



Floral Assessment in Lake Mainit Watershed, Caraga Region, Mindanao Philippines

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ABSTRACT

Lake Mainit is one of the Key Biodiversity Areas (KBA) in the Philippines with unique biodiversity resources that are at risk due to forest degradation and conversion of forested land to agriculture, shifting cultivation, and small scale mining activities. Thus, it is the main concern of this research to identify and assess the endemic and endangered flora of Lake Mainit and its watershed. The survey revealed a total of 202 species of which 14 threatened species, 52 endemic species and 57 economically important species. The floral diversity in Mainit watershed area is currently facing variety of threats which need to be countered if conservation of biodiversity can be seriously considered. Among the threatened species were *Toona calantatas*, *Dracontemelon dao*, *Dipterocarpus validus*, *Shorea negrosensis*, *Shorea contorta*, *Shorea polysperma*, and the *Agathis philippinensis*. Noteworthy is the discovery of *Rafflesia mixta*, a new species of plant found in a secondary growth forest of Mainit Surigao del Norte. This species is also considered site endemic, rare, and threatened. Thus, the result of this study would serve as basis for the formulation of policies for the protection and conservation of these species before these plants become extinct and the formulation of the Lake Mainit Watershed Management Plan.

Keywords: Assessment, Endangered, Endemic flora, Lake Mainit, *Rafflesia mixta*

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1 Introduction

Lake Mainit is blessed with bountiful resources in both upland and lake ecosystems as shown in researches and studies conducted by various institutions (Gracia, 1981). These data are generated several years ago which currently needs assessment and validation to determine whether previously identified species can still be found thriving in their respective habitats. The watersheds of Lake Mainit are located adjacent to Mt. Hilong-hilong which situated within the political boundaries of Agusan del Norte, Agusan Del Sur and Surigao Del Sur provinces. It contains one of the few remaining primary forests in the Philippines, making it a priority conservation area and a Key Biodiversity Area (KBA) within the Eastern Mindanao Biodiversity Corridor (EMBC). Housing the largest block of the country's remaining dipterocarp forests, Mt. Hilong-hilong is also an Important Bird Area (IBA). Lake Mainit is reported to be the habitat of rare fish species; the puyo or perch and gabot. These species have become rare due to the introduction of new fish species. Habitats of other rare and threatened wildlife put the lake and its surrounding area of high ecological value. The lake is undeniably very scenic. Its water has remained generally clear and clean. There are various points around it that could be potential tourist attractions. Thus, in the Caraga Tourism Master Plan, the lake area is defined as tourism subzone, mainly for adventure tourism and ecotourism. The conduct of habitat assessment in the vicinity of Lake Mainit can provide Lake Mainit Development Alliance (LMDA) the appropriate information in terms of floral status as basis in future planning and possible measures to undertake for conservation. This study aims to determine species distribution, abundance and conservation status of flora within the sampling sites and to identify key stone species for conservation criteria within the lake Mainit watershed area.

2 Methodology

Floral Assessment (Field Survey / Data Collection)

Maps were used to initially assess and characterize the area for sampling site selection. Field reconnaissance and transect walk was conducted to identify and describe vegetation types by considering the species richness and dominance, canopy cover, altitude, location and other ecological parameters. A Rapid Resource Assessment was employed to estimate the present condition of floral species within the study sites. Transect Walk is a rapid biodiversity assessment technique that employs a hike, recording of species, and physical attributes. This method seeks all major ecosystems, determines stratified zones, and maps the areas across a landscape. Alpha taxonomy was done in order to list the entire flora encountered, with the help of local guide and field taxonomic keys, species were identified. Photos were taken for the species that was not identified and for proper documentation. Three sampling sites were considered for every sampling locations/municipality. One kilometer transect was considered per sampling site. Within the sampling site, a total of three 20×20 m plots were established. The established plots served as monitoring stations to

assess the temporal condition of the terrestrial flora of the watershed. Global Positioning System (GPS) was used to determine the location of each plot. All species of flora (trees, shrubs, ferns) along and up to 5 meters away from the transect and within the plot were recorded.

