Agham Mindanaw, 2004, Volume 2, pp. 11-24. Ateneo de Davao University

A REVIEW OF RESEARCH ON PHILIPPINE FOREST VEGETATION, PARTICULARLY WORK SINCE 1990

Gerhard Langenberger
University of Hohenheim
Institute of Plant Production and Agroecology in the Tropics and Subtropics (380b)
70593 Stuttgart, Germany
langenbe@uni-hohenheim.de

Key words: Philippines, forest vegetation, vascular plant diversity, lowland forest, local names

Abstract - The Philippines is one of the most important biodiversity hotspots on earth. This paper reviews research on forest vegetation in the Philippines conducted since 1990, identified using modern search technologies such as the internet and scientific online databases. Philippine forest vegetation is still poorly represented in international research compared to other tropical rainforest areas. Only three recent species checklists or enumerations were identified for the whole of the Philippines, one for the island of Cebu, one for Palawan, and one for Cabra Islet in Occidental Mindoro. Two of them are not freely accessible. The number of published studies dealing with forest vegetation is also limited. Despite the ecological importance of Philippine forests and the threats they face, knowledge about them has progressed only slightly since the beginning of the last century when the forest types were defined and described. Most recent research focused on trees, often using the traditional lower diameter limit of 10 cm dbh. Smaller trees and other life forms are usually neglected although they account for the bulk of species richness. Additionally, most studies deal with forest vegetation at higher elevations. Lowland forest, the most threatened habitat in the Philippines, is rarely the focus of studies, very likely because intact lowland forests hardly exist anymore.

Local plant names and the consultation of tree spotters play an important role in Philippine forest vegetation studies. This practice, although potentially very helpful, is prone to errors. Local names used by tree spotters are not necessarily identical with the standardized use in the forestry sector and the scientific literature. The situation is further complicated by the fact that many Philippine tree species can be grouped into timber classes whose names at the same time represent single species, e.g., white lauan. The uncritical "translation" of local plant names into scientific species results in unreliable species lists which hamper progress in understanding Philippine forest vegetation and ecology. In this context the importance of field characters for preliminary identifications must be stressed.

INTRODUCTION

The Philippines is a global biodiversity hotspot with high degrees of species richness and endemism (Ashton 1993, Heaney & Regalado 1998, Myers *et al.* 2000). This uniqueness is largely correlated with pristine vegetation. Devastated areas are mostly occupied by a few ecological generalists which are often pantropical, like the grass *Imperata cylindrica* and the fern *Pteridium aquilinum*, or have been - willingly or unwillingly - introduced by man, as the ornamental amaranth *Celosia argentea*. Such species have insignificant conservation value, and can be aggressive pests that further weaken destabilized ecosystems.

Despite the extraordinary status of the Philippines as a biodiversity hotspot as well as the threats of environmental destruction, the country,s remaining forests and their biodiversity are poorly represented in research. Sohmer (2001) stated that many so-called narrow endemics in the Philippines are likely to go extinct without ever having been described. Concerning the most conspicuous components of forests, the tree species, it has been suggested that the Philippines might be the least known country in southeast Asia (Soerianegara & Lemmens 1994).

Additionally, forest vegetation studies commonly cover only trees above a given minimum diameter, often being 10 cm at breast height (dbh). This practice masks the real plant biodiversity of forests since smaller trees and other life forms like herbs contribute much to the overall plant species diversity. On Mt. Mariveles at the entrance of Manila Bay, Luzon, in the Lamao River Reserve, covering an elevational range from sea level to c. 1400 m a.s.l., of the 1151 species and varieties identified, 686 were woody plants, of which 485 species were classified as trees reaching a height of at least 5 m (Merrill 1906). Thus 58% of all plant species and varieties recorded were either herbaceous (465 species) or woody shrubs, undershrubs, and scandent shrubs (201 species). With the application of a 10 cm dbh limit an additional portion of woody species which were taller than 5 m but did not reach the 10 cm diameter threshold would have been omitted, and the proportion of the plant species richness excluded by this diameter limit would have been at least two-thirds. Gentry and Dodson (1987) also stressed the importance of the contribution of trees smaller than 10 cm dbh as well as "nontrees" to overall species richness in tropical rain forests. My own studies on the species composition in a lowland forest area located at an elevational range between 55 and 530 m a.s.l. on Leyte, Philippines, which covered all vascular plants except crown epiphytes, showed similar results (Langenberger 2003). Of all plant species recorded in a total sampling area of 0.49 ha composed of 49 non-contiguous plots, only c. 30% of the species were trees growing taller than 5 m.

A comprehensive overview of the literature dealing with Philippine botany and vegetation up to 1992 has been compiled by Madulid & Agoo (1992). Since this bibliography is not readily available outside the Philippines, I have listed those publications dealing with Philippine vegetation and not mentioned elsewhere in this paper in Table 1.

The broad foundation of Philippine forest vegetation analysis was established in the beginning of the 20th century. *The Flora of the Lamao Forest Reserve* (Merrill 1906) and the associated *Vegetation of the Lamao Forest Reserve* (Whitford 1906), *The Flora of Mt. Halcon* (Merrill 1907), *The Flora of Mt. Pulog* (Merrill and Merritt 1910), *Philippine dipterocarp forests* (Brown & Mathews 1914), and *Vegetation of Philippine Mountains* (Brown 1919) are valuable records of what Philippine forests used to be. "The ascent of Mount Halcon, Mindoro" (Merrill 1907) describes not only the forest conditions encountered during that first documented ascent of Mt. Halcon, but also gives a very vivid impression of the sacrifices made during expeditions at that time.

