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Priority Areas for Conservation in Northeast India: A Case Study in Meghalaya Based on Plant Species Diversity and Endemism

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ABSTRACT

For setting up priority sites for conservation, information on the distribution of species in the area is required. The present study provides first-hand information on the distribution of threatened and endemic species in Meghalaya, northeast India, which is a part of Indo-Burma hotspot. Distribution of species in different habitats reveals that primary forests are the main habitat of threatened and endemic species. The number of threatened species was high at low and medium-high altitude areas, whereas, endemic species showed high concentration at medium and medium-high altitude areas. Though the current protected area in the state is serving an important role in plant diversity conservation, it is inadequate because of smaller area and being restricted at low-medium altitude. High altitude areas in Meghalaya are poorly represented by protected category and a large number of threatened and endemic species occur in areas located outside the existing protected areas. Eleven priority sites are identified that contain 66 (80%) threatened and 274 (85%) endemic species, where conservation efforts need to be focused at the earliest. Closer monitoring of plant diversity including the populations of endemic and threatened species is suggested for effective conservation of such species.

Key Words: Biodiversity Conservation; Endemic Species; Protected Areas; Threatened Species; Northeast India.

INTRODUCTION

Biodiversity throughout the world is depleting at an alarming rate (Balmford et al. 2003, Jenkins et al. 2003) and this problem is recognized as a global problem of significant magnitude (Wilson 2000). Conservation biologists estimate that about 25% of the total life forms may become extinct during the next thirty years mainly due to habitat loss and fragmentation, overexploitation, pollution, invasion by alien species and global climate change (Singh 1998, IUCN 2003). Therefore, a major challenge before conservation biologists is to effectively protect those species that are on the verge of extinction. Conservation of species can be achieved by setting up conservation priority sites. Two important types of information are necessary for setting conservation priorities: (i) the conservation value of the area and (ii) its vulnerability (Menon et al. 2001). A number of criteria such as species richness, level of endemism and exposure to threats are available for identification of conservation sites (Myers et al. 2000). The details on these aspects can be obtained by extensive biodiversity inventory but studies are far from complete in many of the countries. Recently, herbarium specimens have been given emphasis in biodiversity research and are playing a vital role in biodiversity assessment and conservation (Kress et al. 1998). The distribution of threatened species combined with high resolution distribution map would be a very useful tool for identifying and setting conservation priority sites and for future planning (Dobson et al. 1997, Brooks et al. 2006, Grenyer et al. 2006, Zang and Ma 2008, Bragazza 2009). Identification

of plant diversity conservation areas were also attempted using expert workshops in conservation planning where readily available data were lacking (Rodriguez and Young 2000, Groves 2003). Therefore, information on the distribution of threatened and endemic species would be crucial for taking up effective conservation measures.

The state of Meghalaya in northeast India, comprising the Khasi, Jaintia and Garo Hills, is a part of the Indo-Burma biodiversity hotspot. The State is floristically rich and one of the botanically explored areas of the region. Out of the estimated 17,000 plant species found in India, 3128 (18%) flowering plants including endemic, rare and primitive taxa were reported from the state (Khan et al. 1997). The rich biodiversity of the State is due to its topography, variation in altitude and climatic conditions. Its sub-Himalayan existence and the abrupt raising of hills over the vast plains that surround the State have resulted in rich endemism (Haridasan 1999). However, deforestation, shifting cultivation, urbanization and forest fragmentation (Rao and Hajra 1986, Tripathi et al. 2010) are posing threat to the biodiversity of the State. The flora of the state has been recognized as one of the richest in India, perhaps in Asia as well (Hooker 1872-97, 1904). The State has been a focal point for many botanists and botanical exploration started as early as the middle of the nineteenth century (Hooker 1854). The geographical distribution of the species in the State has been mentioned by Kanjilal et al. (1934-1940), Joseph (1982), Balakrishnan (1981-1983), Kataki (1983), Jain and Rao (1983), Haridasan and Rao (1985-1987) and Shukla (1996). Such information would be of immense help in formulating conservation strategies. Therefore, the objectives of the present study was (i) to build a database on geographic distribution pattern of threatened and endemic plant species of Meghalaya referring to specimen records and published literature, (ii) to assess if existing protected areas are adequate for conservation of such species and (iii) to identify priority sites for conservation so that expansion of the protected area network can be suggested.

STUDY AREA

This study was carried out for the state of Meghalaya (25°02' to 26°10' N latitude and 89° 45' and 95° 45' E longitude) in north east India (Figure 1) covering an area of 22,429 sq km. The altitude of the area ranges from 50-1990 m asl. Vegetation of the State can be broadly categorized into tropical forests, subtropical- broad leaved and -pine forest, temperate forest and grassland. The State has two National parks, three Wildlife sanctuaries and 23 Reserved forests (Figure 1). In addition to these there are five protected forests/green blocks with an area ranging between 0.14 and 7.66 km^2. There are also more than 100 sacred forests spread throughout the State covering an area of 1000 km^2.

