Variations in floristic composition and community structure between disturbed and undisturbed lowland forest in Aklan, Philippines

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**ABSTRACT**

Despite the notable plant biodiversity of the Philippines, the country still exhibits increasing anthropogenic activities in many forests of the archipelago that pose a threat to many floral species of the country. Hence, to test the hypothesis that there are differences in plant distributions and diversity between disturbed and undisturbed tropical forest patches, a rapid floristic assessment in Malinao, Aklan was conducted. A total of 106 species were sampled in both sites, with 68 present in the disturbed site, 53 present in the undisturbed site, and 12 present in both. Rarefied species accumulation curves and calculations of Shannon-Wiener Index (H) showed higher species richness and eveness in the undisturbed forest. Analysis of the similarities in species composition using the nonmetric dimensional scaling combined with the statistical test PERMANOVA showed clear significant difference between the two forest categories. In addition, one species (Artocarpus blancoi (Elmer) Merr.) that is classified as "Vulnerable" according to the IUCN was noted. Thus, standard calls for the establishment of priority areas for forest conservation in the country are recommended.

**INTRODUCTION**

Tropical forests are considered to be one of the most threatened habitats due to their increasing decline in biodiversity (Posa et al., 2008; Tittensor et al., 2011). This is brought about by the disproportion of the increasing demands of a fast growing human population (Squires, 2014) with the utilization of natural plant resources that are far beyond in their recovering capacity (Naidu & Kumar, 2016; Sahoo et al., 2017). This situation resulted in the decrease on the size of natural rainforest at alarming rate in many countries around the world (Lewis, 2006), particularly in the Philippines, which is considered to be one of the earth’s most important biodiversity hotspots, with approximately 13 000 plant species, 39% of which are endemic. Albeit, Philippine biodiversity is widely concentrated on its primary forest ecosystem, only 3.0% of primary forest in the Philippines remains untouched, putting now the current biodiversity of the country at an extremely high risk (Langenberger et al., 2006). Previously occurring species in the Philippines have become endangered or even extinct through continued deforestation, with slash and burn cultivation (Mukul et al., 2016) accounting for the majority of forest destruction. In addition, most of the deforested lands are now used for agricultural production (Langenberger et al., 2006; Myers et al., 2000; Suarez & Sajise, 2010). Forest fragmentation brought about by deforestation results in greater tree mortality (Reis et al., 2018), easier access to the interior forest, which leads to increased resource exploitation, as well as changes in forest microclimatic conditions (Broadbent et al., 2008; Sánchez-Reyes et al., 2019), and loss of faunal specialized niches (Suarez & Sajise, 2010). Thus, forest management entails thorough understanding of the plant species diversity (Dieler et al., 2017; Turnbull et al., 2016), community structure (Chai et al., 2016), and plant composition (Collins et al., 2017; Ssegawa & Nkuu, 2006). This information would ensure environmental managers on accurate assessments of possible impacts and amelioration of degraded forest ecosystem (Borah et al., 2014). More so, floristic surveys help in proper monitoring and developing of effective conservation strategies (Alsherif & Fadl, 2016; Yates et al., 2019) for many highly threatened or endangered plant species. However, quantitative studies on plant inventories for the Philippines are still relatively scarce since majority of the plant surveys conducted for the country during the last years are concentrated on qualitative species listings (see Ordas et al., 2019; Santiago & Buot, 2017; Villanueva & Buot, 2015).

Disturbances do not only influence diversity, but also post disturbance regeneration (Gill et al., 2017;
Kern et al., 2019) and dominance of tree species (Lawes et al., 2007; Shirima et al., 2015). Ultimately, human disturbance on natural landscapes would lead to the homogeneity in species composition (Fuller et al., 2017; Liebsch et al., 2008). This negative effect decreases reproduction and survival of organisms. Although, the inhabitants may be affected due to the anthropogenic disturbance, there is either little (Bongers et al., 2009) or no consistent correlation (Marcial et al., 2001) between disturbance and tree biodiversity and may warrant for further studies (see Caviedes & Ibarra, 2017; Martínez-Ramos et al., 2016). Nevertheless, an ideal area in the Philippines to conduct such floristic assessment would be the underexplored forest fragments in Barangay Kinalangay Viejo, Malinao, Aklan since portions of the forest are either pristine and are likely to be considered undisturbed or have already been undergoing secondary succession due to rampant anthropogenic disturbance caused by “cut down – burn off” practice by the local communities. Furthermore, no profiling of the floral species diversity and on plant species list has ever been conducted for Malinao, Aklan, thus, extensive plant survey is considered to be of urgency.

