Diversity and assessment of plants in Mt. Kitanglad Range Natural Park, Bukidnon, Southern Philippines

Victor B. Amoroso[1], Socorro H. Laraga and Bridget V. Calzada

Department of Biology, Central Mindanao University
University Town, Musuan, Bukidnon 8710, The Philippines
[1]amorosovic@yahoo.com (corresponding author)

ABSTRACT. This research describes the vegetation types, determines the diversity and assesses the conservation status of vascular plants in Mt. Kitanglad Range Natural Park, Bukidnon Province. Twelve 20 m × 20 m nested plots were established per vegetation type. A transect survey with 34 plots revealed three vegetation types, namely the agroecosystem, lower montane forest and mossy forest, with 661 species, 264 genera, and 106 families enumerated. Plant species richness and diversity decreases as the altitude increases, and the mossy forest had the lowest species diversity. *Lithocarpus sp.* obtained the highest Species Importance Value (SIV) for trees in both lower montane and mossy forests together, while *Leptospermum sp.* had the highest SIV in the mossy forest. Tree profile analysis showed that the lower montane forest had the highest mean number of species (7.9 spp.) and individuals (26.9 individuals), mean height (11.12 m) and mean diameter at breast height (dbh, 39.40 cm). The upper mossy forest had the lowest mean number of species (4.4 spp.), individuals (20.2 individuals), average height (7.03 m) and average dbh (16.60 cm). We assess 92 threatened and 82 rare species; 108 endemic species, 50 economically important species, 56 species newly recorded in the locality and 20 species newly recorded for the Philippines. Policy recommendations are given for protecting the remaining threatened, endemic and rare species of plants and their habitats.

Keywords. Conservation status, Mindanao, Mt. Kitanglad, Philippines, species diversity, vascular plants, vegetation types

Introduction

Mt. Kitanglad Range Natural Park has been declared as a protected area on November 9, 2000 and an ASEAN Heritage Park on October 29, 2009. Encompassing 37,236 ha over the North Central portion of Bukidnon and with the highest elevation of 2938 m, the park is the headwaters of three major river systems and sees frequent visitors (NORDECO 1998). Many faunal species were recorded in the park (Heaney et al. 2006, NORDECO 1998) but meager information is available about the richness and status of plants, especially at the northeastern part. It was therefore important that an inventory and assessment of the floral resources be conducted to generate knowledge on plant diversity and status for the conservation and protection of the remaining biodiversity. The findings of this research will be used as the basis for policy formulation by the Protected Area Management Board (PAMB) of Mt. Kitanglad, Department of Environment and Natural Resources (DENR) and for conserving and properly managing the threatened, endemic, rare and economically important species of plants and their habitats.

Objectives

The project objectives were to obtain an inventory, and assess and conserve the threatened, endemic, rare and economically important plants in the Mt. Kitanglad Range Natural Park, Bukidnon, Southern Philippines. Specifically, it aimed to (1) identify and describe the vegetation types; (2) determine the diversity of vascular plants; (3) assess their conservation status; (4) record plant habitats and distribution; and, (5) recommend policy measures regarding the protection and conservation of the threatened/endemic species and their habitats.

Methods and materials

Prior Informed Consent (PIC) and selection of local researchers

To satisfy the legal requirements of EO 247 (Bioprospecting) and RA 9147 (Wildlife Resources Conservation and Protection Act), prior informed consent from the community was obtained by presenting the research proposal. Likewise, this research proposal was presented to the members of the Protected Area Management Board (PAMB) of Mt. Kitanglad Range Natural Park for their approval and eventual issuance of the Gratuitous Permit from the Department of Environment and Natural Resources.

Selection of local researchers (Forest Guides) was made with the stakeholders in Sitio Intavas, Barangay La Fortuna, Impasug-ong, Bukidnon based on their sufficient indigenous knowledge of the floral resources in the study sites. Being co-researchers and since the nature of the research is participatory, the Forest Guides were compensated and involved during the entire duration of field work.

Identification and description of vegetation types

Field reconnaissance and a transect survey were conducted to identify and describe the vegetation types by considering the species richness and dominance, canopy cover, tree profile, altitude, location and other ecological parameters. A GPS was used to determine the location of each vegetation type.

Survey, establishment of sampling sites, collection and processing of specimens

Several transects along the landscape were laid out to inventory and assess the plant species observed. Likewise, a transect belt of 2 km x 10 m wide was established per vegetation type. Within the transect belt, an inventory and assessment of plants were conducted, and their local names, uses and altitude were recorded. Representative specimens collected were pressed, poisoned and mounted as herbarium vouchers using the wet method. Duplicates of the herbarium specimens were sent and deposited at the Philippine National Herbarium and Herbarium of the Taiwan Forestry Research Institute.

Diversity Indices

A total of 34 sampling plots, each 20 m × 20 m, were established in all vegetation types, each type with 12 sampling plots except for the upper mossy forest, with 10 plots. Tree enumeration was carried out for all individuals with a diameter at breast height (dbh) of 10 cm and larger. Within these plots, a 5 m × 5 m subplot was laid out to determine the species richness of pteridophytes, of which all occurring individuals were assessed. We assessed species diversity by using the Shannon index of general diversity (H'):

for trees: $H' = - \Sigma \, ndbh/Ndbh \log ndbh/Ndbh$

(where, ndbh = diameter at breast height of individual tree species
Ndbh = total diameter at breast height of all tree species);

and for pteridophytes: $H' = - \Sigma \, [n_i]/N \log [n_i]/N$

(where, n_i = number of individuals in an area,
and N = total number of individuals in an area).

The Species Importance Value (SIV) was computed using the formula of Brower and Zar (1977):

SIV or ni = RD + RF + Rdom

where, RD = relative density, RF = relative frequency, Rdom = relative dominance.

