Plant Diversity in the Forest Ecosystem of Bataan Natural Park, Philippines

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The diversity of plants at the forested areas of Bataan Natural Park (BNP) was assessed to determine the exploitation and conservation status of the forest ecosystem in Bataan, Philippines. Plants were collected, preserved, described, identified, and classified. The quantitative description of each plant species was determined for diversity assessment. Data were gathered using quadrat sampling method in the ten pre-selected stations. A total of 189 plant species were surveyed in the area, under 65 families of which belong to Moraceae, Rubiaceae, and Araceae. Trees, shrubs, vines and herbs are the most common, with some ferns, grasses and epiphytes and representatives of sedge and moss. Shannon's Diversity Index showed that the forest ecosystem in Bataan Natural Park exhibited high diversity. Jade vine, which is endemic to the country, is still present in the area but is already listed as endangered species in the International Union for the Conservation of Nature (IUCN) Red List of 2013. Fifteen species were endemic, 15 were introduced plant species, and two were invasive plant species. There were threats in the forest ecosystem which included timber poaching, kaingin practices, soil erosion, charcoal making, and wildlife hunting.

Keywords: Diversity, Plants, Endemic, Invasive, Degradation

INTRODUCTION

Bataan National Park (BNP) has a total land area of 18,335 hectares. It is bounded in the north by the Subic Forest and Watershed Reserve (SFWR) and the Municipalities of Dinalupihan and Hermosa. On the south, it is bounded

by the municipalities of Bagac and Balanga, on the west by the municipality of Morong, and on the east by the municipalities of Orani, Samal, and Abucay, facing Manila Bay (Ramirez, n.d.).

The BNP watershed is the main source of ground and surface water that caters to the needs of domestic, industrial, and agricultural sectors in the area. It is declared as a protected area under the National Integrated Protected Area System (NIPAS) Law (Bataan ICM Program, 2006).

Biodiversity refers to the variety of life in all its forms found on earth. It has to be conserved for it leads to a stable and balanced ecosystem, ideal for agriculture and forestry, a source for medicine, natural service for vegetative cover, recreational, aesthetic, ecotourism, scientific, and commercial values (Alberto, 2005). Likewise, natural plant biota serves to maintain air quality as they fix CO_2 release O_2 and help to assimilate other air pollutant by absorbing considerable solar radiation and by releasing water vapor through transpiration, they moderate temperature and help maintain climate (Cunningham & Cunningham, 2007).

As what Duelli and Orbist (2003) stated, biodiversity indicators could be used as quantifiable environmental factors. Therefore, regional and national agencies need to monitor species diversity before and after spending on subsidies, ecological compensation management, as well as research and development activities. The production of a threatened species list is very imperative to aid organizations working on environmental concerns to assess the potentially adverse impacts on species and to help inform conservation priorities (Possingham *et al*., 2002).

The study was conducted to assess the diversity of plants in the forest ecosystem of BNP, identify categories of plant species based on IUCN Red List, determine the presence of endemic and introduced species, and identify problems which contribute to environmental degradation of the forest ecosystem.

METHODOLOGY

Study Sites

Forested areas in Barangay Bangkal, Abucay, Bataan and the Bataan Peninsula State University (BPSU) reservation also located in Bangkal, Abucay, Bataan served as the study areas.

