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Plant diversity in betel leaf agroforestry of South Meghalaya, Northeast India

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Abstract. *Tynsong H, Tiwari BK, Dkhar M. 2018. Plant diversity in betel leaf agroforestry of South Meghalaya, Northeast India. Asian J For 2: 1-11.* Large areas of lowland tropical forests in South Meghalaya, India have been converted into betel leaf agroforestry systems by the tribal people living in the area. Traditional betel leaf agroforestry still maintains high biodiversity and structurally complex shade canopies compared to other agricultural lands despite changes natural forests. Yet, it is not clear the state of biodiversity in betel leaf agroforestry compared to that in natural forests. This study aimed to assess plant diversity of betel leaf agroforestry in South Meghalaya, India and to compare it with a nearby natural forest. A total of 160 plant species were recorded in natural forests out of which 75 were trees, 40 shrubs, and 45 herbs, while in betel leaf agroforestry, a total of 159 plant species, 94 trees, 17 shrubs and 48 herbs were recorded. A total of 34 tree species, 13 shrub species, and 14 herb species were found in the two land uses. All the plant species were native species. The results of the study suggest that the conversion of natural forest into betel leaf agroforestry in South Meghalaya has no significant impact on tree and herb diversity. However, the basal area and density were affected to some extent. The land-use change had also affected the density and diversity of shrubs. The study concludes that betel leaf agroforestry in South Meghalaya developed by the indigenous War Khasi tribe through experiential learning over several generations has emerged as a fairly sustainable agroforestry system causing minimal impact on plant diversity.

Keywords: Betel leaf agroforest, cash crop, natural forest, South Meghalaya

INTRODUCTION

Biodiversity cannot be conserved effectively if conservation strategies are restricted to protected natural ecosystems alone (Moguel and Toledo 1999). Ryan (1992) reported that there are only about 7000 protected areas in the world, covering approximately 650 million ha and representing less than 5% of the earth's land surface. While the rest of terrestrial environments are affected by human activities, including agriculture and other developmental works.

Forest ecosystems can range from intact natural forests to slightly-disturbed forests to monoculture industrial plantations. The area under natural and semi-natural forests is decreasing by 13 million ha annually (FAO 2006). Contrary to this, the average annual rate of forest plantation establishment is 5 million ha (FAO 2014). Among such variety form of forestry landscapes, there is the traditional land-use system that combines agriculture and forestry (often so-called agroforestry) under indigenous management which provides relatively high and sustainable economic benefits with a seemingly diversified, productive system.

Most research in ecology and biodiversity has been focused on undisturbed ecosystems, while human-impacted and managed ecosystems have not received equal attention. Man-made landscapes that are part of the indigenous agricultural practices, such as agroforestry, home gardens, polycultures, also contribute a great deal in biodiversity conservation (Toledo 1990; Tynsong and Tiwari 2011). Toledo et al. (1994) and Tiwari et al. (2017) reported that there is increasing evidence that landscapes under indigenous and local knowledge-based management systems maintain and even improve biodiversity. There are indications that the area under agroforestry systems will continue to increase, making it important to assess its potentials to fulfill biological conservation as well as its economic purpose. The question is whether agroforestry systems can harbor biodiversity which is similar to that in natural forests or not.

Northeastern India is a part of the Indo-Burma biodiversity hotspot, harboring about 50% of plant biodiversity of India (ca. 8000 species), of which 31.58% (ca. 2526 species) is endemic (DE, MEDHI 2014). The region is rich in orchids, ferns, oaks (*Quercus* spp.), bamboos, rhododendrons (*Rhododendron* spp.), magnolias (*Magnolia* spp.), etc. According to Conservation International (2011), Indo-Burma is the most threatened hotspot with 5 % original habitat is remaining. Threats to species, sites, and landscapes are immediate and severe (Baltzer et al. 2001; Nooren and Claridge 2001; IUCN 2011). The combination of economic development and an increasing human population is exerting enormous pressure on the region's natural resources, and overexploitation has eradicated species from many areas.

Meghalaya is a region in northeastern India with high biodiversity importance. This area harbors 3128 species of angiosperms which include 1237 endemic species and 53 threatened plant species (Khan et al. 1997). The biodiversity of natural forests of Meghalaya has been

studied by Tiwari et al. (1998), Upadhaya (2002), Jamir and Pandey (2003) and Tripathi et al. (2006). However, biodiversity of agroforestry has not received due attention.

Betel leaf (*Piper betle* L.) is an important cash crop in India and Bangladesh with huge demand in the Middle East, Britain, Pakistan, and some African counties (Haider et al. 2013). This huge market demand has acted as a driver for conversion of a large chunk of natural forests into betel leaf-based agroforestry systems in India, Bangladesh, Sri Lanka, Malaysia, Philippines, and East Africa (Arambewela et al. 2005; Nath and Inoue 2009a). Betel leaf is traditionally consumed with slices of areca nut and a thin coating of lime by people of South and Southeast Asia, the Gulf States, and the Pacific islands (Nath and Inoue 2009b). Betel leaf has a trade worth of INR 7000 million in India alone (Balasubrahmanyam et al. 1994), where about 15-20 million people consume betel leaves on a regular basis (Jana 1996). Jeng et al. (2002) reported that worldwide, over 2 billion people consume betel leaf.

Although it changes natural forests, traditional betel leaf agroforestry still maintains high biodiversity and structurally complex shade canopies compared to other agricultural lands. The traditional betel leaf agroforestry is more likely to conserve a significant portion of the original forest biodiversity since the establishment of this land use is never clear-felled trees in the natural forests (Tynsong 2009). With a sustained increase of world betel leaf consumption and growing human population in many of the betel leaf consuming regions, pressures to intensify betel leaf production are likely to increase, which will result in more conversions of natural forests to betel leaf-based agroforestry.

In Meghalaya, the farming of plant betel leaf (*Piper betle* L.**)** is done without cutting of naturally growing trees or burning the field. Betel leaf grows along with trees, shrubs, and herbs on the same piece of land. During the first year after planting the betel leaf, the farmers prune the canopy of all trees except a few important timber trees, fruit trees, and non-coppicing tree species. The cutting of tree branches is done, so the newly planted betel leaf grown at the base of the trees may receive enough sunlight and nutrients from the decaying leaves and branches of the lopped trees. After three to four months, most trees start sprouting again and after one year the whole plantation looks like a natural forest again. Important timber trees include *Michelia cathcartii, Toona ciliata, Cedrela toona,* and *Schima wallichii,* fruit trees include *Artocarpus heterophyllus, Gynocardia odorata,* and *Baccuarea sapida* and non-coppicing trees include *Macaranga peltata, Macaranga hypoleuca, Lithocarpus elegans,* and *Ligustrum robustum.* The process involved in the cultivation of betel leaf and management of betel leaf agroforestry in Meghalaya is similar to that reported for the Khasia tribes of Bangladesh as described by Saha and Azam (2004) and Haider et al. (2013).

