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Rapid biodiversity assessment in the buffer zone of Bataan National Park, Luzon Island, Philippines

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Abstract

Rapid biodiversity assessment using communities of flora and fauna was conducted in the buffer zone areas of Bataan National Park. Seventeen stations were designated for the documentation of floral and faunal species. Samples were documented through sight viewing and based from interviews to local communities. Biodiversity indices were also estimated for the floral communities. The 8-month survey recorded 3,850 plant individuals, belonging to at least 118 species, five of which were classified as endemic. Nine angiosperms comprised the 50% of the total mean abundance, eight of which has agricultural significance. Banana (*Musa x paradisiaca*) and mango (*Mangifera indica*) were present in all sampling sites. The top five plant species with the highest Important Value Index were *M. paradisiaca*, *M. indica*, *Cocos nucifer*, *Gliricidia sepium*, and *Anacardium occidentale*. Shannon diversity indices and evenness values are high in all sampling stations with a mean of no less than 1.70, and 0.6, respectively. Recorded faunal species had a total of 34 species including eight mammals, six reptiles, and 20 birds. In this survey, seven avian species were classified as endemic, two in reptile, and one in mammal. This study also attempted to document various anthropogenic activities and land use pattern that can cause the biodiversity loss in the buffer areas.

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Introduction

Biodiversity is widely considered as an essential element of human economic and ecosystem productivities. A thriving biodiversity can endow several natural services for many. Naturally, it can provide water resources protection, soil formation and protection, as well as nutrient storage and recycling. As sources of biological resources, biodiversity can provide not only food, but as well as medicinal resources, wood products, ornamental plants, and livestock breeds. Socially on the other hand, it can contribute to education, research and development, tourism and recreation, and maintenance of cultural values. Declining biodiversity is therefore a serious concern for many reasons, and such has been one of the key subjects of many conservation initiatives locally and internationally (Danielsen, 2000).

Biodiversity assessment is one of the major international activities aimed primarily at conserving and protecting biodiversity. It is essential for sustainable development strategies at all levels. The Protected Area and Wildlife Bureau of the Department of Environment and Natural Resources (DENR-PAWB) in the Philippines is taking part in such international effort, and, in addition, has legal requirements for monitoring stipulated in the NIPAS Act (Lim & Salzer, 2011). But while basic assumptions for quantitative recording of biodiversity have been laid down already in Hayek and Buzas (2010), and broader concepts of biodiversity monitoring have also been outlined in Magurran (2013) and Lindenmayer *et al.* (2006), several suggestions have been made as to how these techniques may be meaningfully applied into a developing country like the Philippines (where resources are often meager), given the inherent tensions between standardization of data, facility of collection, and ease of analysis (Nielsen *et al.*, 2000). Conventionally, in biodiversity assessments, efforts have tended to follow the standards used in developed countries, probably because Western assistance has been involved. Compared with the West however, developing countries have very limited human capacity and financial resources available. Most protected areas

in developing countries serve to meet the daily subsistence requirements of millions of rural, hence, it is unlikely that Western biodiversity assessment systems are suited to developing countries.

For conservation purposes, protected areas in developing countries need monitoring that is realistic and at the same time useful for guidance rather than what is ideally required for in-depth studies of the status of habitat and diversity of species. At the Bataan National Park (BNP), a massive protected area in the peninsular province of Bataan, such of an assessment technique will be highly needed. The province needs an assessment that would entail rapid collection of data to allow conservation decisions to be made swiftly and efficiently. With the vastness of its flora and fauna especially in its lone National Park, coupled with meager manpower, time, and financial resources, Bataan needs a biodiversity assessment technique that would be relatively economical, would include local community engagement, and would focus not only on information on species diversity but on status, stresses, and benefits too.

Considering the paucity of scholarly output and ecological assessment in the buffer zone of BNP, this rapid bio-assessment was conducted to create a baseline inventory / data of the flora and fauna, with emphasis on the characterization of the diversity and abundance of macro-species. The study also intended to provide an appraisal of the ecological status of a particular species in the representative areas, which may provide a cue for the resources stability and ecological condition of the Park and can be used as one of the basis for the refinement of local forest management and environmental policies.

Materials and methods

Study Areas

The BNP is located in the northern Bataan peninsula of Luzon Island, Philippines (14°39'N, 120°36'E) (Fig. 1). The park was first established in 1945 under Proclamation No. 24 with a current area of about 236.88 km² (DENR-PAWB, 2012). It is located 101 km from Manila and is known for its tropical jungle, deciduous and riparian forest, and mountain terrains.

