f.*	Teak	Verbenaceae	Tropical Asia	NL[1], NL[2]	✓	✓			
Theobroma cacao L.	Cacao	Malvaceae	Widespread	NL[1], NL[2]		✓			
Toona calantas Merr. & Rolfe	Kalantas	Meliaceae	Widespread	NL[1], DD[2]		✓	✓	✓	
Trema orientalis (L.) Blume	Anabiong	Cannabaceae	Widespread	NL[1], LC[2]	✓	✓	✓	✓	✓
Triplaris cumingiana Fisch. & C.A. Mey. ex C.A. Mey.	Palo-santo	Polygonaceae	Widespread	NL[1], NL[2]			✓	✓	
Vitex parviflora Juss.	Molave	Verbenaceae	Widespread	EN[1], VU[2]	✓	✓	✓	✓	

Note: NL: Not Listed; CR: Critically endangered; LC/LR: Least Concern/ Lower Risk; DD: Data Deficient; VU: Vulnerable; EN: Endangered. [1]from Fernando et al. (2008); [2]from IUCN (2016)

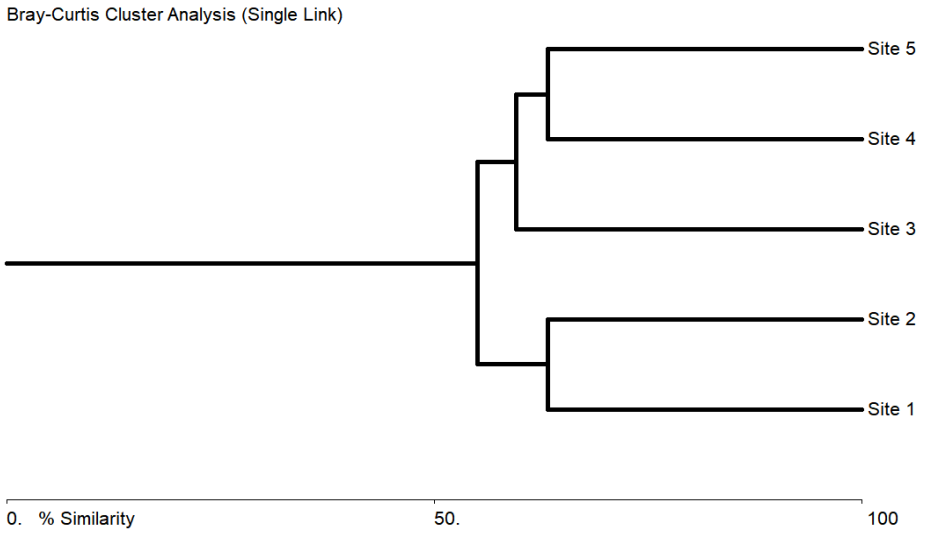

Figure 6. Bray-Curtis distance-based species similarity analysis of tree species across different disturbed habitats within Mt. Apo National Park based on species occurrence

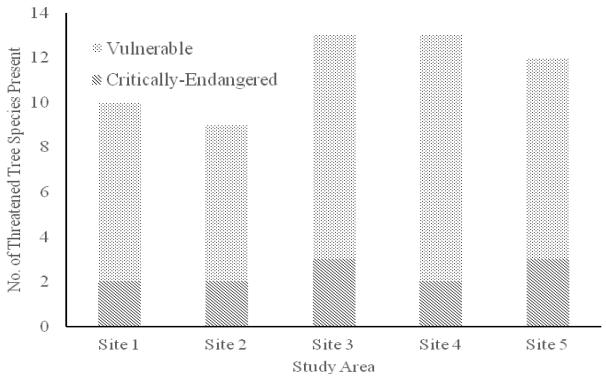

Figure 5. Number of threatened tree species per site categorized into Vulnerable and Critically Endangered