Other agroforestry systems viz., coffee, cocoa, and swidden cultivation have received considerable scientific and public attention for their ability to maintain biodiversity (Perfecto et al. 1996; Moguel and Toledo 1999; Schroth and Harvey 2007), yet the same situation has not happened on betel leaf agroforestry systems. Only a handful of researchers from Bangladesh and Sri Lanka have reported biodiversity of betel leaf agroforestry systems (Alam and Mohiuddin 1995; Nath et al. 2003; Arambewela et al. 2005; Nath and Inoue 2009b). In South Meghalaya, more than twenty thousand farmers are currently engaged in the cultivation of betel leaf on approximately fifteen thousand hectares of land. There is a noticeable gap in our understanding of the biodiversity of betel leaf agroforestry created and maintained by the local tribal communities of South Meghalaya. The objective of this study was to inventory the plant diversity of betel leaf agroforestry and to compare it with a nearby natural forest of the area.

MATERIALS AND METHODS

Study area

The plant diversity survey was conducted in one natural forest (hereafter NF) and one betel leaf agroforestry (hereafter BLA) in South Meghalaya, India. The NF was located in Siatbakon Village (latitude $25^0$16' N, longitude $91^0$56' E, altitude 1003 m asl) and the BLA was located in Nongkwai Village (latitude $25^0$20' N, longitude $91^0$39.54' E, altitude 600 m asl) (Figure 1). Cherrapunjee-Mawsynram Plateau, one of the wettest places in the world is located in this region. The mean annual maximum and minimum temperatures are 23ºC and 13ºC, respectively. The mean annual rainfall is 11565 mm. The slope of the area is predominantly towards the south and the angle of the slope varies between 10º and 40º. The area has a large number of rivers and rivulets, which drain into the plains of Bangladesh. At the present time, narrow and deep river valleys separate one hill range from the other.

The population density in the studied area is sparse. Horticulture, forestry, and fisheries are the principal occupations of the people. Agriculture is limited to some small valleys where mainly tuber crops are grown. Areca nut, orange, betel leaf, jackfruit, bay leaf, honey and broom grass are the important products of the region. The area is inhabited by *War Khasi* people, a tribal community having a long tradition of forest conservation. The local people collect, process, and market a large variety of non-timber forest products (NTFPs) and medicinal and aromatic plants (MAPs) such as *Cinnamomum tamala*, *Piper peepuloides*, *Phrynium capitatum*, bamboo, honey, mushrooms, nuts, wild tubers, edible worms, insects and leafy vegetables from the forests (Tynsong et al. 2012).

Data collection

An extensive survey was carried out during the months of January 2006 to October 2008. The data were collected once in every season of the year for a period of two years. The composition and structure of NF and BLA were determined within 100 m^2 plots (10 m × 10 m) for trees (dbh ≥5 cm); 25 m^2 plots (5 m × 5 m) for shrubs and 1 m^2 plot (1 m × 1 m) for herbs. The total sampled area for each study site was 1 ha for the tree, 0.05 ha for shrub and 0.01 ha for herbs. Tree species with > 10 cm diameter at breast height (dbh) were individually counted, measured and numbered. The density and frequency of occurrence of the species per plot were also estimated.

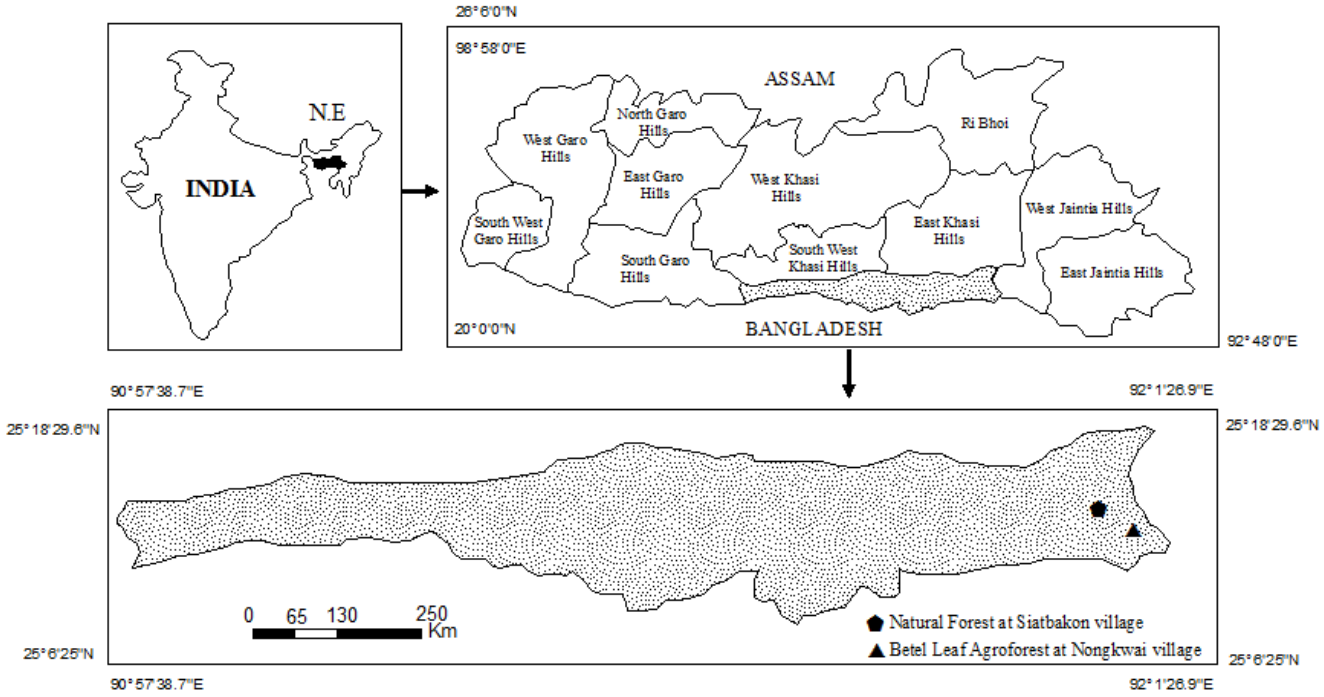

Figure 1. The study sites in natural forest (hereafter NF) and betel leaf agroforestry (hereafter BLA) in South Meghalaya, India

Data analysis

Plant specimens collected from the two forest types were identified with the help of Flora of Assam (Kanjilal et al.1934-1940) and Flora of Jowai (Balakhrishnan 1981-1983). The identifications were confirmed by consulting the herbaria at Botanical Survey of India, Northeastern Circle, Shillong, India. The nomenclatures of the species are as per the regional flora. Analysis of variance (ANOVA) and correlation coefficient values (r) was calculated using Statistica Version 6 (Serial no: BX1117619309D60).

Basal area: The basal area of each overstory tree was calculated using equation (1). The basal area values were then extrapolated to per hectare basis.

$$BA = \frac{\pi D^2}{4} \quad (1)$$

Where:
BA : basal area (m^2ha^{-1});
D : diameter at breast height (cm); and
Π : pi (3.142).