The climate of the area is monsoonal with distinct wet and dry seasons. The wet season extends from May and continues up to October, whereas the dry season extends from November to March. The western part of Meghalaya (Garo hills) being relatively in low elevation, experiences high temperature throughout the year. The average rainfall is 2689 mm that decreases from south to north as the moisture bearing winds strikes the southern part causing heavy downpour, while the central Tura range obstruct their path to the north. The average rainfall in the south-east is >4,000 mm, whereas in the north, it is between 2500–3000 mm (Haridasan and Rao 1985).

The climate of the central and eastern Meghalaya (Khasi and Jaintia hills) experiences low temperature and in the Shillong Plateau, it goes down to about 5.8°C during winter months (December–January). But, at the foothills in the north and east, the climate is warm and humid. The most striking feature of these parts, which distinguishes the area climatically from other parts of Meghalaya is high average rainfall of 7196 mm. Cherrapunjee and Mawsynram, which are 16 km away from each other and about 50 km from Shillong on the South records the highest rainfall (12,000-13,000 mm) in the World (Haridasan and Rao 1985). The Shillong plateau located at high elevation (1990 m asl) obstructs the rainfall thereby reducing the rainfall (2500 mm) to its north.

METHODOLOGY

A database of endemic and threatened plants for the State of Meghalaya was established. It was composed of plant name, threatened category, habit, habitat, endemism and their distribution in the State of Meghalaya, other parts of the country and the world. Two sets of data were used for the present analysis, *viz*., threatened and endemic species. The first set includes plants classified as per the Red Data Book of Indian plants (Nayar and Sastry 1987, 1988, 1990), Walter and Gillett (1998), Molur and Walker (1998), Ved et al. (2005) and the recent IUCN Red List (IUCN 2010), with