Therefore, this plant diversity study aims to (i) determine the floral species present in Barangay Kinalangay Viejo, Malinao, Aklan, (ii) compare the species compositions of the different forest types based on anthropogenic disturbance, and (iii) determine the conservation status of the plant species documented for the area. This study will aid in conservation efforts of Philippine flora, especially on the economically important plant species present in the area.

Materials and methods

Study area

The island of Panay, a triangular island in Western Visayas region, is comprised of four provinces including Aklan province (Figure 1). Aklan has a total land area of 181,789 hectares, of which 74,994 hectares are classified as Forestland or 41% of the province with 46,650 hectares as protection forest and 8,344 hectares as production forest. It is composed of 17 municipalities with 327 Barangays with Kalibo serving as the capital of the province. Malinao is a 4th class municipality composed of 23 barangays. It has a land area of 18,601 hectares with much of it being mountainous. Based on the amount of anthropogenic disturbance on the forested areas of Sitio Bugtong Bato and Sitio Angeles, Barangay Kinalangay Viejo, Malinao, Aklan, two different types of forest were categorized: (i) the undisturbed forest which is basically characterized to be a secondary old growth forest with minimal exposure to extreme human deforestation and forest conversion activities and somehow protected and (ii) the disturbed forest which is intuitively described to be highly exposed to man-made forest conversion due to different farming practices such as the slash and burn farming of the local people.

Taxon sampling and species determination

Two 100 m transects were determined, one each in disturbed and undisturbed forested areas in Sitio Bugtong Bato and Sitio Angeles, Barangay Kinalangay Viejo, Malinao, Aklan (Figure 2). Each plot was divided into ten 10 m x 10 m plots for the assessment of tree species 10 m and above in height. One 5 m x 5 m plot was laid within each of the 10 m x 10 m plot for the assessment of vegetation between 1 m and 10 m high. Subsequently, one 1 m x 1 m plot was laid within each 5 m x 5 m plot for the assessment of vegetation less than 1 m high (Figure 2). Pictures of all specimens were taken, and vouchers were collected for interesting specimens. Identification based on the APG IV system was done through comparison with existing herbarium sheets from the University of Santo Tomas Herbarium (USTH) and Philippine National
Herbarium (PNH), previously identified pictures of specimens from Co’s Digital Flora of the Philippines (http://philippineplants.org/), and consultation with researchers and botanists of the National Museum of the Philippines. Collected specimens were deposited at the Philippine National Herbarium (PNH) and University of Santo Tomas Herbarium (USTH).

**Data evaluation**

To estimate sampling intensity, individual-based species accumulation curves were constructed for disturbed and undisturbed areas using the “default settings” of EstimateS (Version 9.1, Colwell, 2013, 200 randomizations). In accordance with Rasingim and Parthasarathy (2009), Chao1 estimator (Chao et al., 2005) was used to estimate the theoretical number of species in the area. The estimated value for the exhaustiveness of the survey for the disturbed and undisturbed forest type was then determined by dividing the actual number of species we recorded by the mean number of species expected as estimated by the Chao1 estimator multiplied by 100. Abundance-based species data were initially constructed for the analysis of diversity that includes species richness and further diversity indices and β diversity that considers community composition. To determine the dominant plant species, the variables like the Basal area, Relative Basal Area, Density, Relative Density, and Importance Value Index (IVI) were computed using the formula in accordance to Chowdhury et al. (2019).

Patterns of species diversity were analyzed using the common heterogeneity index (based on abundance and evenness) Shannon-Wiener index (H) based on the formula $H = -\sum p_i \ln p_i$ where, $p_i = n_i/N$ and $N =$ Total number of individuals $n_i =$ Number of individuals of a species.

To quantify species evenness Simpson’s equitability ($E_D$) based on the formula $E_D = D/D_{max}$ where $D$ represents the calculated Simpson diversity, and Shannon’s Equitability ($E_H$) based on the formula $E_H = H/\ln S$, where $S$ is the total number of species in the community, were both calculated. To be considered as truly more diverse, an area must show consistently higher values across all the selected indices. To visualize community structures and assessed the floristic similarities between the disturbed and undisturbed forests, a nonmetric multidimensional scaling (NMDS) based on Bray Curtis similarity distances and the semiparametric statistical test PERMANOVA based on 999 total permutations that performs classical partitioning for multivariate data while simultaneously retaining robust statistical properties for variables that are usually consists of counts or abundances for a variety of species (Anderson, 2017) were employed using the R scripts from Dagaet al. (2017) in the vegan package the R environment. For

the determination of the conservation statuses of selected species collected in the area, the local Department of Natural Resources (DENR) List of Threatened Species (2017) and the IUCN Red List of Threatened Species were consulted.