Frequency, density, and abundance: The frequency, density, and abundance of the species were determined following the methods of Misra (1968) and Muller-Dombois and Ellenberg (1974). The frequencies of occurrence were obtained to ascertain species abundance and species evenness. The following biodiversity indices were computed.

Simpson index of dominance (D): Simpson index of dominance (D) (Simpson 1949) was obtained using equation (2):

$$D = \sum (ni/N)^2 \quad (2)$$

Where:
ni : number of individuals of ith species.
N : total number of individuals of all the species.

Species relative density (RD): This refers to the number of individuals of a given species divided by the total number of individuals of all species. This was obtained using equation (3):

$$RD = \frac{n_i \times 100}{N} \quad (3)$$

Where:
RD : relative density;
n_i : number of individuals of species;
N : total number of individuals in the entire population

Importance value index (IVI): For tree species, it was obtained by summing RD and RDo, and then dividing it by 2 as given by Equation (4).

$$\textbf{IVI} = \frac{RD + RDo}{2} \quad (4)$$

For shrub and herb: **IVI** = relative frequency + relative density.

The Shannon-Wiener diversity index (H^-). Shannon-Wiener diversity index (Shannon and Wiener 1963) was obtained by using Equation (5):

Shannon-Wiener diversity index:

$$H^{-} = -\sum (ni/N) \log_e (ni/N) \quad (5)$$

Where:
ni : IVI of each species and
N : total IVI

Species evenness (E): Pielou's evenness index (Pielou 1975) was obtained by using equation 6.

Pielou's evenness index (E):

$$E = \sum (ni/N) \log_e (ni/N) / \log_e S \quad (6)$$

Where:
ni : IVI of each species,
N : total IVI and
S : Number of species

RESULTS AND DISCUSSION

Plant diversity

In the natural forest site (NF), a total of 160 plant species were recorded of which 75 were trees, 40 shrubs, and 45 herbs, while in the betel leaf agroforestry site (BLA) a total of 159 plant species, 94 trees, 17 shrubs and 48 herbs were recorded. A total of 34 tree species, 13 shrub species, and 14 herb species were present in both forest types. All the plant species encountered were native species (Table S1). For shrub components, species richness, number of families and number of genera were significantly higher in NF as compared to BLA. However, for tree and herb components, the number of families, number of genera and Shannon Diversity Index were slightly higher in BLA as compared to NF (Table 1). The similarity between NF and BLA for trees, shrubs and herbs species was 43.34%, 37.93%, and 38.32 % respectively. The one-way analysis of variance (ANOVA) showed significant variation ($P \leq 0.001$) of tree, shrub, and herb between NF and BLA. The correlation coefficient values (r) showed a positive significant correlation between tree ($r = 0.87$, $P \leq 0.001$), shrub ($r = 1.00$, $P \leq 0.001$) and herb ($r = 1.00$, $P \leq 0.001$).

Three dominant families of trees in NF were Lauraceae (11 species), Fagaceae (8 species) and Euphorbiaceae (8 species), while dominant families of trees in BLA were Euphorbiaceae (12 species) Lauraceae (12 species) and Moraceae (8 species). For shrubs, three dominant families in NF were Rubiaceae (9 species), Moraceae (4 species) and Poaceae (3 species), while in BLA they were Rubiaceae (6 species), Arecaceae (2 species) and Urticaceae (2 species). For herbs, three dominant families in NF included Zingiberaceae (5 species), Rubiaceae (4 species) and Melastromaceae (4 species), while dominant families in BLA included Asteraceae (5 species), Rubiaceae (4 species) and Poaceae (3 species). We encountered 24 families of trees, 9 families of shrubs and 9 families of herbs present in both forest types.

Tree species with high IVI in each forest type were: *Lithocarpus fenestatus*, *Lithocarpus elegans*, and *Sarcosperma griffithii (*NF); *Duabanga grandiflora*, *Sarcosperma griffithii*, and *Ficus glomerata (*BLA). The ten most important tree species in the two forest types are given in Table 2. A list of endemics (E) and rare (R) species found in both the forest types is given in Table 3.

Main uses of plants in betel leaf agroforestry

All 94 tree species recorded in BLA were maintained by local people as supporting trees for betel leaf to grow. However, it was observed that most preferred tree species well supporting the growth of betel leaf include *Artocarpus heterophyllus, Duabanga grandiflora, Ficus glomerata, Saraca indica and Sarcosperma griffithii.* It was also observed that in BLA, local people preserved the plant species for various purposes. Based on the usage patterns, the plant species present in the BLA were grouped into ten broad categories of usage, namely as, (i) timber divided into: high-value timber (HT) and low-value timber (LT), (ii) fuelwood divided into: high-value fuelwood (HFW) and low-value fuelwood (LFW), (iii) edible stuff (E), (iv) medicinal stuff (M), (v) tool-making stuff (T), (vi) ornamental stuff (O), (vii) craft (C), (viii) packing leaf (PC), (ix) latex producing plant (L) and (x) nonspecific use (NSU). Edible plants included: fruit, vegetable, and seed. In BLA as a whole, the usages were 21 as timber trees (HT = 10 and LT = 11), 51 as fuelwood (HFW = 20 and LFW = 31), 15 as edible stuff, 17 as medicinal stuff, 40 with nonspecific uses and as making tools stuff, ornamental stuff, craft, spice stuff, packing leaf and latex producing plant for the rests with a total of 15 plant species (Table 4).

Table 1. Diversity and community characteristics of plant species in natural forest (NF) and betel leaf agroforestry (BLA) in South Meghalaya, India

Parameter	NF			BLA		
	Tree	Shrub	Herb	Tree	Shrub	Herb
Sampling size (ha)	1	0.4	0.02	1	0.4	0.02
Number of families	33	21	27	41	13	31
Number of genera	61	33	37	78	21	42
Species richness	75	40	45	94	17	48
Density (ha^{-1})	1972	19280	347563	1788	7660	423688
Basal area (m^2ha^{-1})	52.26	-	-	50.06	-	-
Species evenness index (E)	0.83	0.90	0.93	0.90	0.45	0.95
Shannon diversity index (H^{-})	3.87	3.35	3.55	4.10	2.70	3.68

Table 2. Ten most important tree species in natural forest and betel leaf agroforestry

Tree species	Freq. (%)	DBH (cm)	Basal Area (m^2ha^{-1})	IVI
NF				
Lithocarpus fenestatus (Roxb.) Rehder	41	1.58	4.96	40.66
Lithocarpus elegans (Blume.) Soep.	48	1.37	4.29	30.8
Sarcosperma griffithii Benth.	51	0.94	2.94	16.58
Machilus bombycina King.	38	0.80	2.52	12.35
Schima walichii Choisy.	22	0.68	2.12	11.66
Quercus lanceofolia Roxb.	29	0.65	2.04	10.51
Castanopsis hystrix A.DC.	34	0.58	1.84	10.48
Helicia erratica Hk.f.	40	0.58	1.82	8.76
Castenea sativa Miller.	19	0.51	1.61	8.5
Quercus spicata Smith.	16	0.49	1.55	6.02
BLA				
Duabanga grandiflora (Roxb. Ex DC.) Walp.	33	50.94	11.82	32.78
Sarcosperma griffithii Benth.	58	79.59	5.97	16.36
Ficus glomerata Roxb.	28	18.78	3.66	10.99
Ficus benjamina L. var. *comosa* Kurtz.	8	68.98	2.24	10.51
Phoebe cooperiana U.N.Kanjilal ex A.Das.Nov.sp.	30	17.37	2.18	8.7
Wrightia tomentosa Roem & Sch.	33	31.84	2.07	8.19
Artocarpus lakoocha Roxb.	40	17.51	1.69	7.01
Toona ciliata Roem.	33	28.65	1.68	6.86
Caryota urens L.	28	22.29	1.17	6.85
Adenanthera pavonina L.	40	21.51	1.16	6.39

