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Assessment and Characterization of Dipterocarp Species in Panay Island, Philippines

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Documentation of the remaining dipterocarps is key information to the conservation, protection, and forest restoration programs of different sectors. This study was conducted to assess and characterize the dipterocarp species in Panay, Island Philippines. A 20 m x 500 m plot was established in the study site and all dipterocarps' species with a dbh of 10 cm and above were inventoried. Studies showed that there are three species of dipterocarps in Aklan, and Antique, and eight species found in Iloilo. Genus *Shorea* was found to be the most abundant genus in the three provinces surveyed. *Shorea almon* Foxw., was most abundant in Iloilo, *Parashorea malaanonan* (Blanco) Merr. was the most abundant in Antique and *Shorea negrosensis* Foxw. in Aklan. The majority of dipterocarps in Panay Island belong to the 30 cm - 60 cm diameter class. *Shorea almon* Foxw. has the highest Species Importance Value in Iloilo and Aklan, while *Shorea negrosensis* Foxw. in Antique. One species were found to be critically endangered, five were classified as vulnerable and two were least concern. Three new dipterocarp species were recorded to exist in Panay. Protection of dipterocarps and conservation of the site is highly recommended.
Keywords: Critically endangered, dipterocarps, endangered, species structure, vulnerable species

INTRODUCTION

Dipterocarp species was the major source of timber in the Philippines exported to various parts of the world until the early 1980. However, that was only history, today very few remaining dipterocarp forests exist mostly in protected areas and national parks protected by the government. Many species become endangered and threatened due to logging and forest conversion into different land uses. There were thirteen (13) critically endangered dipterocarps species (DAO, 2017; Fernando, 2009; IUCN, 2006) discovered, three (3) were reported to be found on the island of Panay, but their exact location is not ascertained including their characteristics. Tumaneng, Tumaneng, and Tiburan (2019) state that little emphasis was given to the conservation status of individual species, an expression of the lack of information about the distribution and conservation status of dipterocarps in the Philippines.

The Dipterocarpaceae perhaps holds the distinction of being the most well-known tree of all the families of plants in the tropics (Appanah and Turnbull, 1998). This famous family of trees occupies the dominant canopy level in some of the forest formations in the tropics.

In the Philippines, there are forty-five (45) species in six (6) genera, and nearly half (46%) are endemic to the country (Fernando *et al*., 2009). Represented by small to large resinous and evergreen trees (Rojo and Aragones, 1997). Dipterocarps are considered the most economically important source of timber in the country they added. Timber poaching posed serious threats of dipterocarp in the country. The Forest Management Bureau (FMB) of the Department of Environment and Natural Resources (2022) listed four dipterocarp species as the most frequently illegally cut from the forest, these are palosapis (*Anisoptera thurifera*), yakal (*Shorea astylosa*), guijo (*Shorea guiso*), and red lauan (*Shorea negrosensis*). The DENR has recorded thirteen (13) critically endangered, six (6) endangered, and sixteen (16) vulnerable species of dipterocarps in the country (DAO, 2017). Research on dipterocarps conducted on the Island of Bohol recorded fifteen (15) species in six (6) genera and 12 species are new records on the Island (Fernando *et al*., 2009). In a separate study on the Island of Leyte, 18 species in 6 genera were documented on the island (Langenberger, 2009). The dipterocarp species were found to be the key species in most tropical forests because of their economic and ecological value in nature. The result of the study of Calago and Diola, (2022) on the structure and spatial pattern of dipterocarps in

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Mount Malindang in Mindanao, recorded seven (7) dipterocarp species belonging to the genus *Shorea, Dipterocarpus*, and *Anisoptera* in the area.

In a study conducted by Llait (2024), he identified four species of dipterocarps in the Sierra Madre Mountain Range in Central Luzon, Philippines. This consists of five genera, *Dipterocarpus, Hopea, Parashorea, and Shorea*. In a separate study in Southern Philippines, six hundred seventy-five (675) dipterocarp tree species were recorded by Pito, *et al*., (2019) in the Southern portion of Mt. Malindang Range Natural Park, Mindanao, Philippines. About four genera of dipterocarp species were discovered, including *Shorea, Parashorea, Dipterocarpus, and Anisoptera*. Only a single species of dipterocarp (S. negrosensis) was recorded by Medecilo-Guiang, *et.al*. (2021) in Mt. Agad-Agad, Iligan City, Philippines in a separate study.

