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Tree Diversity and Stand Structure of Permanent Biodiversity Monitoring Area in Mount Makiling

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ABSTRACT

Following the international protocol for establishment of permanent plots, a two-hectare permanent biodiversity monitoring area (PBMA) was established inside Makiling Forest Reserve. Results of the intensive 100% inventory revealed that the PBMA holds tremendous tree diversity. A total of 155 tree species were identified. Of these, 148 are indigenous to the Philippines with 47 endemics (30% endemism). The most abundant native species in the PBMA is Magabuyo *(Celtis luzonica)* with 2,287 individuals, followed by Balobo *(Diplodiscus paniculatus)*, Tinaang pantai *(Drypetes maquilingensis)*, and Apanang *(Mallotus cumingii)*. The average diameter for all trees inside the plot is 14.28 cm. More than 90% of the individual trees fall under the category poles and saplings while large trees account to only 0.6%. Twenty-nine (29) species are listed under either the Philippine Red List (Fernando *et al.* 2008) or the IUCN Red List of Threatened Species (2015-4). Noteworthy among the list are the six critically endangered (CR) premium timber species including Makaasim *(Syzygium nitidum)*, Kamagong *(Diospyros discolor)*, Narra *(Pterocarpus indicus)*, Bagtikan *(Parashorea malaanonan)*, Guijo *(Shorea guiso)*, and White lauan *(Shorea contorta)*. The geodatabase that includes an interactive map developed in this study is of critical importance for future research activities in the area.

Keywords: Permanent biodiversity monitoring area, Makiling Forest Reserve, endemics, threatened species, geodatabase

INTRODUCTION

Permanent biodiversity monitoring plots are designated areas to study various life forms in particular ecosystems or habitats that are geographically located and permanently gridded with standard markers. The biodiversity resources thriving in these plots can be monitored space-wised in time to determine variations structurally and functionally. The patterns will be useful in conservation science and decision-making process for sustainable management of biodiversity resources, together with the continuous flow of goods and services from various ecosystems. Further, the establishment of permanent plots will be very significant for monitoring long-term ecological research on biodiversity-functioning in relation to climate change. Moreover, information generated from these monitoring stations provides vital lessons and action plans for policy makers to strategize mechanism concerning food security and climate change adaptation and mitigation.

Mt. Makiling was established as a forest reserve as early as 1910 and the only forest reserve in the country that is ceded for the control and administration to a university. Mt. Makiling Forest Reserve (MFR) serves as a living research and laboratory of the University of the Philippines Los Baños (UPLB). It also serves as a geothermal resource and a key ecotourism site in the Philippines. Being a research and laboratory area, numerous studies have been conducted inside MFR, and it has also been the study area of different international and national programs and projects.

Mt. Makiling Forest Reserve is considered as one of the Philippines' 18 centers of plant diversity (Lapitan *et al.* 2011). Its flora is composed of a huge number of endemic families, genera, and species. According to Pancho (1983), Mt. Makiling harbors an estimated number of about 2,038 vascular plants. However, many of these species are considered to be threatened to face a high risk of extinction. Thus, the establishment of permanent plots that holds this innumerable number of significant plant species is a vital action for the better management and conservation of these resources. The establishment, development, institutionalization, use and maintenance of a Permanent Biodiversity Monitoring Areas (PBMA) in MFR would not only provide a secured/protected landscape for a number of important organisms but would

also create a field/laboratory and demonstration areas where quality hands-on learning experience for students and researchers could be conducted.

OBJECTIVES OF THE STUDY

This research was conducted to establish and maintain a permanent biodiversity monitoring area (PBMA) in Mt. Makiling to serve as a permanent laboratory area for monitoring long-term ecological research on biodiversity-functioning and forest ecosystem dynamics. Specifically, it aimed to: 1) conduct 100% tree inventory inside the 2-ha PBMA; 2) determine the ecological status of the different species inside PBMA; 3) analyze the stand structure of the PBMA; and 4) develop geodatabase including an Interactive Map of PBMA for easy referencing and information retrieval.