Table 3. Endemic and rare plant species present in the natural forest and betel leaf agroforestry

Plant species	Family	Status	Forest stands
Tree			
Acer oblongum Wall.	Aceraceae	R	NF
Citrus latipes (Swingle.)Tanaka.	Rutaceae	E, R	NF
Cyathea gigantea (Wall ex Hook.) Holttm.	Cyatheaceae	R	NF
Daphniphyllum himalayense Muell.	Euphorbiaceae	E	NF
Drimycarpus racemosus Hk.f	Anacardiaceae	E	BLA
Erythroxylon kunthianum Wall.	Malpighiaceae	E	NF
Euonymus lawsonii Clarke & Prain.	Celastraceae	E	BLA
Ilex embelioides Hk .f.	Aquifoliaceae	E, R	BLA
Sarcosperma griffithii Benth.	Sapotaceae	R	NF & BLA
Shrub			
Ardisia griffithii C.B.Clarke.	Myrsinaceae	E	NF
Ixora subsissillis Wall.	Rubiaceae	E	NF & BLA
Mahonia pycnophylla Fedde.	Berberidaceae	E	NF
Rubus khasianus Cordat.	Rosaceae	E	NF
Herb			
Eriocaulon cristatum Mast.	Eriocaulaceae	E	NF
Impatiens tripetala DC.	Balsaminaceae	E	BLA
Osbekia capitata Benth.	Melastromaceae	E	NF
Sonerilla khasiana Dyer.	Melastromaceae	E, R	NF

Note: NF- natural forest, BLA-betel leaf agroforestry, E- Endemic, R- Rare

Discussion

Tree species diversity and richness (H' = 4.10; 94 species) in BLA was higher than that in NF (H' = 3.87; 75 species). Also, herb species diversity and richness in BLA (H' = 3.68; 48 species) were higher than NF (H' = 3.55; 45 species). However, shrub species diversity and richness (H' = 2.70; 17 species) in BLA was slightly lower than that in NF (H' = 3.35; 40 species) (Table 1). A comparison between the tree species richness in BLA of South Meghalaya recorded in this study with other agroforestry systems shows that tree diversity of BLA is significantly higher (94 tree species) than cocoa agroforestry in southern Cameroon (21 tree species), betel leaf agroforestry in Bangladesh (61 tree species) (Nath et al. 2003) and betel

nut agroforestry in South Meghalaya (83 tree species) (Tynsong and Tiwari 2010) but it is lower than that in the coffee farms in Veracruz, Mexico (Lopez-Gomez et al. 2008). Species richness for herb in BLA in South Meghalaya recorded in this study (48 species) is similar to cocoa agroforestry in south Cameron (48 herb species) (Sonwa et al. 2007) and slightly higher than the betel nut agroforestry in South Meghalaya (41 herb species) (Tynsong and Tiwari 2010). Tree species in BLA are more diverse as compared to traditional agroforestry in Dellomenna District, Southeastern Ethiopia (H' = 2.53 to 2.73) (Molla and Kewessa 2015), home garden in Thailand (H' = 0.9 to 2.7) (Gajaseni and Gajaseni 1999) and traditional agroforestry in Kerala in India (H' = 1.12 to 3) (Kumar et al. 1994).

Tree basal area in BLA (50.05 m^2ha^{-1}) was marginally less than NF (52.26) (Table 1). However, in comparison with other agroforestry systems, the BLA has higher tree basal area. For example, in cocoa agroforestry and mixed food crops agroforestry in Southeastern Ghana, the basal area was recorded at 8.4 m^2ha^{-1} and 8.2 m^2ha^{-1} respectively (Asase and Tetteh 2010). It is also higher than in cocoa plantations in Indonesia (11.9 to 20.5 m^2/ha) (Merijn et al. 2007) and in cocoa plantations in the southern province of Cameroon (29.7 to 42.6 m^2/ha) (Van Gemerden 2004). Our results suggest that a better stock of forest tree species was maintained in the betel leaf agroforestry than that in the natural forest of the area. We also observed that tree species such as *Trema polytoria*, *Macaranga denticulata*, *Macaranga peltata*, *Adenanthera pavonina*, *Ficus roxburghii* and *Wrightia tomentosa* were found only in BLA.

Furthermore, some light-demanding second-storey tree species such as *Trema polytoria*, *Macaranga denticulata*, and *Macaranga peltata* grew luxuriantly in BLA and were absent in NF due to the higher density of trees resulting in the lower sunlight. Higher herb species diversity in BLA may be attributed to the fact that it was dominated by light-demanding plants, specifically those belonging to Asteraceae, Rubiaceae, and Poaceae. Thus in BLA, the species composition of trees and herbs seem to be directly related to the availability of light.

Table 4. Number of plant species and their main uses in BLA in South Meghalaya, India

Main uses		No of plant species
Timber	High value	10
	Low value	11
Fuelwood	High value	20
	Low value	31
Edible		15
Medicinal		17
Tool		6
Ornamental		5
Craft		2
Packing Leaf		1
Latex Producing Plant		1
No Specific Use		40
Total		159

A similar finding was reported in traditional cocoa forest gardens by Bisseleua et al. (2008). The lower number of shrub species in BLA could be explained by the traditional management practices of BLA by local people, such as by the weeding out of shrubs growing close to betel leaf plants twice a year by farmers, so the betel leaf have sufficient space and nutrients to grow. Even though in BLA all tree species were maintained as supporting trees, we observed that high percentage of highly economical useful plant species were retained by purpose. The preference for multipurpose tree species is understandable in the context that the owners of the agroforestry depend on such plants for timber, food, medicine, and fuelwood (Tiwari et al. 2004). Motiur et al. (2006) also found that agroforestry in Bangladesh supply important forest products like fruit, fuelwood, timber and bamboo to meet household demands. Besides supporting trees, tree species were maintained mainly for timber, fuelwood, and edible stuff purposes. *Artocarpus heterophyllus*, *Cedrela toona*, *Duabanga grandiflora*, and *Schima wallichii* were preferred timber trees, while *Macaranga denticulata*, *Macaranga hypoleuca*, *Macaranga peltata*, *Quercus dealbata*, and *Quercus lanceofolia* were most preferred as fuelwood trees. A total of 17 medicinal plant species were recorded in BLAs. BLAs are also the habitat for 14 endemic and 6 rare plants. Thus, these manmade ecosystems contribute to biodiversity conservation, while at the same time they also provide goods and services to the local inhabitants.