No published research was conducted on the presence and distribution of dipterocarps in Panay Island, the study was conducted on the adjacent island of Negros. Documentation on the location and distribution of dipterocarps in Panay Island is key information on the conservation and protection programs since the species are mostly found in major watershed areas in Panay Island.

Data from the study is a baseline information on the remaining dipterocarp species in Panay both for the protection and conservation efforts of different agencies. Data also served as a reference of information on sources of planting material for ex-situ conservation programs including the National Greening Program of the DENR. This study was carried out to determine the species composition, distribution, and species importance value of dipterocarp species in Panay Island.

MATERIALS AND METHODS

***The Study Site*:** The study site includes the Central Panay Mountain Range which is considered as a critical habitat of different species of flora and fauna (Figure 1). It serves also as the watershed area of the major river system in Panay that supports most population both in domestic water supply and agricultural production. It is the natural habitat of many dipterocarp species and also critically endangered wildlife species. One study site was established in Aklan and Antique while three sites were identified in Iloilo.

***Site Identification*:** A preliminary survey of dipterocarp species location was conducted by asking residents about the presence of dipterocarps in their locality. In addition, DENR personnel were also asked about the presence of dipterocarps in the area. Local guides were hired to guide the researchers in the area since most dipterocarps grow in the remote forest far away from the residents.

Establishment of Sampling Plots: Purposive sampling was used in this research. Forest area with known dipterocarps population was used as ample. A 1-ha sampling plot was established in each site where dipterocarp species are naturally growing. To ensure a comprehensive coverage, a rectangular plot measuring 20 meters by 500 meters was designated, allowing for the recording of as many dipterocarps as possible. The boundaries of the sampling plots were determined using Orux Map apps, ensuring accurate demarcation. To clearly identify the plot boundaries on the ground, ribbons were placed at intervals of 50 meters along the perimeter.

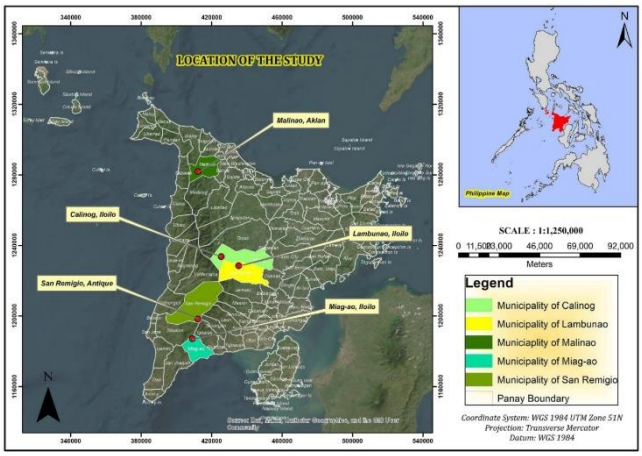

Figure 1. Location of the study site in three provinces in Panay Island, Philippines. **Malinao in Aklan, San Remegi in Antique Calinog, Lambunao and Miag ao in Iloilo.**

In Iloilo, a total of six plots were established, with three plots located at the West Visayas State University-College of Agriculture and Forestry (WVSU-CAF), two plots in Calinog, and one plot in Onop, Miag-ao. Great focused was on documenting dipterocarps within the WVSU-CAF reservation to comprehensively document the diversity within the forested areas of the College.

In Antique, two sampling sites were established Aningalan, while in Aklan, two sites were established in Barangay Capataga, Malinao. Most of the remaining dipterocarps are often found along creeks, the orientation of the sampling plots followed the direction of watercourses. In areas lacking creeks or trails, the plots were established across the contour of the slope, ensuring representative sampling across the topography.