**Results**

**Exhaustiveness of the survey**

A total of 2227 individuals were contained in the two transects, with 1599 belonging to the disturbed forest and 628 belonging to the undisturbed forest. The rarefied curve showed that the disturbed transect contained 48.08 species per 628 individuals sampled, while the undisturbed transect contained 53 species per 628 individuals sampled, thus indicating that the disturbed transect has higher species richness compared to the disturbed transect. According to the Chao1 estimator (Table 1) generated using EstimateS, a total of 112.61 theoretical species are present in the disturbed transect, and 67.06 species are present in the undisturbed transect. This shows that sampling in the disturbed and undisturbed transect is 60.39% complete, and is 79.03% complete, respectively. This is the reason why our species accumulation curve (Figure 3) is still increasing and does not yet reach an asymptote.

**Family composition and conservation status**

A total of 106 species from 10 plots of disturbed agroforest and 10 plots of undisturbed stream bank area, for a total of 20 assessed plots, were recorded (Table 2). Overall, 83.96% were identified up to species level, 100% to genus level, and 100% to family level. Angiosperms accounted for 93.4% of the recorded taxa, with 49 families present. Pteridophytes accounted for 5.66%, with four families present. Only one species of gymnosperm was found (Gnetum gnetom Merr.). The most species-rich families from the recorded plots are Apocynaceae (nine species), Moraceae (eight species), and Rubiaceae (seven species). The ratio of the number of genus to the number of species per family ranged from 1:1 (Acanthaceae) to 1:4 (Moraceae). The floral composition between the

| Table 1. Summary of plant inventory in undisturbed (UND) and disturbed (DIS) forest patches of Aklan, Philippines. |
|---|---|---|
| **Basic data** | **DIS** | **UND** |
| Number of species | 68 | 53 |
| Number of Genera | 59 | 45 |
| Number of Family | 39 | 39 |
| Chao 1 estimated species | 112.61 | 67.06 |
| % Exhausitiveness | 60.39 | 79.03 |
| Diversity indices | | |
| Simpson’s Diversity Index (D) | 0.41 | 0.22 |
| Shannon-Wiener Index (H) | 1.54 | 1.91 |
| Simpson’s equitability ($E_D$) | 0.22 | 0.50 |
| Shannon’s equitability ($E_H$) | 0.56 | 0.81 |
disturbed forest and undisturbed forest showed dissimilarities (Table 2). As such, tree and shrub species belonging to the Apocynaceae family such as *Alstonia scholaris*, * Alyxia linearis*, * Cerbera manghas* is reported to the disturbed forest only but the tree species *Ervatamia pandacaqui* and * Hoya mariae* are reported only for the undisturbed forest. Moreover, floral species from families belonging to Araceae (three species), Araliaceae (three), Arecales (one), Asteraceae (two), Commelinaceae (one), Convulvulaceae (one), Costaceae (one), Davaallia (two), Dioscoreaceae (one), Euphorbiaceae (five), Fabaceae (two), Gentianaceae (one), Gnetaceae (one), Lamiaceae (three), Lygodiaceae (one), Malvae (two), Melatomataceae (one), Myrtaceae (one), Polygonaceae (one), Pteridaceae (two), Rosaceae (one), Rutaceae (two), Solanaceae (one), Thymelaceae (one), Vitaceae (one) were found only in the survey of the disturbed forest. On the other hand floral species from families belonging to Acanthaceae (one), Calophylaceae (one), Casuarinaceae (one), Clusiaceae (one), Dipterocarpaceae (two), Nepenthaceae (one), Pandanaceae (one), Phyllantaceae (one), Primulaceae (one), Rhamnaceae (one), Selaginellaceae (one), and Smilacaceae (one), were occurring only on the survey at the undisturbed forest.