Identification and assessment of conservation status

The collected plants were identified using taxonomic keys from floras and monographs of Merrill (1923-1926); Linder (1987); Madulid (1995); Kalkman et al. (1995-1996); Editorial Committee of the Flora of Taiwan (1996); Rojo (1999); Jebb & Cheek (2001); Cootes (2001); Barcelona et al. (1996); Tan et al. (1996); Zamora & Co (1986); and Amoroso et al. (1993, 1996, 1997).

The assessment of status for each species, whether threatened, endemic, rare or economically important, was determined with the help of the national list of threatened Philippine plants (Fernando et al. 2008), the IUCN (2007) and from published floristic works and monographs.

Definitions of terms adopted from the International Union for the Conservation of Nature (IUCN) (2007), Fernando *et al.* (2008), Zamora (1986) and Department of Environment and Natural Resources (DENR) Administrative Order No. 2007-01 (as defined in its Section 5 of R.A. 9147) include:

a) *Threatened Species* - Actively threatened with extinction and its survival is unlikely without protective measures. Threatened species fall under three categories as defined by Fernando *et al.* (2008):

a1) *Critically Endangered* – A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

a2) *Endangered* – A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in the medium-term future.

a3) *Vulnerable* – A taxon is vulnerable when it is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium term future.

a4) *Other threatened species* – A taxon belongs to other threatened species when it is under threat from adverse factors, such as over collection, throughout its range and is likely to move to the vulnerable category in the near future.

a5) *Other wildlife species* – A taxon belongs to other wildlife species when it has been evaluated but does not satisfy the criteria for any of the categories Critically Endangered, Endangered, Vulnerable or Other Threatened Species, but have the tendency to become threatened due to predation and destruction of habitat or other similar causes as may be listed by the Secretary upon the recommendation of the National Wildlife Management Committee.

b) *Rare Species* – Not under immediate threat of extinction but occurring in such small numbers or in such localised or specialised habitat that it could quickly disappear if the environment worsens; needs monitoring.

c) *Depleted Species* – Although sufficiently abundant for survival, the species has been heavily depleted and in decline as a result of natural causes of human activities.

d) *Endemic Species* – Confined to a certain geographical region or its parts.

e) *Economically Important Species* – Based on known usefulness whether medicinal, ornamental, food, construction material, etc.

Results and discussion

Vegetation types and distribution

Transect survey and establishment of sampling plots was carried out along the trail in the northeastern part of Mt. Kitanglad Range Natural Park to identify and describe the vegetation types by considering the coordinates, species richness and dominance, tree profile, altitude, and other ecological parameters (Fig. 1). Three vegetation types were identified from 1200 m asl to the peak of the park as described below (Fig. 2).

The *agro-ecosystem* (08°10'17"N, 124°56'09"E) ranges from 1200 m to 1700 m asl. Potatoes (*Solanum tuberosum* L.), cabbage (*Brassica oleracea* L.), carrots (*Daucus carota* L.) and tomatoes (*Lycopersicum esculentum* Mill.) dominated this vegetation. The original vegetation was dipterocarp forest but this was logged and later converted to agricultural land and planted with cash crops. Threatened plants such as *Cyathea contaminans* (Wall.) Copel., (*anonotong*), *Podocarpus macrocarpus* de Laub. and *Dicranopteris linearis* (Burm.) Underw. (*agsam*), which is an indicator of a disturbed habitat, was observed at the edge of the vegetable plantation (Fig. 2A). The agroecosystem in Mt. Malindang is also dominated by crops like vegetables, cereals and agroforestry species (Amoroso et al. 2006).