***Species Identification*:** A local guide was hired to locate the different dipterocarp species and identification, especially on local names. A printed picture of the dipterocarps from Co's Digital Flora of the Philippines was used to help in the identification, if available. Pictures using a Smartphone were taken for further identification and documentation. Parts of the dipterocarp such as leaves, fruits, etc., were collected for further identification. Leaves and other important parts were collected for herbarium collection.

***Species Structure*:** The diameter was measured using a diameter tape, with all dipterocarps with a diameter at breast height (DBH) of 10 cm and above included in the study. These trees were categorized into three main classes following established classification criteria: pole (10 cm – 29 cm), standard (30 cm – 59 cm), and veteran (>60 cm) (Burns and Honkala, 1990; Lleno *et al*., 2023).

***Elevation*:** This was determined using GPS and Smartphones to determine the elevation. Species of dipterocarps may vary as elevation increases. Dipterocarp species within sampling plots were geotagged with their relative coordinates using GPS or smartphones with GPS application and Orux Map application. Using GIS software, species distribution was laid in the maps. Other applications such as Google Earth were used to generate maps and locations of dipterocarps.

***Species Importance Value (SIV)*:** This was computed using relative values: relative density, relative frequency, and relative dominance (Razavi *et al*., 2012).

Species Importance Value = Rf + RDen + RDom

Relative density (RDen) is the number of particular species expressed as a percentage of all species. Relative density (RD) was computed using the formula:

$$\text{RDen} = \frac{No.of\ species}{Total\ no.of\ all\ species} \times 100$$

Relative frequency is the frequency of a given species expressed as a percentage of the sum of the frequency of all species present. Relative frequency (RF) was computed using the formula:

$$\text{RF} = \frac{Frequency\ of\ species}{\text{Total frequency of all species}} \times 100$$

Relative dominance. It is the basal area of a given species expressed as a percentage of the total basal area of all species present. It was computed using the formula:

$$\text{RDom} = \frac{\text{Basal area of species}}{\text{Total basal area of all species}} \times 100$$

***Data Analysis*:** Mean values, relative density, relative frequency, relative dominance, and frequency counts were calculated utilizing Microsoft Excel. Graphical representations of dipterocarp attributes were generated, and thematic maps were created to present the distribution of dipterocarps across Panay.

RESULTS

***Species Composition and Distribution in Aklan Province*.** In Aklan, two genera of dipterocarps were observed in the sampling plots (refer to Figure 2a). These include *Shorea* and *Parashorea*, with *S. negrosensis* as the prominent species, constituting 47.27% of the total dipterocarps. Following closely behind are *S. almon* at 38.18% and *P. malaanonan* at 23.64%. A total of 56 individual dipterocarps were recorded in two sampling plots.

The dipterocarp habitats in Aklan extend from 227 meters above sea level (msl) up to 591 msl, at this elevation it belonged to lowland tropical rainforest formation (Fernando, 2009). Aklan is situated on the northern side of the Panay Mountain Range, which spans from the Province of Aklan in the north to the Provinces of Iloilo and Antique in the south.

***Dipterocarp Species Composition and Distribution the Province of Antique*:** *Parashorea malaanonan* (bagtikan) was the most dominant species in Aningalan, San Remegio, Antique (46.88%) while *S. negrosensis* was 29.695% and *S. contorta* was 23.44% of all dipterocarps found in the sampling plots. There are seventy-three (73) dipterocarps found in the area (Figure 2). Two genera were identified, two species belong to *Shorea* while one belongs to *Parashorea.* The result is comparable with only two genera and 3 species found in the sampling plots out of the six genera and forty-seven identified species (De Guzman *et al*., 1986). The result of this study demonstrates that dipterocarp species diversity is low in the Province of Antique. The distribution of dipterocarps in sampling plots in Antique is shown in Figure 2b.

The sampling plots have an elevation range of 875 to 1,006 meters above sea level. The formation was described as a lowland tropical evergreen rainforest and the lauan type was considered the dominant dipterocarp at this formation (Fernando, 2009).