Data Analysis

Species richness was measured per sampling site. The diversity indices of the different sampling areas, which include the Shannon index was also computed. The diversity indices were computed using the following formula:

Shannon-Wiener Index (H'). It is a measure of the average degree of “uncertainty” in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong (Magurran, 1988).

$$H' = - \sum \left[\left(\frac{n}{N} \right) \ln \left(\frac{n}{N} \right) \right]$$

Floral Identification and Assessment of Status

Collected plants were identified using taxonomic keys from floras and monographs of Merrill, E.D. (1926); Brummitt, R.K. (1992); Madulid, D.A. (2000); Barcelona et al. (1996); Rojo (1999); Amoroso et al. (1990). Assessment of status of each species collected in the field was determined whether threatened, endemic, rare or economically important. The floral species was assessed based on the nationally listed of threatened Philippine Plants.

Sampling sites identification

Prior to the actual field data collection, a community entry protocol meeting has been conducted per municipality to inform the stakeholders about the biological assessment project in Lake Mainit. The participation of the community was sought during the meeting particularly the identification of the site for the biological survey. Moreover, the accessibility, representativeness and peace and order situation of the potential site for the survey were the criteria in selecting the sampling sites. The barangay sites identified during the community entry meetings were visited by the biological team to identify further the sampling stations. Reconnaissance survey was done together with the representative of the barangay. The sampling sites for flora assessment in Lake Mainit watershed presented in Figure 1.

3 Results and Discussion

1. Santiago

Barangay Pangaylan is one of the rural barangays of Municipality of Santiago located at 09°15.8.65N and 125° 35.013E. This Barangay is a river valley surrounded with steep slopes of mountain ranges (Fig. 2). Coconut farming is the primary source of income of the community, but some of the inhabitants indulge in small scale mining at the hilly areas of the barangay. Result of the biological assessment revealed that the area still having a high species richness harbouring 92 floral species (Table 1). It has the highest Shannon-Weiner diversity index among the eight sampling sites. Moreover, there are species identified which are an indicator to a good and healthy condition of the environment. Some of the important floral species found were Ipil (*Intsia bijuga*), Kamagong (*Diospyros philippinensis*), Molave (*Vitex parviflora*), Narra (*Pterocarpus indicus*) and Lamio (*Dracontomelon edule*).

2. Tubay

The research site is located in barangay La Fraternidad and part of Santa Ana. The general topography of the area is a loosely ultramafic soil that drains to Tubay River. Mt. Minaasog is the highest peak measuring 475 m.asl characterized as a secondary forest and hilly agricultural followed areas. Results of the floral survey revealed a total of 68 species, of which 15 were classified as endemic and 6 as threatened. Some of the important floral species found were “Tagibukbuk” (*Helicia robusta*), “Kamagong” (*Diospyros philippinensis*), Molave (*Vitex parviflora*), Narra (*Pterocarpus indicus*), and “Tindalo” (*Afzelia rhomboidea*).

3. Kitcharao

Municipality of Kitcharao is located in the northernmost part of the province of Agusan del Norte. It has only few plain areas of which settlements are concentrated and agriculture are dominant. Lake Mainit and lakeshore are utilized as fishing grounds and tourism sites in some areas. The eastern portions are mountainous and rocky having a low income farming production and other plants are lifted denuded. There are 19 creeks and rivers in the municipality of which all will go to the Lake Mainit. Some of these creeks are now dried due to the denuded mountain areas. The development of tourism industry of the municipality is on its infant stage which needs coordinated efforts to make it operational. Results of the biological survey in Barangay Sangay revealed the lowest number of floral species (56 species) among the four sampling sites in Lake Mainit watershed. In spite of its lower species richness, it has the highest number of endemic species and 2nd to the highest threatened species (Table 1). Barangay Sangay is potential for habitat conservation because it is the home of some endemic and threatened species. Some of the important floral species found were “Puso-puso” (*Neolitsea vidalii*), “Tagibukbuk” (*Helicia robusta*), “Ipil”

(*Intsia bijuga*), “Kamagong” (*Diospyros philippinensis*), Molave (*Vitex parviflora*), Narra (*Pterocarpus indicus*), “Law-at” (*Sterculia luzonica*) and “Batino” (*Alstonia macrophylla*).

