

Land use Type Pattern and Woody Species Composition Near Human Disturbed Landscapes on Mount Makiling, Luzon Island

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Abstract: Problem statement: A field study near human disturbed landscape on Mount Makiling, Luzon Island, Philippines was done on the eastern slopes of the legendary mountain to determine the land use patterns and woody species composition. **Approach:** Forty permanent plots of 10×10m in 3 belt transects spaced at 200m apart were established from the undisturbed forests to the agricultural farms. Classification and ordination analysis was done. **Results:** Cluster analysis showed 5 land use types: the agricultural farm, forests near residences, forest edge, buffer zone and the undisturbed forests. Canonical Correspondence Analysis (CCA) indicated moderate to strong linear correlations between environmental variables and the species data (intra set correlations for altitude = 0.420, slope = -0.879 and distance from farms = -0.913). The mean Basal Area (BA) was highest in the undisturbed forest and lowest in the buffer zone though the Analysis of Variance (ANOVA) showed no significant difference ($p>0.05$). However, ANOVA indicated significant differences among mean stem density values ($p<0.01$) and multiple comparison using the least significant difference test (LSD), noted that the undisturbed forest had significantly lower stem density compared with the rest of the land use types ($p<0.05$). **Conclusion/Recommendation:** Current dominant species like *Celtis luzonica* and *Diplodiscus paniculatus* had replaced the original dipterocarps and were found occupying various elevational ranges not occupied before, indicating that past disturbances created habitats and niches favorable for colonization. It would be worthwhile to study the species biology of these present dominants as they play a significant role in stabilizing and sustaining the ecosystem. Results can give insights on the dynamics of forest landscape and the development of appropriate forest management strategy.

Key words: Anthropogenic disturbance, forest management, landscape dynamics, secondary forest, tropical mountain, Basal Area (BA), Analysis of Variance (ANOVA), Philippines Los Baños (UPLB), Plant Biology Division Herbarium (PBDH), Agricultural Farms

INTRODUCTION

When primary forests are subjected to disturbances, the otherwise lush vegetation and seemingly homogeneous landscape would drastically change. This is especially the case if anthropogenic disturbance regimes are rather severe (Heryati *et al.*, 2011a; Muniandy *et al.*, 2009; Gandaseca *et al.*, 2009). The result would be various land use type patterns

(Alfred *et al.*, 2010; Yacouba *et al.*, 2009). Modern vegetation patterns have been shaped and continue to respond to varying degrees of human impacts (Heryati *et al.*, 2011a; Elhadji *et al.*, 2009).

This is the case of Mount Makiling which has always been thought of as an undisturbed primary forest partly because of legendary tales in literary works and its rich scientific history being one of the destinations of European botanical expeditions in the past (Pancho

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and Gruezo, 2006; Pancho, 1983), besides its being a forest reserve managed by the University of the Philippines Los Baños (UPLB), located at its base. However, the once serene tropical forest vegetation had been dissected into diverse patches through the years, but has never been addressed yet in scientific literatures. Hence, better understanding in the development of modern vegetation landscape on Mount Makiling with its consequent appropriate management is greatly hindered.

Fortunately, Brown (1919) had successfully documented the vegetation when Mount Makiling was still dominated by the dipterocarps which could be made as reference point for succeeding comparative studies. Payawal (1983), using cluster and ordination analyses, compared the altitudinal ranges of vegetation on Mount Makiling with the findings of Brown (1919). They found out a total of 37 major taxa showing elevational displacements of various degrees of amplitude. This indicated that anthropogenic disturbance, especially the selective logging between 1942-1944, had resulted in the creation of habitats and niches which these taxa were later able to occupy. In a later study of community structure within the presently undisturbed and protected but once logged-over forest of Mt Makiling, Luna *et al.*, (1999), found various guilds with complex structure differing in topographic preferences, functional status and stages of succession.

The aforementioned studies are providing significant background information regarding the forest as a land use type but did not address the other land use type patterns associated with ongoing human impact developing on Mount Makiling. This needs to be understood well to shed light on the dynamics of change and to better address the issue on appropriate forest landscape management favorable for both man and nature.

In this study, the focus of the discussion is on (1) the diversity of land use type patterns on Mount Makiling using cluster analysis and (2) the environmental variables correlated with development of these patterns using canonical correspondence analysis.

MATERIALS AND METHODS

Study area: The study area was Mount Makiling, Luzon Island, Philippines (121011'E, 14008'N, 1114m altitude) (Fig. 1). It is a national park and a forest reserve situated in Los Baños, Laguna, some 65 kilometers south of Manila. Specifically, the area under investigation was mainly on the eastern slopes covering an altitudinal range of 400-510 m above sea level (a.s.l.).