The most important of the early publications might be *The Forests of the Philippines* by Whitford (1911). Whitford defined the Philippine forest types and described their characteristic tree species as well as the typical environment where these forest types and tree species were found. However, at that time, the taxonomic treatment of Philippine plant species - both for trees and non-trees - was still in its infancy, making comparisons of these early descriptions with later vegetation studies and their respective species lists difficult or even impossible.

The economically dominant role of the dipterocarps appears to have inhibited detailed vegetation studies, because the great majority of forest species have been of minor commercial importance. The tendency to sort the 65 dipterocarp species (Ashton 1993) into few timber groups, e.g., white and red lauan, apitong, and yakal (Anonymous 1977) hampers forest vegetation analysis up to the present day. Comparisons with or reconstructions of the former forest composition of an area are tricky, because it can be impossible to determine which species are really covered by labels like "white lauan", "red lauan", and "apitong".

The objective of this paper is to present an overview of studies on Philippine forest vegetation over the last 15 years that are accessible on an international level. I will try to evaluate the current status of vegetation studies, taking into account my own experience and observations on the island of Leyte (Langenberger 2000, 2003).

METHODS

The focus of this paper is on studies published after 1990 that deal with the ecology and plant-biodiversity of Philippine forest vegetation. These publications were identified using several procedures. The literature already identified for my own study from 1996 to 1998 (Langenberger 2003) served as basis. Additionally, I searched scientific articles indexed or abstracted in the data bases *CAB Abstracts* and *Current Contents* from 1984 to October 2003, and I conducted an internet search with the search engine Google. As search parameters for both electronic searches I applied the following terms as well as combinations of the terms: Philippines, diversity, tropical rain forest, vascular plant species, vegetation, undergrowth. The articles and references brought up by the search were evaluated concerning their relevance for this paper. Papers discussing the importance of forest vegetation for biodiversity conservation, soil preservation, and watershed management that did not add any new facts about those forests were not included in this treatment.

RESULTS

Publications since 1990 addressing Philippine forest vegetation can be classified into three categories:

Articles with a taxonomic background. The revision of Philippine *Medinilla* by Regalado (1995) and all revisions for Flora Malesiana (van Steenis 1950-ongoing) belong to this category. Publications on new species or new records also belong to this category, typical examples being the description of new moss records from Mindanao (Tan *et al*. 2000) or Mindoro (Tan & Mandia 2001). Although such publications contain valuable information on the ecology of the respective species (e.g., life form, distribution, habitat), their main focus is of a documentary and classificatory kind, and not that of an ecological approach.

A second category of article reports the plant species found in a given area or island, like the checklist of flowering plants of Cebu Island by Bicknell & Bicknell (2001). Its information is of special importance for the evaluation of the ecological status and conservation value of the studied locality. Such a checklist enables conclusions on the vegetation types occurring in the area, if the ecology and habitat preferences of species are well known. However, this is often not the case, and only few species or species groups are so characteristic for a given habitat as mangroves.

The third category of publication deals with the interactions between plants and their environment, be it other plants, animals, or the abiotic environment comprising soils, precipitation, and elevation and temperature. These can be classified as ecological studies aiming at a better understanding of complex environmental correlations. Examples are Proctor *et al*. (1998), Buot and Okitsu (1999), or Ingle (2003).

With the exclusion of taxonomic treatments, the first category, all accessible studies and references encountered during my searches on articles on Philippine forest vegetation are listed in Table 2. Taxonomic treatments were omitted because they are focused on plant groups and their classification and not on the species composition of a given vegetation type or locality. Theses and reports that are only locally accessible were not included.

SPECIES LISTS

Bicknell & Bicknell (2001) compiled a species check list for the whole of Cebu island and listed 1467 species of spermatophytes. They did not include plants which were found exclusively in cultivation - a discrimination and clarification desirable also for other studies. As a checklist for the whole island, it encompasses Cebu´s environmental heterogeneity in terms of soils, elevation, and degree of disturbance. In contrast to many other species lists based on herbarium specimens which might have been collected 100 years ago, the list by

Table 1. Publications on Philippine vegetation (excluding mangrove forests) before 1990, based on the compilation by Madulid and Agoo (1992), with some additions.

Title[1]	**Remarks**
Abrams, N. (1961): A short list of Mansaka flora and their uses. Philipp. J. Sci. 90(1): 25-36.	This article lists plants used by the Mansaka in the Davao region. It would nowadays be classified as ethnobotany. The species list is informative, comparing the Mansaka name, the common name, and the scientific name, as well as giving the use of the plants. It covers from mangrove to mountain habitats.
Allen, M.S. (1985): The rainforests of Northeastern Luzon and Agta foragers. In: The Agta of NE Luzon: Recent Studies. University of San Carlos, Cebu City, pp. 45-68.	
Bernard, M.A. (1959): The ascent of Mt. Apo, 1859-1958. Philipp. Studies 7(1): 7-67.	
Brown, W.H. and Argüelles, A.S. (1917): The composition and moisture content of the soils in the types of vegetation at different elevations on Mount Maquiling. Philipp. J. Sci. A, 12(5): 221-234.	An interesting article about moisture content of soils and its impact on vegetation. Despite much progress in knowledge on this matter the article is still worthwhile reading.
Brown, W.H., Merrill, E.D. and Yates, H.S. (1917): The revegetation of Volcano Island, Luzon, PI, since the eruption of Taal Volcano in 1911. Philipp. J. Sci. C. Botany 12(4): 177-248.	A comprehensive account on the status of the plant succession after the eruption of 1911 as well as background information on the volcano's history.
Colina, A. and Jumalom, J. (1973): Report on the flora of Basey Region, Southwestern Samar, Philippines. Leyte-Samar Studies 7(1): 38-68.	
Colina, A. and Jumalom, J. (1974): The geographical distribution of the flora of Catipla, Cebu and Basey, Samar. Philipp. Scientist 9: 33-41.	
Gates, F.C. (1914): Swamp vegetation in hot springs areas at Los Baños, Laguna, P.I. Philipp. J. Sci. C. 9(6): 495-516.	The only article encountered dealing with swamp vegetation. Swamp vegetation at Los Baños has been seriously modified since 1914. The article with its enumeration of species is therefore an important document.
Gates, F.C. (1914): The pioneer vegetation of Taal Volcano. Philipp. J. Sci. C. Botany 9(5): 391-434.	Gives an account on the vegetation of Taal volcano shortly after the 1911 eruption. As stated by Brown *et al.* (1917), the observations seem sometimes to be a bit superficial.