MATERIALS AND METHODS

Establishment and GIS-mapping of PBMA

A 2.0-ha plot was established following the international protocol for the establishment of permanent field plots. There were two phases of the geodatabase development of PBMA. First is the establishment of the PBMA and secondly, is the GIS mapping and development of its geodatabase. The former requires actual ground survey and mapping, gridding and monument marking while the latter phase is more focused on building up information on biodiversity in the area using GIS.

The 2.0-ha plot in Mt. Makiling Forest Reserve (MFR) measures 100 m x 200 m following a bearing of N 55^0 E and N 35^0 W, respectively. The tying point of the PBMA is located along this UTM coordinates – 1,563,000 Northing and 307,723 Easting. The entire plot was then divided into 200 10m x 10m grids for easy referencing and more systematic sampling. Monument markers or mojons were driven in every corner and center of each grid. Each mojon was painted with bright color for easy reference. These corners were later geocoded for easy identification in the field and as future reference for efficient encoding of data.

In GIS, there are three types of Data Base Management Systems (DBMS) that are commonly used depending on the way the data are stored and manipulated. These are relational (RDBMS), object (ODBMS), and object-relational (ORDBMS). For this particular study, the RDBMS was applied. A relational database is mainly comprised of a set of tables, each a two- dimensional list (array)

of records containing attributes about the objects under study. Furthermore, it has proven to be remarkably more flexible and useful in several applications as compared to the other two types of DBMS.

Tree Inventory

Floristic taxa, composition, and structure were determined from the gridded and geo-based permanent biodiversity monitoring plot. 100% tree inventory was used for the whole 2-hectare plot. Trees that are ≥ 1cm in diameter were tagged, measured and recorded. Different attributes such as diameter at breast height (dbh), merchantable height (MH) and total height (TH) were taken from each tree using standard instruments. To plot the location of each tree on a map, distance and bearing of each tree from the center of each 10m x 10m plot were also taken and recorded using meter tape and compass (Figure 1).

Voucher specimens were also collected for identification, authentication, and herbarium collection. Each specimen was tagged using proper coding prior to storage. Floral identification followed a phylogenetic system of classification. All activities were photo-documented, and floristic data were processed and stored in GIS database for interpretation, analysis, and management purposes.

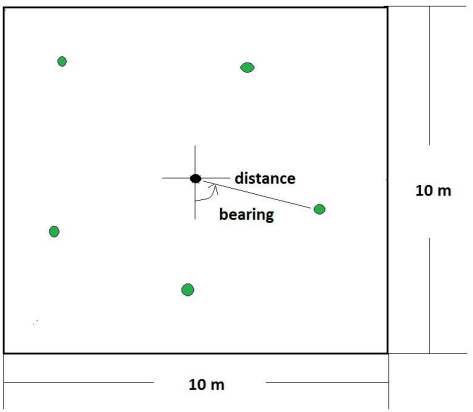

Figure 1. Marking the Position of a Tree Using Distance and Bearing from the Center of the Grid.