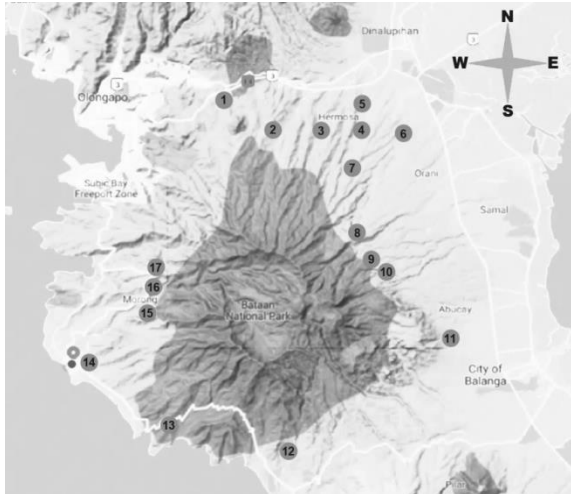


Fig. 1. Map of Bataan National Park showing the studied sites.

Sampling Design and Species Collection

The duration of the survey was from April until December 2017. Collection and/or documentation of species were done within the park’s buffer zone area, covering six representative sites (municipalities). The buffer zone area is pegged at 520 hectares. Exactly 10% of the buffer zone area (52 hectares) was divided into 17 stations (villages) (Table 1), and each station was further subdivided into grids measuring 50 m x 50m. The grids were designated as sampling sites. The number and location of grids per station varied based on each station’s total area, safety, and ease of access to the sampling sites.

Table 1. The 17 study stations with corresponding coordinates and number of grids / sampling sites.

Towns	Stations	Coordinates	Map Code (See Fig. 1)	
Hermosa	Tipo	14°50'15"N 120°21'06"E	1	
	Mabiga	14°48'56"N 120°23'21"E	2	
	Maite	14°49'50"N 120°24'46"E	3	
	Bamban	14°50'11"N 120°26'15"E	4	
	Bacong	14°50'25"N 120°26'11"E	5	
	Sumalo	14°49'01"N 120°27'56"E	6	
	Pag-asa	14°47'47"N 120°25'53"E	7	
	Orani	Tala	14°45'18"N 120°25'50"E	8
		Palili	14°44'33"N 120°26'30"E	9

Towns	Stations	Coordinates	Map Code (See Fig. 1)
Abucay	Bangcal	14°44'15"N 120°26'49"E	10
	Capitangan	14°41'44"N 120°29'28"E	11
	Banawang	14°37'43"N 120°23'39"E	12
Bagac	Nagbalayong	14°38'40"N 120°19'23"E	13
	Poblacion	14°40'40"N 120°16'13"E	14
	Binaritan	14°43'02"N 120°18'46"E	15
Morong	Sabang	14°43'17"N 120°18'38"E	16
	Mabayo	14°44'02"N 120°18'49"E	17

Flora and fauna that were found in each grid were documented and photographed using a single-lens reflex camera. The rapid faunal biodiversity assessment focused only in the assemblages of birds, reptiles, amphibians, and mammals. All relevant data in the sampling sites including anthropogenic activities and habitat alteration were also recorded. In most cases, some plant parts (e.g., leaves) were collected and properly labeled. Plant samples were stored in a plastic container, whereas animal samples were preserved in a 10% buffered formaldehyde solution and brought to laboratory for further identification. The collected plants’ parts were dried and preserved into BPSU herbarium specimens. Preserved animal specimens were deposited in BPSU-Orani Campus.

Species richness was determined by the number of species present in each representative site. The relative abundance of each species was also computed. The quantitative descriptions of the biota were gathered using the following indices:

- Shannon-Weiner diversity index (H') (Shannon and Weaver 1949)
 - Evenness (J') was computed following Shannon’s diversity index
 - Simpson’s index formula (λ) (Simpson 1949)
 - Frequency Distribution (F)
- F = number of grids where the Species occurred/ total number of grids
- Relative Frequency (RF)
- RF = (frequency of one species/total frequency) 100

- Density or the Number of Individuals of a Species per Area Sampled (D)

D = number of individuals / total area sampled

- Relative Density (RD)

RD = (density of a species/total density of all species) 100

- Relative Basal Area (RBA)

RBA = (basal area of a species/total basal area of all species) 100

- Importance Value Index (IVI)

IVI = RF + RD + RBA

Data analyses were performed using Paleontological Statistics version 3.0.