***Dipterocarp Species Composition and Distribution in Province of Iloilo*:** There are eight species of dipterocarps found in the province of Iloilo and *Shorea almon* was the most abundant species (34.01%) of dipterocarps (Figure 2c). This was followed by *S. contorta* (33.50%), *S. ploysperma* (16.24%), *S. negrosensis* (3.05%), *Dipterocarpus validus* (1.52%) *Hopea philippinensis* (1.02%) and *D. grandiflorus* (1.02%). Dipterocarps in Iloilo are represented by four genera *Dipterocarpus, Hopea, Parashorea,* and *Shorea*. The total species inventoried was 197 with most genera found in WVSU-CAF, Lambunao with all four genera present. In Calinog, most of the number of dipterocarps were observed but only represented by two genera, S*horea* and *Parashorea*. In Miag-ao, only two genera were present, *Shorea* and *Parashorea*. *Shorea almon* was found in all areas' samples except in WVSU-CAF, Lambunao, while *P. malaanonan* was found in all areas sampled in Iloilo. Elevation in WVSU CAF, Lambunao ranges from 179 m to 319 meters above sea level, while in Calinog 745 m to 819 asl.

Dipterocarpus grandiflorus, *D. validus*, and *H. philippinensis* were found in elevations lower than 500 m above sea level and growing in the forest reserve of WVSU CAF. On the other hand, *P. malaanonan* was found in a wide range of elevations (200 up to 866 msl). *S. almon* was most abundant dipterocarp in Calinog, *S. contorta* in Miag-ao, and *P. malaanonan* in WVSU CAF, Lambunao. Data also showed that Genus *Shorea* was abundant at an elevation of more than 700 meters above sea level. The species distribution map of dipterocarps in Panay is shown in Figure 2.

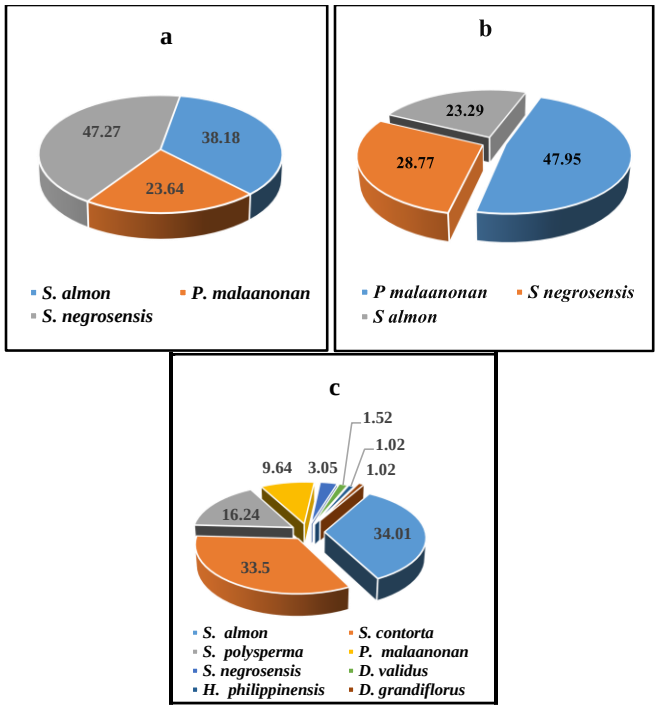

Figure 2. Species composition of Dipterocarps in three Provinces of Panay, Island Philippines (a) *Species Composition of Dipterocarps in Aklan* (b) *Species Composition of Dipterocarps in Antique* (c) *Species Composition of Dipterocarps in Iloilo*. All data in the graphs are expressed in percent.

***Diameter Classes of Dipterocarps in Aklan*:** Diameter classes 30-59 cm dominate the forest in Aklan with 41.67% of total dipterocarps (Figure 3). A diameter class larger than 60 cm is composed of 31.67% of the total population while a diameter less than 30 cm was 26.67%. According to a local guide, in Aklan, most of the large dipterocarps were uprooted or damaged by super typhoon Yolanda in 2013.