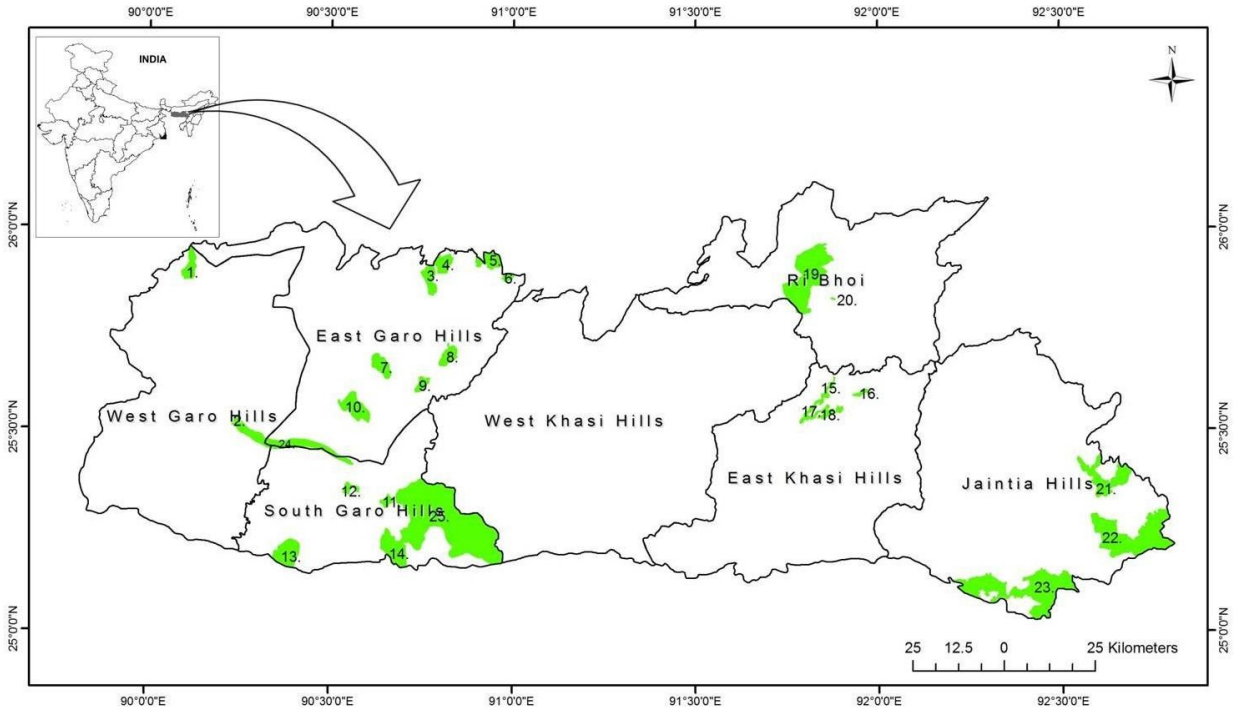

Figure 1. Map showing the distribution of National parks (NP), Wildlife sanctuaries (WLS) and Reserved forests (RF) in Meghalaya (1. Dribru hills RF, 2. Tura peak RF, 3. Chima Bangshi RF, 4.Dhima RF, 5. Rajasimla RF, 6. Iidek RF, 7. Songsak RF, 8. Darugiri RF, 9. Dambu RF, 10. Rongrengiri RF, 11. Siju WLS/RF, 12. Emanggiri RF, 13. Angratoli RF, 14. Baghmara WLS/RF, 15. Rait Khawn RF, 16. Shyrwat RF, 17. Upper Shillong RF, 18. Rait Laban RF, 19. Nongkhyllem WLS/ RF, 20. Umsaw RF, 21. Saipung RF, 22. Saipung RF, 23. Narphu RF, 24. Nokrek NP, and 25. Balphakram NP).

the categories: Extinct (EX), Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least concern (LC), Data deficient (DD) and Not evaluated (NE). The second set includes endemic species, whose distribution is restricted to Meghalaya or to the North-eastern region including Indo-Burma hotspot of which it is a part and at the same time considered as rare to the State (Haridasan and Rao 1985-1987, Walter and Gillett 1998, Jain and Rao 1983, Nayar and Sastry 1987, 1988, 1990). Threatened species that were classified as indeterminate by Walter and Gillett (1998) and Nayar and Sastry (1987, 1988, 1990) and do not fall under the recent IUCN threatened categories were excluded in the present analysis. Furthermore, the possibly extinct species were also excluded for identification of priority areas for biodiversity conservation in the State.

The details of the distribution of the threatened and endemic species were collected from the following sources: (1) herbarium records from the Botanical Survey of India, North-eastern circle, Shillong and Department of Botany, North-Eastern Hill University, Shillong (2) Red Data Books of Indian Plants (Jain and Sastry 1984, Nayar and Sastry 1987, 1988, 1990) (3) floras (Hooker 1872-1897, Kanjilal et al. 1934-1940, Joseph 1982, Balakrishnan 1981-1983, Haridasan and Rao 1985-1987) (4) theses on floristic work and plant diversity inventory studies (Myrthong 1980, Kumar 1984, Jamir 2000, Upadhaya 2002, Upadhaya et al. 2003, Prabhu 2004, Lakadong 2009, Thapa et al. 2011) (5) published books (Shukla 1996, Kataki 1986, Hajra 1974, Takhtajan 1969, 1988, Tiwari et al. 1999, Jain and Rao 1983, Pandey and Barik 2006) and book chapters on threatened and endemic plants (Jain and Rao 1983, Kataki 1983, Kumar and Rao 1983, Rao and Haridasan 1983, Haridasan 1999, Lakadong and Barik 2006), (6) scientific literature dealing with endemic and threatened categories of plants (Deb 1958, Jamir and Pandey 2003, Khan et al. 1997, Kumar 1991, Rao and Haridasan 1982, Rao and Hajra 1986, Pandey et al. 2005, Upadhaya et al. 2009, Prabhu et al. 2010). The nomenclature of vascular plants follows the regional floras (Haridasan and Rao 1985-1987, Balakrishnan 1981-1983).

As species may have narrow or wider altitudinal distribution range, the altitudinal ranges were categorized into: low (0-750 m), medium (750-1500m),

high (>1500 m), low-medium (0-1500 m), medium high (750 to > 1500 m) and low-medium- high (> 0 m) following Khan et al. (1997). Similarly, habitats were classified into: primary forests- refer to broad leaved forest (tropical, subtropical and temperate), pine forest - refers to forest dominated by *Pinus kesiya*, secondary forests- refers to disturbed and degraded forests, shady areas - refers to moist, under forest or near stream habitats, rocky and grassland areas. Based on the geographic distribution and the concentration of threatened and endemic species, priority areas for conservation were identified.

RESULTS

Species Diversity

A total of 363 species belonging to 263 genera and 108 families that are either threatened or endemic were generated from the database for the State of Meghalaya. Of this, 82 species belonging to 72 genera and 51 families fall under various threatened species categories of IUCN (Table 1). It includes possibly extinct (5 species), critically endangered (7), endangered (24), vulnerable (26), near threatened (4), least concern (13) and data deficient (3) (Appendix 1). Out of the 363 species, 321 species in 236 genera and 93 families are endemic to the region, which are also considered as rare to the State. Among them, 130 species are exclusively endemic to the State. Out of the 82 threatened species, 17 (21%) are endemic to the state and 24 (29%) are near endemic (Appendix 1).

Table 1. Species richness and life form distribution of threatened and endemic plant species of Meghalaya

Parameters	Threatened	Endemic	Overall
Number of species	82	321	363
Number of genera	72	236	263
Number of families	51	93	108
Life forms			
Trees	39	105	129
Shrubs	9	56	59
Herbs	20	77	84
Climbers	7	41	43
Epiphytes	7	42	48

Over all in terms of family richness, Orchidaceae was the dominant family with 34 genera and 59 species, followed by Poaceae, Rubiaceae, Lauraceae and Acanthaceae. Family-wise distribution of threatened and endemic species is shown in Table 2.