Herbert, D.A. (1924): Plant life on Mt. Makiling. Philipp. Agric. 13(5): 183-197.	
Jacobs, M. (1972): The plant world of Luzon´s highest mountains. Rijksherbarium, Leiden. 32 pp.	
Kellman, M.C. (1970): Secondary plant succession in tropical montane Mindanao. Research School of Pacific Studies. Publication BG/2. Australian National University. ISBN 0708103510.	Comprehensive study on plant succession and determining factors on Mindanao including species lists.
Mendoza, D.R. and Jacobs, M. (1968): A preliminary report of the botanical exploration of Mt. Pulog and Tabayoc, Kabayan, Benguet and the Sierra Madre Mt. Ranges at Dingalan and Baler, Quezon. Proc. of the 1968 Nat. Sci. and Tech. Week, Part 3: 411-439.	
Merritt, M.L. (1908): The Forests of Mindoro. Bur. For. Bull. No. 8. Manila, 51 pp.	
Pancho, J.V. (1967): F1ora of Volcano Island. Philipp. Agric. 50(7): 587-625.	
Panot, I.A. (1983): F1oristic composition of Mt. Pulog. Canopy 6:	
Payawal, P.C. and Markgraf, V. (1981): Vegetation and modern pollen rain of Mt. Makiling, Philippines. I. Vegetation analysis of the NE slope. Kalikasan, Philipp. J. Biol. 10(2-3): 255-267.	Classifies forests on Mt. Makiling using cluster analysis. Names some common species but does not give complete species list used for the analysis.
Seidenschwarz, F. (1988): Forest types of Cebu Island. Philipp. Quart. Cult. and Soc. 16(2): 93-105.	
Sutherland, R.K. (1944): Vegetation Study of the Philippines. AGS, SW Pacific Area, Philippines. 114 pp.	
Weidelt, H.J. and Banaag, V.S. (1982): Aspects of Management and Silviculture of Philippine Dipterocarp Forests. TZ Verlagsgesellschaft mbH, Bruchwiesenweg 19, D-6101 Rossdorf 1. (GTZ Publication Nr. 132). 302 pp. ISBN 3-88085-157-3.	Although dealing with the management of dipterocarp forests, this book contains much information about species composition of forest types and habitat preferences of tree species, especially on Mindanao. It also contains a chapter on mountain forests.
Whitford, H.N. (1909): Studies in the vegetation of the Philippines. I The composition and volume of the dipterocarp forests of the Philippines. Phil. Jour. Sci. C, 4(6): 699-747.	Deals mainly with economic aspects of dipterocarp forests in different regions of the Philippines.

Bicknell & Bicknell (2001) is the result of intensive field work during recent years and represents the current status of the island´s species composition. A comparable work is the "Preliminary checklist of the flowering plants of Palawan, Philippines" by Soejarto et al. (1995). While the check list by Bicknell & Bicknell (2001) was - at least for a short time - accessible as a web page that by Soejarto et al. (1995) is not publicly available (see entry in the Literature Cited section). A third species list has been published by Buot *et al*. (1990). They studied the flowering plants of the small Cabra Islet (965 ha) which is part of Lubang Island, Occidental Mindoro. They identified 68 families, 245 genera, and 308 species of flowering plants. As the authors state and as can be seen from the species list itself, Cabra Islet is a disturbed site dominated by weeds.

For completeness, the few, historical, species enumerations are also mentioned here. A comprehensive treatment of the flora found around Manila was given by Merrill (1912) in his *Flora of Manila*. It includes plant descriptions and identification keys, but suffers from its outdated taxonomy and age, which makes its present-day applicability questionable, taking into consideration the tremendous environmental changes which have taken place in the Manila area since the beginning of the 20th century. Another approach for a single mountain, the *Vascular Flora of Mount Makiling and Vicinity* by Pancho (1983), which includes very good drawings, has never been completed and is represented by only one volume. The most comprehensive species list is the *Enumeration of Philippine Flowering Plants* by Merrill (1923-26), which is the only publication dealing with the whole Philippines, but which is also in urgent need of a revised and taxonomically updated edition.

ECOLOGICAL STUDIES OF VEGETATION

The second group of data set treated here covers vegetation studies dealing with plants and their interactions with the environment. Five data sets deal with vascular plants and are not restricted to trees or woody plants alone. Gruezo and Badayos (1996) conducted an Environmental Impact Assessment for the Philippine National Oil Corporation around Mt. Labo, Camarines Norte Province, Luzon. They established six circular plots of 40 m diameter and seven rectangular plots of 50 m^2 within an elevational range from 410 to 1500 m a.s.l. The area was affected by large scale logging operations 30 years ago. A total of 385 species, 255 genera, and 112 families were identified, but the number of species found cannot be referred to the overall plot size inventoried (ca. 0.789 ha) because plants observed in the vicinity of the plots were also included.