Discussion

The number of species in Mt. Apo (current study) is significantly higher than in Mt. Malindang (n=86) (Arances et al. 2004), and in Southern Mindanao (n=117) (Gregorio et al. 2009). However, the range of the survey area and effort allocated may have contributed to the difference in species richness across the study sites. In this study, five areas along Mt. Apo were surveyed compared to Arances et al. (2004) and Gregorio et al. (2009) wherein only two areas were surveyed. In addition, other environmental factors such as elevation, geographic locations, previous succession events and degree of disturbance, which were not taken into account in the current survey, may have contributed to variation in species richness and community structure (Colwell et al. 2004; Salvaña et al. 2019). In addition, the result of this study is similar to the findings of Agduma et al. (2011) in a rubber plantation in Makilala, Cotabato, Gregorio et al. (2009) in Southern Mindanao and Madulid (2000) in Samar, Philippines, wherein some highly occurring families comprised of Euphorbiaceae, Moraceae, Fabaceae, Dipterocarpaceae, Arecaceae, Myrtaceae and Lauraceae. Moraceae which is mostly represented by the genus *Ficus* are dominant as they are highly adapted and can thrive on a wide range of altitudinal gradient and are dispersed by a large number of birds and volant mammals like bats (Gregorio et al. 2009).

Differences of species composition between different disturbed habitats within Mt. Apo Natural Park can be attributed to several factors. It can be observed that most of these forests are planted with crops which might affect the species composition within the area. Clearing of land through slash and burn done by several locals also attributed to the invasion of pioneer species. These species, such as the invasive alien species, were observed to be common in all sites. Furthermore, there were also native species recorded to be common in all sites. These tree species are documented to be widespread in Mt. Apo.

The study recorded a total of 16 introduced species in the Philippines (Table 2). These introduced species are most likely planted due to their economic value and for forest rehabilitation purposes (Uriarte 2007). Introduced species can be also invasive and are strong competitors for local species in terms of space and other resources, however not all invasive species are introduced but rather most introduced species are explicably invasive. Thus, not only it is a large threat to the survival of endemic species but also for threatened species as well (Uriarte 2007). With this, it is highly advised that these tree species listed must be controlled to allow the conservation of endemic and threatened species.

In the study, the presence of an invasive tree species, *Leucaena leucocephala* (Ipil-ipil), was recorded in all five

study areas. According to Cronk and Fuller (1995), *L. leucocephala* is classified as a serious widespread weed invading semi-natural and disturbed habitats. It was also classified into Category II weed (Henderson 2001), a species which has a local distribution but either expanding populations, has a known potential to invade in disrupted native vegetation. The presence of *L. leucocephala* may also account to the variation of the number of endemic among the study areas. This species is fast-growing and has high reproductivity, which is one of the characteristics of an invasive plant. It is noticed that this species is abundant and may have taken over open spaces and takes up nutrients from the soil thus outcompeting native/endemic species which are slow growing in nature. Also, the presence of tree species that are considered as bioindicators such as the *Macaranga* spp., *Mallotus* spp. and *Trema orientalis* indicate previously disturbed areas (Zamora 1999). These trees are pioneer softwood species thus, they are the first successors of semi-disturbed areas considering the fact that these species can tolerate a considerable degree of disturbance.

Fernando et al. (2008) classified *S. contorta* and *S. negrosensis* to be Vulnerable while the IUCN Red List (2016) assessed them to be critically endangered. *S. contorta* and *S. negrosensis* is continuously exploited due to their valued timber as a raw material for furniture (Fernando 2009). Furthermore, *P. malaanonan* and *T. philippinesis* are also high-valued timbers found in lowland-middle Dipterocarp forests threatened by logging. A greater number of threatened species were found above 1000 masl compared to lower elevated sites. This is because threatened species are more sensitive and vulnerable to environmental disturbances and takes time to adapt (Gregorio et al. 2009). Higher threatened species are expected in the region due to the unprecedented rate of degradation in many lowlands of protected areas i.e., conversion of lowlands for agricultural cultivations and logging, whether it may be legal or illegal, accounts as the most serious threat to the forest trees. (Amoroso et al. 2011; Salvaña et al. 2019)

Tree species like *D. philipinensis* and *L. ovalis* are categorized as Least Concerned according to the assessment of Fernando et al. (2008) but based on global distribution (i.e., IUCN Red List criteria) it is considered as Vulnerable with decreasing population trends on its known geographical distribution. In contrast to this, *V. parviflora* was classified as Endangered by Fernando et al. (2008) and was categorized as Vulnerable by the IUCN Red List (2016).