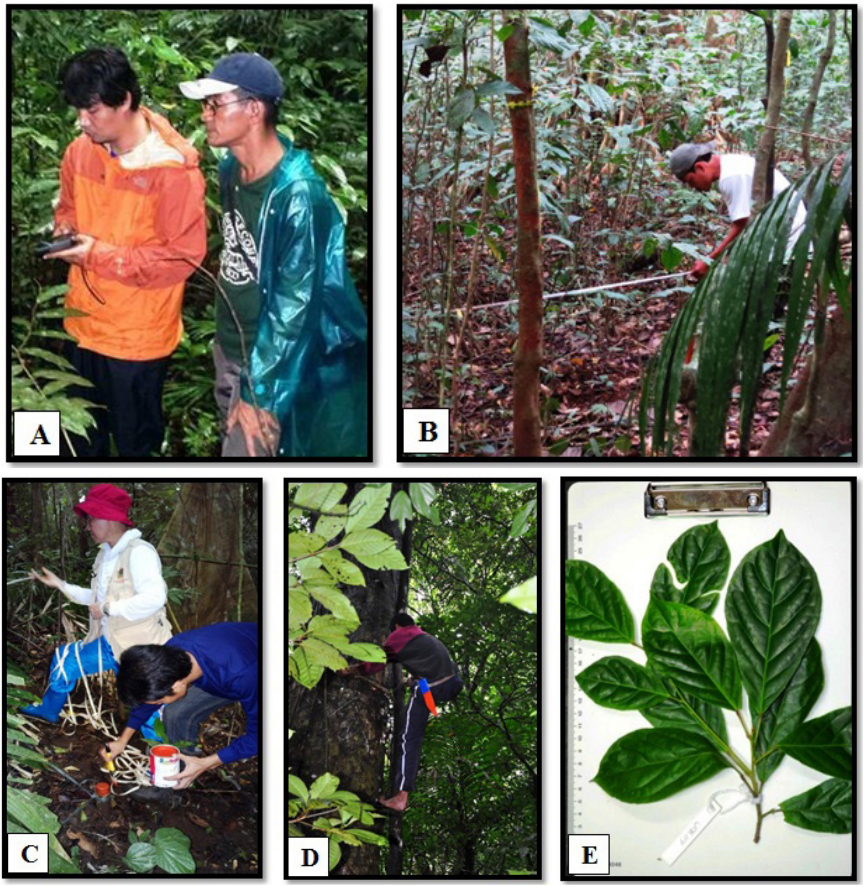

Plate 1. Establishment of Permanent Plot and Collection of Specimens: A) Establishment of benchmark's coordinates; B) Establishment of 10m x10 m grids; C) Painting/marking of mojons of every corner and center of 10m x 10m grid; D) Climber collecting leaf samples as voucher specimens; and E) Properly coded voucher specimen.

RESULTS AND DISCUSSION

Tree Diversity

A total of 155 tree species belonging to 103 genera and 55 families were found present in the permanent plot. Of the 155 species identified, 148 are found to be indigenous (native) to the Philippines of which 47 are endemic or exclusively found in the country. There are six exotic tree species recorded inside the permanent plot. These include kape *(Coffea Arabica)*, bigleaf mahogany *(Sweitenia macrophylla)*, African tulip *(Sphatodea campanulata)*, Malatanglin *(Adenanthera pavonina)*, and Talampunay *(Solanum verbascifolium)*. The genera with the most number of species are *Ficus* (with nine species), followed by *Syzygium* (6), *Garcinia* and *Palaquium* (5 each) and *Canarium* (4).

The most abundant species is Magabuyo *(Celtis luzonica)* with 2,287 (about 26% of the total) individuals, followed by Kape *(Coffea arabica)*, Balobo *(Diplodiscu spaniculatus)*, Tinaang pantai *(Drypetes maquilingensis)*, and Apanang *(Mallotus cumingii)*. Nine of the ten most abundant species are indigenous species of which two are Philippine endemics (Table 1).

Table 1. Ten Most Abundant Species in the Permanent Plot

Common Name	Scientific name	Abundance	Endemism
1. Magabuyo	*Celtis luzonica* Warb.	2287	PE
2. Kape	*Coffea arabica* L.	747	Ex
3. Balobo	*Diplodiscus paniculatus* Turez.	512	PE
4. Tinaangpantai	*Drypetes maquilingensis* (Merr.) Pax & K. Hoffm.	495	NE
5. Apanang	*Mallotus cumingii* Muell.-Arg.	454	NE
6. Malasaging	*Aglaia edulis* (Roxb.) Wall.	336	NE
7. Malatapai	*Alangium javanicum* (Blume) Wangerin	298	NE
8. Katong matsing	*Chisocheton pentandrus* (Blanco) Merr. subsp. *pentandrus*	297	NE
9. Bagtikan	*Parashorea malaanonan* (Blanco) Merr.	219	NE
10. Tamayuan	*Strombosia philippinensis* (Baill.) Rolfe	214	NE