Table 2. Dominant families of threatened and endemic plant species in Meghalaya

Family	Threatened		Endemic		Overall	
	Genera	Species	Genera	Species	Genera	Species
Acanthaceae	-	-	7	10	7	10
Annonaceae	2	2	7	9	7	9
Apocynaceae	1	1	5	6	6	7
Asclepiadaceae	1	3	4	8	4	8
Celastraceae	2	2	2	3	4	5
Euphorbiaceae	-	-	7	8	7	8
Fabaceae	3	3	3	6	8	10
Lauraceae	-	-	8	11	8	11
Magnoliaceae	2	2	4	7	4	7
Orchidaceae	9	11	32	52	34	59
Poaceae	-	-	15	18	15	18
Rubiaceae	2	5	10	16	11	17
Others	50	53	132	167	147	194
Total	72	82	236	321	263	363

Life Form and Distribution

The habit-wise distribution of threatened and endemic plant species in Meghalaya reveals that the dominant life form is trees (36%), followed by herbs (23%), shrubs (16%), epiphytes (13%) and climbers (12%) as shown in Table 1. The altitudinal distribution of threatened and endemic plants showed a different trend. The number of threatened species was high at low and medium-high altitude areas, whereas, the endemic species showed high concentration at medium and medium-high altitudes. Of the total number of threatened and endemic species, only 4 (5%) and 10 (3%) species had wide distributional range and occurred at low, medium and high altitudes. Life-form distribution at different altitudes is shown in Figure 2.

Habitat-wise distribution of threatened and endemic species showed that 54–74% species are restricted to primary forest, followed by shady areas under forest or near stream (8–12%), grassland (8–10%), and rocky areas and pine forest (1–2% each). Only 7–18% of the

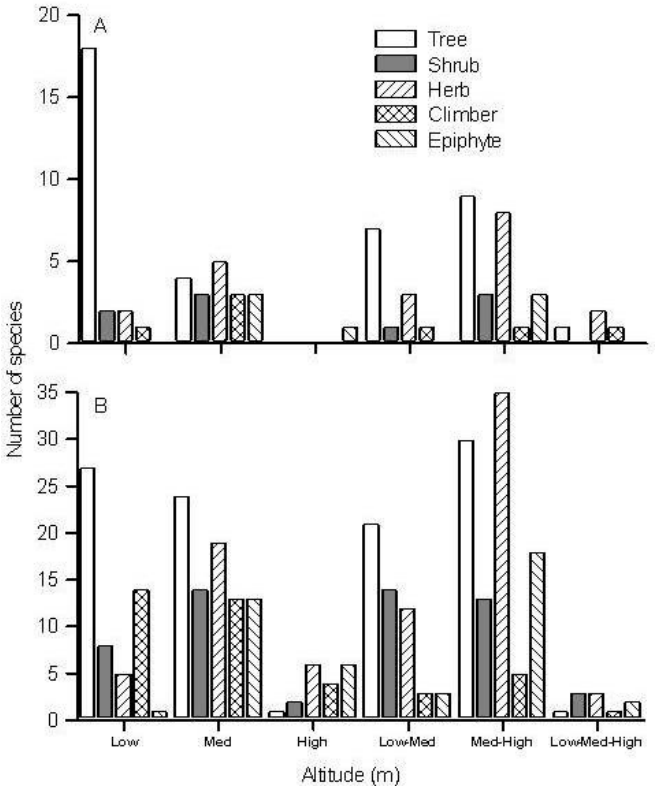

Figure 2. Life form distribution of threatened (A) and endemic (B) species at various altitudes

species occurred in more than one habitats. Some species like *Dioscorea deltoidea*, *Engelhardtia spicata*, *Saurauia punduana* and *Toona ciliata* were found both in primary and secondary forests, whereas *Gleditsia assamica* and *Tetrameles nudiflora* were characteristic of secondary or open forest (Table 3). *Nepenthes khasiana* showed a wide range of habitat distribution ranging from primary forest to grassland.

Table 3. Habitat-wise distribution of threatened and endemic species in Meghalaya

Habitat	Number of species			
	Threatened	%	Endemic	%
Primary forest	44	53.7	239	74.5
Secondary forest	2	2.4	3	0.9
Pine forest	1	1.2	1	0.3
Grassland	8	9.8	25	7.8
Moist shady areas	10	12.2	26	8.1
Rocky areas	2	2.4	3	0.9
Multiple Habitats	15	18.3	24	7.5