All the sites surveyed in this study are categorized either as early secondary growth forest or agroforest, where disturbance and land-modification remain incessant. Notably, on these sites, cultivated tree crops are present e.g., *Mangifera indica* (Mango), *Artocarpus odoratissimus* (Marang-banguhan), *Citrus maxima* (Pomelo), *Cocos nucifera* (Coconut), *Durio zibethinus* (Durian), *Lansium domesticum* (Lanzones), *Persea americana* (Avocado), *Sandoricum koetjape* (Santol) and *Theobroma cacao* (Cacao) which are mostly present on the agroforest of site 2.

To conclude, the destruction of some parts of Mt. Apo National park was clearly observed and imminent in many areas particularly in the lowlands where agriculture and conversion for settlement are increasing. Our present study revealed interesting initial findings on the tree composition in a disturbed habitat in Mt. Apo National Park. Our result showed that the disturbed habitats i.e., cleared for industry and cultivation, of the protected areas can still hold several ecologically and economically important plant species. Also, these habitats harbors threatened species in national and global scale that requires urgent conservation protection. The results of this study are an important baseline to develop effective conservation and appropriate restoration efforts in degraded habitats such as in disturbed lowlands of the national park. Furthermore, timely monitoring initiative should be collaboratively joint by multiple stakeholders including local government units, NGO's, and academics to circumvent future loss of biodiversity in the area.

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REFERENCES

Agduma AR, Achondo MJM, Bretaña BLP, Bello VP, Remollo LL, Mancao LS, Supremo JP, Salem JG, Salvaña FR. 2011. Diversity of vascular plant species in an agroforest; The case of rubber (*Hevea brasiliensis*) plantation in Makilala. North Cotabato. Philipp J Crop Sci 36 (3): 57-64.

Amoroso CB, Coritico FP, Amoroso VB. 2013. Diversity and status of plants in three mountain ecosystems in southern Mindanao, Philippines. Asian J Biodivers 83: 50-73.

Amoroso VB, Amoroso CB, Coritico FP. 2012. Diversity and status of plants in three mountain ecosystems in southern Mindanao, Philippines. Asian J Biodivers 3 (1): 50-73

Amoroso VB, Aspiras RA. 2011. Hamiguitan Range: A sanctuary for native flora. Saudi J Biol Sci 18 (1): 7-15.

Apan A, Suarez LA, Maraseni T, Castillo JA. 2017. The rate, extent and spatial predictors of forest loss (2000-2012) in the terrestrial protected areas of the Philippines. Appl. Geogr. 81: 32-42.

Arances JB, Amoroso VB, Comilap R, Comilap C, Galvezo JB, Gruezo WS, Lumaray C, Montimar B, Opiso G, Pacut G, Ridsdale C, Rufila L, Sacal S, Tan S, Visser L. 2004. Development of participatory methodology for inventory and assessment of floral resources and their characterization in the montane forests of Mt. Malindang. PDM Press Inc. Quezon City, Philippines 1: 15-94.

Barcelona JF, Nickrent DL, LaFrankie JV, Callado JRC, Pelser PB. 2013. Co's digital flora of the Philippines: Plant identification and conservation through cybertaxonomy. Philipp J Sci 142: 57-67.

Brown RM, Diesmos AC. 2009. Philippines, Biology. Encyclopedia of Islands. University of California Press. Berkeley, CA.

Bryan BA, Raymond C, Crossman ND, King D. 2011. Comparing spatially explicit ecological and social values for natural areas to identify effective conservation strategies. Conserv Biol 25 (1), 172-181.

Colwell RK, Rahbek C, Gotelli NJ. 2004. The mid-domain effect and species richness patterns: What have we learned so far? Am Nat 1: 23-63.

Corlett RT, Primack RB. 2008. Tropical rainforest conservation: a global perspective. Trop For Comm Ecol 15 (51): 442-457.