These differences in the community composition was further ascertained in terms of community analysis, the nonmetric multidimensional scaling (NMDS) ordination (Figure 4, stress = 0.03) clearly showed the bifurcation in community structure between the disturbed and undisturbed sites. This indicates that the plant communities found in the two sites are significantly different (R = 0.224, p = 0.001) from each other. Of all the identified species, only 16.9% are endemic to the Philippines. 70.8% are indigenous, 12.4% are introduced or exotic species. Out of the introduced species, 2 are considered invasive (*Piper aduncum* L. & *Chromolaena odorata* (L.) R.M. King & H. Rob.). Based on the DENR Updated List of Threatened Philippine Plants and their Categories (2017), five species (*Pterocarpus indicus* Willd., *Shorea contorta* S. Vidal, *Alpinia elegans* (C. Presi) K. Schum., *Prunus grisea* Balkim., *Tristaniopsis decorticata* (Merr.) Peter G. Wilson & Waterhouse) are classified as “Vulnerable” and two are classified as “Other Threatened Species” (*Canarium ovatum* Engl., *Alyxia linearis* Markgr.). In addition, one species (*Artocarpus blancon* (Elmer) Merr.) is classified as “Vulnerable” according to IUCN standards.

**Diversity assessments**

The calculated importance value index (IVI) of the accumulated plants species determined the dominant species of plants within their respective habitat and plot. The disturbed forest showed high importance value for species of *Imperata cylindrica* (L.) Raesouh. (86.32), *Miscanthus floridulus* (Labill.) Warb ex K. Schum.&Lauterb. (30.02), and *Cocos nucifera* L. (156.64). Undisturbed forest showed high importance value for species of *Machaerina disticha* (C.B. Clarke) T. Koyama (42.10), *Garcinia rubra* Merr. (29.70), and *Casuarina equisitifolia* L. (120.55). For the combined computations of the two sampled forest, the dominant species were *Imperata cylindrica*, *Miscanthus floridulus*, and *Cocos nucifera* with their IVI values of 68.75, 20.80, and 70.24 respectively. In terms of species diversity, the Shannon-Wiener Index (H) calculations showed the same trend with undisturbed forest having a higher mean H than the disturbed forest (Table 1). For the index that takes into considerations evenness measurement, both Simpson’s equitability (E_s) and Shannon’s equitability (E_H) calculations showed greater values for the undisturbed forest in comparison to the disturbed forest (Table 1).

**Discussion**

**Patterns of diversity**

A clear pattern of higher diversity of undisturbed forest than the disturbed forest emerges as we look on the results of our diversity indices (Table 1) and the rarefied values (Figure 2) of species richness of the species accumulation curve. It is important to note that in our present study, there were no environmental parameters measured, thus providing an inadequacy to explain what accounts for the species present. Nevertheless, the lower richness of species on anthropogenically disturbed forest may suggest that local communities in the area heavily used much of the forest resources like woods for making charcoals, housing or even building furniture as a source of their livelihood income. This now implicates that anthropogenic factors (Ghosh et al.,

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Figure 3. Smooth Species accumulation curve of disturbed and undisturbed areas generated using EstimateS.
Table 2. List of the plant species recorded in the disturbed (DIS) and undisturbed (UND) study areas with their families, habit (Beentje & Williamson, 2010) and conservation status as indicated by the DENR and IUCN.