Results and discussion

Composition and Abundance

An 8-month survey in the buffer zone inventoried at least of 3,850 plant individuals, belonging to 114 species. These species were mostly composed of angiosperm trees (81 species), and other were categorized as herbaceous, vines, or shrubs (33

species) (Tables 2 and 3). Ten tree species were classified as endemic in the Philippines. Only nine plant species comprised 50% of the total mean abundance. These were *Musa x paradisiaca* (9.63%), *Dimocarpus crinitu* (9.13%), *Chromolaena odorata* (5.86%), *Cocos nucifera* (5.54%), *Coffea arabica* (4.68%), *Schizostachyum lumampao* (4.56%), *Swietenia macrophylla* (4.21%), *Gliricidia sepium* (3.52%), and *Anacardium occidentale* (3.38%). Among the most abundant plant species, only the Jack in the bush, *S. lumampao* has no agricultural importance. Considering the other ecological variables such as frequency and density of plants species, the value of IVI (highest value = 300) gave different results on the chronological dataset of plant species. The five most important plant species based on this parameter were (in order of importance) *M. paradisiaca*, *Mangifera indica*, *C. nucifera*, *G. sepium*, and *A. occidentale* (Table 2). Trees of banana (*M. x paradisiaca*) and mango (*Mangifera indica*) were the only plants species that were present in all sampling stations.

Table 2. Distribution and Importance Value Index (IVI) of documented plant tree species in the buffer zone areas in Bataan National Park, Philippines. M = Morong, B = Bagac, A = Abucay, H = Hermosa, S = Samal, O = Orani.

Rank	Common Name	Scientific Name	Representative Stations					IVI	
			M	B	A	H	S		O
1	Banana	<i>Musa x paradisiaca</i> (Linn.)	+	+	+	+	+	+	119.25
2	Mango	<i>Mangifera indica</i> (Linn.)	+	+	+	+	+	+	105.71
3	Coconut	<i>Cocos nucifera</i> (Linn.)	+	+	-	+	+	+	94.41
4	St. Vincent's Plum	<i>Gliricidia sepium</i> (Jacq.)	+	+	+	+	-	+	90.37
5	Cashew	<i>Anacardium occidentale</i> (Linn.)	+	+	+	+	-	+	90.09
6	Antipolo	<i>Artocarpus blantoi</i> (Elmer) Merr.	+	+	+	+	-	+	85.63
7	Guava	<i>Psidium guajava</i> (Linn.)	+	+	+	+	+	+	85.39
8	Ramboutanier	<i>Dimocarpus crinitus</i> (Lour.)	-	+	-	+	+	+	84.92
9	Rain Tree	<i>Samanea saman</i> (Jacq.) Merr.	+	+	+	+	-	+	84.72
10	Sacking Tree	<i>Ficus nota</i> (Blanco) Merr.	+	-	+	+	+	+	84.63
11	Rosewood	<i>Pterocarpus indicus</i> (Wild)	+	+	+	+	-	+	84.38
12	Bamboo (Buho)	<i>Schizostachyum lumampao</i> (Blanco)	+	-	+	+	-	+	75.79
13	Broad Leaf Mahogany	<i>Swietenia macrophylla</i> (King)	+	-	+	+	-	-	75.08
14	Jumpy Bean	<i>Leucaena leucocephala</i> (Lam.) de Wit	+	+	-	+	-	+	71.68
15	Hauili Fig Tree	<i>Ficus septica</i> (Burm.)	+	+	+	+	-	-	68.82
16	Oriental Cashew	<i>Semecarpus cuneiformis</i> (Blanco)	+	+	-	+	-	+	68.42
17	Source of Timber	<i>Sandoricum koetjape</i> (Burm.) Merr.	+	+	-	+	-	+	68.10
18	Alligator Pear	<i>Persea americana</i> (Mill)	+	-	-	+	+	+	67.77
19	Blue Gum Eucalyptus	<i>Eucalyptus globulus</i> (Labill.)	+	+	-	+	-	+	67.75
20	Jackfruit	<i>Artocarpus heterophylla</i> (Lam.)	+	-	+	+	+	-	67.71
21	Fragrant Premna	<i>Premna odorata</i> (Blanco)	+	+	-	+	-	+	67.40
22	Tamarind	<i>Tamarindus indica</i> (Linn.)	+	+	-	+	+	-	67.35
23	Tropical Almond	<i>Terminalia catappa</i> (Linn.)	+	-	+	+	-	+	67.30
24	Tooth Scrubber *	<i>Ficus ulmifolia</i> (Lam.)	-	+	+	+	-	+	67.14
25	Bamboo	<i>Bambusa blumeana</i> (Schult & Schult. F.)	+	+	-	+	-	-	54.92
26	Coral Tree/ Parasol Leaf Tree *	<i>Macaranga grandifolia</i> (Blanco) Merr.	-	-	+	+	-	+	51.99