Gruezo (1998) established transect lines on Pagbilao in Quezon, Luzon, and Pagbilao Grande Island covering a total area of 0.26 ha. The elevational range is not given, but the locality is a typical lowland environment. Gruezo (1998) encountered 301 vascular plant species. As can be seen from the species lists - which are of prime importance for every vegetation study - the area is highly degraded. Many of the listed species are typical pioneers, as well as naturalized exotics. A study by Belonias (2002) on Mt. Pangasugan, Leyte used plots covering 0.35 ha in total along an elevational gradient from lowland forest to the mossy forest at the summit of Mt. Pangasugan at 1158 m a.s.l. to investigate the impact of elevation on the occurrence of dicotyledons. My own study on the foothills of the same mountain (55-530 m a.s.l.) (Langenberger 2000, 2003), which comprised 49 plots of 100m^2 each, included all vascular plants except crown epiphytes. The comprehensive approach of these studies is reflected in the high species numbers encountered, e.g., the 314 dicotyledons found by Belonias (2002) on Mt. Pangasugan on an inventory area of 0.35 ha, or my own figure of 685 vascular plant taxa on 0.49 ha in the foothills of the same mountain. At higher elevations (1600-2701 m a.s.l.) on Mt. Amuyao, in Mountain Province on Luzon, Gonzales-Salcedo (2001) studied the impact of elevation on species occurrence and richness. In her data set the high number of species in the elevational zone from 1891 m to 2400 m a.s.l. is remarkable (202 species versus

64 in the zone below and 74 in that above). However, the elevational zones cover different ranges: the lowest zone (1600-1800 m a.s.l.) comprises an elevational range of 200 m, and the highest zone (2401-2701 m a.s.l.) covers 300 m, compared to 509 m elevational range of the species rich zone between them. The difference in species numbers between that height zone and the zones above and below may simply reflect the elevational extent of the zones combined with a high species turn-over with increasing elevation.

Six data sets published since 1990 provide information on species richness in forests below 1000 m, but all are limited to trees. In the 16 ha Palanan Plot in the Sierra Madre on Luzon 333 tree species of 1 cm dbh or more have been identified (Co *et al.* (year not given), CTFS 2004). As part of the Polillo Island Project, trees Θ30 cm dbh were inventoried in 88 belt transects of 10 m width at sixteen different sites on the island of Polillo and two smaller neighboring islands covering a total area of 7.42 ha (Clements 2003). Including species found outside the belt transects, 273 tree species (diameter restrictions not clear) and 37 shrubs, ferns and herbs were documented. For the Sibulan Watershed Reserve 167 tree species Θ30 cm dbh were recorded for a transect area of 0.75 ha.

Proctor et al. (2000) studied the impact of geologic parent material at the foot of Mt. Bloomfield, Palawan, at c. 50 m a.s.l., on tree species occurrence on either side of a sharp boundary between greywacke and serpentinized peridotite. They established 12 plots (20 m x 20 m) totalling 0.48 ha perpendicular to the geologic boundary. All in all they found 79 tree species Θ10 cm dbh (1,4 m). A total of 75 species were confined to greywacke or serpentinized peridotite, and four occurred in the transition zone where soil types were mixed. Only one tree species occurred on greywacke as well as on serpentinized peridotite. On the same mountain but at 170 m and 200 m a.s.l. Proctor *et al.* (1997) had conducted a study which was focused on soil parameters and plant physiology rather than on the vegetation. They recorded 21 tree species ≥2 cm dbh in three plots of 48 m^2 (total), and 9 tree species ≥10 cm dbh in one plot of 400m^2.

Proctor et al. (1998) established 0.25 ha. plots at seven altitudes on Mt. Giting-Giting on Sibuyan, four of them being below 1000 m a.s.l. The number of tree species ≥10 cm dbh in those plots below 1000 m a.s.l. ranged between 80 and 111. Aragones (1991) studied two plots of 0.42 ha at 750 m a.s.l. and 950 m a.s.l., which contained 77 and 49 species of trees ≥10 cm dbh, respectively. All other data sets listed in Table 2 cover elevations above 1000 m a.s.l.

Within the studies of forest vegetation listed in Table 2, a trend can be observed in the pattern of species richness and elevation. The data on tree species with a dbh of 10 cm or more show a clear drop of species numbers between c. 700 and 1000 m a.s.l.. On Mt. Giting-Giting, Proctor *et al.* (1998) recorded 80 – 111 species of trees ≥10 cm dbh in 0.25 ha plots from 325 to 860 m a.s.l., but for the 1240 m a.s.l. plot the number of tree species had decreased to 38. Hamann *et al.* (1999) documented 92 species of trees ≥ 10 cm dbh in a 1 ha plot at 1000 m a.s.l on Negros. Aragones (1991) documented a clear drop in species richness of trees ≥10 cm dbh from 77 to 49 species between 750 m a.s.l. to 950 m a.s.l. This reflects the common decrease of tree species and the change in taxa composition with elevation as it has been described by Whitford (1911) and - in detail - by Koch (1982).

Three other studies providing more general information on Philippine vegetation shall be mentioned here. Luna *et al.* 1999 studied a 4 ha plot of logged-over forest in the Mt. Makiling Forest Reserve. Unfortunately, they listed only the 22 dominant out of the 179 tree species (=5 cm dbh) recorded during that study. Buot Jr. (2002) characterized the vegetation types of Mount Akiki in northern Luzon, giving altitudinal ranges of forest types and naming prominent plant taxa, but without providing a species list or data on species richness. Madulid & Agoo (1997) described the occurrence, characteristics and

Table 2. Studies on Philippine forest vegetation (excluding mangroves) published since 1990.