4. Jabonga

Barangay San Pablo of Jabonga Agusan del Norte is located northwest of Lake Mainit. It is characterized as hilly and mountainous area surrounding the lake. Its altitude ranges from 10-300 meters above sea level which coconut is the main cash crops of the Mamanwa tribe, the native inhabitants of the area. Starting from the access road, the area was considered a coconut-banana plantation, which “cogon” (*Imperata cylindrica*), “hagonoy” (*Chromolaena odorata*) and several species of ferns dominated the understorey. A remaining primary forest was observed in the southern portion that serves as the source of potable water for the community. Floral assessment result showed that a total of 79 species were identified in Barangay San Pablo. It houses 12 endemic species and 8 threatened species. Species like Narra (*Pterocarpus indicus*), “mangacahpoi” (*Hopea acuminata*), “Kamagong” (*Diospyros philippinensis*), “bagtikan” (*Parashorea plicata*) were found with saplings grows abundantly. These species were considered threatened according to IUCN red list 2010. Waterfalls were also observed in this area and a potential for tourist destination. “Kaong” or sugar palm (*Arenga pinnata*) is a unique species of Jabonga. It is not a threatened species, but an important species as food of several endangered species, including cloud rats of the genus *Phloeomys*.

5. Motorpol, Tubod

Tubod lies in a valley at the middle of the peninsula that is the mainland portion of Surigao del Norte, with mountains to the east and west of the town. Tubod in early times is woodland or otherwise known as virgin forest lived with native inhabitants the “Mamanwas”. Coconut farming is the primary source of income of the community. The sampling site for the biological assessment was located in Barangay Motorpool, Tubod, SDN (Fig. 3). Result of the biological assessment revealed that the area still having a high species richness (70) species. Of these, 22 were endemic and 12 were considered threatened. Moreover, there are species identified which are indicators to a good and healthy condition of the environment. It houses 22 endemic species and 7 threatened species. Species like “Kamagong” (*Diospyros philippinensis*), “olingo” (*Cratoxylum sumatranum*), Molave (*Vitex negundo*), and “Almaciga” (*Agathis philippinensis*) were found with saplings grows abundantly. These species were considered threatened according to IUCN red list 2010. A cave with waterfalls was also observed in this area which can be a potential tourist destination of Surigao del Norte. In General the area is a limestone secondary forest where plants are clinging on the sharp and pointed rocks forming buttress roots in the forest floor. Several formations of caves were observed and served also as the breeding ground and habitat of bats and the highly prized birds nest the “Balinsasayao” (Fig. 4). Species

richness in the area is relatively high compared to the other sampling area.

6. Cantugas, Mainit

The research site was located in Barangay Cantugas, Mainit SDN. The general topography of the site is classified as secondary forest and hilly agricultural followed areas. Patches of forest were seen in a sloppy area with an altitude ranges from 250-380 meters above sea level. Some of the important floral species found were Narra (*Pterocarpus indicus*), red "lauan" (*Shorea negrosensis*) and *Rafflesia mixta* the largest flowering plant and a new record for Philippine plants in Caraga Region (Barcelona et al, 2014). It is noteworthy that this is a new species in the Philippines. Moreover, during the sampling period, there were about 14 individuals of *Rafflesia* in the area, unlike the other areas of the Philippines that there are only a maximum of 3 individuals. A total of 68 species of plants recorded in the area. Of this number, 17 species were endemic in the Philippines and 6 species were threatened based on IUCN (2010).

7. Budlingin, Alegria

The Municipality of Alegria is situated 9°53'8" North, 125°31'50". It is bounded in the North by the Municipality of Mainit and in the South by the Municipality of Kitcharao. Barangay Budlingin as a sampling sites is a hinterlands located northeast about two kilometres from the Poblacion. The area is graced with the presence of Lumundo falls which serves as source of water for households and rice fields. Patches of secondary forest were dominated by Families Anacardiaceae and Rubiaceae species. Remains of Dipterocarp spp were also observed. The area had a total of 76 species of flora and 17 of these were endemic and 6 species were considered threatened.

8. Mayag, Sison

The sampling site was located in Barangay Mayag, Sison SDN. Mayag is a valley surrounded with Mt. Cangyagtiw in the Northern portion and mountains of Barangay Imma in the western portion. The sampling sites were located in the rolling hills and plains abundant with crystal clear mountain springs, streams and brooks. A secondary forest was dominated by small to medium size of ulayan, lawuan and ilang-ilang trees. Along the creek are stands of fruiting *Ficus* species which attracts fruit bats and other birds. Floral inventory revealed a total of 63 species with 18 species were endemic in the Philippines and 6 were considered threatened.