Dipterocarps are characterized as very large trees and without perturbation, the red lauan (*S. negrosensis)* can reach more than 200 cm in diameter (De Guzman *et al*., 1986). Like other Provinces, very few regenerants and saplings were observed in the sampling sites. These findings suggest that once the upper and mid-canopy level dipterocarps are disturbed it will take a long period to recover due to the absence of regenerants in the forest floor.

***Diameter Classes of Dipterocarps in Antique*:** Data in Figure 4 shows a majority of the dipterocarps in Aningalan, San Remigio Antique belong to the 30 cm to 59 cm diameter class (48.65%) while 33.78 % are thrifty mature (>60 cm) and only 17.57% are saplings to pole stage (10 cm – 29 cm). The area is accessible to the community and the presence of pasture was observed. No visible illegal cuttings were observed, since the area is protected and developed as an eco-tourism site of the Municipality of San Remigio, Antique.

The highest diameter recorded was *S. negrosensis* (red lauan) with a diameter of 133 cm. Very few wildlings and small saplings were observed in the lower canopy. The upper canopy (dominant) is occupied by large dipterocarps, while the general canopy is occupied by pole-sized to mature dipterocarps associated with non-dipterocarps.

***Diameter Distribution of Dipterocarps in Iloilo*:** The study showed that the majority of the dipterocarps belonged to the 30-60 cm diameter class (49.48%), while thrifty mature (>60 cm) was 36.08% and 14.43% belonged to 10 cm – 29 cm diameter classes (Figure 4). Most of the large dipterocarps

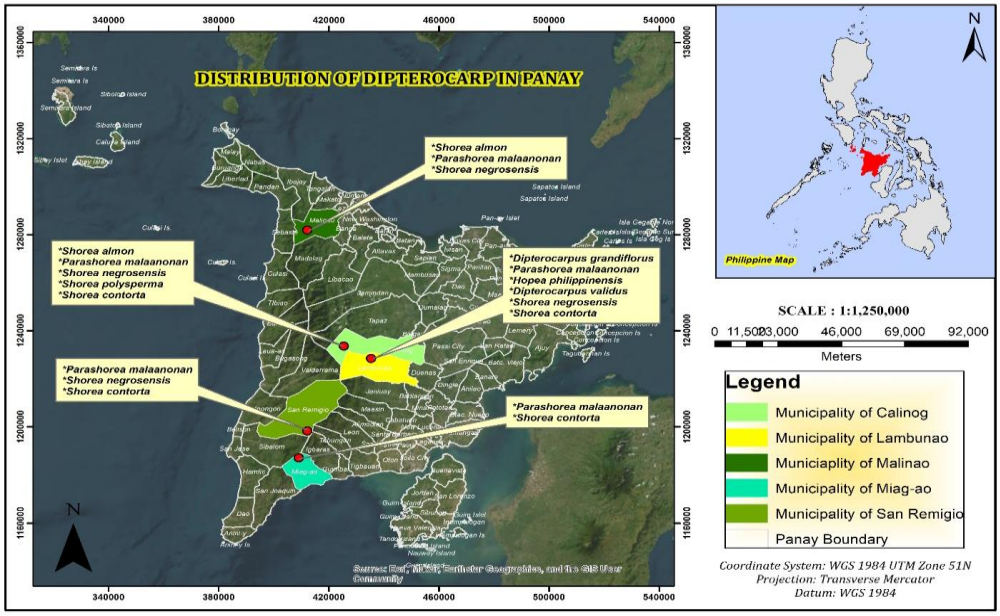

Figure 3. Species distribution of dipterocarps in Panay Island, Philippines.

were found in Calinog since the area was not subjected to logging and was protected by residents. The largest diameter recorded was *S. negrosensis* with a diameter of 210 cm in Calinog. Large diameter dipterocarps (> 60 cm) occupy the highest canopy level of the forest while the majority (30 – 60 cm) occupy the general canopy level. The small diameter dipterocarps (< 30 cm) occupy the third canopy level (intermediate).