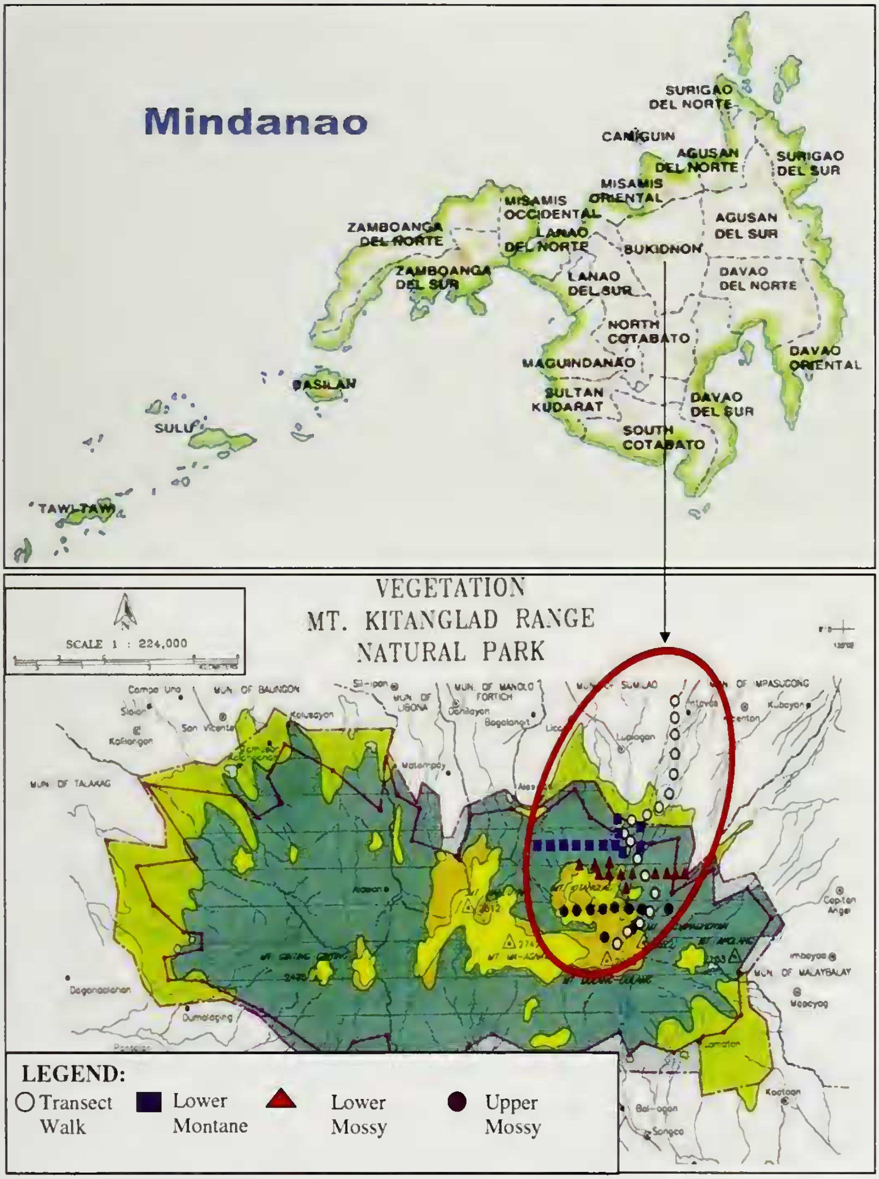

Fig. 1. Location of Bukidnon Province on Mindanao (upper map), and layout of the transect walk and 34 sampling plots in the Mt. Kitanglad Range Natural Park (lower map).

The *lower montane forest* (08°09'54"N, 124°55'58"E) already begins from the foot of Mt. Kitanglad and ranges from 1700 m to 2100 m asl. This forest is characterised by the presence of numerous species of mosses, lichens and other epiphytes. The dominant tree species include *Phyllocladus hypophyllus* Hook.f. (mountain *tungog*), *Lithocarpus spp.* (*ulayan*), *Erythrina subumbrans* (Hasskarl) Merr. (*anii*), while the common shrubs observed included the endemic *Hydrangea scandens* Ser., *Drimys piperata* Hook f. and several *Medinilla* spp. Emergent trees are 5–20 m tall, averaging

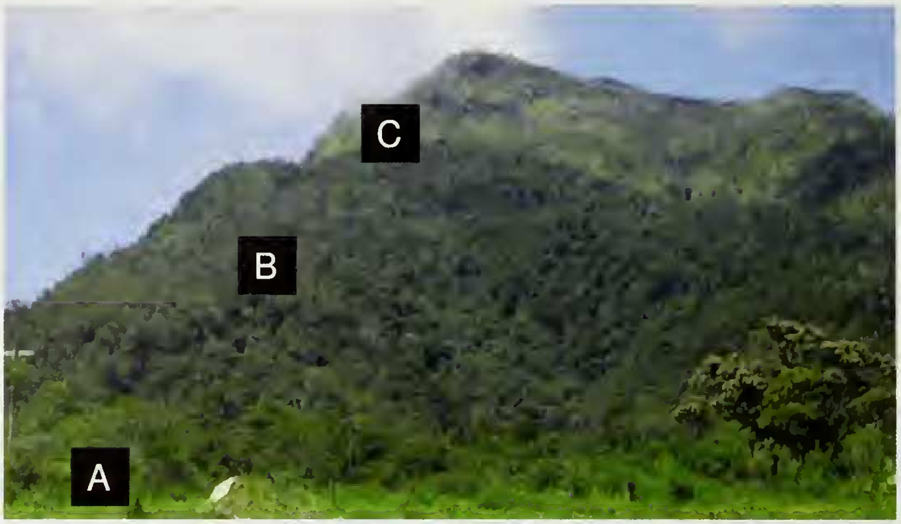

Fig. 2. Panoramic view of Mt. Kitanglad Range Natural Park, Intavas, Impasug-ong, Bukidnon showing the vegetation types. **A.** Agroecosystem. **B.** Montane Forest. **C.** Mossy Forest. Photo by V. Amoroso, June, 2007.

12 m. The moss cover ranges from 50-75%. The edge of the montane forest is usually inhabited by *Trema orientalis* (L.) Blume (*andalnyong*), *Pteridium aquilinum* (L.) Kuhn (*sigpang* or bracken) and *Cyathea* spp. (*Anonotong* or tree ferns) (Fig. 2B). This is similar to what was observed by Amoroso et al. (2006) in the montane forest on Mt. Malindang, which has a high relative humidity and rainfall and has trees on the average taller than in the mossy forest; they also noted that the moss layer was less conspicuous than in the mossy forest.

The *mossy forest* begins from 2100 m asl up to the peak as described below. The branches and trunks of trees and the forest floor were largely covered with mosses, hence the name mossy forest (Amoroso et al. 2006). We consider there to be lower and upper facies of these mossy forests from plant diversity considerations.

(a) The lower mossy forest (08°09'27"N, 124°55'49"E to 08°09'16"N, 124°55'30"E) starts from 2100 m asl, reaching 2400 m asl. Moss cover is thick in this vegetation type, over the ground, roots, trunks and branches of trees. *Lithocarpus* sp., *Phyllocladus hypophyllus* Hook.f. and *Podocarpus* spp. were the most abundant trees. Tree height ranges 7–13 m, with an average of 10 m.

(b) The upper mossy forest (08°09'16"N 124°55'30"E to the peak at 08°08'38"N 124°55'06" E) starts from 2401 m asl to 2900 m asl. Moss cover was very thick in this vegetation type and largely covered the forest floor, roots, and the twisted trunks and branches of trees. *Leptospermum javanicum* Blume was an abundant tree, while *Rhododendron* spp., *Dimorphanthera apoana* (Merr.) Schltr., *Vaccinium* spp. and *Rubus* spp. were abundant shrubs. Tree height ranges 6–12 m, with an average of 9 m.

The summit of the park has an abundance of the dwarf bamboo (*Yushania nitakayamensis* (Hayata) Keng f.) and the wet ground is covered with *Nertera diffusa* (Mutis ex L.f.) Druce, *Sphagnum* moss and lycopods.