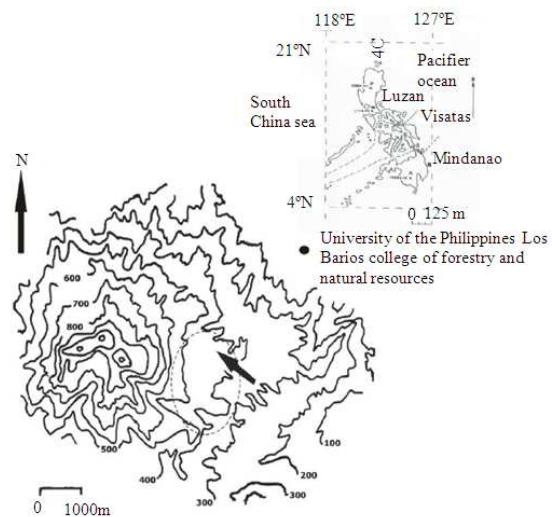


Fig. 1: The study area (enclosed by an oval as pointed by an arrow) on the eastern slopes of Mount Makiling, Los Baños, Laguna, Philippines. The Philippine map (inset) shows the location of Mount Makiling (M)

The study site was selected because of the presence of agricultural farms, residential areas and undisturbed forests in the vicinities. The biodiversity of Mount Makiling, especially the eastern portion, is generally well managed and protected by the Makiling Center for Mountain Ecosystems (MCME) of the College of Forestry and Natural Resources (CFNR), UPLB. Entry of migrants and expansion of clearings are greatly regulated.

The climate is tropical monsoon in nature with two distinct seasons as clearly presented in the climate diagram (Fig. 2). It is wet from May to December and dry, from January to April. The mean annual precipitation recorded in ten years at the UPLB Meteorological Station, College, Laguna, was 2,045mm while the mean annual temperature from the same station and in that same ten-year-period was 27.4°C (Fig. 2).

Establishment of plots: Three belt transects of 200m interval from each other, spanning north to south direction from the most undisturbed forests to the most vulnerable agricultural farms, were established in the main study site (Fig. 1). The length of each belt was dependent on the distance from the undisturbed forest to the farms. A total of forty permanent plots were set up, thirty-five of which were 10×10m in size, while five were 20×20m in size.

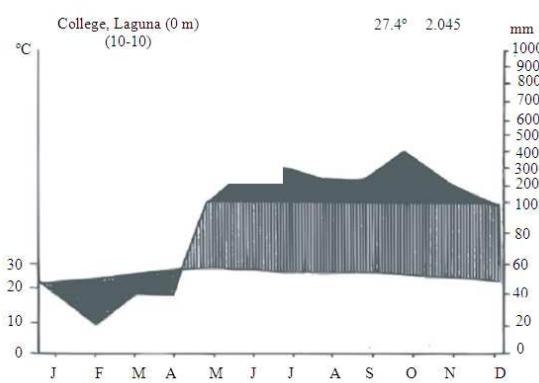


Fig. 2: The climate diagram (average of 10 years for both temperature and rainfall data) of College, Los Baños, Laguna, Philippines located at the base of Mount Makiling

Field data collection: All woody species encountered in each plot, including palms having a diameter at breast height (DBH) of 5cm or more were tagged and mapped out. The common and scientific names were identified and the DBH was recorded. Stem density was calculated while the basal area was computed from DBH data. Likewise, the slope, altitude and distance from the agricultural farms were indicated. Herbarium specimens were also prepared and deposited at the Plant Biology Division Herbarium (PBDH), Institute of Biological Sciences, College of Arts and Sciences, UPLB. Nomenclature follows that of Pancho and Guezo (2006).

Dominance analysis: Dominance was based on the Relative Basal Area (RBA) of each species. The number of dominant species was determined quantitatively using the equation of Ohsawa (1984) as follows:

$$d = \frac{1}{N} \left\{ \sum_{i \in T} (x_i - \bar{x})^2 + \sum_{j \in U} x_j^2 \right\}$$

where, d = the deviation, x_i = the actual percent share [in this case, the RBA] of the top species (T), i.e., the top dominant in the one-dominant model, or the two top dominants in the two-dominant model and so on, \bar{x} = the ideal percent share based on the aforementioned model, x_j = the percent share of the remaining species (U) and N = the total number of species.

Cluster analysis: The total stem density values of each species in a plot were subjected to cluster analysis using

the Euclidean distance. A dendrogram was then constructed using the average linkage clustering within group (Sneath and Sokal, 1973). Each distinct cluster was indicated with the dominant species and the prevailing land use type.