PE – Philippine endemic; NE – Native but non-endemic; Ex – Exotic

Stand Structure

A total of 8,806 tree individuals with a diameter at breast height of 1 cm or more were recorded from the 2-ha plot. This accounts to a plot density of 4,403 trees ha^{-1}, which is about 44 trees for every 10m x 10m grid. The computed density is relatively lower as compared to the density of the 16-ha permanent forest plot in Palanan, Isabela at 4,999 trees ha^{-1} (Co *et al.* 2006). This is understandable since Palanan, which is part of Northern Sierra Madre Mountain Ranges, is an old growth forest while Mt. Makiling is a secondary forest.

The average diameter of all trees inside the plot is only 14.28 cm. Moreover, there is a big discrepancy in the proportion of the different diameter classes of the trees. More than 90% of the individual trees fall under the category poles and saplings while the large trees account for only 0.6% (Table 2). This bias can be attributed to the relatively young forest of Mt. Makiling, which underwent a series of logging operations in the past. The species with the biggest average diameter are Igyo *(Dysoxylum gaudichaudianum)*, Banilad *(Sterculia comosa)*, Bangulo *(Litsea garciae)*, and a species of *Saurauia*.

Spatial distribution of the inventoried trees was plotted (Figure 2) for easy referencing and future monitoring. More importantly, an interactive map was produced using ArcGIS. Aside from the position of the trees, all information generated for each tree individuals (name, scientific name, family name, dbh, mh, th, etc.) can be viewed by just pointing the cursor to the individual circle on the map (Figure 3). The interactive map was stored and saved in a shapefile (.shp) format. This shapefile will serve as the geodatabase of trees in PBMA-MFR that can be opened using any GIS software.

Table 2. Number of Individuals per Diameter Class

Diameter Class	Diameter Range	Number of Individuals
Poles and saplings	< 10cm	7,958
Small trees	10cm to <30cm	591
Medium-size trees	30cm to <60cm	202
Large trees	>60 cm	55

Ecologically Important Species

Endemic Species. The geographical distribution of plant species has been very useful for assessing biodiversity values of regions, countries, and islands. Species confined to a particular site should be given particular conservation management strategies, as they are more vulnerable to disturbance due to their narrow range. However, categorizing species as endemic is very much dependent on the availability of recent revisions, nomenclatural changes, and new evidence from various disciplines used in systematics, among others. There are at least 47 Philippine endemics encountered in the study area (Table 3). These account to more than 30% endemism. This very much conforms to the recently suggested country endemism for Philippine flowering plants at around 25-30%.

Threatened Species. Twenty-nine (29) species recorded from the area are listed under either the Philippine Red List (DAO 2007-01) or the IUCN Red List of Threatened Species (2012.2). Noteworthy among the list are the six critically

endangered (CR) premium timber species including Makaasim, Kamagong, Narra, Bagtikan, Guijo, and White lauan (Table 4).