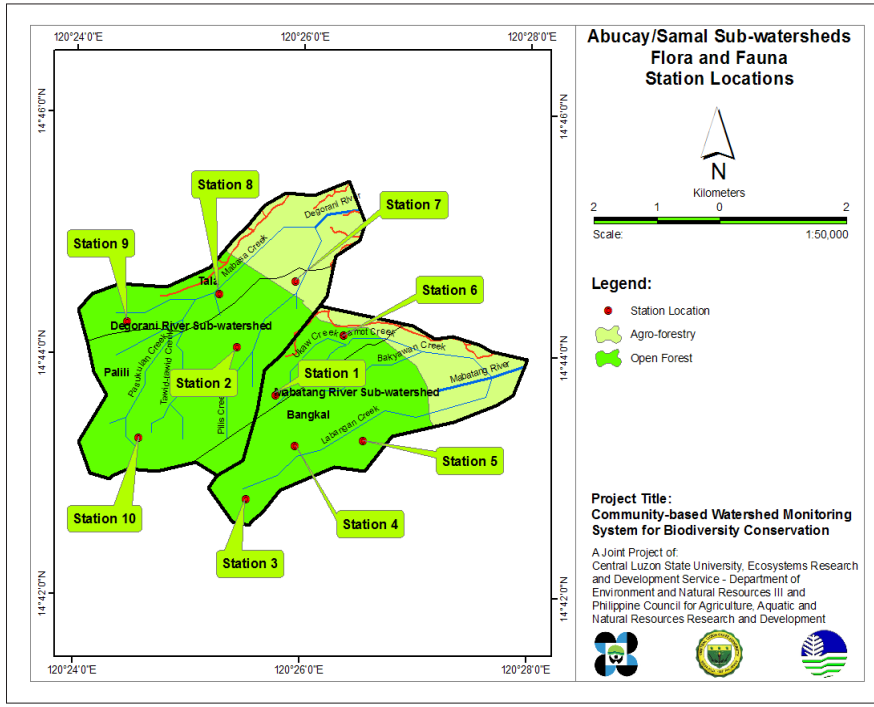

Figure 1. The map showing the locations of the different stations.

Barangay Bangkal has an estimated area of 1,154.95 has, which represents 14% of the total land area of the town, Abucay. The land area devoted to watershed consists of 100 ha; 80 ha were allotted for residential; 50 has to government establishment of the agricultural university, now the Bataan Peninsula State University, Abucay campus; and 453 hectares were awarded as community based forest management program areas. The remaining 471.95 hectares are designated as forest area and agricultural production of fruits, vegetables and upland rice. Bangkal serves as an important catchment area as a watershed, providing Bangkal and neighboring barangays with water. As a watershed, it serves as tributary to five major rivers in the area.

The sampling areas. There were ten preselected stations located within the forest ecosystem of Bataan Natural Park. Each station had ten quadrats with an area of 10 m x 12 m per quadrat. The study areas were located in Brgy. Bangkal, Abucay, Bataan and BPSU Reservation located in Brgy. Bangkal (Figure1). A total area of 12,000 sq. m. was surveyed in Bataan Natural Park.

Data gathering, documentation, and collection of samples

The local name, habit, number of individual plant per species, and the quadrats where they were present were recorded. The data were used to compute for the various ecological parameters such as frequency, relative frequency dominance, relative dominance, density, relative density, species importance value, and diversity index value.

The plants were photographed in their natural habitat. In case of very tall trees whose leaves were not observable due to their height and the understory trees that obscured viewing, barks or young individuals were photographed instead.

Samples were collected to aid in identification and to be preserved as herbarium specimens. As much as possible, parts with reproductive organs were collected. Small shrubs, ferns, mosses, and herbs were collected whole.

Specimens were also categorized based on the IUCN Red List of Threatened Species version 2013.

Information on uses of the plants recorded and associated beliefs if there were any were also gathered.

Sources and Level of Impacts of Environmental Degradation of the Terrestrial Ecosystems

The condition of the ecosystem was assessed through ocular inspections. Checklist 1, i.e. sources and level of impacts on environmental degradation of forest ecosystems (Alberto, 2005), was utilized.

The checklist was rated using the values 1-4 by a minimum number of ten evaluators from the DENR, CLSU, BPSU, and PCARRD, DOST to determine the present condition of the forest ecosystem. Four levels of impacts in each source of environmental degradation were used. For each level a value was assigned. The level of impact was estimated based on the percentage of impact/damage in the study area.

To get the mean of the answers of the respondents, the sum of the answers for each level was divided by the total number of respondents, and a scale was used to interpret the scores in the level of impacts on the environmental degradation of any ecosystem. This scale is presented in Table 1.

RESULTS

Assessment of Plants in Bataan Natural Park

There were a total of 189 plants observed in the forest ecosystems of Bataan Natural Park. Of the 189 plants, 165 had already been identified, of these 83 were identified up to species level, 58 species were identified up to genus level while 24 species were identified up to family level only. There were still 24 unidentified species.