Rank	Common Name	Scientific Name	Representative Stations						IVI
			M	B	A	H	S	O	
27	Woodson *	<i>Kibatalia gitingensis</i> (Elmer) Woodson	+	+	-	+	-	-	51.75
28	Blue Pea/ Butterfly Pea	<i>Clitoria ternatea</i> (Linn.)	+	-	+	+	-	-	51.43
29	Papaya	<i>Carica papaya</i> (Linn.)	+	+	-	-	+	-	51.11
30	Soursop	<i>Annona muricata</i> (Linn.)	+	-	-	+	-	+	50.76
31	Star Apple	<i>Chrysophyllum cainito</i> (Linn.)	+	-	-	+	-	+	50.73
32	Java Plum	<i>Syzygium cumini</i> (Linn.) Skeels	+	+	-	+	-	+	50.69
33	Governor's Plum	<i>Flacourtia indica</i> (Burm.) Merr.	+	-	+	-	-	+	50.31
34	Flambouyant Tree	<i>Delonix regia</i> (Hook.) Raf.	+	+	-	-	-	-	35.14
35	Pink Butterfly Tree	<i>Bauhinia monandra</i> (Kurz)	-	-	-	-	+	+	34.53
36	Elephant's Ear	<i>Macaranga tanarius</i> (Linn.) Muell.-Arg	-	+	-	+	-	-	34.17
37	Tree Bean	<i>Parkia javanica</i> (Lam.)	+	+	-	-	-	-	34.00
38	Variegated Fig	<i>Ficus sum</i> (Gagnep)	-	-	+	+	-	-	33.80
39	New Guinea Basswood	<i>Endospermum peltatum</i> (Merr.)	-	-	-	+	-	+	33.79
40	Crape-myrtle	<i>Lagerstroemia speciosa</i> (Linn.) Pers.	+	-	-	+	-	-	33.79
41	Mandarin Orange	<i>Citrus reticulata</i> (Blanco)	-	-	+	+	-	-	33.77
42	White Cheesewood	<i>Alstonia scholaris</i> (Linn.) R. Br.	+	-	-	+	-	-	33.76
43	Velvet Apple	<i>Diospyros discolor</i> (Willd.)	+	+	-	-	-	-	33.76
44	Climbing Fern	<i>Diplazium esculentum</i> (Retz.) Sw.	-	+	-	+	-	-	33.72
45	Sweet Tamarind	<i>Pithecellobium dulce</i> (Roxb.) Benth.	+	+	-	-	-	-	33.71
46	Horse Radish Tree	<i>Moringa oleifera</i> (Lam.)	-	-	-	+	-	+	33.71
47	Spanish Plum	<i>Spondias purpurea</i> (Linn.)	+	+	-	-	-	-	33.60
48	Teak **	<i>Tectona grandis</i> (Linn.)	-	-	+	+	-	-	33.50
49	Chinese Salacia	<i>Salacia chinensis</i> (Linn.)	-	-	-	+	-	+	33.45
50	Pahutan**	<i>Mangifera altissima</i> (Blanco)	-	-	-	+	-	+	33.43
51	Cheesewood	<i>Nauclea orientalis</i> (Linn.)	+	-	-	+	-	-	30.13
52	West Indian Mahogany	<i>Swietenia mahogani</i> (Linn.) Jacq.	-	-	-	+	-	-	18.46
53	Alder	<i>Alnus japonica</i> (Steud.)	-	-	-	-	+	-	18.17