Locality	Elev. m a.s.l.	Sampled area/ha	Number of spp.[1]	Reference[2]
		No diameter or life form restrictions		
Mt. Pangasugan, Leyte[3]	55-520	0.49	685 vascular plant spp.	Langenberger 2003
Mt. Pangasugan, Leyte[4]	90-1158	0.35	314 dicotyledon spp.	Belonias 2002
Mt. Amuyao, Luzon[5]	1600-1800	~ 0.754	64 vascular plant spp.	Gonzales-Salcedo 2001
"	1891-2400	~ 0.754	202 vascular plant spp.	"
"	2401-2701	~ 0.754	74 vascular plant spp.	"
Pagbilao & Pagbilao Grande Island[6]	? (lowland)	0.26	301 vascular plant spp.	Gruezo 1998
Mt. Labo, Luzon[7]	410 - 1500	(~ 0.789)	385 vascular plant spp.	Gruezo and Badayos 1996
		Restriction to trees or woody plants		
Palanan Forest Dynamics Plot	80-120	16	333 tree spp. > 1 cm dbh	Co *et al*. (no year), CTFS 2004
Mt. Kitanglad, Mindanao	1450	0.75	100 woody spp. ≤ 5 cm dbh	Ingle 2003
Polillo Island[8]	?	7.42(?)	273 tree spp. > 30 cm cbh, 37 shrubs, ferns, herbs	Clements 2003
Mt. Bloomfield, Palawan[9]	~ 50	0.48	79 tree spp. ≤ 10 cm dbh (1,4 m)	Proctor et al. 2000
Mt. Makiling	400	4	179 tree spp. > 5 cm dbh	Luna et al. 1999
Mt. Mandalagan, Negros	1000	1	92 tree spp. ≤ 10 cm dbh	Hamann et al. 1999
Mt. Kinasalapi, Mindanao	2065-2360	1	43 tree spp. ≤ 10cm dbh	Pipoly and Madulid 1998
Mt. Giting-Giting, Sibuyan Island	325	0.25	100 tree spp. ≤ 10 cm dbh	Proctor et al. 1998
"	385	0.25	80 tree spp. ≤ 10 cm dbh	"
"	770	0.25	111 tree spp. ≤ 10 cm dbh	"
"	860	0.25	98 tree spp. ≤ 10 cm dbh	"
"	1240	0.25	38 tree spp. ≤ 10 cm dbh	"
"	1540	0.0625	13 tree spp. ≤ 10 cm dbh	"
"	1540	0.0625	7 tree spp. ≤ 10 cm dbh	"

Mt. Pulog, Luzon[10]	2325 - 2715	?	37 woody spp. Θ 1.3 m height	Buot and Okitsu 1997
Mt. Bloomfield, Palawan[11]	170	0.0049	21 tree spp. ≤ 2 cm dbh	Proctor *et al*. 1997
“	200	0.04	9 tree spp. ≤ 10 cm dbh	“
Mt. Banahaw, Luzon	750	0.42	77 tree spp. ≤ 10cm dbh	Aragones 1991
“	950	0.42	49 tree spp. ≤ 10cm dbh	“
“	1200	0.42	36 tree spp. ≤ 10cm dbh	“
“	1500	0.42	22 tree spp. ≤ 10cm dbh	“
“	1800	0.42	12 tree spp. ≤ 10cm dbh	“
“	2100	0.42	11 tree spp. ≤ 10cm dbh	“

1 When species figures are provided for large areas and islands it is usually not clear if exotic and domesticated species are included. Abbreveations mean: dbh = diameter at breast height; cbh = circumference at breast height.

2 The references are first sorted considering comprehensiveness of the studies (vascular plants versus trees), and secondly according to the year of publication.

3 The study comprised 49 plots of 100 m^2. Plants up to 2.5 m tall and lianas were sampled in subplots of 25 m^2; crown epiphytes were not assessed.

4 Based on 35 plots of 4 m x 25 m in which all trees taller than 3 m were assessed. Within the main plots two subplots of 4 m x 4 m were used to sample shrubs and lianas, and within the subplots herbs were studied on 1 m^2.

5 The sampling area consisted of 3 circular plots of 20 m radius for each vegetation type. The understorey and lower canopy (no specification is given) was evaluated in 5 m x 5 m quadrats.

6 The study consists of 26 non-contiguous plots of 100 m^2 each arranged along transect lines across the two islands. The species list includes crops and exotic species.

7 The study comprised 6 circular plots with a diameter of 40 m plus 7 rectangular plots of 10 m x 5 m, the latter being arranged along an elevational transect. Since species composition has also be inventoried in the vicinity of the plots the species number given refers to a larger area than is covered by plots. The area was affected by ‘large scale logging operations ca. 30 years before the inventory.

8 The sampled area refers to transect lines of 10 m widths and variable length at different localities. The number of species given also includes records from outside the plot, but it is not clear if the 30 cm circumference threshold has been also applied on them.

9 The inventory was composed of 12 plots of 20 m x 20 m each, where all trees Σ 10 cm dbh (at 1,4 m) were assessed, and eight sub-plots of 4 m x 4 m in which trees Π 6 m tall, pandans, rattans, and herbaceous angiosperms were inventoried. Only tree species Σ 10 cm are listed in the article, many of them unidentified or on generic level, only.

10 The sampling procedure used was the point-centered-quarter-method, which is plotless sampling.

11 The study actually consisted of four plots of 4 m x 4 m at 170 m a.s.l., but one of the plots was located in a tree-less area. Only very general information is given on the vegetation. Since the species found in the 400 m^2 plot at 200 m a.s.l. were except one different from those in the three plots at 170 m a.s.l. the total number of species is 29.

extend of ultramafic rocks in the Philippines, and the status of the vegetation that covers these areas. Some noteworthy species of such areas are listed.

IMPLICATIONS

Only few data sets published since 1990 deal with plant diversity in the Philippines in a comprehensive manner (Table 2). Most of these studies cover only trees, and most of them are restricted to the traditional 10 cm dbh lower limit. Out of the 17 vegetation studies listed in Table 2, 12 are confined to trees or woody plants. The high number of plant species recorded within relatively small total sampled areas on Mt. Pangasugan in Leyte in the study of dicotyledons by Belonias (2002) or my own study on vascular plants (Langenberger 2003) demonstrate not only high levels of local species richness but also document that the traditional restriction to trees of Θ10 cm dbh results in an underestimation of species in plant biodiversity assessments.