Cronk QCB, Fuller JL. 1995. Plant invaders: the threat to natural ecosystems. Chapman & Hall, London, UK.

Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau. 2009. Assessing Progress Towards the 2010 Biodiversity Target: The Fourth National Report to the Convention on Biological. Diversity. Cavite, Philippines.

Fernando E. 2009. Habitats of Philippine Dipterocarps. In: Dipterocarps of the Philippines, Los Baños, Laguna, Philippines.

Fernando ES, Co LL, Lagunzad DA, Gruezo WS, Barcelona JF, Madulid DA, Lapis AB, Texon GI, Manila AC, Zamora PM. 2008. Threatened plants of the Philippines: A preliminary assessment. Philippines Threatened Plants 2: 23-54.

Gregorio N, Doydora U, Harrison S, Herbohn J, Sebua J. 2009. Inventory and assessment of mother trees of indigenous timber species in Leyte Island and Southern Mindanao, Philippines. ACIAR Seedling Enhancement Project (1): 113-125.

Henderson L. 2001. Alien Weeds and Invasive Plants. Plant Protection Research Institute Handbook No. 12. Paarl Printers. Cape Town. South Africa.

Hughes AC. 2017a. Understanding the drivers of Southeast Asian biodiversity loss. Ecosphere 8 (1): e01624.

Hughes AC. 2017b. Mapping priorities for conservation in Southeast Asia. Biol Cons 209: 395-405.

Joppa LN, Pfaff A. 2011. Global protected area impacts. Proc R Soc Lond [Biol] 278 (1712):1633-1638.

Kubitzki K, Kadereit JW. 2003. The Families and Genera of Flowering Plants: Volume I-VII, Springer-Verlag Berlin Heidelberg. New York.

Madulid D. 1989. Biodiversity on Philippine Mountains. http://www.ched.gov.ph/wp-content/uploads/2013/05/CHED-00000004.pdf. Accessed 4 August 2016.

Madulid DA. 2000. Philippine Plants: Endangered Plants. Island Publishing House, Manila.

McGinley M. 2013. Biological Diversity of the Philippines. http://www.eoearth.org/view/article/150648/

Posa MRC, Diesmos AC, Sodhi NS, Brooks TM. 2008. Hope for threatened tropical biodiversity: Lessons from the Philippines. BioScience 58: 231-240.

Rojo JP, Aragones EG Jr. 1997. Botanical Identification Handbook on Philippine Dipterocarps, Forest Products Research and Development Institute. Department of Science and Technology, College, Laguna.

Salvaña FRP, Carillo CK, Mangaoang CC, Bretaña BL. 2019. Diversity and community structure of trees in two forest types in Mt. Apo Natural Park (MANP), Philippines. Biodiversitas 20 (7): 1794-1801.

Salvaña FRP, Gruezo WS, Hadsall AS. 2018. Recent taxonomic notes and new distribution localities of P*odocarpus* Pers. species in the Philippines. Sibbaldia: J Bot Gard Hortic No 16: 99-120.

Salvaña FRP, Gruezo WS. 2018. Threatened species of genus *Podocarpus* in the Philippines. Asian J Conserv Biol 7 (2): 125-127.

Suarez RK, Sajise PE. 2010. Deforestation, swidden agriculture and Philippine biodiversity. Philippine Sci Lett 3 (1): 91-99.

Tanalgo KC. 2017. Wildlife hunting by indigenous people in a Philippine protected area: a perspective from Mt. Apo National Park, Mindanao Island. J Threat Taxa 9 (6): 10307-10313.

The Plant List. 2016. http://www.theplantlist.org.

Turner IM, Corlett RT. 1996. The conservation value of small, isolated fragments of lowland tropical rain forest. Trends Ecol Evolut 11 (8): 330-333.

Uriarte M. 2007. Some introduced alien species in the Philippines and their effects on ecosystems. Food and Agriculture Organization Corporate Document Repository (1): 1-81.

Zamora PM. 1999. Inventory of important species. Mount Apo Foundation Inc. http://www.mafi.org.ph/information/featured_topics/ft_sub_04.html.