Amoroso et al. (2004) observed that the mossy forest of Mt. Malindang was characterised by the presence of small trees with prop roots and aerial roots developing at 1–few meters from the base of irregularly shaped tree trunks. The presence of prop roots appeared to be correlated to steep slopes, which were prevalent in this zone. As in other mossy forests in the Philippines, the trees were dwarfed and their trunks gnarled, especially those that grew near the mountain peak, possibly due to strong wind pressure.

If Mt. Kitanglad has three vegetation types, Mt. Hamiguitan showed five vegetation types (Amoroso et al. 2009), while Mt. Malindang exhibited six (Amoroso et al. 2004).

Species richness and diversity

The sampling plots and transect survey enumerated a total of 661 species, 264 genera, and 106 families of vascular plants (Table 1). There were 439 pteridophyte species, 11 gymnosperm species and 211 angiosperm species.

Table 1. Number of families, genera and species of plants in Mt. Kitanglad Range Natural Park, based on the present study of sampling plots and the transect survey. Of 661 total taxa, 495 were identified to the species level.

Plant group	Number of		
	Families	*Genera*	*Species / Taxa*
Pteridophytes			
Ferns	25	100	408
Lycopods	3	4	31
Gymnosperms	4	8	11
Angiosperms	74	152	211
TOTAL	106	264	661

The Philippines has a total of 9,060 species of vascular plants, or perhaps more (Madulid 1991). Of these, Mt. Kitanglad has 42.8% of the pteridophytes, 33.3% of the gymnosperms and 2.6% of the angiosperms The species richness of vascular plants in Mt. Kitanglad (7.3%) is lower than in Mt. Hamiguitan (9.6%) and Mt. Malindang (12.8%). The lower species richness of angiosperms in Mt. Kitanglad is due to the absence of dipterocarp forest, whereas this forest type was found on Mt. Malindang and Mt. Hamiguitan. Mt. Kitanglad, however, has a higher species richness of pteridophytes compared to the Mt. Hamiguitan and Mt. Malindang (Table 2).

Pteridophyte, as well as tree, diversity decreases from lower montane to mossy forest (Table 3). The same pattern was observed for trees at Mt. Malindang and Mt. Hamiguitan (Amoroso et al. 2006, 2009).

Table 2. Plant species richness of Mt. Kitanglad, Intavas, Bukidnon and two other protected areas in Mindanao, compared with overall statistics for the Philippines.

Plant group	Total number (and percentage) of species				
	Philippines	*Mindanao*	*Malindang* (Amoroso et al., 2006)	*Hamiguitan* (Amoroso et al., 2009)	*Kitanglad*
Pteridophytes	1027	632 (61.5%)	280 (27.3%)	155 (15.0%)	439 (42.8%)
Gymnosperms	33	No data	11(33.3%)	25 (75.8%)	11(33.3%)
Angiosperms	8000+	No data	873 (10.9%)	698 (8.7%)	211 (2.6%)
TOTAL	9060+	No data	1164 (12.8%)	878 (9.6%)	661 (7.3%)

Table 3. Plant species diversity (Shannon index of general diversity, H') in different vegetation types of the Mt. Kitanglad Range. Pteridophyte enumerations are based on 5 m × 5 m plots, with 10 plots in Lower Montane Forest, 12 plots in Lower Mossy Forest, and 10 plots in Upper Mossy Forest. Tree enumerations are based on 20 m × 20 m plots, with 12 plots in Lower Montane Forest and Lower Mossy Forest, and 10 plots in Upper Mossy Forest.

Vegetation type	*Mean number of*				*Mean diversity value*	
	Individuals		*Species*			
	Pteridophytes	Trees	Pteridophytes	Trees	Pteridophytes	Trees
Lower Montane (1700–2100 m)	94.6	26.9	7.48	7.9	0.45	0.80
Lower Mossy (2100–2400 m)	45.8	24.8	9.5	6.9	0.83	0.84
Upper Mossy (2400–2800 m)	48.8	20.2	7.0	4.4	0.69	0.72

The pteridophyte diversity value was higher (H'=0.83) in the lower mossy forest than in both the lower montane and upper mossy forests with H'= 0.45 and 0.69, respectively. Among trees, however, the highest diversity value was obtained in the lower mossy forest (H'=0.84), followed by the lower montane and upper mossy forests with H'=0.80 and H'=0.72, respectively. This implies that the diversity is highest at mid-elevations, although comparison with lowland vegetation types was not possible in this study. As a comparison, mossy forests in Mt. Kitanglad and Mt. Hamiguitan had lower diversity values. However, the upper mossy forest has a significantly reduced diversity compared with the lower mossy forest. In terms of species richness, however, it is clear that there are progressively fewer species from lower montane forest upwards. These facts support the contention of various ecologists that the number of species (i.e., richness) or diversity values at higher altitudes is lower as a response to increasing environmental stresses like wind pressure, steep slopes, thin soil substrates, etc. (Perez 2004).

Species Importance Values (SIV)

Species importance values determine the dominant species in an area and at the same time provide an overall estimate of the influence of these species in the community. The removal of these species from the community will greatly affect the physical and biological structure of the community.

The species of pteridophytes which obtained the highest Species Importance Value (SIV) in the lower montane forest (Table 4) were *Mecodium reinwardtii* (van der Bosch) Copel., *Trichomanes* sp., *Hymenophyllum* sp., *Nephrolepis cordifolia* (Linn.) Presl. and *Grammitis* sp. while for lower mossy forest, they were *Plagiogyria pycnophylla* (Kunze) Mett., *Phymatosorus* sp., *Plagiogyria christii* Copel., *Hymenophyllum* sp. and *Microsorum scolopendria* (Burm.f.). Further, the upper mossy forest species with the highest SIV were *Hymenophlyllum* sp., *Asplenium normale* Don, *Dicranopteris, Humata repens* (Linn.) Diels, and *Plagiogyria glauca* (Blume) Mett. *Hymenophyllum* sp. and *Plagiogyria christii* were the top two pteridophytes with the highest SIV values on Mt. Kitanglad. This observation is in consonance with the results of Amoroso et al. (2009).