Ordination analysis: In order to identify the environmental factors correlated with the species stem density data in each land use type, Canonical Correspondence Analysis (CCA) of (Gajoti *et al.*, 2010; Ter Braak, 1986) was used. Three environmental variables, altitude, slope and distance from the agricultural farm were chosen and measured in the field.

RESULTS

Land use types on mount makiling: The total stem density values of each species in each of the 40 plots near human disturbed landscapes on Mount Makiling, were subjected to cluster analysis using the Euclidean distance. At a dissimilarity level of 7, the dendrogram (Fig. 3), constructed using the average linkage clustering within groups, shows 4 clusters or groups representing different land use types. The uppermost cluster (near residence and forest edge), however, was purposely separated due to the obvious difference in the specific type of disturbance associated with each, as actually observed in the field. The near residence site was associated with a farm house, while the forest edge was associated with an agricultural farm. Therefore at this dissimilarity level of 7, we arbitrarily recognized 5 distinct clusters of land use types, namely, agricultural farm, area near residence, forest edge, buffer zone and undisturbed forest.

Agricultural farm refers to clearings of farmers planted to crops. Area near residence includes sites in the immediate vicinity of farm houses where farmers either reside temporarily or permanently. Forest edge is the forested area immediately next to the agricultural farm. The buffer zone is also a forested area but lies in between the forest edge and the undisturbed forest. The undisturbed forest refers to the well protected and intact forest of Mount Makiling.

Interestingly, at a dissimilarity level of around 15, the dendrogram (Fig. 3) showed only 2 distinct clusters clearly delineated by the associated disturbance regime. The cluster associated with an anthropogenic disturbance (agricultural farm, near residence and forest edge) and the more or less stable cluster, relatively free from human activity, composed of the buffer zone and the undisturbed forest are clear and evident.

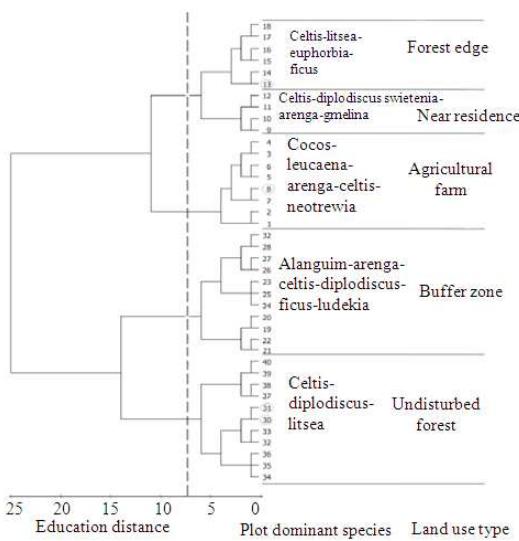


Fig. 3: The dendrogram constructed by average linkage within groups of the Euclidean distance showing 5 land use types and their respective dominant species from among 40 plots

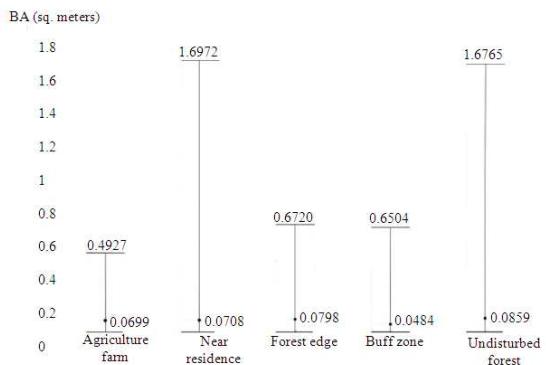


Fig. 4: The maximum and mean basal area (BA) values (sq m/100 sq m) of the the 5 land use types

This suggests that stem density as the species variable used in the cluster analysis was indeed reflective of the actual field conditions.

Floristic composition and dominant species in each land use type: The details of the structural characteristics of the species composition in each of the aforementioned land use types are indicated in Table 1. A total of 89 species in 72 genera and 42 families were recorded from 40 plots having an aggregate area of 0.55 hectare. The species are arranged alphabetically within genera and within families respectively with their

abbreviations as used in the statistical analysis and the common names for convenience in case someone has to trace in the locality. The RBA and the Relative Density (RD) of each species in a land use type are also indicated to allow comparison of these values.

The number of species in each land use type varied as expected (Table 1). The frequently disturbed land use types, the agricultural farms, near residences and forest edges had only 17, 19 and 25, respectively. This is considerably lower compared with the buffer zone (45) and the undisturbed forest (45), obviously because man selected to a large extent what species he had wanted to grow in his farm or near his residence. Incidentally, the buffer zone and the undisturbed forest had the same total number of species, though not necessarily identical (Table 1).