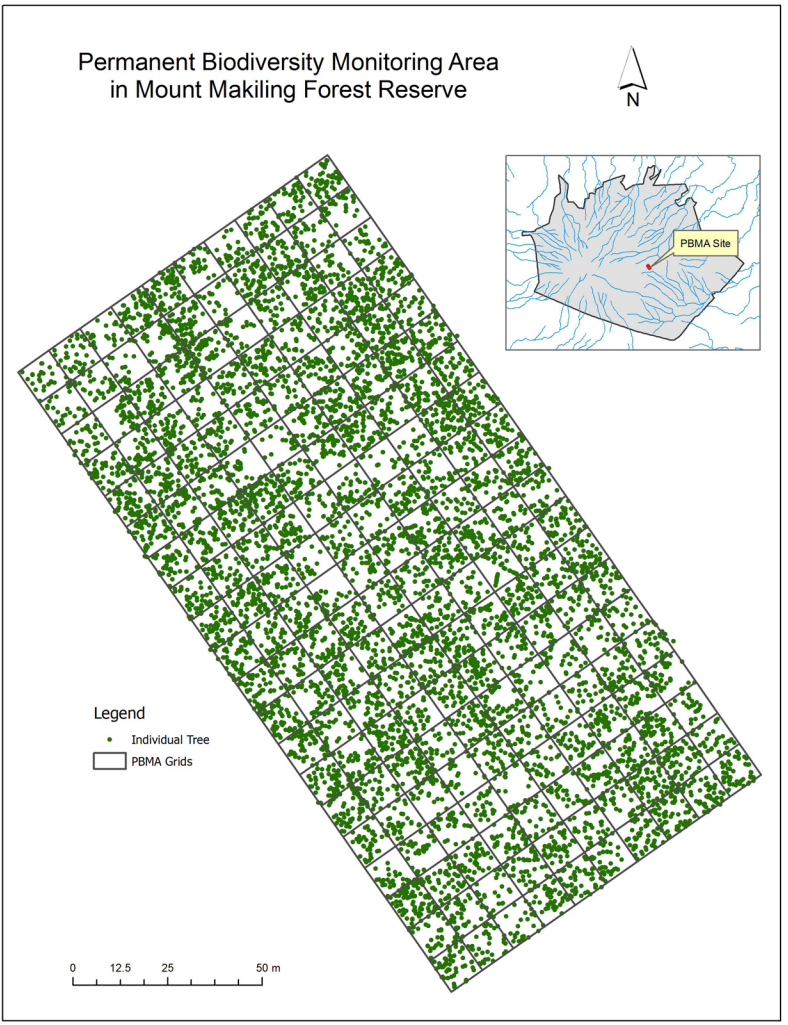

Figure 2. Spatial Distribution of Trees inside the PBMA in Mt. Makiling Forest Reserve.

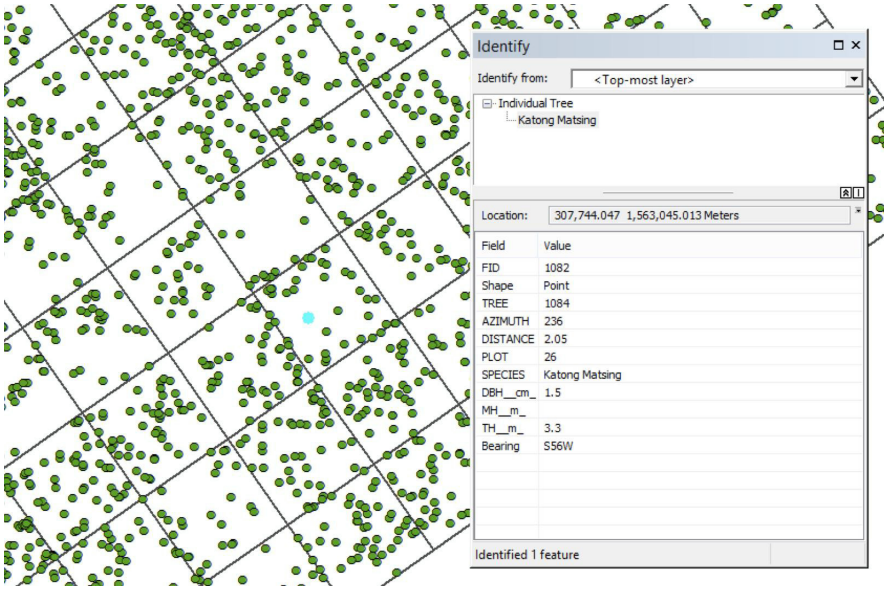

Figure 3. The Interactive Map for PBMA-MFR Displaying the Information for a Chosen Tree.