| FAMILY               | TAXA                                      | DIS | UND | TOTAL | HABIT          | CONSERVATION STATUS |
|----------------------|-------------------------------------------|-----|-----|-------|----------------|---------------------|
| ACANTHACEAE          | Hemigraphis sp.                           | 0   | 17  | 17    | Herb           | Not threatened      |
| ANACARDIACEAE        | Buchanania arborescens (Blume) Blume      | 6   | 17  | 23    | Tree           | Not threatened      |
|                      | Semecarpus cuneiformis Blanco             | 2   | 11  | 13    | Tree           | Not threatened      |
| ANNONACEAE           | Uvaria littoralis (Blume) Blume           | 3   | 0   | 3     | Shrub          | Not threatened      |
| APOCYNACEAE          | Alstonia parvifolia Merr.                 | 0   | 11  | 11    | Tree           | Not threatened      |
|                      | Alstonia scholaris (L.) R. Br.            | 1   | 0   | 1     | Shrub          | Not threatened      |
|                      | Alyxia linearis Markgr.                   | 0   | 2   | 2     | Shrub like     | Other Threatened    |
|                      | Cerbera manghas L.                        | 1   | 0   | 1     | Tree           | Not threatened      |
|                      | Eretamnia pandacoccii (Poir.) Pichon      | 0   | 3   | 3     | Tree           | Not threatened      |
|                      | Eretamnia subglobosa (Merr.) Pichon       | 0   | 1   | 1     | Tree           | Not threatened      |
|                      | Hoya mariae (Schltr.) L.Wanntorp & Meve   | 0   | 8   | 8     | Vine           | Not threatened      |
|                      | Hoya buoti Klokpenb.                      | 0   | 8   | 8     | Shrub          | Not threatened      |
|                      | Voacanga globosa (Blanco) Merr.           | 0   | 3   | 3     | Tree           | Not threatened      |
| ARACEAE              | Aglaonema commutatum Schott               | 1   | 0   | 1     | Herb           | Not threatened      |
|                      | Caladium bicolor (Alton) Vent.            | 1   | 0   | 1     | Shrub          | Not threatened      |
|                      | Homalomena philippinensis Engl.           | 2   | 0   | 2     | Herb           | Not threatened      |
| ARLIACEAE            | Hydrocotyle vulgaris L.                   | 2   | 0   | 2     | Herb           | Not threatened      |
|                      | Osmoylan yatesii (Merr.) Philipson        | 1   | 0   | 1     | Shrub          | Not threatened      |
|                      | Schefflera sp.                            | 1   | 0   | 1     | Shrub          | Not threatened      |
| ARECACEAE            | Cocoons nuciera L.                        | 1   | 0   | 1     | Tree           | Not threatened      |
| ASTERACEAE/           | Chromolaena odorata (L.) R.M. King & H. Rob. | 14  | 0   | 14    | Shrub          | Not threatened      |
| COMPOSITAE           | Pseudodephalontus spicatus (B.Juss. ex Aubl.) Rohr ex Gleason | 22  | 0   | 22    | Herb           | Not threatened      |
| BURSERACEAE          | Canarium hirsutum Willd.                  | 3   | 1   | 4     | Tree           | Not threatened      |
|                      | Canarium ovatum Engl.                     | 0   | 3   | 3     | Tree           | Other Threatened    |
|                      | CALOPHYLLACEAE                            | Calophyllum blancoi Planch. & Tiana | 0   | 4   | 4     | Shrub           | Not threatened      |
|                      | CASUARINACEAE                            | Casuarina equisetifolia L.          | 0   | 48  | 48    | Tree           | Not threatened      |
|                      | CLUSIACEAE                               | Garcinia rubra Merr.                | 0   | 94  | 94    | Tree           | Not threatened      |
|                      | COMMELINACEAE                            | Commelina diffusa Burm. F.           | 2   | 0   | 2     | Herb           | Not threatened      |
|                      | CONVOLVULACEAE                           | Ipomoea batatas (L.) Poir.          | 1   | 0   | 1     | Shrub          | Not threatened      |
|                      | COSTACEAE                                | Costus speciosus (J. Koenig) Sm.    | 1   | 0   | 1     | Herb           | Not threatened      |
|                      | CYPERACEAE                               | Machaerina glomerata (Gaud.) Koyama | 1   | 0   | 26    | Graminoid       | Not threatened      |