Trees and shrubs made up most of the plants that were seen in the forest ecosystem. Several herbs, ferns, vines, and grasses were also observed in the study area. There were 83 tree species, 47 shrubs, 21 herbaceous plants, 14 vines, 13 fern species, two grasses, seven epiphytic plants, one sedge, and a single moss species (Figure 2).

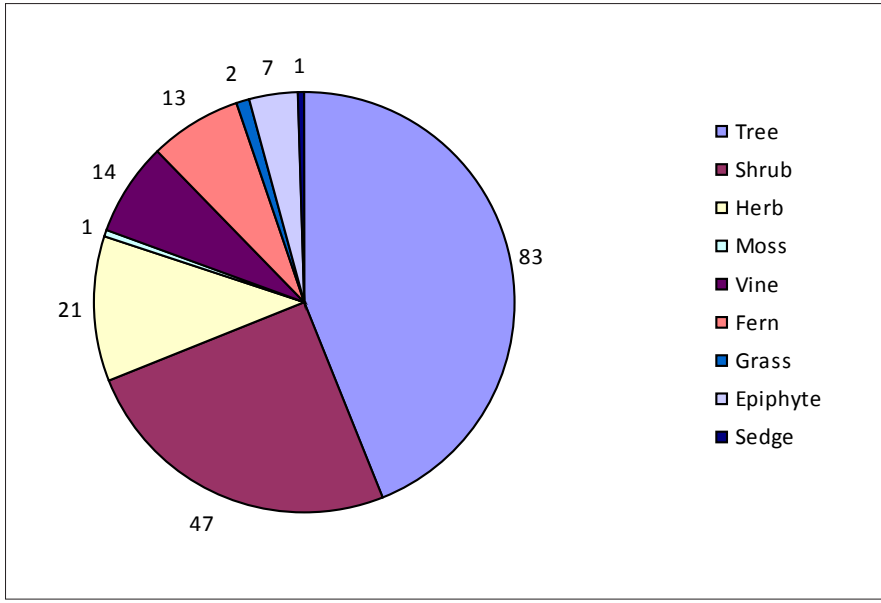

Figure 2. Types of plants observed at Bataan Natural Park

Identified plants were classified into 65 different families. Family Moraceae, Rubiaceae and Araceae had more than 10 representative species. Many of the families were represented by one to three different species only. Members of the genus *Ficus* had the most number of observed plants in the study area.

Station 10 exhibited the highest number of species with 75 recorded plants followed by Station 4 with 73 plants. Station 10 and Station 4 are located in land devoted to residual forest and forest plantation maintained by the DENR and Bangkal Bataan Upland Farmers Association, Incorporation (BBUFAI); thus, these areas are protected from anthropogenic activities such as logging/timber poaching and kaingin. Station 7 had the lowest number of species with only 26 plants. Station 7 is located in an agroforestry land cultivated by the locals and indigenous people for reforestation and agro forestry project (Table 2).

In addition, a member of Family Araceae, locally known as "gabi-gabihan" (*Aglaonema commutatum* Schott.) showed the highest percentage occurrence with 90% occurrence. "Kakawati" [*Gliciridia sepium* (Jacq.) Steud.], "balagtakan" (*Freycinetia apayaoensis* Merr.) and "yantok" [*Calamus usitatus* Blanco.] obtained 80% occurrence. One hundred fifty-seven (157) or about 83% of the plants had less than 50% occurrence.

As to the uses of the plants, eight trees, shrubs, and bamboo were harvested as source of wood and timber for various applications such as for construction, woodworking purposes, and production of charcoal. Twenty-two of the identified plants were used for medicinal purposes. Fifteen species produce edible fruits and leaves as well as spices.

Bambusa sp. in Station 6 at Brgy. Bangkal, Abucay, Bataan had the highest importance value index of 77.52%. *Bambusa sp.* is a member of a grass family that grows in clumps and is spread by rhizomes. The stems are hollow except the nodes; the long thin leaves are shed from the lower parts of the stem (James Cook University, 1995). This was followed by *Amphineuron terminans* (J. Sm.) Holttum in Station 4 and *Trichomanes thysanostomum* (Makino.) in Station 3 with 76.01% and 63.75% IVI, respectively (Table 3).