Using Ohsawa (1984) model in determining the number of dominant species per land use type, the agricultural farm had 8 dominant species (Table 2 and those with asterisk * in Table 1), areas near residences had 6, the forest edge had 5, the buffer zone had 7, while the undisturbed forest had 3. A number of similar dominant species occurred in many land use types as dominants as well (Table 2). *Arenga pinnata*, *Celtis luzonica* and *Diplodiscus paniculatus* were prominent examples of these important species on Mount Makiling.

The mean and maximum BA values for 100 sq m were also compared across land use types (Fig. 4). The buffer zone had the lowest mean BA while the undisturbed forest had the highest mean. The maximum BA however, was highest in near residence and undisturbed forest and lowest in agricultural farm. This is indeed possible on Mount Makiling, since all activities in the park are now being closely managed and monitored by the UPLB authorities. Residents are bound by a contract not to cut existing trees even if these are near residences or agricultural farms. Hence, it is not unusual to find older stands of trees growing in patches near agricultural farms and near residences (Table 1 and 2) and some of them even exceeded the BA values of trees in the undisturbed 6 forests (Fig. 4). Nevertheless, the analysis of variance (ANOVA) did not show any significant difference among mean BA values across land use types ($p\text{-value}>0.05$).

Stem density, (Table 1) was also analyzed. ANOVA showed significant differences in mean stem density among land use types ($p\text{-value}<0.01$). Multiple comparisons using the least significant difference test (LSD) indicated that the mean stem density of the undisturbed forest was significantly different from the mean stem density of all the other land use types ($p\text{-value}<0.05$).

Table 1: Species composition of the 5 land use types on Mount Makiling showing Relative Basal Area (RBA) and Relative Density (RD). Species are arranged alphabetically in genera and in families. Dominant species are indicated with asterisk (*)

Land use type	Agricultural Farms		Near Residence		Forest Edge		Buffer Zone		Undisturbed Forests	
	10x10	10x 10	10x 10	10x 10	10x10	10x10	10x10	10x10	20x20 / 10x10	
No. of Plots	7		6		5		13		5/4	
No. of Species	17		19		25		45		45	
Mean stem density/ha	0.0174		0.0188		0.0129		0.0157		0.0061	
	RBA	RD	RBA	RD	RBA	RD	RBA	RD	RBA	RD
Family / Species	Common name									
Alangiaceae										
<i>Alangium longiflorum</i> Merr.	malatapai		2.84	2.78			10.38*	4.1	0.78	2.58
<i>Alangium javanicum</i> (Blume) Wang var. <i>jaheri</i> Bloem.	putian				0.1	1.82	0.99	1.79	0.45	2.28
Annonaceae										
<i>Papualthia lanceolata</i> (Vid.) Merr.	anolang						0.38	1.54		
<i>Platymitra arborea</i> (Blanco) Kesler	bolon								0.06	0.41
Apocynaceae										