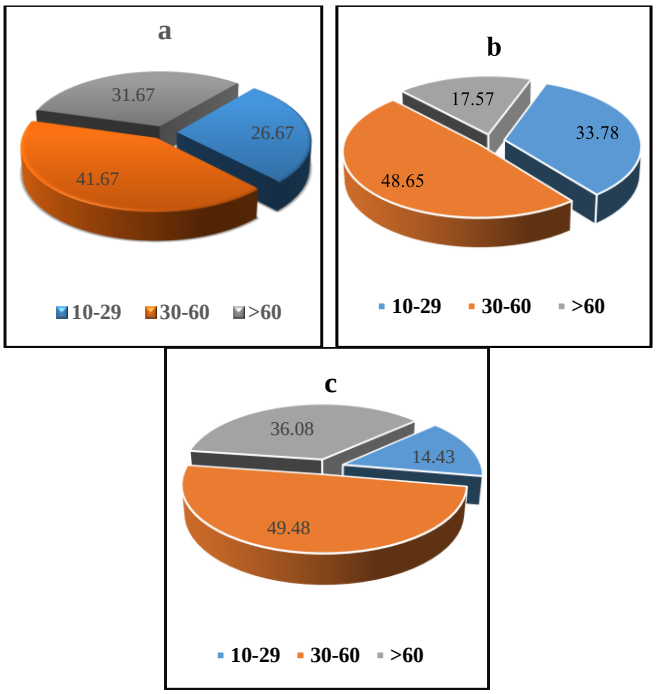

Figure 4. Diameter classes (cm of dipterocarps in Panay (a) *diameter* classes in Aklan, Diameter classes in Antique (c) Diameter classes in Iloilo.

***Species Importance Value of Dipterocarps in Aklan*:** Of the three species of dipterocarps recorded in Aklan, *S. almon* was the most important species (112.22%). *Shorea. negrosensis* has an importance value of 98.61% and *P. malaanonan* with 89.07%). All three species were found in all sampling plots, however, *S. almon* is the most dominant in terms of basal area among the three species (Figure 3). Species importance Value (SIV) is an ecological index of the importance of species to a particular ecosystem (Timilsina *et al*., 2007; Razavi *et al*., 2012). Results also suggest that *S. almon* was the most adapted to the local conditions in Aklan.

***Species Importance Value of Dipterocarps in Antique*:** Red lauan (*S. negrosensis*) is the most important dipterocarp in Aningalan, San Remegio, Antique with an importance value of 162.91% (Figure 5). This shows that *S. negrosensis* is the most abundant, most frequent, and most dominant dipterocarps in Antique. *Shorea. contorta* (white lauan) has an importance value of 96.449% and the least important dipterocarps were bagtikan (*P. malaanonan*) with an IV value of 40.638%.

***Species Importance Value in Iloilo*:** The Species Importance Value is an indicator of species dominance in an ecosystem. *Shorea. almon* was the most important species of dipterocarps in Iloilo with an importance value of 80.03%. It was the most dominant in terms of basal area, the most abundant, and the most frequent species (Figure 5). It was found in Calinog, but absent in Lambunao and Miag-ao. The second most important dipterocarp was *S. contorta* (76.16%) and was found to be the most dominant in Brgy Onop, Miag-ao, Iloilo. The least dominant was *H. philippinensis* which was only found in the WVSU CAF, Reservation, in Lambunao, Iloilo (5.11%).