"Lokdo" *A. Terminans* is a long creeping ornamental plant usually found in areas with distinct dry season, and *T. thysanostomum* is a filmy terrestrial or epiphytic fern found commonly on wet shaded rocks of cliffs ranging from 400-400 masl. In addition, *Calamus usitatus* (Blco.) in Station 9 had the lowest IVI of 14.53%. *C. usitatus* is a slender to moderate clustering, thicket-forming rattan with stems to rarely more. It is widespread in the Philippines and is used for tying purposes, baskets, fish traps; apparently, it is fairly durable (PALMweb, n.d.).

Critically Endangered, Endangered, Vulnerable, Near Threatened and Least Concerned Plant Species in Bataan Natural Park

Out of the 189 plants observed at Bataan Natural Park, eight were listed in the IUCN Red List 2013.1 (Table 4). Jade vine (*Strongylodon macrobotrys* A. Gray), considered as one of the plants with the most beautiful flowers in the world and is endemic to the Philippines, was evaluated as endangered. The population of this vine in Bataan is threatened by logging of trees for charcoal production. Three other plants recorded were endemics listed as vulnerable such as "antipolo" [*A. blancoi* (Elm.) Merr.],"is-is" (*F. ulmifolia* Lam.) and "pahutan" (*Mangifera altissima* Blanco). Based on the DAO 2007-01 list of threatened species, *Medinilla magnifica* Lindl. was listed as endangered while *Mangifera altissima* Blanco and *Asplenum nidus* L. were listed as vulnerable.

Endemic, Introduced and Invasive Plant Species in Bataan Natural Park

Fifteen plant species were found out to be endemic to the country and Southeast Asia (Table 5). Of these, eight species were endemic only in the Philippines and seven species are both endemic in Philippines and Southeast Asia. Aside from the endemic species recorded, there were also introduced species. So far, there were five species which were non-native to the Philippines. Two of these were trees: *Gliciridia sepium* (Jacq.) Steud. and *Gmelina arborea* Roxb. Currently, there is an order to cut down all the paper trees present within the forest area since they tend to disrupt normal water cycle by absorbing almost all water present near them. There were also two introduced and invasive plants such as *Chromolaena odorata* (L.) R.M. King and H. Robinson and *Lantana camara* L.

Diversity Indices of the Plants in Ten Stations Located at Bataan Natural Park

The diversity indices of the plants for the various stations in Bataan Natural Park is shown in the diversity index map (Figure 3). Station 9 which had 55 plant species and 1638 number of individuals obtained the highest value for Shannon's Diversity Index, with 3.801 as its diversity value index. This is followed by Station 10 with 3.746 diversity index

value. Station 7 recorded the lowest biodiversity index value for plants among the stations, with only 3.074. Still, this shows that the area has high floral diversity. All the stations showed high to very high diversity of plant species.