The tree species which obtained the five highest SIV (Species Importance Values) in the lower montane forest includes: *Lithocarpus* sp., *Fagraea blumei* G. Don, *Melicope* sp., *Phyllocladus hypophyllus* and *Cinnamomum mercadoi* Vidal. The lower mossy forest had the following species with the five highest SIV: *Lithocarpus* sp., *Phyllocladus hypophyllus*, *Leptospermum* sp., *Syzygium* sp. and *Podocarpus costalis* C. Presl. For the upper mossy vegetation, *Leptospermum* sp., *Dacrycarpus cumingii* (Parl.) de Laub., *Fagraea blumei*, *Phyllocladus,* and *Podocarpus* sp. were the five species with the highest SIV. For the trees, *Leptospermum* sp. and *Lithocarpus* sp. had the highest SIV value on Mt. Kitanglad. This finding is also supported by the study of Amoroso et al. (2009). *Lithocarpus* sp. ranked first in both lower montane and lower mossy forests of Mt. Kitanglad, with SIV of 115% and 94.32%, respectively. At Mt. Hamiguitan, *Agathis philippinensis* Warb. ranked first in both lower montane and mossy forest. It is noteworthy to mention that *Hymenophyllum* sp. and *Plagiogyria christii* with high SIV were observed in the three vegetation types (Amoroso et al. 2009).

According to Krebs (1994), variation in important species may be caused by differences in the response of various species to environmental conditions. He also noted that elevation provides complex environmental gradients including temperature, rainfall and relative humidity. It was noted that the species composition of the three vegetation types here differed, suggesting that habitat differences catered differently to the requirements of tree species.

Table 4. Species importance values of pteridophytes and trees in the different vegetation types.

Vegetation	Pteridophytes	SIV (%)	Trees	SIV (%)
Lower Montane (1700–2100 m)	*Mecodium reinwardtii*	94.75	*Lithocarpus* sp.	115.0
	Trichomanes sp.	80.67	*Fagraea blumei*	85.67
	Hymenophyllum sp.	76.63	*Melicope* sp.	76.42
	Nephrolepis cordifolia	72.27	*Phyllocladus hypophyllus*	66.95
	Grammitis sp.	64.32	*Cinnamomum mercadoi*	64.84
Lower Mossy (2100–2400 m)	*Plagiogyria pycnophylla*	154.67	*Lithocarpus* sp.	94.32
	Phymatosorus sp.	137.00	*Phyllocladus hypophyllus*	83.50
	Plagiogyria christii	102.01	*Leptospermum* sp.	80.32
	Hymenophyllum sp.	85.96	*Syzygium* sp.	70.16
	Microsorum scolopendria	81.99	*Podocarpus costalis*	60.00
Upper Mossy (2400–2800 m)	*Hymenophyllum* sp.	209.66	*Leptospermum* sp.	168.91
	Asplenium normale	138.94	*Dacrycarpus cumingii*	78.99
	Dicranopteris linearis	111.93	*Fagraea blumei*	72.91
	Humata repens	97.46	*Phyllocladus hypophyllus*	57.29
	Plagiogyria glauca	95.11	*Podocarpus costalis*	56.87

Tree profile

Table 5 shows the mean number of species and individuals, average height and average diameter at breast height (dbh) of trees in the sampled plots of the different vegetation types. The lower montane forest obtained the highest average number of individuals in 20 m × 20 m plots with 26.9 individuals, while upper mossy forests had the lowest average number of trees with 20.2 individuals. As altitude increases, the average number of individuals (of 10 cm diameter or bigger) decreases. The highest average height (11.12 m) and average dbh (39.30 cm) were recorded from trees of the lower montane forest. These values decrease with elevation. The lowest value for average height and average dbh were recorded in the upper mossy forest. *Lithocarpus* sp. was the tallest tree recorded in the lower montane forest and lower mossy forest, attaining 25.0 m and 24 m, respectively. *Dacrycarpus cumingii* (20 m) were tallest in the upper mossy forest.

Tree profile diagrams for the 34 plots were individually made to record the species distribution and indicate relative heights of trees in the 20 m × 20 m plots. From these, canopy cover in the sampling plots were calculated and ranged from 70–95% in the lower montane forest compared 60–80% in the lower mossy forest, and

Table 5. Mean number of individuals, average height and diameter at breast height (dbh) of trees in different vegetation types on Mt. Kitanglad Range, Intavas, Bukidnon.
Calculated based on enumerations of 12 plots each in Lower Montane Forest and Lower Mossy Forest, and 10 plots in Upper Mossy Forest: each plot 20 m × 20 m.

Vegetation type	Mean number of		Average height (m)	Average dbh (cm)
	Individuals	*Species*		
Lower Montane (1700–2100 m)	26.9	7.9	11.12	39.30
Lower Mossy (2100–2400 m)	24.8	6.9	9.60	21.69
Upper Mossy (2400–2800 m)	20.2	4.4	7.03	16.60

10–15% in the upper mossy forest. Since tree coordinates were taken in each of the 34 sampling plots, long-term monitoring of tree dynamics will be possible.

Assessment of conservation status

The habitat of the plants, whether epiphytic, terrestrial or petrophytic / lithophytic, was noted. The distribution of threatened, endemic and economically important species of plants was mapped based on elevation and vegetation types. Recording of altitudinal distribution of the threatened, endemic, and economically important species in these vegetation types will be an important basis in allocating priority to their protection and conservation.

The conservation status of each species was noted and recorded. This was carried out to establish a foundation for their protection, conservation and monitoring. Of the total number of taxa, only 495 species have been identified up to the species level. Of these species, about 92 species were recorded as threatened, 82 rare species, 108 endemic species, 50 economically important species, 56 species as new records for the locality and 20 species as new records for the Philippines (Table 6).