|                      |                                           | Machaerina disticha (Clarke) Koyama | 1   | 0   | 91    | Graminoid       | Not threatened      |
|                      |                                           | Scleria srobcilatae Nees & Meyen   | 22  | 0   | 22    | Graminoid       | Not threatened      |
| DAVALLIACEAE         | Nephrolepis brownii (Desv.) Hovenkamp & Miyam. | 73  | 0   | 164   | Herb           | Not threatened      |
|                      | Nephrolepis falcatum (Cav.) C. Chr.       | 71  | 0   | 23    | Herb           | Not threatened      |
| DIOCIOREACEAE        | Dioscorea alata L.                       | 3   | 0   | 3     | Herb           | Not threatened      |
| DIPTEROCARPACEAE     | Shorea contorta S.Vidal                  | 0   | 2   | 2     | Tree           | Vulnerable          |
|                      | Shorea guiso Blume                       | 0   | 6   | 6     | Shrub          | Not threatened      |
| EUPHORBIACEAE        | Acalypha amentacea Roxb.                  | 4   | 0   | 4     | Tree           | Not threatened      |
|                      | Euphorbia hirta L.                       | 1   | 0   | 1     | Herb           | Not threatened      |
|                      | Macaranga hispida (Blume) Mull.Arg.       | 3   | 0   | 3     | Shrub          | Not threatened      |
|                      | Macaranga tamarindus (L.) Mull. Arg.      | 1   | 0   | 1     | Tree           | Not threatened      |
|                      | Manihot esculenta Crantz                 | 14  | 0   | 14    | Shrub          | Not threatened      |
| FABACEAE/LEMINOSAE   | Mimosa pudica Leg.                       | 13  | 0   | 13    | Herb           | Not threatened      |
|                      | Pterocarpus indicus Willd.                | 8   | 0   | 8     | Tree           | Vulnerable          |
| GENTIANACEAE         | Fagarea racemosa Jack                    | 2   | 0   | 2     | Tree           | Not threatened      |
| GNETACEAE            | Gnetum gneton L.                          | 1   | 0   | 1     | Shrub          | Not threatened      |
| HYPERICACEAE         | Crataxyum sumatranum Blume               | 2   | 0   | 2     | Tree           | Not threatened      |
| LAMIACEAE            | Callicarpa sp.                            | 1   | 0   | 1     | Shrub          | Not threatened      |
|                      | Clinodendrum sp.                         | 14  | 0   | 14    | Shrub          | Not threatened      |
|                      | Hypiptis capitata Jacq.                  | 12  | 0   | 12    | Shrub          | Not threatened      |
| LAURACEAE            | Litsea perrottetii (Blume) Fern.-Vill.    | 18  | 21  | 39    | Tree           | Not threatened      |
| LYGODIACEAE          | Lygodium auriculatum Alston              | 1   | 0   | 1     | Fern           | Not threatened      |
| MALVACEAE            | Sterculia rubiginosa Vent.               | 1   | 0   | 1     | Shrub          | Not threatened      |
| Urena lobata L.      | 3                                        | 0   | 3     | Shrub          | Not threatened      |
| MARANTACEAE          | Doraes cannformis (G. Forst.) K. Schum.  | 19  | 7   | 26    | Herb           | Not threatened      |
|                      | Phynium pubinerve Blume                   | 7   | 0   | 7     | Shrub          | Not threatened      |
| MELASTOMATACEAE      | Medinilla quadrifolia Blume               | 1   | 0   | 1     | Tree           | Not threatened      |
| MELIACEAE            | Lansium domesticum Corrêa                | 7   | 0   | 7     | Shrub          | Not threatened      |
| Voevea amicorum Benth.| 3                                        | 0   | 3     | Shrub          | Not threatened      |
| MORACEAE             | Artocarpus blancoi Merr.                 | 1   | 1   | 2     | Tree           | Not threatened      |
|                      | Artocarpus ovatus Blanco                  | 3   | 0   | 3     | Shrub          | Not threatened      |
|                      | Ficus mininassae Miq.                    | 0   | 1   | 1     | Tree           | Not threatened      |
|                      | Ficus nata (Blanco) Merr.                | 8   | 0   | 8     | Shrub          | Not threatened      |
|                      | Ficus pseudopalmata Blanco               | 12  | 0   | 12    | Shrub          | Not threatened      |
|                      | Ficus septica Burm. F.                   | 9   | 0   | 9     | Shrub          | Not threatened      |