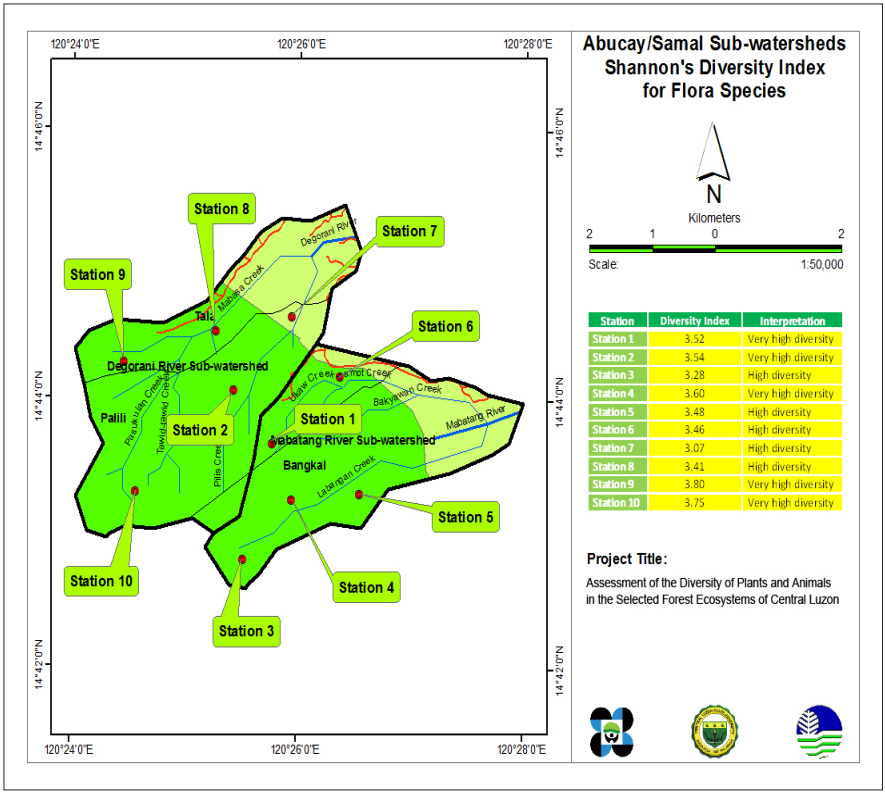

Figure 3. Diversity index map of fora in Bataan Natural Park

Major Sources of Environmental Degradation in the Forest Ecosystem of Bataan Natural Park

Illegal logging or timber poaching posed moderate impact to the forest ecosystem of Bataan Natural Park. It was observed that there is logging/ timber poaching going on in the immediate areas near the watershed; however, according to the respondents, this was for construction of their houses and charcoal making, which is part of their livelihood activities in the community.

Most of the threats in the forest ecosystem of Bataan Natural Park were caused by activities which are part of the livelihood of the Aetas in the area. Areas near the foot of the mountain were often cleared for kaingin. Mango, pineapples, and vegetables were the common crops planted in these areas (Table 6).

Another threat was the harvesting of bamboo utilized by the community for their personal use or as marketable goods. Charcoal making was also observed in the area. Oftentimes, parts of the forest near the water systems also served as area for making charcoal which is one of the main income generating products of the community.

The Aetas, being expert hunters hunt wildlife as part of their culture. Many of these animals were caught as food, while others served as pets and the animals were being sold for money. Hunted animals include monitor lizards, phytons, flying foxes, and birds.

DISCUSSION

Generally, BNP is rolling to moderately steep with portions of flat and steep topography. Elevation ranges from 300 to 400 meters above sea level. It is drained with Baksawan River and Yamot Creek which consist of major water sources in the locality. It has two distinct seasons: wet and dry seasons; wet season starts in May and ends in October while the rest of the year is dry with occasional rains. The average rainfall is 1, 203.70 mm and the temperature throughout the year ranges from 25-30 °C.

The soil composition is generally Anti-polo series characterized by its reddish brown to almost red color with friable clay surface comprising the Hydrosol (de Guzman, 2010).

The major land use types found in BNP are forests and reservation areas. Due to the physical factors present in the area, the forest ecosystems are favorable to have good growth for trees and other plants; hence, the result of the diversity assessment study is still high.

Several herbs, ferns, vines, and grasses were also observed in the study area. There were 83 tree species, 47 shrubs, 21 herbaceous plants, 14 vines, 13 fern species, two grasses, seven epiphytic plants, one sedge and a single moss species. However, there were four species of plants which were found to occur in most stations that were surveyed and these are *Aglaonema commutatum* Schott (gabi-gabihan), *Gliciridia sepium (*Jacq) Steud (kakawate), *Freycinetia apayaonensis* Merr (balagtakan) *and Calamus usitatus* Blanco (yantok).

Gliricidia sepium is a small to medium-sized, thornless tree which usually attains a height of 10-12 m. Branching is frequently from the base with basal diameters reaching 50-70 cm. The bark is smooth and can vary in colour from whitish grey to deep red-brown. The stem and branches are commonly flecked with small white lenticels. Trees display spreading crowns. Despite mixed perceptions of gliricidia as a forage crop, it has been widely promoted by development agencies and researched, due largely to its high productivity and quality. Interest has increased in recent years following the widespread defoliation of *Leucaena* by psyllid. Gliricidia is one of the few forage trees capable of leaf and will grow on a wider range of soils, tolerating low pH provided that this is not associated with high aluminium saturation. Recently they are being been integrated into farming practices for poles, firewood, hedges, forage, green manure, and soil stabilization (Suttie, 2016).