In conclusion, the betel leaf agroforestry harbors plant diversity comparable to the natural forests and provides habitat for endemic and rare plant and animal species. The land-use change has a negligible impact on tree and herb diversity. However, it has a significant impact on density and diversity of shrub species. Betel leaf agroforestry in South Meghalaya is best-suited land use practice with minimal impact on plant diversity and forest community structure. We conclude that for a more robust study and conclusions regarding the impact of betel leaf agroforestry on plant diversity, further research needs to be carried out across the region.

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Table S1: Plant species, their families, density (individual ha^{-1}) recorded in Natural Forest (NF) and Betel Leaf Agroforest (BLA) of South Meghalaya, Indonesia

Tree species	Family	Frequency		Density		IVI	
		NF	BLA	NF	BLA	NF	BLA
Acer oblongum Wall.	Aceraceae	3.00	-	4	-	0.48	-
Actinodaphne abovata (Nees.) Blume.	Lauraceae	4.00	10.00	7	16	0.77	2.93
Actinodaphne angustifolia Nees.	Lauraceae	3.00	-	7	-	0.61	-
Adenanthera pavonina L.	Mimosaceae	-	40.00	-	44	-	6.39
Aesculus assamica Griff.	Hippocastanaceae	-	7.50	-	6	-	1.02
Aglaia perviridis Hiern.	Meliaceae	-	37.50	-	36	-	5.29
Alstonia scolaris Brown.	Apocynaceae	-	10.00	-	8	-	1.32
Amoora rohituka W&A.	Meliaceae	-	12.50	-	10	-	1.71
Antidesma khasianum Hk.f.	Euphorbiaceae	-	15.00	-	12	-	2.10
Aporosa dioica (Roxb.) Muell. Arg.	Euphorbiaceae	11.00	7.50	18	6	2.24	1.03
Ardisia floribunda Wall.	Myrsinaceae	16.00	-	42	-	4.48	-
Artocarpus heterophyllus Ham.	Moraceae	-	12.50	-	20	-	2.45
Artocarpus lakoocha Roxb.	Moraceae	-	40.00	-	36	-	7.01
Baccuarea sapida (Roxb.) Muell.	Euphorbiaceae	24.00	20.00	46	18	5.52	3.34
Bambusa tulda Roxb.	Poaceae	12.00	-	58	-	5.82	-
Bambusa vulgaris Schrad.	Poaceae	-	2.50	-	80	-	5.06
Beilschmiedia brandisii Hk f.	Lauraceae	-	7.50	-	6	-	1.78
Bischofia javanica Blume.	Euphorbiaceae	-	15.00	-	12	-	2.60
Bombax malabaricum DC.	Malvaceae	-	2.50	-	4	-	0.82
Brassaiopsis glomerulata (Blume.) Regel.	Araliaceae	-	7.50	-	14	-	1.90
Bridelia monta Willd.	Euphorbiaceae	-	20.00	-	16	-	2.67
Calicarpa vestica Wall. ex Cl.	Verbenaceae	-	12.50	-	10	-	1.66
Canthium glabrum Blume.	Rubiaceae	6.00	-	11	-	1.17	-
Caryota urens L.	Arecaceae	-	27.50	-	26	-	6.85
Casearia kurzii C.B.Clarke.	Pittosporaceae	-	10.00	-	8	-	1.50
Castanopsis hystrix A.DC.	Fagaceae	34.00	-	59	-	10.48	-
Castenea sativa Miller.	Fagaceae	19.00	-	48	-	8.50	-
Cedrela toona Roxb.	Meliaceae	-	7.50	-	6	-	1.28
Chrysophyllum rozburghii G.Don.	Sapotaceae	5.00	-	7	-	0.96	-
Cinnamomum bejolghota Buch.-Ham.	Lauraceae	-	20.00	-	20	-	3.27
Cinnamomum camphora F.Nees.	Lauraceae	9.00	-	14	-	1.71	-
Cinnamomum tamala Fr. Nees.	Lauraceae	21.00	10.00	36	12	4.86	2.24
Citrus latipes (Swingle.)Tanaka.	Rutaceae	6.00	-	6	-	1.05	-
Citrus macroptera Lour.	Rutaceae	-	2.50	-	2	-	0.36
Cryptocarya amygdalina Nees.	Lauraceae	12.00	15.00	20	12	2.76	2.16
Cryptocarya andersoni King.	Lauraceae	-	25.00	-	20	-	3.46
Cryptocarya floribunda Nees.	Lauraceae	-	5.00	-	6	-	1.30
Cyathea gigantea (Wall ex Hook.) Holttm.	Cyatheaceae	2.00	-	5	-	0.37	-
Daphniphyllum himalayense Muell.	Euphorbiaceae	5.00	-	18	-	1.72	-
Derris robusta Benth.	Fabaceae	-	7.50	-	10	-	1.39
Diospyros kaki L.	Sapotaceae	8.00	35.00	11	28	1.49	4.43
Diospyros pilosula Wall.	Ebenaceae	-	10.00	-	8	-	1.26
Diospyros sp.	Ebenaceae	-	10.00	-	8	-	1.43
Drimycarpus racemosus (Roxb.) Hk.f.	Anacardaceae	-	10.00	-	10	-	1.71
Duabanga grandiflora (Roxb. Ex DC.) Walp.	Sonneratiaceae	6.00	32.50	15	58	2.32	32.78
Dysoxylum hamiltoni Hiern.	Meliaceae	-	20.00	-	30	-	4.14
Ehretia acuminata Br.	Boraginaceae	7.00	10.00	10	8	1.32	1.47
Elaeocarpus lancifolius Roxb.	Elaeocarpaceae	-	7.50	-	6	-	1.13
*Elaeocarpus sikkimensis*Mast.	Elaeocarpaceae	-	17.50	-	32	-	4.59
Elaeocarpus lancifolius Roxb.	Elaeocarpaceae	11.00	-	22	-	2.58	-
Engelhardtia spicata Blume.	Jaglandaceae	5.00	7.50	7	14	0.94	1.80
Erythroxylon kunthianum Wall.	Malpighiaceae	7.00	-	10	-	1.34	-
Erythroxylum kunthianum Wall.	Malpighiaceae	7.00	-	25	-	2.39	-
Euonymus lawsonii Clarke & Prain.	Celastraceae	-	10.00	-	8	-	1.37
Eurya acuminata DC.	Theaceae	8.00	5.00	14	26	1.64	1.98
Ficus benjavina L. var.*comosa* Kurtz.	Moraceae	-	7.50	-	12	-	10.51
Ficus faveolata Wall.	Moraceae	4.00	10.00	13	12	1.21	1.83
Ficus gibbosa Blume.	Moraceae	-	12.50	-	10	-	1.60
Ficus glomerata Roxb.	Moraceae	-	27.50	-	92	-	10.99
Ficus hirta Vahl.	Moraceae	5.00	-	5	-	0.82	-
Ficus roxburghii Wall.	Moraceae	-	20.00	-	46	-	5.72
Ficus sp.	Moraceae	13.00		27		3.15	
Garcinia gummi-gutta (L.) Roxb.	Clusiaceae	-	5.00	-	4	-	0.72
Garcinea spicata Hk.f..	Guttiferae	5.00	-	13	-	1.38	-
Garcinia lanceolarium Dalz.	Guttiferae	7.00	-	12	-	1.73	-
Garcinia paniculata (G.Don) Roxb.	Guttiferae	13.00	-	17	-	2.42	-