Species Richness

The survey documented a total of 202 species, comprising 158 genera in 107 Families in all sampling sites. Among the group of plants, 165 (81.68%) species were angiosperms,

4(1.98%) species were classified as Gymnosperms and 33 species (16.33%) were Pteridophytes (Fig. 5). Angiosperms had 78 genera and 58 families. Moraceae, Rubiaceae, Fabaceae, and Myrtilaceae were amongst the most dominated families in flowering plants. On the other hand, Gymnosperms and Ferns have a total of 2 and 16 families respectively. *Nephrolepis bisserata* constantly dominated among all sites for the ferns while species of Gymnosperms were observed only in Tubod and Sison areas only. List of flora species of the four municipalities is presented in Appendix 1.

Species Diversity and Distribution

Concerning species diversity level, the highest species diversity index was obtained from Santiago with $H' = 2.94$, followed by Tubod and Jabonga with $H' = 2.36$ and 2.17, which according to Fernando Biodiversity Scale (1998), these values were categorized as moderate to low diverse areas. The lowest species diversity index was obtained in Kitcharao with diversity value of 1.04. As observed, the area of Santiago and Tubod were considered as secondary old growth forest to a pristine forest with higher altitudes ranging from 200-600 m asl. According to Barthlott et al. (1996), that biodiversity is high in mountain area because of the varied ecological conditions which give rise to wide range of habitats. Altitudinal and ecological zones provide plants with different exposures over short distances. Moreover mountains have been less altered by various human activities because of the logistical difficulties inherent in the mountain areas (Gotame, 2008).

Species Similarity

Among all sampling sites, Kitcharao and Tubod have more similar species compared to the rest of the sites. Ninety-five percent of the species in Kitcharao are also found in Tubod area (Figure 6). This similarity maybe attributed to soil of these two areas which is a limestonic type. On the other hand, Mainit and Santiago had 90% species similarity even they are not of the same province but these two areas have the least similar species to the rest of the sampling sites with only 84%. This means that these two sampling sites have more species which are unique and rare to the rest of the area.

There are several species that were found only on a specific area or these species can be an indicator of a particular habitat and were considered rare and must be a priority for protection and conservation because they have also a fewer in number of individuals. In Tubod area, most of the species are indicators of higher altitude area which have more than 500 meters above sea level. The species of trees was observed to have stunted growth due to the rocky with a limestone substrate. The species in Alegria, Mainit and Sison areas were indicators of an old growth forest and hilly Dipterocarp forest that extends from 300m to 450m asl. It includes numerous epiphytes, climbers and stranglers. This forest is also rich in a variety of fruit trees such as durian, rambutan and coconut, as well as figs. Figs have been proven to be one of the most important sources of food, especially for monkeys

and civets and for larger birds such as hornbills and barbets.

Conservation status and Endemic Species

Of the total 202 plant species encountered, 52 species or (25.74%) were endemic in the Philippines. Among the endemic species were *Shorea negrosensis*, *Xantostemon verdugonianus*, *Vitex parviflora*, *Dellinia philippinensis*, *Stenochlaena palustris* and *Dipterocarpus grandiflorus* (Table 2). Some of these Philippine endemic species were also threatened and endangered and it must be given sufficient protection measures in order to ensure their continued existence in the wild. Endangered species are defined as species that are threatened by disturbance such that the population of the species may become extinct in the immediate future if the disturbance remains unchecked. To protect these species, they are included in the endangered species list of the International Union for the Conservation of Nature (IUCN) and the Convention on the International Trade of Endangered Species (CITES).

Figure 7 presents the plant species which are threatened and endemic to each sampling sites. As observed, Tubod and Kitcharao had the highest number of endemic and threatened with 22 and 21 species respectively. Most of these threatened species were distributed in all sampling sites of Lake Mainit watershed.

Threatened Species-Habitat Relationship

Canonical correspondence analysis revealed that threatened species has negative response to environmental factor like altitude, slope and canopy cover. They are not affected with short changes of altitude except for *Agathis philippinensis* which is an outlier and an indicator of higher altitude area (Fig. 8a & b). Moreover, all tree species were distributed to right axis which is an indicator of a true forest species but are threatened due to anthropogenic activities such as timber poaching, shifting of forestland into agricultural area and mining, while herbaceous species were distributed in the lower left axis which means they are the ground layer vegetation and are dependent to tree species. Some of these species can still be found in the area growing naturally but should be given high priority for protection and conservation measures.