<i>Wrightia pubescens</i> R.Br. Ssp. <i>laniti</i> (Blanco) Ngan	lanete	0.54	1.79							
Araliaceae										
<i>Brassaia actinophylla</i> Endl	umbrella tree	11.33*	1.59							
<i>Polyscias nodosa</i> (Blume) Seem	malapapaya					0.38	2.5			
Arecaceae										
<i>Arenga pinnata</i> (Wurmb) Merr.	kaong	6.41*	1.79	7.03*	1.39	5.15	17.60*	11.49		
<i>Caryota cumingii</i> Lodd.	pugahan				0.23	1.85		0.49	1.18	
<i>Cocos nucifera</i> L.	coconut	19.57*	21.79							
<i>Psedopinanga insignis</i> (Becc) Burr.	sarauag							0.12	1.4	
Bignoniaceae										
<i>Spathodea campanulata</i> Beauv.	African tulip					4.39	2.5			
Burseraceae										
<i>Canarium hirsutum</i> Willd.	dulit			0.02	2.08					
Cecropiaceae										
<i>Musanga cecropioides</i> R. Br.	musanga			3.46	2.78					
Clusiaceae										
<i>Garcinia dulcis</i> (Roxb.) Kur	taklang-anak			0.2	1.85				0.02	0.22
<i>Garcinia venolusa</i> (Blanco) Choisy	gatasan								0.92	0.57
Combretaceae										
<i>Terminalia foetidissima</i> Griff.	talaisai-gubat		0.2	1.85						
<i>Terminalia microcarpa</i> Decne.	kalumpit		2.85	2.78						
<i>Terminalia nitens</i> Presl	sakat							1.52	1.25	
Dilleniaceae										
<i>Dillenia philippinensis</i> Rolfe	katmon				5.01	1.82	0.72	1.28	0.38	1.13
Dipterocarpaceae										
<i>Parashorea malaanonan</i> (Blanco) Merr.	bagtikan				0.38	5.15	0.48	0.7	0.38	1.78
<i>Shorea contorta</i> Vidal	white lauan	1.76	1.85							
<i>Shorea guiso</i> (Blanco) Blume	guijo						0.82	3.23	0.21	0.64
Ebenaceae										
<i>Diospyros discolor</i> Willd.	kamagong								0.7	0.91
<i>Diospyros pyrrhocarpa</i> Miq.	anang			2.23	5	2.35	3.08			
Euphorbiaceae										
<i>Antidesma pentandrum</i> (Blanco) Merr. var pentandrum	bignai-pugo					0.04	0.77			
<i>Bridelia penangiana</i> Hook.f.	subiang	0.19	1.59							
<i>Claoxylon albicans</i> (Blanco) Merr.	malalipa								0.04	0.41
<i>Dimorphocalyx luzoniensis</i> Merr.	kulis-pakatan									
<i>Euphorbia</i> sp.					17.21*	3.33	0.26	0.51		
<i>Macaranga bicolor</i> Muell.-Arg.	hamindang					0.07	1.54	0.08	0.57	
<i>Macaranga grandifolia</i> (Blanco) Merr.	takip-asin			0.43	2.5	0.1	0.55	0.09	0.58	
<i>Neotrewia cumingii</i> (Muell.-Arg.) Pax & K. Hoffm.	apanang	5.21*	4.76			1.44	1.28	1.51	5.39	
Fabaceae										
<i>Leucaena leucocephala</i> (Lamk.) de Witt	ipil-ipil	14.72*	16.07							
<i>Pterocarpus indicus</i> Willd. forma <i>indicus</i>	narra								0.06	0.57
Icacinaeae										
<i>Gomphandra luzoniensis</i> (Merr.) Merr.	mabunot					0.19	0.55			
Lauraceae										
<i>Litsea garciae</i> Vid.	bangulo				20.40*	9.77			9.07*	1.85
<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	sablot	1.31	1.79	0.06	2.78					
<i>Persea americana</i> Mill.	avocado									
Lecythidaceae										
<i>Planchonia spectabilis</i> Merr.	lamog	0.18	4.76				0.23	0.51	2.82	0.84
Malvaceae										
<i>Thespesia populnea</i> (L.) Soland. ex Corr.	banalo							0.67	0.56	
Melastomataceae										