Garuga pinnata Roxb.	Burseraceae	4.00	-	4	-	0.65	-
Glochidion khasicum Hk.f.	Euphorbiaceae	6.00	12.50	13	10	1.37	1.66
Glochidion thomsoni Hk.f.	Euphorbiaceae	-	10.00	-	10	-	1.39
Gynocardia odorata R.Br.	Flacourtiaceae	-	22.50	-	22	-	3.43
Helicia erratica Hk.f.	Proteaceae	40.00	2.50	52	2	8.76	0.35
Hydnocarpus kurzii Warb.	Flacourtaceae	-	7.50	-	6	-	1.16
Ilex embelioides Hk .f.	Aquifoliaceae	-	7.50	-	6	-	1.33
Itea macrophylla Wall.	Saxiferaceae	7.00	-	21	-	2.42	-
Knema andamanica Hk.f.	Myristicaceae	2.00	-	2	-	0.33	-
Knema linifolia (Roxb.) Warb.	Myristicaceae	8.00	27.50	9	32	1.40	4.79
Ligustrum robustum (Roxb.)Blume.	Oleaceae	8.00	7.50	8	6	1.30	1.17
Lithocarpus elegans (Blume.) Soep.	Fagaceae	48.00	10.00	133	8	30.80	1.38
Lithocarpus fenestatus (Roxb.) Rehder	Fagaceae	41.00	-	169	-	40.66	-
Litsea citrata Blume.	Lauraceae	8.00	-	11	-	1.53	-
Litsea elongata Wall.	Lauraceae	-	7.50	-	10	-	1.40
Litsea laeta Benth. Hk.f.	Lauraceae	-	7.50	-	6	-	1.06
Litsea leiantha (Kurz) Hk.f.	Lauraceae	3.00	-	5	-	0.60	-
***Litsea** semecarpifolia* (Wall. ex Nees) Hook.f.	Lauraceae	4.00	7.50	4	6	0.70	1.04
Macaranga denticulata Muell. Arg.	Euphorbiaceae	-	2.50	-	2	-	0.34
Macaranga peltata (Roxb.) Muell.Arg.	Euphorbiaceae	-	10.00	-	20	-	2.07
Machilus bombycina King.	Lauraceae	38.00	22.50	79	46	12.35	5.46
Macropanax undulatus (Wall.ex D.Don) Seem.	Araliaceae	-	22.50	-	34	-	4.82
Magaranga indica Wight.	Euphorbiaceae	9.00	-	13	-	1.74	-
Magnolia pterocarpa Roxb.	Magnoliaceae	2.00		4		0.49	-
Magnolia sp.	Magnoliaceae	14.00	5.00	42	4	4.61	0.83
Mallotus ferrugineus Roxb.	Euphorbiaceae	-	20.00	-	20	-	2.90
Mesua ferrea L.	Clusiaceae	-	2.50	-	2	-	0.50
Michelia cathcartii Hk.f.&Th.	Magnoliaceae	-	25.00	-	20	-	3.58
Morus laevigata Wall.	Moraceae	-	25.00	-	22	-	3.87
Musa paradisiaca L.	Musaceae	-	12.50	-	12	-	2.30
Myrica esculenta Buch-Ham.ex D.Don.	Myricaceae	9.00	-	11	-	1.61	-
Myrica nagi Thunb.	Myricaceae	4.00	-	7	-	0.81	-
Oroxyrum indicum Vent.	Bignoniaceae	14.00	10.00	25	8	3.82	1.45
Ostodes paniculata Blume.	Euphorbiaceae	2.00	12.50	4	12	0.33	2.14
Pandanus odoratissimus L.	Pandanaceae	5.00	-	14	-	1.59	-
Phoebe cooperiana U.N.Kanjilal ex A.Das.Nov.sp.	Lauraceae	17.00	30.00	24	70	3.61	8.70
Phoebe lanceolata Nees.	Lauraceae	9.00	10.00	17	12	2.52	1.82
Pinus khasya Royle.	Pinaceae	1.00	-	4	-	0.16	-
Pittosporum glabratum Lindl.	Pittosporaceae	-	12.50	-	12	-	1.74
Pterospermum acerifolium Willd.	Sterculiaceae	-	2.50	-	2	-	0.85
Quercus dealbata Hk.f.&Th.	Fagaceae	8.00	-	24	-	3.06	-
Quercus dilatata Lindle.	Fagaceae	12.00	-	46	-	5.50	-
Quercus lanceaelia Roxb.	Fagaceae	-	12.50	-	10	-	1.54
Quercus lanceifolia Roxb.	Fagaceae	29.00	-	67	-	10.51	-
Quercus spicata Smith.	Fagaceae	16.00	5.00	53	6	6.02	0.98
Rhododendron arboreum Sm.	Ericaceae	1.00	-	5	-	0.21	-
Sapium baccatum Roxb.	Euphorbiaceae	6.00	7.50	12	6	2.27	3.80
Sapium insigne Benth.	Euphorbiaceae	7.00	25.00	9	30	1.61	5.13
Saprosma ternatum Hk.f.	Rubiaceae	-	12.50	-	14	-	1.98
Saraca indica L.	Caesalpiniaceae	-	12.50	-	10	-	1.71
Sarcosperma griffithii Benth.	Sapotaceae	51.00	57.50	106	132	16.58	16.36
Schima walichii Choisy.	Theaceae	22.00	10.00	64	8	11.66	1.66
Sterculia roxburghii Wall.	Sterculiaceae	3.00	12.50	6	10	0.54	1.81
Streospermum chelonoides (L.f.) DC.	Bignoniaceae	4.00	22.50	6	38	0.65	4.41
Styrax serrulatum Roxb.	Styraceae	14.00	10.00	25	10	3.06	1.44
Symplocos ramosissima Wall.	Symplocaceae	7.00	-	12	-	1.54	-
Tetrameles nudiflora R.Br.	Tetramelaceae	-	2.50	-	2	-	1.44
Toona ciliata Roem.	Ochnaceae	12.00	32.50	19	26	2.46	6.86
Travesia palmata (Roxb.) Vis.	Araliaceae	27.00	-	37	-	6.02	-
Trema polytoria Planch.	Ulmaceae	-	17.50	-	18	-	2.74
Unidentified1	Unidentified	-	15.00	-	16	-	3.01
Unidentified2	Unidentified	16.00	-	32	-	4.20	-
Unidentified3	Sapotaceae	-	15.00		16		2.18
Unidentified4	Unidentified	6.00	-	21	-	1.20	-
Unidentified5	Guttiferae	9.00	-	17	-	2.24	-
Unidentified6	Unidentified	2.00	-	6	-	0.52	-
Villebrunea intigrifolia Gaud.	Urticaceae	-	10.00	-	16	-	1.93
Wenderhardia tinctoria DC.	Rubiaceae	18.00	15.00	37	16	4.84	2.30
Wendlandia paniculata DC.	Rubiaceae	-	7.50	-	16	-	1.62
Wrightia tomentosa Roem & Sch.	Apocynaceae	-	32.50	-	76	-	8.19
Syzygium tetragonum (L.) Skeels.	Myrtaceae	42.00	2.50	86	2	12.50	0.36