4 Conclusion

Lake Mainit watershed is the habitat of 202 species of flora, of which 14 threatened species and 47 endemic species. The area is considered a moderately high in terms of biodiversity status with high endemism status which is noteworthy for conservation and protection. Most of these threatened species were distributed in all sampling sites but diminishing in numbers due to natural and several anthropogenic activities thus these areas worth conserving and preserving for future use. The result of this study is very useful to developed the template for the local ordinance to support local endemics. Revived the LMDA

Sustainable Fishery Management Team that plays vital roles in initiating conservation of lake resources.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Fig. 1: Map of Lake Mainit showing eight sampling locations for biological assessment.



Fig. 2: Selected Panoramic Views around Lake Mainit Area

(a) *Barangay Pangaylan overview showing the river flowing towards Lake Mainit*



(b) *Northeastern part of Mt. Minaasog, Tubay Agusan del Norte where sampling sites are located*



(c) *Coconut plantation in Barangay Sangay, Kitcharao Agusan del Norte*



(d) *Western part of the sampling site in Jabonga Agusan del Norte*



Fig. 3: Select Panoramic View of Sampling Sites around Lake Mainit Watershed

(a) Part of sampling site in Barangay Motorpool, Tubod categorized as secondary limestone forest.



(b) Panoramic view of the sampling stations in Mainit, Surigao del Norte



(c) Panoramic view of the sampling sites in Barangay Mayag, Sison, Surigao del Norte



(d) A secondary forest in Alegria, Surigao del Norte



Fig. 4: Possible tourist destinations in Surigao del Norte part of the Lake Mainit Watershed

(a) Nest of *Balinsasayao* inside the cave in Motorpool, Tubod Surigao del Norte



(b) Habit of *Rafflesia mixta* in Barangay Cantugas, Mainit, Surigao Del Norte



(c) Lumundo falls in Barangay Budlingin, Alegria, Surigao del Norte



Fig. 5: Pie chart showing the percentage of the major group of plants in Lake Mainit watershed sampling sites.

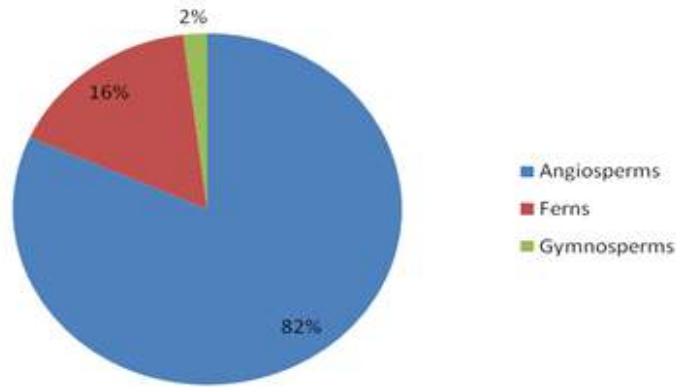


Fig. 6: Dendrogram showing the Bray-Curtis cluster analysis in all sampling sites

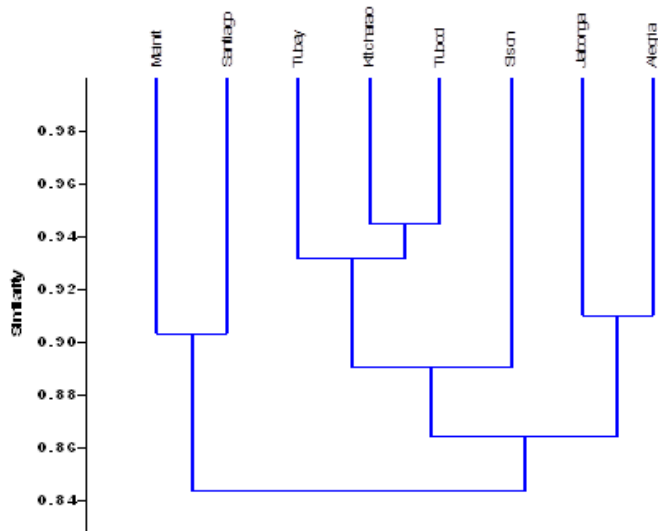


Fig. 7: Graph showing the number of threatened and endemic species per sampling sites