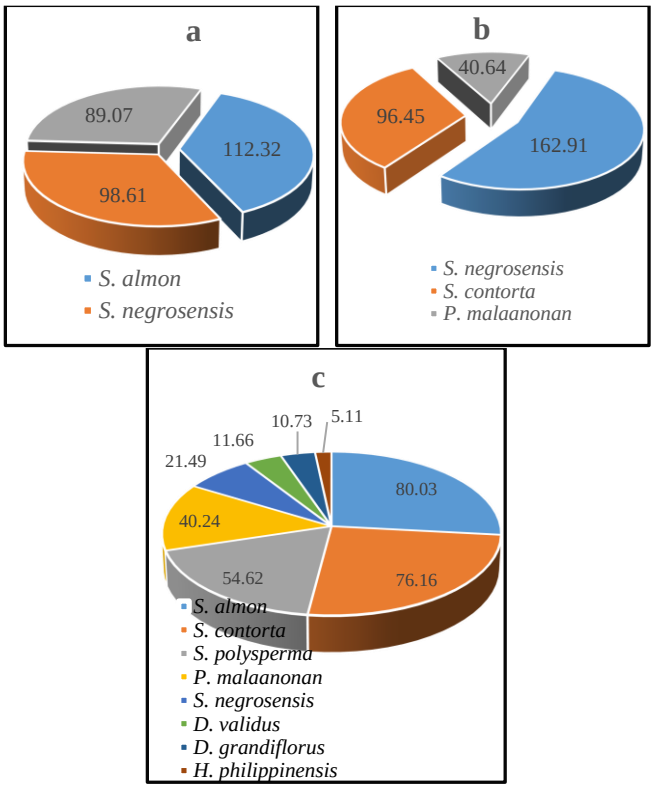

Figure 5. Species Importance Value of Dipterocarps in Panay Island, Philippines (a) *Species Importance Value of Dipterocarps in Aklan* (b) *Species Importance Value of Dipterocarps in Antique* (c) *Species Importance Value of Dipterocarps in Iloilo*.

DISCUSSIONS

***Species Composition in Panay Island, Philippines*:** Panay Island is a habitat to eight species of dipterocarps, representing a remnant of once-rich biodiversity. These species belong to four different genera: *Shorea*, *Dipterocarpus*, *Parashorea*, and *Hopea*, or four out of six genera of dipterocarps in the Philippines. The Province of

Iloilo consists of the highest species composition of dipterocarps on Panay Island, with all eight recorded species existing. This indicates a high level of biodiversity of dipterocarps on the entire island. In Antique and Aklan Province, only three dipterocarp species were recorded.

In Leyte Cordillera, 18 species were found belonging to the six Philippine dipterocarp genera and representing all eight Philippine dipterocarp timber groups (Langenberger, 2006). This finding suggests that Leyte Cordillera is a habitat of a more diverse range of dipterocarp species than Panay Island. Of the eight species in Panay Island, *H. philippinensis* was classified as Critically Endangered by DAO No. 11 (2017), five species were "Vulnerable", these includes *D. grandiflorus* (DAO, 2017), *S. almon* (almon), *S. contorta* (white lauan), *S. ploysperma* (tanguile) and *S. negrosensis* (red lauan). Two species that were previously classified as critically endangered under IUCN (2006) was reclassified into less concerned (LS), these are *D. validus* (Barstow, 2021) and *P. malaanonan* (Randi, et al., 2019).

The critically endangered species were found in WVSU CAF, Jayubo, Lambunao, Iloilo with an elevation range from 179 m to 319 m above sea level. . This study demonstrates that dipterocarps were more diverse in lower elevations since most genera were represented within that range. Based on interviews and observations, most of the dipterocarps were found in areas with high elevation and far from human settlements. Only a few dipterocarps were reported to exist at lower elevations, mostly located on private lands and in school reserves such as at WVSU-CAF. Understanding the specific habitats and elevational ranges of these species is crucial for planning conservation strategies aimed at protecting their remaining populations. Documentation of this species will be key information in the formulation of conservation and to be considered as the top priority species for the conservation program of the West Visayas State University where these species were documented to exist. In addition, the research areas were identified as one of the key diversity areas under the Philippine Biodiversity Strategic Action Plan 2015-2028 dated 2016.

Based on the record, eight dipterocarp species are found in Panay, representing five out of six dipterocarp genera (Fernando, 2009). The listed species include three under the genus *Hopea*, two under *Dipterocarpus*, and one under *Shorea*, *Parashorea*, and *Anisoptera*. The current study recorded the presence of three additional dipterocarp species on Panay Island: *Shorea contorta* (white lauan), *Shorea negrosensis* (red lauan), and *Shorea almon* (almon). These species were not included in the list provided by the researchers previously mentioned indicating new records for dipterocarp diversity on the island.