The distribution of threatened and endemic species in the State of Meghalaya was uneven (Figure 3). Few gaps were observed in all the districts of the State, where it showed no distribution of endemic or threatened species. Ten threatened species (*Ceropegia angustifolia*, *Cyclea debiliflora*, *Diplomeris pulchella*, *Elaeagnus conferta*, *Gleditsia assamica*, *Goniothalamus simonsii*, *Mastixia arborea*, *Nepenthes khasiana*, *Saraca asoca* and *Taxus baccata*) were distributed in National Parks, whereas 19 species (*Aglaia edulis*, *Ailanthus integrifolia*, *Alstonia scholaris*, *Aphanamixis polystachya*, *Cycas pectinata*, *Dimocarpus longan*, *Engelhardtia spicata*, *Elaeocarpus rugosus*, *Goniothalamus simonsii*, *Magnolia griffithii*, *Mangifera sylvatica*, *Mastixia arborea*, *Nepenthes khasiana*, *Ophiorrhiza hispida*, *Prunus ceylanica*, *Shorea robusta*, *Tetrameles nudiflora*, *Toona ciliata* and *Vatica lanceafolia*) were distributed in wildlife sanctuaries and reserved forests. The concentration of endemic species was highest in Jowai (73 species)

Table 4. Distribution of threatened and endemic species in protected areas of Meghalaya

Protection category	Altitude	Area (ha)	% of total area of the State	Number of Species	
				Threatened	Endemic
National Parks	50-1415	26748	1.19	11	68
Wildlife Sanctuaries	40-800	3420.7	0.15	3	7
Reserve forests	50-1400	71312.1	3.18	10	25
Protected forests	1100-1950	1239.1	0.05	3	25
Sacred groves	600-1900	10000	0.45	22	126

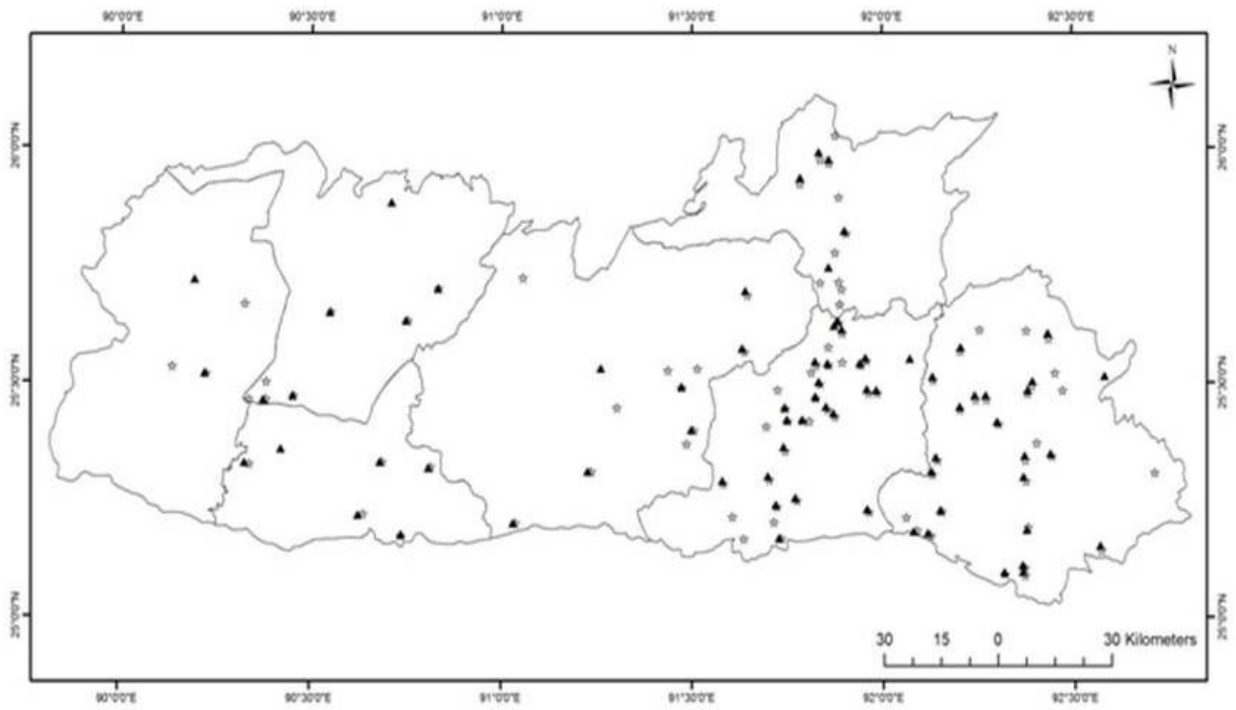

Figure 3. Map showing the distribution of threatened (▲) and endemic (★) species in Meghalaya

followed by Nokrek National Park (48) and Jarain (46). Thus, 29 threatened and 86 endemic species were distributed in protected areas such as National parks, Wildlife sanctuaries and Reserve forests. Besides, a large proportion of threatened and endemic species were restricted to sacred groves (Table 4).