Table 1: Continuous

<i>Astronia williamsii</i> Merr. ex C.B.Rob.var. williamsii Merr.ex C.B.Rob.	dungau				0.06	1.54		
<i>Memecklon subfurfuraceum</i> Merr.	digneck						0.08	0.57
Meliaceae								
<i>Aglaia edulis</i> (Roxb.)Wall.	malasaging				2.06	2.28	0.69	1.97
<i>Chisocheton cumingianus</i> (C. DC.)	balukanag	7.91*	8.33	2.86	8.33	1.25	1.4	3.4
Harms ssp.cumingianus								12.92
<i>Chisocheton pentandrus</i> (Blanco) Merr. ssp.pentandrus	katong-matsin				0.09	0.48	0.08	0.44
<i>Dysoxylum arborescens</i> (Blume) Miq.	kalimutan						0.2	0.22
<i>Swietenia macrophylla</i> King	mahogany	17.61*	6.48				1.53	3.38
<i>Toona calantas</i> Merr. & Rolfe	kalantas						1.46	0.56
					0.08	1.47	0.15	0.57
Moraceae								
<i>Artocarpus blancoi</i> (Elm.) Merr.	antipolo				0.12	1.25		
<i>Ficus congesta</i> Roxb.var. congesta	malatibig						0.02	2.22
<i>Ficus heteropoda</i> Miq.	alangas	2.38	1.79					
<i>Ficus irisana</i> Elmer var irisana	aplas				0.03	0.55		
<i>Ficus magnolifolia</i> Blume.	kanapa							
<i>Ficus nota</i> (Blanco) Merr.	tibig	0.06	1.59	0.16	4.17	11.83*	2.5	
<i>Ficus</i> sp.					1.96	8.48	5.03*	3.59
<i>Ficus ulmifolia</i> Lam.	is-is				13.91*	5.45	4.45*	2.44
						0.04	0.7	
Myristicaceae								
<i>Gymnanthera farquhariana</i> (Hook.f&Th.)Warb.	anuping				0.06	1.82	0.04	0.55
var. paniculata(A.DC.) Schout.	yabnob					0.35	0.48	0.02
<i>Horsfieldia costulata</i> (Miq.) Warb.	tambalau				0.24	1.85	0.82	0.71
<i>Knema glomerata</i> (Blanco) Merr.								2.11
Myrsinaceae								
<i>Ardisia squamulosa</i> Presl	tagpo	2.53	1.79					
Myrtaceae								
<i>Leptospermum flavescens</i> J. Sm.	malasulas				0.18	0.48		
<i>Syzygium caudatifolium</i> (Merr.) Merr.	taguhangin				1.11	1.28		
<i>Syzygium</i> sp.							0.02	0.41
Nyctaginaceae								
<i>Pisonia umbellifera</i> (Forst.)Seem.	anuling				0.06	1.82	0.39	1.44
Olaceace								
<i>Strombosia philippinensis</i> (Baill.) Rolfe	tamayuan					0.15	0.7	0.29
Oraginaceae								
<i>Oraginaceae</i> sp.							0.45	0.22
Rosaceae								
<i>Prunus grisea</i> (Blume)Kalkm. var grisea	lago				0.07	1.82		
Rubiaceae								
<i>Coffea arabica</i> L.	coffee	0.75	7.94		0.16	2.5		
<i>Ludekia bernardoi</i> (Merr.)Ridsd	ludek					5.48*	0.85	0.03
Rutaceae								
<i>Citrus macroptera</i> Montr.	kabuyau							0.03
<i>Citrus</i> sp.		0.58	3.21					0.36
Sabiaceae								
<i>Meliosma pinnata</i> (Roxb.)	balilang-uak				0.02	2.08		
Maxim. ssp.macrophylla (Merr.)v.Beus.							3.08	0.7
Sapindaceae								
<i>Cubilia cubili</i> (Blanco) Adelb.	bulala					0.87	0.51	
<i>Sapindus saponaria</i> L.	kusebeng					0.47	0.7	
Sapotaceae								
<i>Palaquium philippense</i> (Perr.)C.B.Rob.	malak-malak				0.38	3.7	1.34	4.32
Staphyleaceae								
<i>Turpinia ovalifolia</i> Elmer	anongo							0.07
Sterculiaceae								
<i>Pterospermum diversifolium</i> Blume	bayok							
<i>Pterocymbium tinctorium</i> (Blanco). Merr.	taluto	11.02*	8.13	0.35	6.02		0.32	3.1
<i>Sterculia crassiramea</i> Merr.	tapinag						1.08	1.13
Theaceae								
<i>Camellia lanceolata</i> (Blume) Seem.	haikan				0.06	1.82		
Tiliaceae					0.41	2.5	0.59	0.7
<i>Diplodiscus paniculatus</i> Turcz.	balobo				27.23*	9.72		
Ulmaceae							20.84*	9.63
<i>Celtis luzonica</i> Warb.	magabuyo	15.23*	17.86	14.50*	26.39	13.63*	8.64	13.43*
Urticaceae							18.48	15.45*
<i>Dendrocnide luzonensis</i> (Wedd.) Chew var. luzonensis	lipa					0.06	3.64	
<i>Villebrunea trinervis</i> Wedd.	alilaua					0.89	5	0.25
Verbenaceae								1.44
<i>Clerodendrum minahassae</i> Teysm. & Binn.	bagauak						0.3	1.4
<i>Gmelina arborea</i> Roxb.	yemane				13.14*	11.11		
<i>Vitex turczaninowii</i> Merr.	lingo-lingo						0.06	0.85
Vitaceae								
<i>Leea guineensis</i> G.Don	mali-mali	7.99*	1.79			0.05	1.82	

Table 2: Occurrence of dominant species in various land use types on Mount Makiling