Additionally, it can be observed that pristine rain forest below ca. 500 m a.s.l. is hardly represented in data sets while the majority of data is available for higher elevations and montane environments. I assume that this simply reflects the fact that pristine lowland forests have been destroyed on most Philippine islands. Given the fact that lowland habitats are the most species rich and that their destruction will have the most serious impact on biodiversity this is very unfortunate. An exception is the 16 ha Palanan Forest Dynamics Plot (PFDP) which is coordinated by Smithonian's Tropical Forest Research Institute - Center of Tropical Forest Science (STRI-CTFS). This is a long-term and well-documented project that will provide comprehensive ecological data on the lowland rain forest of the Sierra Madre (CTFS 2004). But, unlike the results from the Palanan Forest Dynamics Plot, or those from the forest inventory on Polillo Island (Clements 2001) many studies are not published in internationally accessible journals or the internet but are filed as reports or theses, never reaching the science community.

Even if results are presented over the internet, they may only be accessible for a fleeting time. For example, the species checklist by Bicknell & Bicknell (2001) is no longer available on the internet. On the other hand, after nearly 100 years, I still have direct access to Whitford´s description of the vegetation of the Lamao Forest Reserve published in the ‚Philippine Journal of Science' at the beginning of the last century (Whitford 1906). Another critical point of internet presentations - which is also true for printed reports - is the question of accuracy and quality. Both aspects often stay unclear since the requirements for reports are by far not as strict as for reviewed journals, and no control mechanisms exist for the internet.

A point of key importance in vegetation studies is species identification. In many reports, inventories, and theses it can be observed that local people or tree spotters have been consulted to name the species. Although local names can be very valuable (Madulid 1991) their application can render a whole inventory or study worthless if used uncritically. Often local names are simply translated into scientific names using the *Lexicon of Philippine Trees* by Salvosa (1963) and, recently, its revised version by Rojo (1999). In that Lexicon one local name is assigned to one scientific name. The names in the Lexicon are "common offical names" resulting from agreement and standardization within the forestry sector. But local people and tree spotters name species not according to those rules but according to their traditions. To understand the difference and the intricacies in using local names as the basis for species lists it is helpful to have a look at Madulid´s *Dictionary of Philippine Plant Names* (2001a,b). As an example, "Apitong" is documented to be used for eight different species in the genus *Dipterocarpus* (Madulid 2001a). On the other hand, Dipterocarpus grandiflorus, which is the common official equivalent for "Apitong" (Salvosa 1963), has been documented with 38 different local names (Madulid 2001b).

Therefore, if local names are just translated into scientific names without a proper botanical check the species lists are likely to be worthless. If obvious mistakes, like the listing of mangrove species in mountain forests, which I once observed in a student´s report, do not demonstrate the lack of reliability, such reports give the impression that the studied locality is well-known. In fact the real biodiversity is "masked" and stays unrecorded and unknown. For example, red lauan and its equivalent in the Lexicon of Philippine trees (Salvosa 1963) which is Shorea negrosensis is a species occurring regularly in species lists of Mt. Pangasugan, Leyte. Nevertheless, during many field trips in that area I have never encountered a single individual of that species. The explanation is easy. The name red lauan is locally used in the sense of the timber group red lauan. This group comprises three botanical species (Anonymous 1977), one of them being *Shorea polysperma*, which is a common feature of ridge habitats in the Mt. Pangasugan area. The name red lauan given by local informants is thus correct but the translation into a scientific name using the Lexicon by Salvosa (1963) results in a wrong scientific name.

I am certain that many such cases are hidden and masked in species lists. Therefore, to make the use of local names a sound practice, it is important that the researcher is aware of the variability of local names and able to confirm scientific names achieved by translation on a sound botanical basis, which generally requires collection of herbarium specimens. If this can be guaranteed the application of local names can be of great help.

In the context of species identification the importance of field characters must be stressed. Many plants can easily be pre-identified and assigned to a family or genus if one is familiar with field characters. Vegetative features are especially important in tropical rain forests where there is no uniform flowering or fruiting season which would make the collection of fertile specimens feasible. A big step forward in the use of field characters are the three volumes of *Malesian Seed Plants* by van Balgooy (1997, 1998, 2001). They can be recommended to everybody interested in Philippine botany.

Additionally, the collection of voucher specimens and their deposition at a herbarium is of key importance in any vegetation study. The specimens act as reference collection for follow researchers, and are important documents for the taxonomic revision of plant groups.

To summarize my conclusions I would like to stress the following points: more focus should be given to the highly threatened remnants of pristine lowland forest vegetation; the restriction to trees in forest inventories is artificial and leads to a massive underestimation of the real plant biodiversity; the application of local names can be a serious source of error, and should therefore be practiced responsibly, and only if backed by a botanical check; voucher specimens should be collected and deposited at a herbarium which can maintain the collection (e.g., the Philippine National Herbarium (PNH)); reports and papers should refer to the herbarium where the collection is deposited; results should be published in a way that the science community can access the study, ideally, in a journal that is internationally accessible.

Acknowledgments

I would like to thank Nina Ingle and the two reviewers Leonardo Co and Peter Ashton for their comments and constructive criticism, as well as the A.F.W. Schimper Foundation, Stuttgart, Germany, for its grant which allowed me to participate in the WCSP Symposium 2004.

LITERATURE CITED

Anonymous. 1977. The Philippines recommends for dipterocarps I. Lumber. Philippine Council for Agriculture and Resources Research Los Baños, Laguna, Philippines. 125 pp.