Priority Areas for Conservation

Majority of the threatened and endemic plant species occurred in areas located outside the protected areas. Based on their number per site, 11 priority areas for conservation have been identified (Figure 4). These identified sites had 66 (80%) threatened species and 274 (85%) endemic species. Of the 11 priority sites, one site (Norkek-area) is completely covered by present protected area system, while Nongkhyllem-Lailad belt and Balphakram-Mahadeo area are partially protected. The two National Parks (Balphakram and Nokrek) represents low-medium altitude (Table 4). Out of the 23 reserved forests in the State, only Tura peak catchment appear in the present analysis as priority site for conservation. Besides Nongkhyllem-Lailad area, one more priority site was identified at low altitude i.e. Dawki-Pongtung area. Five sites (Cherrapunjee-, Jowai-, Shillong peak – Mawphlang-, Raliang and Shangpung- and Khliehriet-Lumshnong-area) have been identified as priority areas for conservation at medium-high and high altitude areas of Khasi and Jaintia hills district of Meghalaya. These identified sites are not covered by the present protected area network and are represented exclusively either by sacred groves or community owned forests (Table 5).

Table 5. Priority areas for conservation in Meghalaya

Sites	Altitude range (m)	Number of species	
		Threatened	Endemic
Cherrapunjee area	1200-1500	22	64
Jowai area	1000-1450	20	120
Dawki area	50-750	14	21
Balphakram area	50-1026	13	27
Shillong peak-Mawphlang area	1450-1990	9	51
Raliang-Shangpung area	1300	9	45
Nongkhyllem –Lailad area	300	9	15
Tura area	870	9	12
Nokrek area	150-1415	7	44
Khliehriet-Lumshnong area	1200	7	10
Barapani area	800-1500	1	11

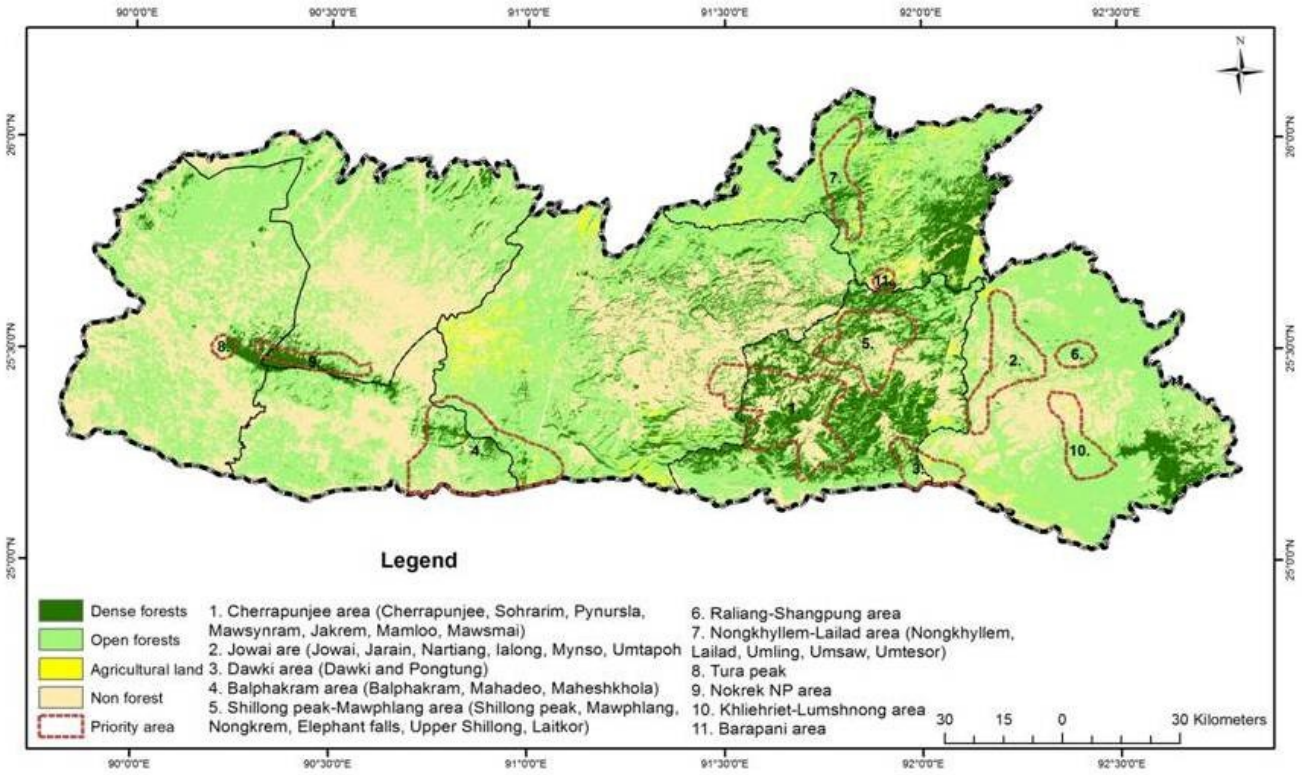

Figure 4. Map showing different land use and priority areas for conservation in Meghalaya