54	Dapong-kahoi	<i>Loranthus ferrugineus</i> (Roxb.)	-	-	-	+	-	-	18.03
55	Breadnut	<i>Artocarpus camansi</i> (Blanco)	-	-	-	-	+	-	17.42
56	Rattan (Malauban)**	<i>Calamus</i> sp.	-	-	+	-	-	-	17.36
57	Devil's Claw	<i>Pisonia aculeata</i> (Linn.)	-	-	-	+	-	-	17.35
58	Longsat	<i>Lansium parasiticum</i> (Osbeck) Sahni & Bennet	-	-	-	-	+	-	17.23
59	White Siris	<i>Albizia procera</i> (Roxb.)	-	-	-	+	-	-	17.14
60	Common Maidenhair Fern	<i>Adiantum pedatum</i> (Linn.)	+	-	-	-	-	-	17.02
61	Ayumit	<i>Ficus</i> sp.	-	-	+	-	-	-	16.97
62	Giant sword fern	<i>Nephrolepis biserrata</i> (Sw.) Schott	-	-	+	-	-	-	16.97
63	Rattan (palasan)**	<i>Calamus</i> sp.	-	-	+	-	-	-	16.82
64	Tree Bean	<i>Parkia javanica</i> (Lam.) Merr.	-	-	+	-	-	-	16.82
65	Weeping Fig	<i>Ficus benjamina</i> (Linn.)	-	-	+	-	-	-	16.82
66	Sesendok	<i>Endospermum malaccense</i> (Benth.)	-	-	-	+	-	-	16.80
67	Octopus Tree	<i>Schefflera actinophylla</i> (Endl.)	-	-	-	+	-	-	16.78
68	Marang	<i>Artocarpus odoratissimus</i> (Blanco)	-	-	-	+	-	-	16.78
69	Alupag**	<i>Dimocarpus didyma</i>	-	-	+	-	-	-	16.77
70	Lanite*	<i>Kibatalia gitingensis</i> (Elmer) Woodson	-	-	-	-	-	+	16.74
71	Fish Killer Tree	<i>Barringtonia racemosa</i> (Linn.) Spreng.	-	-	-	-	-	+	16.74
72	Malasapsap	<i>Pterocymbium tinctorium</i> var. <i>javanicum</i> (R.Br.)	-	-	-	-	-	+	16.74
73	Tagunay/ Tagumbaw	<i>Jathropa</i> sp.	-	-	-	+	-	-	16.73
74	Sand Paper Tree	<i>Streblus asper</i> (Lour.)	-	-	-	+	-	-	16.73
75	Noni, Indian Mulberry	<i>Morinda citrifolia</i> (Linn.)	-	-	-	+	-	-	16.72
76	Testicle Tree	<i>Voacanga globosa</i> (Blanco) Merr.	+	-	-	-	-	-	16.71
77	Pakiling	<i>Ficus odorata</i> Merr.	-	-	-	+	-	-	16.71
78	Birch Flower*	<i>Broussonetia luzonica</i> (Blanco)	-	-	-	+	-	-	16.69
79	Johey Oak	<i>Litsea perrottetii</i> (Blume) Fern.- Vill.	-	-	-	+	-	-	16.69
80	Java Cotton/Silk Cotton	<i>Ceiba pentandra</i> (Linn.) Gaertn.	-	-	-	+	-	-	16.69
81	Chinese Salacia	<i>Phyllanthus rhamnoides</i> (Retz.)	-	-	-	+	-	-	16.69