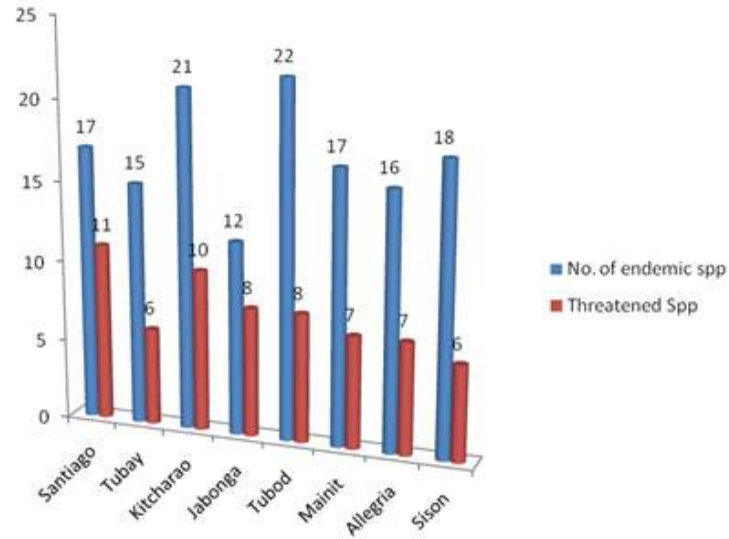
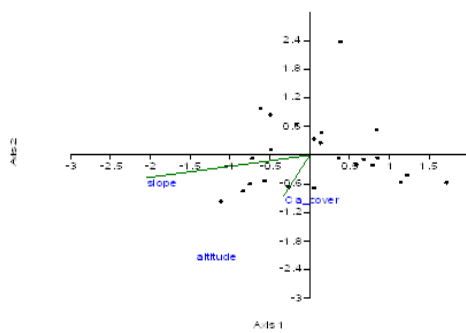


Fig. 8: Canonical correspondence analysis(CCA) results

(a) CCA on altitude and species richness



(b) CCA on threatened species in response to richness and altitude

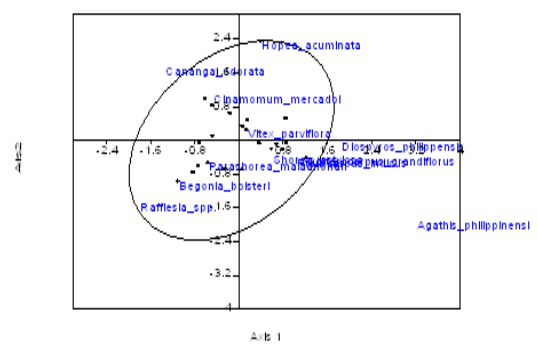


Table 1: Species richness and number of endemic and threatened species in Lake Mainit watershed sampling sites

Sites	No. of Species	No. of endemic species	Threatened Species	H'
Pangaylan, Santiago	92	17	11	2.94
La Fraternidad, Tubay	68	15	6	1.28
Sangay, Kitcharao	56	21	10	1.04
San Pablo, Jabonga	79	12	8	2.17
Motorpool, Tubod	22	22	8	2.36
Cantugas, Mainit	68	17	7	1.18
Budlingin, Alegria	76	16	7	2.04
Mayag, Sison	63	18	6	1.03

Table 2: List of threatened species found in eight sampling areas in Lake Mainit Watershed

Local Name	Scientific Name	Conservation Status (2010)
Kamagong	<i>Diospyros philippinensis</i>	Endangered
Molave	<i>Vitex parviflora</i>	Vulnerable
Ilang-ilang	<i>Cananga odorata</i>	Vulnerable
Apitong	<i>Dipterocarpus grandiflorus</i>	Vulnerable
Bagtikan	<i>Parashorea plicata</i>	Vulnerable
Mangachapui	<i>Hopea acuminata</i>	Endangered
Palosapis	<i>Anisoptera thurifera</i>	Vulnerable
White lawaan	<i>Shorea contorta</i>	Vulnerable
Yakal	<i>Shorea astylosa</i>	Vulnerable
Almaciga	<i>Agathis philippinensis</i>	Endangered
Begonia	<i>Begonia bolsterii</i>	Vulnerable
Kalingag	<i>Cinamomum mercadoi</i>	Vulnerable
Rafflesia	<i>Rafflesia mixta</i>	Endangered
Kalantas	<i>Toona calantas</i>	Endangered