Oncosperma horridum is a slender, tall, clump-forming palm, with usually 6 - 12 mature stems per clump. The plant is particularly valued in its native range for its edible, apical bud which is gathered from the wild. The tree also provides a useful timber. It is commonly observed in Valleys or hill slopes in rainforests at elevations up to 1,500 metres with their crowns sometimes reaching up to the canopy of the rainforest (Fern, 2014).

A. *commutatum,* known as the Philippine evergreen loves shady tropical forest habitat. It is perennial herbs with stems growing erect or decumbent and creeping. Stems that grow along the ground may root at the nodes ("How to survive", 2015)

However, it is very interesting to note that introduced species or invasive plants are already present in the study area.

Chromolaena odorata which is a candidate for one of the top 100 worst weeds in the world and tolerates a wide range of soil conditions and severe drought is already present in the area. It rapidly forms dense thickets in disturbed/cleared areas and could create a fire hazard. It has also an allelopathic property (prevents other plants from growing nearby) and could be an allergen/toxic to humans (causes skin problems and asthma in allergy-prone people). This species can also be toxic to animals, causing diarrhea and death in extreme cases; can host recognized pests and pathogens that can grow and spread from cut stems; can mature in a year and begin producing seed; and can produce many wind-dispersed seeds (up to 800,000 per plant) persisting more than a year in soil. And its seeds are easily spread unintentionally by hikers, vehicles, equipment, and mammals (OISC, n.d.).

Management and control of this invasive plant should be done before it could affect and harm the endemic and native plant species in the forest ecosystems of BNP. Results revealed that at the present time this plant has no significant impact yet in the forest ecosystems of the BNP, but in time, if no management action will be made, this invasive plant can lead to loss of diversity of plants in the watershed.

A number of environmental conditions posed threats to the forest ecosystems in BNP. Illegal logging or timber poaching showed high value with moderate impacts to the forest ecosystems.

Lands near the foot of the mountain and even in higher areas were used for cultivating vegetables such as tomatoes and eggplants. The soil of these areas is often exposed after harvest season, making them vulnerable to soil erosion and landslides during rainy season. Evidences of timber poaching were also observed in one of the field days of the research team; trees were being harvested with a chainsaw and the farmers admitted that this practice is rampant due to low income of the people living nearby. Wildlife hunting also posed small impact on the forest ecosystem. During the duration of the study, selling of the local community of monitor lizards and "labuyo" were observed. It was found out that these animals were trapped/hunted in the forest.

CONCLUSIONS

Bataan Natural Park has "high diversity" in terms of its plants species. There are still many endemic plants species thriving in the National park which need to be conserved and protected. Anthropogenic activities such as illegal logging/ timber poaching, kaingin practices, charcoal making, and wildlife hunting are the main contributors in the degradation of the forest ecosystem.

RECOMMENDATIONS

The research team recommends further studies on the flora of the other areas not surveyed during the duration of the study. These include the forest areas in other mountains present in the other side, facing Subic Bay Metropolitan Area and Zambales. It is also recommended that intensive survey on the economic uses of the plants be done with interviews of the

local community. Collection of samples is better done during months when trees are most likely to bloom (November to January). This is to make sure that identification of plants will be easier. Moreover, further studies on the impacts of invasive species should be conducted in the BNP to verify the extent of growth and distribution as well as damage on the endemic and native trees in the watershed. Results could be used as guide in the establishment of ecological tourism spot for forest ecosystems in Central Luzon.

ACKNOWLEDGMENT

The authors would like to thank the following: PCAARRD – DOST for the funding support; CENRO-Muñoz for the secondary data they shared; military detachments of the respected barangays for ensuring the safe passage of the research team and the National Museum of the Philippines for the identification of several species.

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Table 1 Scale for the levels of impact of environmental degradation.