Aragones, E.G. Jr. 1991. Vegetation-soil pattern along altitudinal gradient in the western slopes of Mt. Banahaw, Luzon, Philippines: I. The forest communities and changes in forest composition with altitude. Sylvatrop 1(1): 15-45.

Ashton, P.S. 1993. Philippine Phytogeography. Asia Life Sciences 2(1): 1-8.

Belonias, B.S. 2002. The dicot flora on the western slopes of Mt. Pangasugan, Leyte Island, Philippines. PhD Thesis, University of the Philippines, Los Banos, Philippines. 133 pp.

Bicknell, D. and Bicknell, L. 2001. Flora of Cebu Checklist. www.geocities.com/tokyo/springs/6295/david.html (no longer accessible, no alternative source identified; see also citation in: Flora Malesiana Bulletin 12(7/8), p. 349.

Brown, W.H. 1919. Vegetation of Philippine Mountains. The relation between the environment and physical types at different altitudes. Bureau of Science, Manila. 434 pp.

Brown, W.H. & Mathews, D.M. 1914. Philippine dipterocarp forests. Philipp. J. Sci. A, 9(5): 413-561.

Buot, I.E.; Aguilar, N.O. & Llanor, L.T. 1990. An enumeration of the flowering plants of Cabra Islet, Lubang Island, Occidental Mindoro, Philippines. Philipp. J. Sci. 119(1): 49-62.

Buot, I.E. Jr. & Okitsu, S. 1997. Woody species composition in the altitudinal zones of the mossy forest of Mt. Pulog, Luzon, Philippines. Flora Malesiana Bulletin 12(1), Rijksherbarium/Hortus Botanicus, The Netherlands. Pp. 6-11.

Buot Jr., I.E. & Okitsu, S. 1999. Leaf size zonation pattern of woody species along an altitudinal gradient on Mt. Pulog, Philippines. Plant Ecology 145: 197-208.

Clements, T. 2001. Inventory of forest fragments in the Polillo Islands. http://mampan.50megs.com/polillo/2001/pdf/allforests.pdf.

Co, L., Bartolome, N., Molina, J., & Yap, S., (year not given): Pictorial guide to the tree and shrub flora of the Palanan Forest Dynamics Plot and vicinity, Northern Sierra Madre Natural Park. Department of Environment and Natural Resources (DENR) and Conservation International Philippines (CI).

CTFS 2004: Web-page of the Center for Tropical Forest Science, of the Smithsonian Tropical Research Institute. http://www.ctfs.edu/.

Gentry, A.H. and Dodson, C. 1987. Contribution of nontrees to species richness of a tropical rain forest. Ecotropica 19(2): 149-156.

Gonzales-Salcedo, P.V. 2001. Floral diversity and vegetation zones of the northern slope of Mt. Amuyao, Mountain Province, Luzon, Philippines. Asia Life Sciences 10(2): 119-157.

Gruezo, W.S. 1998. Species alpha diversity of Pagbilao Grande Island vegetations, Quezon Province, Philippines. Asia Life Science 7(1): 39-92.

Gruezo, W.SM. & Badayos, R.B. 1996. Vegetation of Mt. Labo and vicinity, Camarines Norte Province (Lucon, Philippines). Asia Life Sciences 5(2): 63-106.

Hamann, A., Barbon, E.B., Curio, E. & Madulid, D.A. 1999. A botanical inventory of a submontane tropical rainforest on Negros Island, Philippines. Biodiversity and Conservation 8: 1017-1031.

Heaney, L. & Regalado, J.C. Jr. (1998): Vanishing treasures of the Philippine Rain Forest: a comprehensive introduction to the biodiversity of the Philippines. The Field Museum, Chicago. University of Chicago Press. 88 pp.

Ingle, N. (2003): Seed dispersal by wind, birds, and bats between Philippine montane rainforest and successional vegetation. Oecologia 134: 251-261.

Koch, N. (1982): Altitudinal changes of forest structure and composition in the high elevation rain forest of Davao Oriental. Pp. 108-135 in Weidelt, H.J. & Banaag, V.S. Aspects of Management and Silviculture of Philippine Dipterocarp Forests. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Eschborn. TZ-Verlagsgesellschaft Roßdorf.

Langenberger, G. 2000. Forest Vegetation Studies on the foothills of Mt. Pangasugan, Leyte, The Philippines. TÖB-Publication F-II/10e. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, P.O. Box 5180, 65726 Eschborn, Germany. 56 pp.

Langenberger, G. 2003. Diversität, Struktur und Reliefabhängigkeit der Vegetation in einem Tieflandregenwald der Insel Leyte, Philippinen. Dissertation. Institute of Plant Production and Agroecology in the Tropics and Subtropics (380), University of Hohenheim. 181 pp.

Luna, A.C., Osumi, K., Gascon, A.F., Lasco, R.D., Palijon, A.M. & Castillio, M.L. 1999. The community structure of a logged-over tropical rain forest in Mt. Makiling Forest Reserve, Philippines. Journal of Tropical Forest Science 11(2): 446-458.

Madulid, D.A. & Agoo, M.G. 1992. A bibliography on Philippine Biodiversity: Part I - Plants. National Museum, Manila, Philippines. 189 pp. ISBN: 971.567-000-8.

Madulid, D.A. 1991. On the significance of local plant names with particular reference to the Philippines. ASBP Communication 3: 48-56.

Madulid, D.A. 2001a. A dictionary of Philippine plant names Vol. I: local name -scientific name. The Bookmark, Inc., Makati City, Philippines. 781 pp.

Madulid, D.A. 2001b. A dictionary of Philippine plant names Vol. II: scientific name - local name. The Bookmark, Inc., Makati City, Philippines. 329 pp.