Table 3. List of Endemic Species Recorded in the Permanent Plot

Common Name	Scientific name	Family name
1. Tanglin	*Adenanthera intermedia* Merr.	FABACEAE
2. Tagpo	*Ardisia squamolosa* Elmer	PRIMULACEAE
3. Anubing	*Artocarpus blancoi* (Elmer) Merr.	MORACEAE
4. Kalulot	*Artocarpus rubrovenius* Warb.	MORACEAE
5. Tuai	*Bischofia javanica* Blume	PHYLLANTHACEAE
6. Piling liitan	*Canarium luzonicum* Blume (A. Gray)	BURSERACEAE
7. Puni	*Canthium megacarum* (Merr.) Merr.	RUBIACEAE
8. Magabuyo	*Celtis luzonica* Warb.	CANNABACEAE
9. Malalipa	*Claoxylon albicans* (Blanco) Merr.	EUPHORBIACEAE
10. Karaskas	*Cryptocarya acuminate* Merr.	LAURACEAE
11. Paang dalaga	*Cryptocarya pacifica* Elmer	LAURACEAE
12. Katmon	*Dillenia philippinensis* Rolfe	DILLENIACEAE
13. Kamagong	*Diospyros blancoi* A. DC.	EBENACEAE
14. Balobo	*Diplodiscu spaniculatus* Turez	MALVACEAE
15. Kalomala	*Elaeocarpus calomala* (Blanco) Merr.	ELAEOCARPACEAE
16. Balete	*Ficus balete* Merr.	MORACEAE
17. Pakiling	*Ficus odorata* (Blanco) Merr.	MORACEAE
18. Binukaw	*Garcinia binucao* (Blanco) Choisy	CLUSIACEAE
19. Tagkon	*Garcinia macgregorii* Merr	CLUSIACEAE
20. Kamandiis	*Garcinia rubra* Merr	CLUSIACEAE
21. Malabagna	*Glochidion phyllanthoides* Merr.	PHYLLANTHACEAE
22. Mabunot	*Gomphandra luzoniensis* (Merr.) Merr.	STEMUNORACEAE
23. Bigus	*Goniothalamus elmeri* Merr.	ANNONACEAE
24. Anuping	*Gymnacranthera farquhariana* (Hook.f. & Thomson) var *paniculata* (A.DC.) R.T. Schouten	MYRISTICACEAE
25. Anolang	*Haplosticanthus lanceolatus* (Vidal) Heusden	ANNONACEAE
26. Mayanman	*Ixora longistipula* Merr.	RUBIACEAE
27. Mali-mali	*Leea guineensis* G. Don	LEEACEAE
28. Kaliantan	*Leea philippinensis* Merr.	LEEACEAE
29. Bangulo	*Litsea garciae* Vidal	LAURACEAE
30. Hamindang	*Macaranga bicolor* Muell-Arg	EUPHORBIACEAE
31. Takip asin	*Macaranga grandifolia* (Blanco) Merr.	EUPHORBIACEAE
32. Matang araw	*Melicope triphylla* (Lam. Merr)	RUTACEAE
33. Duguan	*Myristica philippinensis* Lam.	MYRISTICACEAE
34. Tagotoi	*Palaquium foxwortyi* Merr.	SAPOTACEAE
35. Nato	*Palaquium luzoniense* (F.Vill) Vidal	SAPOTACEAE
36. Malak-malak bundok	*Palaquium montanum* Elmer	SAPOTACEAE
37. Malak-malak	*Palaquium philippinense* (Perr.) C.B. Rob.	SAPOTACEAE
38. Lamog	*Planchonia spectabilis* Merr.	LECYTHIDACEAE
39. Saurauia	*Saurauia denticulate* C Robinson	ACTINIDIACEAE
40. Kolalabang	*Saurauia latibractea* Choisy	ACTINIDIACEAE
41. Saurauia	*Saurauia luzoniensis* Merr.	ACTINIDIACEAE
42. White lauan	*Shorea contorta* Vidal	DIPTEROCARPACEAE
43. Kalogkog	*Syzygium calcicolum* (Merr.) Merr.	MYRTACEAE
44. Kalubkob	*Syzygium calubcob* (C.B. Rob.) Merr.	MYRTACEAE
45. Malahagnit	*Syzygium everettii* (C Robinson) Merr.	MYRTACEAE
46. Lipote	*Syzygium polycephaloides* (C Robinson) Merr.	MYRTACEAE
47. Panglomboien	*Syzygium simile* (Merr.) Merr.	MYRTACEAE