Out of the 9060+ vascular plant species of the Philippines, 530 are threatened, including 85 pteridophytes, 5 gymnosperms and 440 angiosperms (Fernando et al. 2008). Of this number, 17.4% threatened species are located in Mt. Kitanglad comprising 77, 7 and 8 species of pteridophytes, gymnosperms, and angiosperms, respectively (Table 7). The percentage of threatened species in Mt. Kitanglad is 7% and 11% higher than in Mt. Malindang and Mt. Hamiguitan, respectively.

The Philippines has a total of 3557 endemic species, including 351 pteridophytes, 6 gymnosperms, and 3200 angiosperms (Madulid 1991, Fernando et al. 2008). Mt. Kitanglad has 21% of this endemism, which is higher than for Mt. Malindang, but lower than for Hamiguitan. It has, however, a higher percentage endemism of pteridophytes as compared to both mountain ranges (Table 8). The high species endemism in Mt. Hamiguitan may be due to effects of the specialised ultramafic geology there.

Table 6. Number of threatened, endemic and economically important plants, and new records for Mt. Kitanglad Range Natural Park, Intavas, Impasug-ong, Bukidnon. TS - Threatened species; RS - Rare species; ECS - Endemic species; NRL - New record for locality; EIS - Economically important species; NRP - New records for the Philippines.

Plant groups	*Status*					
	TS	RS	ECS	EIS	NRL	NRP
Pteridophytes						
Ferns	75	70	43	40	47	19
Lycopods	2	4	2	3	3	1
Gymnosperms	7	4	1	3	0	0
Angiosperms	8	4	62	4	6	0
TOTAL	*92*	*82*	*108*	*50*	*56*	*20*

Table 7. List of some threatened and endemic species in Mt. Kitanglad Range Natural Park. Conservation status rankings: CR - Critically Endangered; EN - Endangered; OTS - Other Threatened Species; OWS - Other Wild Species; VU - Vulnerable; ECS - Endemic. Vegetation types: LMo - Lower Montane; LM - Lower Mossy; UM - Upper Mossy. A denotes the agro-ecosystem lower down.

	Family	Species	Status	Vegetation type	Altitude (m)
1	Aspleniaceae	*Asplenium nidus* L.	VU	A	1711
2	Aspleniaceae	*Asplenium vittiforme* Cav.	VU	LMo	1935, 2030
3	Blechnaceae	*Blechnum fraseri* (A. Cunningham) Luerss.	VU	LM, UM	2280–2530
4	Cyatheaceae	*Cyathea elmeri* Copel.	VU	LMo	1935–2050
5	Cyatheaceae	*Cyathea philippinensis* Baker	VU, ECS	LMo	2030
6	Cyatheaceae	*Cyathea contaminans* (Wall.) Copel.	VU	LMo	2030
7	Dennstaedtiaceae	*Dennstaedtia williamsi* Copel.	EN	LMo	2020
8	Dryopteridaceae	*Polystichum elmeri* Copel.	OWS	LM	2280
9	Ophioglossaceae	*Botrychium daucifolium* Wall.	VU	LM	2300
10	Polypodiaceae	*Aglaomorpha cornucopia* (Copel.) Roos	VU, ECS	Mo	1797
11	Polypodiaceae	*Aglaomorpha heraclea* (Kuntze) Copel.	VU	LM	2245

12	Polypodiaceae	*Microsorum punctatum* (L.) Copel.	VU	LMo	1711
13	Polypodiaceae	*Microsorum sarawakense* (Baker) Ching	VU	LMo	1797
14	Polypodiaceae	*Microsorum scolopendria* (Burm.f.)	VU	LMo, LM	1797–2280
15	Psilotaceae	*Tmesipteris lanceolata* Dang.	VU	LMo, LM, UM	2050–2600
16	Araucariaceae	*Agathis philippinensis* Warb.	VU	LMo	1945
17	Podocarpaceae	*Podocarpus costalis* C. Presl.	VU	LMo	2113
18	Podocarpaceae	*Podocarpus macrocarpus* de Laub.	OWS	LMo, LM, UM	1985–2840
19	Ericaceae	*Rhododendron kochii* Stein	EN, ECS	LMo, LM	2245–2495
20	Ericaceae	*Rhododendron javanicum* (Blume)	EN	LMo, LM	2245–2495
21	Lauraceae	*Cinnamomum mercadoi* Vidal	VU, ECS	LMo, LM	2050–2300
22	Rosaceae	*Rubus heterosepalus* Merr.	OTS, ECS	LMo	2010

Table 8. Endemism in the Philippines compared to that at Mt. Kitanglad Range, Intavas, Bukidnon. Based on specimens identified to the species level. A dash refers to lack of data. Malindang data from Amoroso et al. (2006); Hamiguitan data from Amoroso et al. (2009).

	Total number of species (Tspp) and number endemic (*Espp*)									
Plant group	*Philippines*		*Mindanao*		*Malindang*		*Hamiguitan*		*Kitanglad*	
	Tspp	*Espp*	Tspp	*Espp*	Tspp	*Espp*	Tspp	*Espp*	Tspp	*Espp*
Pteridophytes	1027	351	632	183	246	28 (*11%*)	99	9 (*9%*)	363	45 (*12%*)
Gymnosperms	33	6	—	3	11	3 (*27%*)	13	1 (*7%*)	11	1 (*9%*)
Angiosperms	8000+	3200	—	—	450	107 (*23%*)	365	153 (*41%*)	121	62 (*51%*)
TOTAL	9060+	3557	—	—	825	138 (*16%*)	477	163 (*34%*)	495	108 (*21%*)

New records

Nineteen species of fern and one species of fern ally are new records for the Philippines, while 50 species of pteridophyte and six species of angiosperm are new records for the locality (Table 6). A significant output of this research was the new record of *Athyrium erythropodum* Hayata (Woodsiaceae) (Fig. 3) for the Philippine flora (Liu et al. 2008). This species had previously been recorded as endemic to Taiwan and was only subsequently discovered on Mt. Kitanglad. Another species newly recorded for the Philippines is *Huperzia monticola* Underw. & F.E Loyd (Fig. 4). This was earlier reported in Sumatra, Indonesia, and is now recorded for the first time on Mt. Kitanglad.