Dominant species	Agricultural Farms	Near Residence	Forest Edge	Buffer Zone	Undisturbed Forest
<i>Alangium longiflorum</i> Merr.	-	-	-	+	-
<i>Arenga pinnata</i> (Wurm) Merr.	+	+	-	+	-
<i>Brassaia actinophylla</i> Endl.	+	-	-	-	-
<i>Celtis luzonica</i> Warb.	+	+	+	+	+
<i>Chisocheton cumingianus</i> (C. DC.) Harms ssp. <i>cumingianus</i>	-	+	-	-	-
<i>Cocos nucifera</i> L.	+	-	-	-	-
<i>Diplodiscus paniculatus</i> Turcz.	-	+	-	+	+
<i>Euphorbia</i> sp.	-	-	+	-	-
<i>Ficus magnoliifolia</i> Blume.	-	-	+	-	-
<i>Ficus nota</i> (Blanco) Merr.	-	-	-	+	-
<i>Ficus</i> sp.	-	-	+	+	-
<i>Gmelina arborea</i> Roxb.	-	+	-	-	-
<i>Leea guineensis</i> G.Don	+	-	-	-	-
<i>Leucaena leucocephala</i> (Lamk.) de Witt	+	-	-	-	-
<i>Litsea garciae</i> Vid.	-	-	+	-	+
<i>Ludekia bernardoi</i> (Merr.) Ridsd.	-	-	-	+	-
<i>Neotrewia cumingii</i> (Muell.-Arg.) Pax & K. Hoffm.	+	-	-	-	-
<i>Pterocymbium tinctorium</i> (Blanco). Merr.	+	-	-	-	-
<i>Swietenia macrophylla</i> King	-	+	-	-	-

+ present, - absent

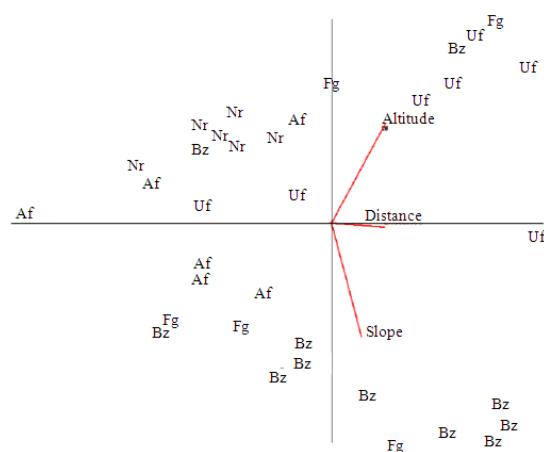


Fig. 5: Ordination diagram using the canonical correspondence analysis (CCA) of Ter Braak (1986, 1994), showing a linear relationship between the species data (stem density) and the environmental variables, altitude, slope and distance from the agricultural farm (Ag=agricultural farm, Nr=near residence, Fg=forest edge, Bz=buffer zone, Uf=undisturbed forest)

Environmental variables related to species variation: The CCA multiple correlations (the intra set correlations of Ter Braak, 1986) (Table 3) and the CCA graph (Fig. 5) revealed linear relationship between the species data (stem density) and the three CCA axes,

represented by altitude as axis 1 ($R = 0.420$), slope as axis 2 ($R = -0.879$) and distance from the agricultural farm as axis 3 ($R = -0.913$).

Many plots of Undisturbed Forests (Uf) were influenced by altitude and were quite far from the Agricultural Farms (Af), which were generally found in lower altitudes and gentle slopes as the near residence (Nr) plots. If ever, residences were situated in higher altitudes, they were in moderately gentle slopes (Fig. 5). In contrast, buffer zones (Bz), were almost always in steeper slopes. Forest edges (Fg), follow the trend of the agricultural farms.

DISCUSSION

Results showed diverse land use types in a belt transect spanning from the undisturbed forest to an agricultural farm. The once homogeneous tropical rain forest landscape on Mount Makiling, has now diverse land use types (Fig. 3), in the study area, particularly on the eastern side of the mountain (Fig. 1). The arbitrarily designated land use types are clearly distinct and well delineated by the species stem density data (Fig. 3).

A totally different group of species are dominating on Mount Makiling now (Table 1-2) as compared with the original vegetation reported by Brown (1919). The dominating dipterocarps in 1919 were selectively logged and heavily harvested between 1942-1944 (Payawal, 1983; Luna *et al.*, 1999; Lasco *et al.*, 2001).

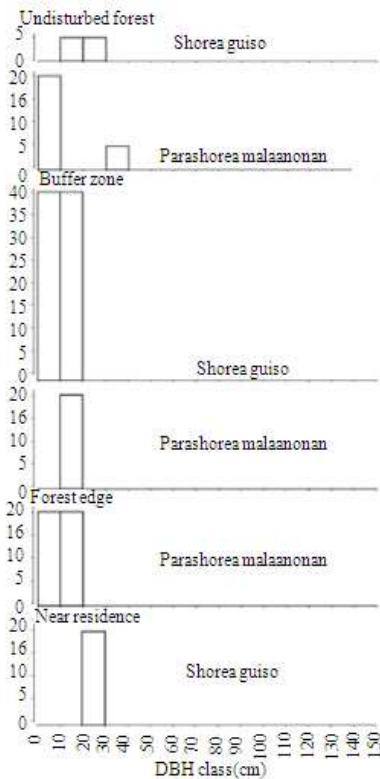


Fig. 6: The diameter at breast height (DBH) class distribution of the three species of dipterocarps, the former dominants of the forest landscape on Mount Makiling

Table 3: Canonical coefficients and intra set correlations of experimental variables with the 3 axes of CCA for the Mt. Makiling data (axis 1-altitude, axis 2-slope and axis 3-distance from farms).