DISCUSSION

Due to high plant diversity of the State (Khan et al. 1997) and fast disappearance of the forest cover in Meghalaya, it was essential to produce a plan that could guide prompt conservation action. The database was prepared based on herbarium specimens and information pooled from various scattered scientific literature. This technique offers the most practical way to identify priority areas for conservation. However, it has some limitations. Though herbarium specimen-based data provides the most comprehensive and reliable information of known taxa (Ponder et al. 2001, Zhang and Ma 2008), it usually represents high diversity of well collected areas (Tchouto et al. 2006). With the current rate of deforestation and habitat loss some of these species may have altered distribution and may no longer exist in a particular area (Krupnick and Kress 2003). Field collections are also not performed uniformly with the same intensity by different botanists (Puyravaud et al. 2003). In this study, a combination of herbarium data coupled with recent inventories and published literature were used to reduce the error and increase the reliability of the data. However, in spite of all these limitations, the available data basically aims at explaining the geographic distribution of threatened and endemic species and provide update information that can be used for conservation planning of these species.

Among the 82 threatened species, 17 are exclusively endemic to the State of which 4 are considered as possibly extinct and the disappearance of the rest 13 species would mean their extinction from the State. These are, therefore the key species for biodiversity conservation. Among the life forms of threatened species, the high proportion of trees indicates that many plants might have become endangered due to logging as well as shifting cultivation. Similarly, Xie (2003) reported that out of the total threatened species in the Yangtze valley, 73% were trees. The altitudinal distribution patterns of threatened species were high in low and medium-high altitude areas, whereas endemic species were concentrated at medium and medium high altitudes. This observation is similar to Dhar (2002) and Samant and Joshi (2005) who reported an increase in endemic species with the increase in the altitude that often favours varied habitats. This can also be attributed to climatic factors such as rainfall, which is usually more at higher altitudes as compared to lower altitude areas of

the State. The distribution of species in different habitats is due to its adaptative ability. The high concentration of threatened plants in primary forests reflects that forests are the main habitat for such species and warrants immediate conservation efforts.

The uneven distribution of endemic and threatened species and the absence of these species in many parts of the State can be attributed to various factors. For instance, analysis of the gap areas in Garo hills reveals that such areas are represented by open forest, non-forest, plantation, bamboo brakes, shifting cultivation areas and human settlements (Sarma et al. 2010). In Ribhoi district, such gaps represent open forest and shifting cultivation areas, whereas, in West Khasi hills, it represents open forest and non-forest. In Jaintia hills, gaps represent coal mining, non forest and open forest areas (Sarma 2005). Further, many of these blank areas throughout the State have been exploited for cultivation for hundreds of years, resulting in fewer wild plant species of lower conservation value.

Out of the 11 areas identified as priority areas for conservation, seven are not included in the protected area system and only two falls under National Parks and accounts for 1.19% of the total geographical area of the State. Therefore, focusing conservation efforts in these areas would be of local, regional as well as of national importance. Although surrogate approach of using threatened or endemic species as indicators for the distribution of other poorly known groups remains a critical question for biodiversity conservation (Zhang and Ma 2008), a number of studies have confirmed that focusing conservation efforts on such species could also benefit most other species (Dobson et al. 1997, Warman et al. 2004). Similarly, areas of high endemism should receive priority in conservation (Myers 1988, 1990, Kerr 1997), as such areas have high species richness (Kerr 1997). The identified priority sites for conservation are consistent and overlap with the findings of Chaterjee et al. (2006), who had identified these areas as important habitats for endemic birds of the region.

The current protected area system in Meghalaya is inadequate for biodiversity conservation. National Parks and Wildlife Sanctuaries of the State are distributed only in low and medium altitudes. Similarly, reserve forests are also restricted to low –medium altitudes whereas, protected forest /green blocks are represented by medium and high altitude. Reserve and protected forests are managed forests basically designated for multiple uses including timber and fuel wood extraction and conservation of soil and water. They are not designated for wildlife and biodiversity conservation. Absence of National Parks and Wildlife Sanctuaries at high altitudes and lack of adequate protection for subtropical and temperate forests of Meghalaya are critical issues for conservation and found as one of the major gaps in the protected area coverage in Meghalaya and northeastern India as a whole. The protection of forest at high altitude for biodiversity conservation has also been emphasized by Rodgers and Panwar (1988).

The sacred groves found in Cherrapunjee, Ialong, Jowai, Mawphlang, Raliang, Sohrarim and Shangpung have played major roles in conservation of threatened and endemic species. Khan et al. (1997) and Pandey et al. (2005) highlighted that the sacred groves are the storehouse of rare and threatened species of the region. The present analysis revealed the presence of 22 threatened and 126 endemic species in the sacred groves alone. However, the sacred groves are exposed to disturbances of different magnitude, and many of the species found in sacred groves are under severe stress (Upadhaya et al. 2008). Strengthening the traditional institution and paying incentives to the local community managing the sacred groves and other village forests can play major roles in conservation, especially in the medium and medium-high altitude areas, where the concentration of such forests is high.