Although not all possible areas with dipterocarps were sampled in the study, the presence of the new records *emphasizes* the importance of continued research and monitoring to better understand the distribution and diversity of dipterocarp species in Panay Island.

Overall, the study contributes to the understanding of dipterocarp diversity in Panay Island by providing new records into the distribution of these valuable tree species. Continued research and conservation efforts are essential to protect and preserve the dipterocarp forests of Panay Island and ensure ecosystem health at the highest level. With the threat of climate change, especially Panay Island experienced one of the worst high-temperature levels brought by El Niño from December 2023 to May 2024 documentation is essential to evaluate its effect on dipterocarps dynamics in the future.

***Diameter Class of Dipterocarps in Panay Island*:** The majority of dipterocarps in Panay Island belonged to "standard" trees (Petras, 2002). The diameter of dipterocarps varies depending on the history of disturbance, in two plots in Sitio Aldegara forest in WVSU CAF, dipterocarps were only remnants of illegal logging in the early 1990s where almost all large trees were cut illegally.

In Aklan, most dipterocarps were severely damaged by Typhoon Yolanda (Haiyan) in 2013, with most large trees being affected. Based on records, no commercial logging operation in Panay Island. Therefore, the major causes of forest destruction were attributed to slash-and-burn farming practices and timber poaching for domestic uses. In Malaysia, agriculture expansion was also found to be the greatest threat to dipterocarps (Khoo *et al*., 2023).

***Species Importance Value*:** Introduced as one of the most important indexes in forest management, the index can be useful in biodiversity protection. It measures how dominant a certain species is in an ecosystem (Asigbaase *et al*., 2019). In this study, SIV is the function of Relative Density, Relative Frequency, and Relative Dominance (Razavi *et al*., 2012**).** *Shorea almon* was the most important dipterocarp species in the Province of Aklan and Iloilo while *S. negrosensis* was the highest SIV in Antique.

These species are present in all plots sampled and occupy the highest basal area in the sampling plots. This finding suggests that these species have a very important role in maintaining a healthy and functioning ecosystem. Biodiversity conservation and protection must focus on these dipterocarp species.

***Conclusions*:** There are eight dipterocarp species recorded in Panay, four (4) species represented Genus *Shorea*, two (2) belong to the genus *Dipterocarpus* one (1) for *Parashorea* and *Hopea.* One hundred ninety-seven (197) dipterocarps were recorded in Iloilo most of which belong to Genus *Shorea* and *S. almon* was the most abundant, all eight species were present in the province. In Antique three species with seventy-three individuals were recorded that belong to two genera *Shorea* and *Parashorea.* Bagtikan (*P. malaanonan*) was the most abundant dipterocarps. Three species were identified in Aklan that belong to only two genera with fifty-six

individuals, *S. negrosensis* (red lauan) was the most abundant dipterocarp.

Habitat disturbance influenced the diameter class of dipterocarps. The undisturbed area contained bigger trees of which the majority belong to the diameter classes 30 cm to 60 cm. *Shorea almon* was the most important species in Iloilo, and Aklan while *Shorea negrosensis* was in the Province of Antique.

The researchers recommend the protection of the area and the conservation of dipterocarps to maintain high-level biodiversity and a healthy ecosystem. Future research shall focus in areas of Panay where dipterocarps were reported to exist with particular consideration of the elevation of study sites, to better represent the distribution of dipterocarps in the island.

***Conflicts of Interest*:** The authors declare no conflicts of interest regarding the publication of this paper.

***Data availability statement*:** The paper accurately portrays the authors' independent research and analysis comprehensively and honestly. It is not under consideration for publication elsewhere.

***Author contributions*:** The conceptualization of the research: Jose Ariel A. Tutor. Gathering of research data: Jose Ariel A. Tutor and Belinda G. Leonida. Analysis: Jose Ariel A. Tutor and Jose Raymund Librodo. Writing of the Draft: Jose Ariel A. Tutor and Belinda G. Leonida. Review and editing: Stephen G. Sabinay and Jose Raymund L. Librodo.

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