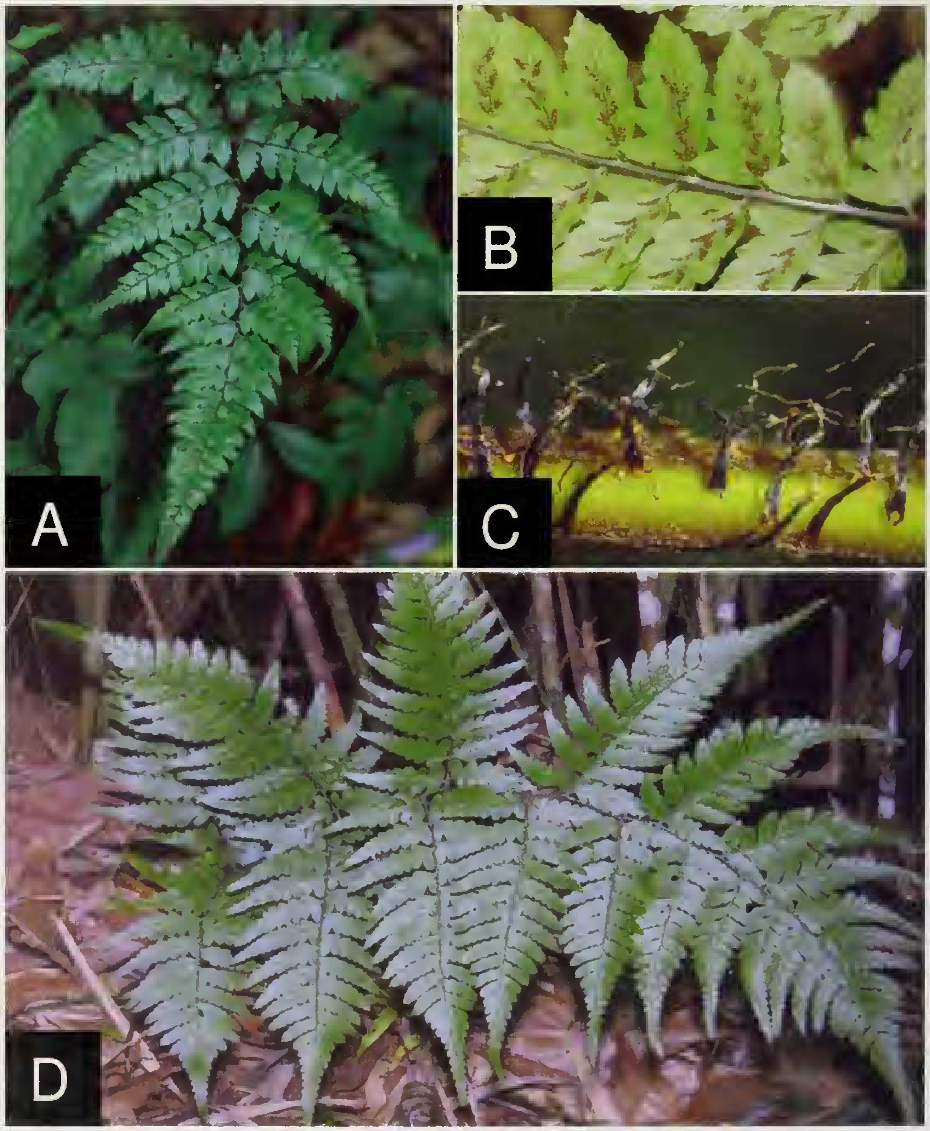

Fig. 3. *Athyrium erythropodum* Hayata, a new Philippine record. **A.** Frond. **B.** Sori with indusia. **C.** Scales on stipe base. **D.** habit. Photographs from Yea-Chen Liu et al. 2009.

Fig. 4. *Huperzia monticola* Underw. & F.E. Loyd. **A.** Habit. **B.** Aerial axis showing microphylls (a) and sporangia (b). Photos by V. Amoroso.

Dissemination of Information, Education and Communication (IEC) Materials
The Information, Education and Communication (IEC) materials were prepared in the form of flyers, with relevant information such as scientific name, local name, family name and status of the floral species (Fig. 5). These help to enhance community awareness for the conservation and protection of these species, and will be disseminated to the community and local researchers and guides for their use.

Policy recommendations

The results of this project should be useful to Local Government Units (LGUs) of Impasug-ong and other municipalities and communities around the park; the Protected Area Wildlife Division (PAWD) of the Department of Environment and Natural Resources; and the Protected Area Management Board (PAMB) in the formulation of policies and ordinances to protect and conserve the remaining botanical resources of the Mt. Kitanglad Range Natural Park.

Fig. 5. Some threatened plants of Mt. Kitanglad, Bukidnon, Mindanao. Photos by V. Amoroso.

Recommended policies for the PAMB include: (1) The LGU's of Intavas and other LGUs around the park should officially organise their porters/guides for long-term monitoring of threatened and endemic species. (2) *Ex-situ* and *in-situ* conservation of species and habitats should be carried out to protect the remaining endemic, threatened, rare, and economically important species of plants. For *ex-*

situ conservation, each municipality should have an economic garden / nursery to propagate their threatened, endemic and economically important plants. (3) Collection of threatened and endemic species should be regulated. (4) Denuded mountains should be planted with indigenous tree species. (5) Threatened and endemic species found in agricultural areas should be protected. (6) Mountaineers / hikers should be given proper orientation before trekking and should follow forest guides in their trekking. Temporary campsites at the middle zone (about 2000 m asl) should be discouraged because of the presence of threatened vascular plants.