Madulid, D.A. & Agoo, M.G. 1997. Assessment of the vegetation of Philippine mountains on ultramufic rocks. Pp. 113-121 in Jaffré, T., Reeves, R.D. & Becquer, T. (eds.): Écologie des Milieux sur Roches Ultramafiques et sur Sols Métallifères. ORSTROM, Noumea.

Merrill, E.D. 1906. The Flora of the Lamao Forest Reserve. Phil. J. Sci. 1, Suppl. I.: 1-141.

Merrill, E.D. 1907. The ascent of Mount Halcon, Mindoro. Philipp. J. Sci. C, 2(4): 179-206.

Merrill, E.D. 1907. The flora of Mt. Halcon, Mindoro. Philipp. J. Sci. C, 2(4): 251-309.

Merrill, E.D. 1912. A Flora of Manila. Bureau of Science, Manila, Philippines. 491 pp.

Merrill, E.D. 1923-26. An Enumeration of Philippine Flowering Plants. Vol. I-IV. The Government of the Philippine Islands Department of Agriculture and Natural Resources, Bureau of Science, Manila.

Merrill, E.D. and Merritt, M.L. 1910. The flora of Mt. Pulog. Philipp. J. Sci. C, Bot. 5: 287-403.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000): Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Pancho, J.V. 1983. Vascular Flora of Mt. Makiling and Vicinity Part 1. Kalikasan, the Philippine Journal of Biology, Supplement No. 1. New Mercury Printing PRess, Quezon City, Philippines. 476 pp.

Pipoly III, J.J. & Madulid, D.A. 1998. Composition, structure and species richness of a submontane moist forest on Mt. Kinasalapi, Mindanao, Philippines. 591-600 in Dallmeier, F. & Comiskey, J.A.: Forest biodiversity research, monitoring and modeling: conceptual background and old world case studies. - Man and the biosphere; v. 20). UNESCO and The Parthenon Publishing Group Limited, Carnforth, UK, UNESCO, France.

Proctor, J.; Baker, A.J.M.; van Balgooy, M.M.J.; Jones, S.H.; Bruijnzeel, L. & Madulid, D.A. 1997. Mount Bloomfield, Palawan, the Philippines: the scrub and Gymnostoma-woodland on ultramufic rocks. 123-131 in Jaffre, T.; Reeves, R.D. & Becquer, T. (eds.): The ecology of ultramufic and metalliferous areas. Documents Scientifique et Techniques, ORSTROM 3(2) (Special issue).

Proctor, J.; Argent, G.C. & Madulid, D.A. 1998. Forests of the ultramafic Mt. Giting-Giting, Sibuyan Island, the Philippines. Edinburgh Journal of Botany 55 (2): 295-316.

Proctor, J., Baker, A.J.M., Van Balgooy, M.M.J., Bruijnzeels, L.A., Jones, S.H. & Madulid, D.A. (2000): Mount Bloomfield, Palawan, Philippines: Forests on greywacke and serpentinized peridotite. Edinb. J. Bot. 57(1): 121-139.

Regalado, J.C. (1995): Revision of the Philippine Medinilla. Blumea 40: 113-93.

Rojo, J.P. (1999): Revised lexicon of Philippine trees. Forest Product Research and Development Institute, Department of Science and Technology, College, Laguna, Philippines. 484 pp.

Salvosa, F.M. (1963): Lexicon of Philippine Trees. Forest Products Research Institute, College, Laguna, Philippines. Bulletin No. 1. 136 pp.

Soejarto, D.D., Regalado, J.C., Madulid, D.A. and Ridsdale, C.E. 1995. Preliminary checklist of the flowering plants of Palawan, Philippines, vs. 3. Hard copy of unpaged msc. Copies in L and presumably in F, PCRPS, PNH, and/or with the authors. (cited from: FM Bulletin 12(4), 1998, p. 220).

Soerianegara, I. and Lemmens, R.H.M.J. (Eds.) 1994. Plant Resources of South-Est Asia No. 5(1): Timber Trees: Major commercial timbers. Prosea Foundation, Bogor, Indonesia & Pudoc-DLO, Wageningen, the Netherlands. 610 pp.

Sohmer, S.H. 2001. Conservation Lessons from Studies in Philippine Psychotria. Malayan Nat. J. 55 (1 & 2): 43-47.

Tan, B.C. & Mandia, E.H. 2001. New and noteworthy records of mosses from Mindoro, the Philippines, and their biogeographical implication. Garden´s Bulletin Singapore 53: 315-322.

Tan, B.C.; Lubos, L. & Schwarz, U. 2000. New and biogeographically noteworthy records of Philippine mosses from Mindanao Island. Tropical Bryology 18: 27-37.

van Balgooy, M.M.J. 1997. Malesian Seed Plants. Vol. 2: Portraits of Tree Families. Rijksherbarium /Hortus Botanicus, Leiden. 307 pp.

van Balgooy, M.M.J. 2001. Malesian Seed Plants. Vol. 3: Portraits of Non-Tree Families. Rijksherbarium /Hortus Botanicus, Leiden. 260 pp.

van Balgooy, M.M.J. van 1997. Malesian Seed Plants. Vol. 1: Spot-characters. Rijksherbarium /Hortus Botanicus, Leiden. 154 pp.

van Steenis, C.G.G.J. (ed.) 1950-ongoing. Flora Malesiana. Martinus Nijhoff Publishers, Dordrecht, the Netherlands.

Whitford, H.N. 1906. The Vegetation of the Lamao Forest Reserve. Phil. Jour. Sci. 1: 373-431 & 637-682.

Whitford, H.N. 1911. The Forests of the Philippines Part I & II: Forest Types and Products. Department of the Interior Bureau of Forestry, Bulletin No. 10, Manila, Bureau of Printing. 94 + 113 pp.