Total		-	-	**1972**	**1788**	**300**	**300**
Shrub component							
Adenosaeme sp.	Rubiaceae	20.00	-	260	-	3.70	-
Ardisia griffithii C.B.Clarke.	Myrsinaceae	10.00	-	80	-	1.59	-
Ardisia sp.	Myrsinaceae	10.00	-	140	-	1.90	-
Boehmeria malabarica Wedd.	Urticaceae	10.00	10.00	180	1005	2.11	25.10
Calamus arborescence Griff.	Arecaceae	-	8.00	-	1480	-	28.01
Camellia caduca C.B. Clarke.	Theaceae	40.00	-	340	-	6.47	-
Cephalostachyium sp.	Poaceae	10.00	-	400	-	3.25	-
Cephalostachyum pallidum Munro.	Poaceae	15.00	-	280	-	3.22	-
Chloranthus glaber Thunb.	Chloranthaceae	35.00	-	1000	-	9.30	-
Clerodendron serratum Spreng.	Verbenaceae	55.00	3.00	2020	100	16.95	4.23
Coffea benghalensis Roxb.	Rubiaceae	20.00	-	360	-	4.22	-
Coffea sp.	Rubiaceae	25.00	-	480	-	5.43	-
Cyathea albosetacea Copel.	Cyatheaceae	35.00	-	440	-	6.40	-
Daphne involucrata Wall.	Thymelaeaceae	20.00	-	240	-	3.60	-
Daphne involucrata Wall.	Thymeleaceae	-	4.00	-	120	-	6.16
Dracaena fragrans (L.) Ker-Gawl.	Agavaceae	-	3.00	-	112	-	4.39
Eupatorium odoratum Spreng.	Asteraceae	-	3.00	-	280	-	6.27
Eurya japonica Thunb.	Theaceae	45.00	-	1400	-	12.56	-
Ficus clavata Wall.	Moraceae	5.00	-	40	-	0.80	-
Ficus hirta Vahl.	Moraceae	5.00	-	40	-	0.80	-
Ficus pyriformis Hook. &Arn.	Moraceae	5.00	-	20	-	0.69	-
Ficus sarmentosa Wall.	Moraceae	5.00	3.00	80	120	1.00	4.29
Flemingia macrophylla (Willd.) Prain.	Fabaceae	20.00	-	160	-	3.18	-
Goniothalamus sesquipidalis Hk.f.&Th.	Annonaceae	10.00	2.00	120	76	1.80	3.16
Hedychium coccineum Buch.-Ham.ex Sm.	Zingiberaceae	5.00	-	40	-	0.80	-
Hedychium thyrsiforme Buch.-Ham.ex Sm.	Zingiberaceae	20.00	6.00	340	401	4.12	12.38
Ixora subsissillis Wall.	Rubiaceae	20.00	7.00	-	340	-	12.09
Justicia sp.	Acanthaceae	15.00	-	560	-	5.26	-
Laportea crenulata (Roxb) Gaud.	Urticaceae	15.00	7.00	180	260	2.70	11.05
Luculia pinceana Hook.	Rubiaceae	5.00	3.00	20	123	0.69	5.01
Mahonia pycnophylla Fedde.	Berberidaceae	5.00	-	60	-	0.90	-
Medinilla rubicunda Blume.	Melastromaceae	5.00	-	100	-	1.11	-
Morinda angustifolia Roxb.	Rubiaceae	45.00	9.00	440	400	7.58	15.01
Mussaendra roxburghii Hk.f.	Rubiaceae	5.00	9.00	80	339	1.00	14.11
Myrioneuron nutans Kurtz.	Rubiaceae	20.00	5.00	640	224	5.67	8.03
Ophiorhiza hispida Hook.f.	Rubiaceae	10.00	-	160	-	2.01	-
Phrynium capitatum Willd.	Marantaceae	20.00	10.00	1020	860	7.64	8.01
Phrynium sp.	Marantaceae	35.00	-	980	-	9.20	-
Phyllanthus debilis Ham.	Euphorbiaceae	10.00	-	120	-	1.80	-
Pinanga cracilia (Roxb.) Blume.	Arecaceae	35.00	-	1200	-	10.34	-
Psychotria erratica Hk.f.	Rubiaceae	60.00	-	2140	-	18.16	-
Rubus khasianus Cordat.	Rosaceae	5.00	-	20	-	0.69	-
Sylvianthus bracteotus Hk.f.	Rubiaceae	-	2.00	-	120	-	3.08
Thysanolaena maxima (Rozb.)O.Ktze.	Poaceae	35.00	4.00	1680	600	12.83	19.07
Unidentified	Unidentified	20.00	-	760	-	6.29	-
Wallichia densiflora Mart.	Arecaceae	55.00	2.00	540	700	9.27	11.31
Zanthoxylum armatum DC.	Rutaceae	20.00	-	120	-	2.98	-
Total		**-**	**-**	**19280**	**7660**	**200**	**200**
Herb component							
Achyranthes japonica (Miq.) Nakai.	Amaranthaceae	29.37	14.38	15250	7938	9.80	4.01
Ageratum conzynoides L.	Asteraceae	-	10.63	-	11313	-	4.25
Ananas bracteatus (Lindl.) Schult. & Schult. f.	Bromeliaceae	-	6.88	-	2563	-	1.63
Ananas comosus (L.) Merr.	Bromeliaceae	-	12.50	-	6626	-	3.42
Andropogon glomeratus Walt.	Poaceae	-	13.75	-	7375	-	3.78
Anotis wightiana Hk.f.	Rubiaceae	-	3.75	-	1500	-	0.91
*Anthyrium drepanopterum (*Kuntze.) A.Brown.	Anthyriaceae	8.75	16.25	6188	15250	3.82	6.01
Begonia josephii A.DC.	Begoniaceae	16.88	20.63	7375	10625	5.23	5.57
Begonia palmata D.Don.	Begoniaceae	6.88	-	4650	-	2.83	-
Begonia picta Sm.	Begoniaceae	-	12.50	-	6313	-	3.35
Bidens pilosa (Blume.) Sherff.	Asteraceae	-	16.25	-	17250	-	6.49
Bolbitis appendiculata J.Sm.	Lomariosidaceae	12.50	15.63	10290	8876	5.85	4.42
Borreria articularis (L.f.) F.N. Will.	Rubiaceae	10.63	-	6885	-	3.93	-
Borreria pilosa K.Schum	Rubiaceae	11.25	24.38	7635	20625	3.98	8.49
Calanthe masuca (D.Don) Lindl.	Orchidaceae	18.75	-	8280	-	5.83	-
Carex vesiculosa Booth.	Cyperaceae	-	48.75	-	53000	-	19.75
Centella asiatica (L.) Urban.	Apiaceae	-	10.63	-	16563	-	5.49
Commelina beghalensis L.	Commelinaceae	6.88	20.00	6998	11563	3.76	5.70