(Continued)
caused by unsustainable exploitation of forest resources have influence on the changing diversity patterns and species compositions (Aleign et al., 2007) in the area. In contrast with other similar floristic studies (Bhurban Hills, Borah et al., 2014; Goalpara district in Western Assam; Rabha, 2014; Rio de Janeiro, Carvalho et al., 2016; New South Wales, Garcia_Florez et al., 2017; Eastern Nepal; Gautam & Mandal, 2018, Arsi Mountains Ethiopia, Girma et al., 2018) our result concurred the similar trend of higher floral diversity for undisturbed forest in comparison to disturbed forest.

**Community variations and structure between disturbed and undisturbed forest**

A clear significant difference between the plant communities between the anthropogenically disturbed and undisturbed forests in Aklan were noted (Figure 4). Perhaps, the introduction of various plant species in the

| FAMILY       | TAXA                          | DIS | UND | TOTAL | HABIT    | DENR | IUAN |
|--------------|-------------------------------|-----|-----|-------|----------|------|------|
| MUSACEAE     | Ficus sp. 1                   | 0   | 1   | 1     | Herb     |      |      |
|              | Ficus sp. 2                   | 1   | 0   | 1     | Tree     |      |      |
|              | Musa paradisiaca L.           | 106 | 31  | 38    | Herb     | Not threatened |      |
|              | Musa sp.                      | 10  | 0   | 10    | Herb     |      |      |
| MYRTICACEAE  | Myristica philippinensis Gand.| 3   | 1   | 4     | Tree     | Not threatened |      |
| MYRTACEAE    | Tristanopsis decorticata (Merr.) Peter G. Wilson & Waterhouse | 1  | 0  | 3     | Tree     | Vulnerable |      |
| NEPENTHACEAE | Nepenthis graciliflora Elmer  | 0   | 4   | 4     | Epiphyte | Not threatened |      |
| PANDANACEAE  | Freycinetia sp.               | 0   | 21  | 21    | Vine     |      |      |
| PHYLLANTHACEAE | Bridelia penangiana Hook. f. | 0   | 1   | 1     | Tree     | Not threatened |      |
| PIPERACEAE   | Piper aduncum L.              | 19  | 2   | 21    | Shrub    | Not threatened |      |
|              | Piper sp.                     | 1   | 0   | 1     | Shrub    |      |      |
| POACEAE      | Dinochloa luzoniea (Munro) Merr. | 0  | 22  | 22    | Graminoid | Not threatened |      |
|              | Imperata cylindrica (L.) Raeusch. | 895 | 0  | 895   | Graminoid | Not threatened |      |
|              | Miscanthus floridulus (Labill.) Warb. ex K. Schum. & Lauterb. | 106 | 31 | 137   | Graminoid | Not threatened |      |
|              | Phragmites karka (Retz.) Trin. ex Steud. | 0  | 6   | 6     | Graminoid | Not threatened | Least Concern |
| POLYGONACEAE | Coccocula uvifera (L.) L.    | 1   | 0   | 1     | Shrub    | Not threatened |      |
| PRIMULACEAE  | Myrsine sp.                   | 0   | 16  | 16    | Tree     |      |      |
| PTERIDACEAE  | Pteris sp.                    | 3   | 0   | 3     | Fern     |      |      |
|              | Pters vittata L.              | 1   | 0   | 1     | Fern     | Not threatened | Least Concern |
| RHAMNACEAE   | Zaphiurus sp.                 | 0   | 3   | 3     | Shrub    |      |      |
| ROSACEAE     | Prunus grisea Kalkman         | 4   | 0   | 4     | Shrub    | Vulnerable | Lower Risk/Least concern |
| RUBIACEAE    | Antirhea sp.                  | 0   | 28  | 28    | Shrub    |      |      |
|              | Musoaenda philippica A-Rich. | 11  | 0   | 11    | Shrub    | Not threatened |      |
|              | Neonaucea formicaria (Elmer) Merr. | 0 | 3  | 3     | Shrub    | Not threatened |      |
|              | Neonaucea puberula (Merr.) Merr. | 0 | 3   | 3     | Shrub    | Not threatened |      |
|              | Psychotria sp.                | 0   | 9   | 9     | Shrub    |      |      |
|              | Uncaria radughiana Korth.     | 1   | 0   | 1     | Shrub    | Not threatened |      |
|              | Uncaria sp.                   | 1   | 0   | 1     | Shrub    |      |      |
| RUTACEAE     | Eudia confusa Merr.           | 2   | 0   | 2     | Herb     | Not threatened |      |
|              | Micromelum minutum (G.Forst.) Wight & Arn. | 1  | 0   | 1     | Shrub    | Not threatened |      |
| SELAGINELLACEAE | Selaginella delicata (Desv. ex Poir.) Alston | 0 | 15  | 15    | Herb    | Not threatened |      |
| SMILACEAE    | Smilax sp.                    | 0   | 3   | 3     | Shrub    |      |      |
| SOLANACEAE   | Solanum torvum Sw.           | 2   | 0   | 2     | Shrub    | Not threatened |      |
| THYMELAEACEAE | Phaleria perrottetiana (Decne.) Fern.-Vill. | 1  | 0   | 3     | Shrub    | Not threatened |      |
| URTICACEAE   | Leucosyce capillitata Wedd.   | 18  | 21  | 39    | Shrub    | Not threatened |      |
|              | Oreoccline trinervis (Wedd.) Trin. | 0 | 23  | 23    | Tree     | Not threatened |      |
| VITACEAE     | Lelea philippinensis Merr.    | 7   | 0   | 7     | Shrub    | Not threatened |      |
|              | Lelea sp.                     | 2   | 0   | 2     | Shrub    |      |      |
|              | Tetrastigma loheri Gagnep.    | 1   | 0   | 1     | Herb     | Not threatened |      |
| ZINGIBERACEAE | Alpinia elegans (C. Presl) K. Schum. | 21 | 3   | 24    | Herb     | Vulnerable |      |