(-) absent, (+) present

* Endemic,

** Endemic per For. Romualdo de Guzman (2018)

Table 3. Distribution of documented plant species (vine, shrub, and herb) in the buffer zone areas in Bataan National Park, Philippines. M = Morong, B = Bagac, A = Abucay, H = Hermosa, S = Samal, O = Orani.

Rank	Common Name	Scientific Name	Representative Stations					
			M	B	A	H	S	O
1	Jack in the Bush	<i>Chromolaena odorata</i> (Linn.)	+	-	+	+	-	+
2	Stink Grass	<i>Lantana camara</i> (Linn.)	+	+	-	+	-	+
3	China Rose	<i>Hibiscus rosa-sinensis</i> (Linn.)	+	+	-	+	-	+
4	Edible Fern/ Vegetable Fern	<i>Athyrium esculentum</i> (Retz.)	+	+	-	+	-	-
5	Coffee	<i>Coffea arabica</i> (Linn.)	-	-	+	-	-	+
6	Lipstick Plant	<i>Bixa orellana</i> (Linn.)	-	-	-	+	+	-
7	Ringworm Bush	<i>Cassia alata</i> (Linn.)	+	-	-	+	-	-
8	Sweet Potato	<i>Ipomoea batatas</i> (L.) Lam.	-	+	-	-	-	-
9	Ginger	<i>Zingiber officinale</i> (Roscoe)	-	-	+	-	-	-
10	Cassava, Tapioca Plant	<i>Manihot esculenta</i> (Crantz)	-	-	-	-	-	+
11	Arrowroot	<i>Maranta arundinacea</i> (Linn.)	-	-	-	-	-	+
12	Wire Weed/ Broom Weed	<i>Sida acuta</i> (Burm.)	-	-	-	+	-	-
13	Broad Leaf Bramble	<i>Rubus moluccanus</i> (Linn.)	-	-	-	+	-	-
14	Wire Grass	<i>Eleusine indica</i> (Linn.) Gaertn.	-	-	-	-	-	+
15	Paperflower	<i>Bougainvillea glabra</i> (Choisy)	-	-	-	-	-	-
16	Black Pepper	<i>Piper nigrum</i> (Linn.)	-	-	+	-	-	-
17	Chinese Honeysuckle	<i>Quisqualis indica</i> (Linn.)	-	-	-	+	-	-
18	Long Turmeric	<i>Curcuma longa</i> (Linn.)	-	-	+	-	-	-
19	Caesar Weed	<i>Urena lobata</i> (Linn.)	-	-	-	+	-	-
20	Rainbow Bracket Fungi	<i>Trametes versicolour</i> (Linn.) Lloyd	-	-	-	+	-	-
21	Sword Leaf Dianella	<i>Dianella</i> sp.	-	-	-	+	-	-
22	Giant Taro	<i>Alocasia macrorrhiza</i> (Linn.) G. Don	-	-	-	+	-	-
23	Pineapple	<i>Ananassa sativa</i> (Lindl.)	-	-	-	-	-	+
24	Wild Cane	<i>Saccharum spontaneum</i> (Linn.)	-	-	-	+	-	-
25	Bayag-usa	<i>Gardenia pseudopsidium</i> (Blanco)	-	-	-	+	-	-
26	Velvet Beans	<i>Mucuna nigricans</i> Lour.	-	-	-	+	-	-
27	Cogon Grass/ Spear Grass	<i>Imperata cylindrica</i> (Linn.) P. Beauv.	-	-	-	+	-	-
28	Fortune Plant	<i>Dracaena braunii</i> (Engl.)	-	-	-	+	-	-
29	Pomelo	<i>Citrus maxima</i> (Burm.) Merr.	+	-	-	-	-	-
30	Wild Amaranth	<i>Amaranthus viridis</i> (Linn.)	-	-	-	+	-	-
31	Deadly Nightshade	<i>Solanum nigrum</i> (Linn.)	-	-	-	+	-	-
32	Pineapple	<i>Ananas comosus</i> (Linn.) Merr.	-	-	-	+	-	-
33	Watermelon	<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	-	-	-	+	-	-

Rapid faunal species assessment recorded a total of 34 species including eight mammals, six reptiles, and 20 avian species. The most common species was *Bos taurus* for mammals and *Eublepharis* sp. in reptiles; *Pycnonotus goiavier*, *Oriolus chinensis*, *Passer montanus*, *Gallus gallus domesticus*, and

Dendrocopos maculates were avian species observed in all sampling stations (Table 4). The highest number of recorded faunal species was found in Bagac (23 species), it was followed by Hermosa (19 species), Morong (18 species), Abucay (17 species), Orani (16 species), and Samal (13 species). Although

it is not conclusive, most of the sightings of wild native species has occurred in the western part of BNP, which comprised of sites in Morong and Bagac.

This is particularly true to avian species despite of the fact there are more sampling sites in the eastern stations of BNP.

Table 4. Distribution and sightings of mammals, reptiles, and birds documented during the rapid bioassessment in the buffer zone areas in Bataan National Park. M = Morong, B = Bagac, A = Abucay, H = Hermosa, S = Samal, O = Orani.