Costus speciosus (koenig) Smith.	Zingiberaceae	8.13	-	4063	-	2.38	-
*Crassocephalum crepioides (*Benth.)Moore.	Asteraceae	-	21.88	-	12000	-	6.08
Crotalaria ferruginea Garh.	Fabaceae	6.88	-	5125	-	2.45	-
Curculigo orchioides Gaertn.	Hypoxidaceae	15.63	31.88	10875	29750	6.71	11.76
Cyperus compressus L.	Cyperaceae	-	5.63	-	1875	-	1.28
Cyperus flavidus Retz.	Cyperaceae	35.00	-	34625	-	16.41	-
Cyperus odoratus L.	Cyperaceae	16.88	-	7813	-	5.35	-
Drymaria cordata (L.) Roem. & Schult.	Caryophyllaceae	-	6.88	-	3875	-	1.94
Dryopteris sp.	Dryopteridaceae	20.63	-	19750	-	9.48	-
Elatostema sesquifolium Hassk.	Urticaceae	6.25	-	5063	-	2.32	-
Elatostemma sessile Forst.	Urticaceae	15.00	15.63	7000	7625	4.78	4.12
Eleusine indica Gaertn.	Eragrosteae	-	15.00	-	4500	-	3.29
*Eragrostis gangetica (*Roxb.) Steud.	Poaceae	11.88	-	7563	-	4.36	-
Eriocaulon cristatum Mast.	Eriocaulaceae	8.75	-	6875	-	3.59	-
Ficus pumila L.	Moraceae	11.88	-	7563	-	4.36	-
Galingsoga parviflora Cay.	Asteraceae	-	8.13	-	12125	-	4.07
Gentiana tenella Fries.	Gentianaceae	18.13	-	11625	-	6.68	-
Globba clarkii Baker.	Zingiberaceae	9.38	-	4563	-	3.04	-
Globba racemosa Sm.	Zingiberaceae	15.00	-		10813	-	4.78
Globba sp.	Zingiberaceae	10.00	-	5688	-	3.48	-
Goodyera repens (Ker-Gawl.) Hook.	Orchidaceae	6.88	-	1750	-	1.77	-
Hemiphragma heterophyllum Wall.	Scrophulariaceae	-	13.13	-	8813	-	4.03
Hydrocotyle javanica Thunb.	Apiaceae	7.50	13.75	2813	6125	2.29	3.49
Impatiens balsamina L.	Balsaminaceae	-	12.50	-	4000	-	2.80
Impatiens benthamii V.Steenis.	Balsaminaceae	2.50	25.00	770	12375	0.78	6.63
Impatiens tripetala DC.	Balsaminaceae	9.38	27.50	3388	11188	2.64	6.73
Imperata cylendrica (L.)P.Beauv.	Poaceae	-	7.50	-	1938	-	1.57
Ipomea purpurea (L.) Roth.	Convolvulaceae	-	9.38	-	4688	-	2.50
Justicia sp.	Acanthaceae	-	5.63	-	1500	-	1.19
Kaulina pteropus (Blume) Nayar.	Polypodiaceae	-	6.25	-	1938	-	1.39
Knoxia corymbosa Willd.	Rubiaceae	16.25	-	9750	-	5.80	-
Miconia prasina (SW.) DC.	Melastromaceae	9.38	-	3375	-	2.70	-
Onoclea sensibilis L.	Onocleaceae	-	10.63	-	4875	-	2.73
Ophiorrhiza hispida Hk.f.	Rubiaceae	12.50	-	5938	-	4.01	-
Ophiorrhiza hispida Hk.f..	Rubiaceae	-	14.38	-	8063	-	4.04
Oplismenus compositus P.Beauv.	Paniceae	10.00	12.50	3188	4250	2.76	2.86
Osbekia capitata Benth.	Melastromaceae	5.00	-	5438	-	2.33	-
Oxalis corniculata L.	Oxalidaceae	8.13	-	7500	-	2.50	-
Paspalum dilatatum Pior.	Poaceae	13.13	17.50	13063	5250	6.17	3.84
Peperomia heyneana Miq.	Piperaceae	-	6.25	-	2500	-	1.52
Peperomia reflexa A.Dietr.	Piperaceae	14.38	-	6000	-	4.37	-
Phryma leptostachya L.	Verbenaceae	-	6.88	-	4375	-	2.05
Polygonum hydropiper L.	Polygonaceae	-	10.00	-	4125	-	2.46
Polygonum thunbergii Sieb. & Zucc.	Polygonaceae	-	18.13	-	7374	-	4.43
Polystichum aculeatum (L.)Roth.	Aspidiaceae	-	20.00	-	8500	-	4.98
Pronephrium nudatam (Roxb)Holttum.	Thelypteridaceae	-	3.75	-	2813	-	1.22
Pteris quadriaurita Retz.	Pteridaceae	-	3.13	-	4500	-	1.53
Richardia brasiliensis Gomes.	Rubiaceae	-	6.88	-	3875	-	1.94
Selaginella chrysocaulos Hk. et. Grev.) Spring.	Selaginellaceae	11.25	-	8663	-	4.91	-
Sida cordifolia L.	Malvaceae	-	6.88	-	5751	-	2.38
Smithea ciliata Royle.	Fabaceae	18.13	-	16475	-	8.97	-
Sonerila khasiana Clarke.	Melastromaceae	21.25	-	9895	-	6.99	-
Sonerilla khasiana Dyer.	Melastromaceae	8.13	-	5090	-	2.94	-
Spilanthes paniculata DC.	Asteraceae	5.63	14.38	6188	5564	1.95	3.45
Srobilanthus sp.	Acanthaceae	15.63	-	10813	-	5.99	-
Tacca laevis Roxb.	Taccaceae	-	9.38	-	4115	-	2.37
Torenia diffusa D.Don.	Scrophulariaceae	-	14.38	-	10188	-	4.54
Trillium erectus L.	Liliaceae	5.63	-	3974	-	1.85	-
Urena labata L.	Malvaceae	-	10.63	-	5062	-	2.77
Viola palmaris Ging.	Violaceae	3.13	-	560	-	0.78	-
Viola sikkimensis W.Becker	Violaceae	6.25	-	3650	-	1.82	-
Zingiber rubens Roxb.	Zingiberaceae	12.50	-	6750	-	4.24	-
Zingiber sp.	Zingiberaceae	4.38	-	790	-	1.02	-
Total		-	-	**347563**	**423688**	**200**	**200**

Note: '-' : indicates absent