Variable	Coefficients			Correlations		
	Axis 1	Axis 2	Axis 3	Axis 1	Axis 2	Axis 3
Distance	0.633	-0.053	-0.35	0.406	-0.029	-0.913
slope	0.608	-0.443	-0.21	0.233	-0.879	0.417
altitude	0.706	-0.297	0.222	0.42	0.782	0.46

Eigenvalues for axes 1=0.483, 2=0.388 and 3=0.260; Total variance (inertia) in species data: 11.7412

So far, in the study site, only three species of dipterocarps were noted, *Shorea contorta*, *S. guiso* and *Parashorea malaanonan*. The three species were still occupying the lower DBH classes and only in four land use types of this study (Fig. 6). Judging from the results as shown in Fig. 6, it will still have to take several years before the dipterocarps can regain dominance over the forest landscape on Mount Makiling, even under the present set up, where the mountain is a national park and a forest reserve managed by UPLB.

It has been repeatedly emphasized in literature that factors causing landscape heterogeneity are either natural or anthropogenic in nature or a combination of both (Alfred *et al.*, 2010; Solaimani *et al.*, 2009; Elhadi *et al.*, 2009; Marian *et al.*, 2009). Natural factors can be site factors such as soil, elevation, slope or disturbances as typhoons and landslides. These can induce distinct patches in a matrix and produce a heterogeneous landscape. Similarly, human clearings and croplands can result to diversity of patches depending on the magnitude of activity.

In the present study, altitude, slope and distance from the agricultural farms had been linearly correlated with the species stem density in various land use types (Fig. 5). The results confirmed that site factors are considered main important determinants of landscape heterogeneity as previously reported by (Suzuki *et al.*, 2002). Thus, most of the undisturbed forests on Mount Makiling were located in higher altitudes and many buffer zones were in steeper slopes (Fig. 5). Higher altitudes and steeper slopes posed some difficulty for humans to establish their farms and farm houses. Consequently, human disturbances on Mount Makiling, created patches of agricultural farms and residences situated in lower altitudes and moderate slopes at a considerable distance from the undisturbed forest plots.

CCA results, however, could explain only 11.74% of the variance in the data (Table 3), implying that there should be more environmental variables that could possibly explain the variation but were not included in the analysis. These environmental variables, known and established to cause variation in species data may include precipitation (Buot and Okitsu, 1999, Ohsawa 1995), temperature (Buot and Okitsu, 1999; Richards, 1952), humidity (Richards, 1952), soil conditions (Heryati *et al.*, 2011b, Suzuki *et al.*, 2002), microbial composition, natural disturbances particularly, typhoon, erosion and landslides and anthropogenic disturbance history (Heryati *et al.*, 2011a; Muniandy *et al.*, 2009; Hong *et al.*, 1995; Osumi *et al.*, 2003). However, more works and experiments have to be done in testing these variables on Mount Makiling.

CONCLUSION

The role of the University of the Philippines Los Baños (UPLB) in implementing the Philippine forest policy so as to regulate the further spread of various land use types on Mount Makiling should have contributed to the present vegetation pattern as well. Knowing that the original dominants, the dipterocarps, will still have a long way to regain dominance over the forest landscape, it is urgent to do intensive studies on

the present dominants, *Celtis luzonica*, *Diplodiscus paniculatus* and *Ficus* spp. These species play a very significant role in stabilizing and sustaining the ecosystem landscape. Elucidating the species biology of these dominants will shed light on the dynamics of the once logged-over forest landscape on Mount Makiling and even other southeast Asian mountain forests for that matter. Hopefully, when these data will be made available on hand, we can finally develop appropriate forest landscape management system favorable to both the forest and the human population living in the uplands.

ACKNOWLEDGEMENT

The researchers are grateful to Dr. Edwino S. Fernando, then Director of the Makiling Center for Mountain Ecosystems (MCME), College of Forestry and Natural Resources (CFNR), University of the Philippines Los Baños (UPLB), Dr. Emmanuel Abraham, the then Superintendent of the Makiling Forest Reserve, MCME and Ms. Amelita C. Luna of the Office of the Coordinator for Research and Extension, CFNR, for facilitating the fieldwork. The Japan Society for the Promotion of Science (JSPS) through the Forestry and Forest Products Research Institute (FFPRI), Japan, awarded a postdoctoral fellowship to the senior author.

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