Local Name	Common Name	Scientific Names	Representative Stations					
			M	B	A	H	S	O
Mammals								
Unggoy	Monkey	<i>Macaca fascicularis</i> (Raffles)	+	+	-	-	-	-
Baka	Cow	<i>Bos taurus</i> (Linn.)	-	+	+	+	+	+
Kalabaw	Carabao	<i>Bubalus bubalis carabanesis</i> (Linn.)	-	-	-	+	+	-
Kambing	Goat	<i>Capra aegagrus hircus</i> (Linn.)	-	-	-	+	+	-
Kabayo	Horse	<i>Equus caballus</i> (Linn.)	+	-	-	-	-	+
Baboy Ramo	Philippine Warty Pig*	<i>Sus philippensis</i> (Nehring)	+	+	-	+	+	-
Bayakan	Giant Flying Fox	<i>Acerodon</i> sp.	+	+	-	-	-	-
Alamid	Asian Palm Civet	<i>Paradoxurus hermaphroditus</i> (Pallas)	+	+	-	-	-	-
Reptiles								
Bayawak	Monitor Lizard	<i>Varanus</i> sp.	+	+	+	+	+	-
Tuko	Gecko	<i>Eublepharis</i> sp.	+	+	+	+	+	+
Sawa	Reticulated Python	<i>Phyton</i> sp.	+	+	-	-	-	-
Ulupong	Philippine Cobra*	<i>Naja philippinensis</i> (Taylor)	-	-	+	+	+	+
Dahong Palay	Philippine Pit Viper*	<i>Trimeresurus flavomaculatus</i> (Gray)	-	-	+	+	+	+
Manawal	Manawal	unidentified	-	-	+	+	+	+
Aves								
Bato-Bato	Turtle Dove	<i>Streptopelia dusumieri</i> (Temminck)	+	+	+	-	-	-
Bato-batong Gubat	White-eared Dove *	<i>Phapitreron leucotis</i> (Temminck)	+	+	-	-	-	-
Bato-batong Parang	Zebra Dove	<i>Geopelia striata</i> (Linn.)	+	-	-	-	-	-
Luklak	Yellow Vented Bulbul	<i>Pycnonotus goiavier</i> (Scopoli)	+	+	+	+	+	+
Kilyawan	Old World Oriole	<i>Oriolus chinensis</i> (Linn.)	+	+	+	+	+	+
Kulasisi	Philippine Hanging Parrot*	<i>Loriculus philippensis</i> (Muller)	-	+	+	-	-	-
Maya	Tree Sparrow	<i>Passer montanus</i> (Linn.)	+	+	+	+	+	+
Bakaw	Heron	<i>Ardea modesta</i> (Gray)	-	-	-	+	-	-
Manok	Chicken	<i>Gallus gallus domesticus</i> (Linn.)	+	+	+	+	+	+
Manoktok	Philippine Woodpecker*	<i>Dendrocopos maculatus</i> (Scopoli)	+	+	+	+	+	+
Bato-bato	Spotted Dove	<i>Spilopelia chinensis</i> (Scopoli)	+	+	-	-	-	-
Tikling	Buff-banded Rail	<i>Hypotaenidia philippensis</i> (Linn.)	-	-	-	+	-	-
Uwak	Crow/ Raven	<i>Corvus</i> sp.	-	+	+	-	-	-
Gansa	Goose	<i>Anser anser domesticus</i> (Linn.)	-	+	-	-	-	-
Siyabokot/ Sabukot	Spotted Dove	<i>Centropus viridis</i> (Scopoli)	-	-	-	+	-	-
Piskador	King Fisher*	<i>Ceryx</i> sp.	-	-	+	+	+	+
Tariktik	Luzon Hornbill*	<i>Penelopides manillae</i> (Boddaert)	+	+	-	-	-	-
Pipit	Paddyfield Pipit	<i>Anthus lugubris</i> (Walden)	-	-	-	+	+	+
Lawin	Philippine Hawk-eagle*	<i>Nisaetus philippensis</i> (Gould)	-	+	+	-	-	-
Kuwago	Philippine Giant Scops Owl*	<i>Otus megalotis</i> (Walden)	+	+	+	-	-	-

(-) absent, (+) present

*endemic

Biological Indices

Different biodiversity indices in each sampling site were summarized in Table 4. Highest number of collected plant samples was found in Hermosa ($n = 1,468$), whereas the smallest number of documented plants was from Samal ($n = 177$). Similar observations on species richness and density were also observed, with highest recorded taxa being observed in Hermosa. Shannon-Weiner index was found to be high in Hermosa, Morong, Bagac, and Orani, and Abucay (> 2.5). Samal had the lowest H' index of 1.71, although this value was still at ideal range. Values of the Shannon diversity index for real communities

typically fall between 1.5 and 3.5 (Kemp *et al.* 1993). Evenness values are remarkably high in all sampling stations with no less than 0.6 (highest value = 1.00). Simpson's dominance values were very low and measured from 0.05–0.11. The species dominance weighted towards the most dominant species among each representative station and was inversely proportional to diversity index. In this community, no pronounced dominance of one or two plant species was observed, in spite of the occurrence of major plant commodities mentioned above. High evenness values signify equitable allocation of niche space for dominant and non-dominant species (Ramsundar, 2004).