SCALE	IMPACT LEVEL
1.01 – 1.75	No Significant Impact
1.76 – 2.50	Small Impact
2.51 – 3.25	Moderate Impact
3.26 – 4.00	Major Impact

Table 2 Summary of the occurrence of plants present in Bataan Natural Park, Abucay, Bataan

Station	Number of Species Occurred/Station
Station 1 (Bgry. Bangkal, Abucay)	50 Species
Station 2 (Bgry. Bangkal, Abucay)	54 Species
Station 3 (Bgry. Bangkal, Abucay)	55 Species
Station 4 (Bgry. Bangkal, Abucay)	73 Species
Station 5 (Bgry. Bangkal, Abucay)	48 Species
Station 6 (Bgry. Bangkal, Abucay)	50 Species
Station 7 (Bgry. Bangkal, Abucay)	26 Species
Station 8 (Bgry. Bangkal, Abucay)	36 Species
Station 9 (Bgry. Bangkal, Abucay)	55 Species
Station 10 (Bgry. Bangkal, Abucay)	75 Species

Table 3 Importance value index of flora per station in Bataan Natural Park, Abucay, Bataan

Station	Scientific Name	IVI
Station 1	Alpinia haenkei Presl.	18.01
Station 2	SP 10 (Unidentified)	59.76
Station 3	Trichomanes thysanostomum (Makino.)	63.75
Station 4	Amphineuron terminans (J. Sm.) Holttum	76.01
Station 5	Lygodium circinnatum (Burm.) Sw.	29.29
Station 6	Bambusa sp.	77.52
Station 7	Trichomanes thysanostomum (Makino.)	39.01
Station 8	Alocasia sp.	44.85
Station 9	Calamus usitatus (Blco.)	14.53
Station 10	Amphineuron terminans (J. Sm.) Holttum	38.19

Table 4 Critically endangered, endangered, vulnerable, near threatened and least concerned species observed at Bataan Natural Park, Bataan

Species	Ecological Status	
	IUCN 2013.1	**DAO 2007-01**
Strongylodon macrobotrys A. Gray	Endangered	---
Artocarpus blancoi (Elm.) Merr.	Vulnerable	---
Ficus ulmifolia Lam.	Vulnerable	---
Mangifera altissima Blanco	Vulnerable	Vulnerable
Calophyllum inophyllum L.	Least concern	---
Coffea arabica L.	Least concern	---
Colocasia esculenta (L.) Schott.	Least concern	---
Knema glomerata (Blco.) Merr	Least concern	---
Medinilla magnifica Lindl.	---	Endangered
Asplenum nidus L.	---	Vulnerable

Table 5 Endemic, introduced and invasive species observed at Bataan Natural Park, Bataan

Species	Ecological Status
Strongylodon macrobotrys A. Gray	Endemic (Philippines)
Artocarpus blancoi (Elm.) Merr.	Endemic (Philippines)
Ficus ulmifolia Lam.	Endemic (Philippines)
Mangifera altissima Blanco	Endemic (Philippines and Southeast Asia)
Aglaonema commutatum Schott.	Endemic (Philippines and Southeast Asia)
Areca catechu L.	Endemic (Philippines)
Caryota mitis Lour.	Endemic (Philippines and Southeast Asia)
Ficus nota (Blco.) Merr.	Endemic (Philippines and Southeast Asia)
Livistona rotundifolia (Lam.) Mart. *var. luzonensis* Becc.	Endemic (Philippines)
Macaranga grandiflora (Blco.) Merr.	Endemic (Philippines)
Medinilla magnifica Lindl.	Endemic (Philippines)
Melicope triphylla (Lam.) Merr.	Endemic (Philippines and Southeast Asia)
Oncosperma horridum (Griff.) Scheff.	Endemic (Philippines and Southeast Asia)
Schizostachyum lumampao (Blco.) Merr.	Endemic (Philippines)
Spathiphyllum commutatum Schott.	Endemic (Philippines and Southeast Asia)
Chromolaena odorata (L.) R.M. King & H. Robinson	Introduced, invasive
Gliciridia sepium (Jacq.) Steud.	Introduced
Gmelina arborea Roxb.	Introduced
Lantana camara L.	Introduced, invasive
Philodendron lacerum (Jacq.) Schott.	Introduced

Table 6 Major sources of environmental degradation observed at the forest ecosystem of Bataan Natural Park, Abucay, Bataan

Sources of environmental degradation	Computed value	Interpretation
Illegal logging/ Timber poaching	2.63	Moderate impact
Soil erosion/ silt run-off	2.38	Small impact
Charcoal making	2.30	Small impact
Kaingin/ Shifting cultivation	2.19	Small impact
Wildlife hunting	2.12	Small impact

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