**Figure 4.** Nonmetric multidimensional scaling of species composition between disturbed and undisturbed forest types. Small dark dots represent the position of plant species in the ordination space. Big blue and red circles represent the 10 plots for each site; ellipses denote dispersion based on standard deviation of point scores.
disturbed community, may have contributed to the uneven distribution of species. Also, naturally occurring forest fires are rare in the Southeast Asian region, and thus, flora and fauna in the said region are more sensitive to human-induced disturbances than in other places such as the boreal regions. These kinds of disturbances may hinder floral reproductive success and thus alter floral demographics and distribution (Aizen & Feinsinger, 1994; Sodhi et al., 2009). At the same time, disturbance can disrupt the biotic interactions which are essential for the maintenance of the ecosystem’s integrity (Lefevre & Rodd, 2009). In the case of this study, it seems that similar with the report of Matson et al. (1997); agricultural expansions have provided anthropogenic alterations to the disturbed forest. Human forest disturbance threatens biodiversity through reduction of species richness in disturbed sites, and through introduction of species, some of which are invasive. Rising disturbance levels would threaten the robustness of forest structure, and thus negatively impact the forest ecosystem (Tripathi & Shankar, 2014). This is evident in our disturbed forest where it showed an abundance of weed species as well as cultivated plant species. In addition, our disturbed forest showed occurrences of all the introduced and invasive plant species in contrast to the undisturbed forest where only two individuals of introduced Piper aduncum L. was noted. Imperata cylindrica scored highest in importance value index of the disturbed forest. This is not that surprising since high occurrences of Imperata cylindrica is common to communities recovering from fires, as it is opportunistic, invasive, highly resistant to heat and water stress, and propagates through aggressive and easily-regenerating rhizomes (Aulakh et al., 2014; Brewer, 2008). Although, the area rarely experience natural forest fires, the slash and burn (kaingin) method used by the local people in the area allowed an opportunity for the weed species to spread in the disturbed forest. The same concept can be observed for the spread and dominance of the species Miscanthus floridulus for the plants in the same disturbed forest. In addition to this, Cocos nucifera is found to be the dominant species in terms of trees which measured 10 meters or more in height. This result can be attributed to the area being formerly used as a coconut plantation site.

With regards to our undisturbed forest, the species of Casuarina equisetifolia, Garcinia rubra, and Machaerina disticha were found to be dominant. Minimal human activities within the area of the undisturbed forest allowed the conservation of its native plant species. The presence and prevalence of the endemic species Garcinia rubra, which are frequently established within primary forests, (Pelser et al., 2011) in the area is an indicator that the fragment is indeed undisturbed. The topography of the forest fragment also contributed to the distribution of its dominant plant species Casuarina equisetifolia commonly found along sandy substrates that can extend inland in sandy valleys along streams, and could reach to a height of 800 meters (Orwal et al., 2009; Pelser et al., 2011). The inclusion of the introduced invasive species of Piper aduncum of the undisturbed plot might be due to the proximity (206.52 meters) of the quadrat to the disturbed forest fragment. Although the species are more common in disturbed forest, they are observed to span as much as 150 km beyond their dominated areas (Padmanaba & Sheil, 2014). Seed dispersal of the invasive species can be attributed to its succulent fruits being dispersed by birds or other animals (Starr et al., 2003). In general, almost all of the identified species of plant in the undisturbed forest were either indigenous or endemic to the area. This shows that even with its proximity, the overall ecological health of the undisturbed forest has not yet been fully influenced by introduced species at this point of time.

**Implications for conservation measures**

The presence of five vulnerable species (Pterocarpus indicus, Shorea contorta, Alpinia elegans, Prunus grisea, and Tristantiopsis decorticata) and two other threatened species (Canarium ovatum, Alyxia linearis) calls for an increase in conservation efforts, especially for Philippine endemic species. Also, the conduction of further sampling and assessment studies is recommended, especially in the disturbed forest, where sampling is less complete. Of the 15 endemic species sampled, 9 were found only in the undisturbed forest. At the same time both, disturbed and undisturbed forest showed occurrences of threatened species, suggesting that more conservation acts should be promoted in the area by the local government of the Philippines.

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No potential conflict of interest was reported by the authors.

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