ACKNOWLEDGEMENTS. The authors gratefully acknowledge the financial support from Central Mindanao University, Musuan, Bukidnon, Philippines. We appreciate our international collaborators from the Taiwan Forestry Research Institute (TFRI) and the University of Zurich. We are also thankful to previous research assistants during this study: A.J. Veloso, R.N. Dopenio, and various graduate and undergraduate students of the first author.

References

Amoroso, V.B. (1993) Valuable Ferns in Mindanao. *CMU J. Sci.* 6(2): 23–36.

Amoroso, V.B. (1997) Ferns of the Philippines. Paper presented during a workshop seminar. Quezon City: University of the Philippines, Diliman, Philippines.

Amoroso, V.B., Acma, F.M. & Pava, H.P. (1996) Diversity status and ecology of pteridophytes in three forests in Mindanao. In: Canus, J.M. & Johns, R.J. (eds) *Pteridology in Perspective*, pp. 53–60. Kew: Royal Botanical Gardens, Kew.

Amoroso, V.B., Arreza, G.R., Bornales, R.G., Cambel, T.L., Canencia, O.P., Estoista, R.B., Lariosa, E.A., Mero, D.C. & Roxas, A.T. (2004) *Participatory rural appraisal in the lowland ecosystem of Mt. Malindang, Misamis Occidental, Philippines.* College Laguna: SEAMCO SEARCA and Quezon City: PDM Press, Philippines.

Amoroso, V.B., Aspiras, R.A. & Polizon, J.J. (2009) Participatory inventory and distribution of endangered, endemic and economically important plants in Hamiguitan Range Wildlife Sanctuary, Davao Oriental. *Blumea* 54: 71–76.

Amoroso, V.B., Ruba, R.P., Demetillo, M.T., Stortelder, A., Lagunzad, D.A., Aranico, E.C., Arances, J.B., Rufila, L.V., Kessler, P.J.A., Tan, B.C., Roscom, B.A., Gorne, N.D., Opiso, G.S., Van Den Berg, A., Gruezo, W.Sm., Co L.L., & Alava, C.G. (2006) *Plant diversity in the northern landscape of Mt. Malindang Range and environs, Misamis Occidental, Philippines.* College Laguna: SEAMCO SEARCA and Quezon City: PDM Press, Philippines.

Barcelona, J.F., Hernandez, B.F. & Price, M.G. (1996) Philippine Schizaea. *Asia Life Sci.* 5: 27–34.

Brower, J.E. & Zar, J.H. (1977) *Field and Laboratory Methods for General Ecology.* Dubuque, Iowa: C. Brown Company Publishers.

Cootes, J. (2001) *The Orchids of the Philippines.* Singapore: Times Editions.

Department of Environment and Natural Resources (DENR) *Administrative Order No. 2007-01. Establishing the National List of Threstened Plants and their Categories and the List of other Wildlife Species.* Diliman Quezon City: Department of Environment and Natural Resources.

Editorial Committee of the Flora of Taiwan (1996) *Flora of Taiwan* Vol. 2, Angiospermae, 2nd edn. Taipei: National Science Council of the Republic of China.

Fernando, E.S., Co, L.L., Lagunzad, D.A., Gruezo, W.Sm., Barcelona, J.F., Madulid, D.A., Lapis, A.B., Texon, G.I., Manila, A.C., & Zamora, P.M. (2008) Threatened Plants of the Philippines: A Preliminary Assessment. *Asia Life Sci.* Suppl. 3: 1–52.

Heaney, L., Tabaranza, B.R., Rickart, E.A., Balete, D.S. & Ingle, N.R. (2006) The mammals of Mt. Kitanglad Nature Park, Mindanao, Philippines. *Fieldiana*, n.s. 112: 1–63.

Jebb, M. & Cheek, M. (2001) Nepenthaceae. *Flora Malesiana* Ser. I, 13: 145–168.

Kalkman, C. et al. (1995–1996). *Flora Malesiana* Series I, volume 12. Leiden: Rijksherbarium / Hortus Botanicus, Leiden University.

Krebs, J.R. (1994) *Introduction to Plant Biology.* Dubuque, Iowa: C. Brown Company Publishers.

Linder, G.R. (1987) Monograph of the fern genus *Goniophlebium* (Polypodiaceae). *Blumea* 34: 283–328.

Liu, Yea-Chen, Fraser-Jenkins, C.R., Amoroso, V.B. & Chiou, W.L. (2008) *Athyrium erythropodum* (Woodsiaceae Pteridophyta), a new Philippine Record. *Blumea* 53: 447–457.

Madulid, D. (1991) The endemic genera of flowering plants in the Philippines. *Acta Manillana* 39: 47–58.

Madulid, D. (1995) *A Pictorial Cyclopedia of Philippine Ornamental Plants.* Philippines: Bookmark, Inc.

Merrill, E.D. (1923–1926) *An Enumeration of Philippine Flowering Plants.* Volumes I–IV. Manila: Bureau of Printing, Philippines.

NORDECO (1998) Nordic Agency for Development and Ecology (NORDECO) and Department of Environment and Natural Resources (DENR) Technical Report. Integrating conservation and development in protected area management in Mount Kitanglad Range Range Natural Park, Philippines. Copenhagen: NORDECO and Manila: DENR.

Perez, H. (2004) Diversity of trees along altitudinal gradient: Layawan River to North Peak in Mt. Malindang National Park, Baranggay Lake Duminagat, Don Victoriano, Misamis Occidental. *Samu't-Sari* 3(2).

Rojo, J.P. (1999) *Revised Lexicon of Philippine Trees.* College, Laguna: Forest Products Research and Development Institute, Department of Science and Technology, Philippines.

Tan, B.C., Fernando, E.S. & Rojo, J.P. (1996) An Updated list of Endangered Philippine Plants. *Yushania* 3(2): 1–5.

Zamora, P.M. & Co, L.L. (1986) *Guide to Philippine Flora and Fauna.* Vol. IV. Quezon City: Goodwill.