Table 5. Biological indices of flora in the buffer zone of Bataan National Park. H' = Shannon-Weiner diversity index; J' = Shannon evenness Index; λ = Simpson's species dominance index.

	Morong	Bagac	Abucay	Hermosa	Samal	Orani
Taxa	49	34	35	83	14	42
Abundance	763	294	677	1,468	177	471
H'	3.24	3.1	2.74	3.49	1.71	3.1
J'	0.83	0.88	0.77	0.79	0.65	0.83
λ	0.056	0.064	0.11	0.05	0.27	0.06

Table 6. Anthropogenic activities and land use pattern in the buffer zones of Bataan National Parks. (+) = present or perceived to be occurring.

Anthropogenic Activities	Representative Stations					
	Hermosa	Orani	Samal	Abucay	Bagac	Morong
Quarrying	+			+	+	
Encroachment		+	+	+	+	
Soil erosion/run off	+			+	+	
Illegal logging				+	+	
Alien/ introduced species		+	+	+		
Environmental aesthetic degradation	+	+	+	+	+	+
Land conversion						
Tourism /recreation area	+	+	+	+	+	+
Ecotourism					+	+
Human settlement / housing project	+			+	+	
Agriculture						
Vegetable crops	+	+	+	+	+	+
Rice	+	+	+	+	+	+
Fruit trees	+	+	+	+	+	+
Livestock raising	+	+	+	+	+	+
Pollution						
Solid waste	+	+	+	+	+	+
Animal wastes	+	+	+	+	+	+
Air pollution		+		+		
Construction of industrial firms	+					
Charcoal making					+	
Firewood collection					+	
Wildlife hunting	+	+			+	+
Road construction	+	+	+	+	+	+

Anthropogenic Activities

Anthropogenically-induced changes and use pattern in the buffer zones of BNP were listed in Table 6. These activities were identified as the major threats in biodiversity loss, with *quarrying* and *encroachment* being perceived to have the most negative effect in BNP. Land conversion in various forms was also recognized as threat although this factor has been incessantly in check by the local government and the community themselves since *settlement*, *ecotourism*, and *agriculture* serves as the main source of livelihood of the communities within the BNP buffer zones. It is noteworthy to mention that agricultural practices in the BNP play a key role in the changes of plant ecosystem, i.e. conversion of pristine forested areas into vegetable and fruit tree plantations.

Conclusion

The survey recorded 3,850 plant individuals, belonging to at least 118 species, five of which were classified as endemic. Nine angiosperms comprised the 50% of the total mean abundance, eight of which has agricultural significance. Banana (*Musa x paradisiaca*) and mango (*Mangifera indica*) were present in all sampling sites. The top five plant species with the highest Important Value Index were *M. paradisiaca*, *M. indica*, *Cocos nucifer*, *Gliricidia sepium*, and *Anacardium occidentale*. Shannon diversity indices and evenness values are high in all sampling stations with a mean of no less than 1.70, and 0.6, respectively. Recorded faunal species had a total of 34 species including eight mammals, six reptiles and 20 birds.

Anthropogenic activities mainly quarrying, encroachment, and land conversion are placing pressures on the BNP buffer zone biodiversity. The said activities were found to be rampant in significant portions of all subject municipalities (Hermosa, Orani, Samal, Abucay, Bagac, and Morong) threatening the survival of many floral and faunal species. Protecting these species is crucial in achieving better ecological condition not only along the BNP periphery but within the whole park itself as buffer zones function as transitory protection to specific conservation areas.

Integrated and participatory approaches to environmental management are wanting on this issue, where there will be a systematic integration of all environmental and developmental activities along the BNP buffer zone, and there will be collaboration among all conservation initiatives among different stakeholder groups such as the village people, government and non-government agencies, the academe, and the private sector when it comes to planning and decision-making processes. A review of the current municipal land use plans and assessment of their implementation are also imperative to address human intrusions into areas where restrictions are supposedly enhanced.

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