Table 4. List of Threatened Species Recorded in the Permanent Plot

Species	Scientific Name	Family Name	Conservation Status	
			Fernando *et al.* 2008	IUCN 2015-4
1. Makaasim	*Syzygium nitidum* Benth	Myrtaceae	CR	
2. Kamagong	*Diospyros blancoi* A. DC.	Ebenaceae	CR	VU
3. Narra	*Pterocarpus indicus* Wild.	Fabaceae	CR	VU
4. Bagtikan	*Parashorea malaanonan* (Blanco) Merr.	Dipterocarpaceae		CR
5. Guijo	*Shorea guiso* (Blanco) Blume	Dipterocarpaceae		CR
6. White Lauan	*Shorea contorta* Vidal	Dipterocarpaceae	VU	CR
7. Kubili	*Cubilia cubili* (Blanco) Adelb.	Sapindaceae	EN	
8. Anang	*Diospyros pyrrhocarpa* Miq	Ebenaceae	EN	EN
9. Alupag	*Litchi chinensis* Sonn subsp. *philippinensis* (Radlk.) Leenh.	Sapindaceae	EN	EN
10. Lamio	*Dracontomelon edule* (Blanco) Merr.	Anacardiaceae	VU	
11. Malasaging	*Aglaia edulis* (Roxb.) Wall.	Meliaceae	VU	
12. Bayanti	*Aglaia rimosa* (Blanco) Merr.	Meliaceae	VU	
13. Kalulot	*Artocarpus rubrovenius* Warb	Moraceae	VU	
14. Malatapai	*Alangium longiflorum* Merr	Cornaceae	VU	VU
15. Kangko	*Aphanamixis polystachya* (Wall.) R.N. Parker	Meliaceae	VU	VU
16. Nato	*Palaquium luzoniense* (F.Vill.) Vidal	Sapotaceae	VU	VU
17. Malakmalak	*Palaquium philippinense* (Perr.) C.B. Rob.	Sapotaceae	VU	VU
18. Piling liitan	*Canarium luzonicum* (Blume) A. Gray	Burseraceae		VU
19. Magabuyo	*Celtis luzonica* Warb	Cannabaceae		VU
20. Katmon	*Dillenia philippinensis* Rolfe	Dilleniaceae		VU
21. Kalomala	*Elaeocarpus calomala* (Blanco) Merr.	Elaeocarpaceae		VU
22. Hamindang	*Macaranga bicolor* (Muell-Arg.)	Euphorbiaceae		VU
23. TakipAsin	*Macaranga grandifolia* (Blanco) Merr.	Euphorbiaceae		VU
24. Tanglin	*Adenanthera intermedia* Merr.	Fabaceae		VU
25. Balobo	*Diplodiscus paniculatus* Turez	Malvaceae		VU
26. Antipolo	*Artocarpus blancoi* (Elmer) Merr.	Moraceae		VU
27. Duguan	*Myristica philippinensis* Lam.	Myristicaceae		VU
28. Tagpo	*Ardisia squamolosa* Elmer	Myrsinaceae		VU
29. Balakat	*Ziziphus talanai* (Blanco) Merr.	Rhamnaceae		VU

CONCLUSIONS

Results of the intensive study revealed that the permanent biodiversity monitoring area in Makiling Forest Reserve holds tremendous tree diversity. It also showed very high species endemism and harbored a significant number of ecologically threatened trees. The geodatabase developed in this research should serve as the baseline information for the PBMA, which is of critical importance for the future research activities in the area. The established PBMA could be a principal venue for current and planned conservation efforts for the Makiling Forest Reserve. The information on the ecological status of the biodiversity in PBMA should be disseminated to advocate conservation.

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