The present study provides a mechanism by prioritizing areas of the State where immediate conservation attention can be focused. It also provides scopes for re-evaluation of such sites at intervals for biodiversity monitoring and assessment. Thus, close monitoring of plant diversity including the populations of endemic and threatened species in these areas is suggested for effective conservation of such species.

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Appendix 1. Diversity, life form, distribution and endemism of threatened plants in Meghalaya

Species	Family	Life-form	Altitude	Habitat	Nativeness	Endemism	**Status**
Mangifera sylvatica Roxb.	Anacardiaceae	T	100–500	PF	India and Thailand		LC
Goniothalamus simonsii Hk. f. & Th.	Annonaceae	T	200–1400	PF	Meghalaya	E	EN
Trivalvaria kanjilalii D. Das	Annonaceae	T	500	PF	Meghalaya	E	EN
Alstonia scholaris (L.) R. Br.	Apocynaceae	T	50–600	PF	Wide distribution		LC
Ilex khasiana Purk.	Aquifoliaceae	T	1300–2000	PF, PiF	Meghalaya	E	CR
Ilex venulosa Hook.f.	Aquifoliaceae	T	1000–2000	PF	Meghalaya	E	EN
Acorus calamus L.	Araceae	S	1000–1500	PF	Europe, Western Asia		VU
Aralia chinensis L.	Araliaceae	S	1200	PF	China		VU
Panax wangianus Sun.	Araliaceae	H	1200>1500	SA	N-E India & Himalayas	NE	EN
Livistona jenkinsiana Griff.	Arecaceae	T	100–1000	PF	N-E India	NE	EN
Phoenix rupicola T. Anders.	Arecaceae	S	<500	RA	N-E India	NE	NT
Ceropegia angustifolia Wt.	Asclepiadaceae	C	300–2000	G	N-E India, Nepal, Bangladesh	NE	VU
Ceropegia arnottiana Wt.	Asclepiadaceae	C	1000	G	Meghalaya	E	EN
Ceropegia lucida Wall.	Asclepiadaceae	C	50–300	G	Meghalaya, Sikkim	NE	EN
Begonia brevicaulis DC.	Begoniaceae	H	300	SA	Meghalaya	E	EN
Mahonia nepalensis DC.	Berberidaceae	S	1200>1500	PF,SF	Indo-Burma, Eastern Himalayas & Nilgiris		VU
Oroxylum indicum (L.) Vent.	Bignoniaceae	T	100–1000	PF, SF	Indo-Malaya throughout India		VU
Bhesa robusta (Roxb.) Ding Hou	Celastraceae	T	50–200	PF	Indo-Malaya		LC
Euonymus grandiflorus Wall.	Celastraceae	T	1000–1900	PF	Temperate Himalaya, China, Myanmar, Nepal		LC
Garcinia pedunculata G.Don.	Clusiaceae	T	100–1000	PF	Indo-Burma, confined to N-E India	NE	DD
Cycas pectinata Griff.	Cycadaceae	S	500–700	PF, RA	Nepal, Bhutan, Burma, Bangladesh, Thailand	NE	VU
Mastixia arborea Cl.	Cornaceae	T	200–1400	PF	N-E India, South India, Sri Lanka		LC
Carex repanda Cl.	Cyperaceae	H	1000–1700	G	Meghalaya	E	EX
Shorea robusta Gaertn.	Dipterocarpaceae	T	100–700	PF, SF	India and Nepal	NE	LC
Vatica lanceaefolia Bl	Dipterocarpaceae	T	100–500	PF	Burma, Bhutan, India		CR
Dioscorea deltoidea Wall. ex Kunth.	Dioscoreaceae	C	1000–2000	PF, SF	Kashmir, Afganistan, Indo-China,		VU
Drocera peltata Sm.	Droseraceae	H	1000–1600	G	Australia, Tasmania, New Zealand, S-E Asia and India		VU
Elaeagnus conferta Roxb.	Eleagnaceae	S	900–1800	PF, SF	Indo-Malaya, Himalaya & South India		EN
Elaeocarpus prunifolius Wall. ex Mast.	Elaeocarpaceae	T	900–1800	PF	Manipur & Khasi Hills in Meghalaya	NE	VU
Elaeocarpus rugosus Roxb.	Elaeocarpaceae	T	50–500	PF	Bangladesh, Burma, Malayasia		VU
Rhododendron formosum Wall.	Ericaceae	T	1200–2000	PF	Eastern Himalaya & N-E India	NE	VU
Eriocaulon barba-caprae Fyson	Eriocaulaceae	H	1200	G	Meghalaya	E	EX

Appendix 1 (continued)

Species	Family	Life-form	Altitude	Habitat	Nativeness	Endemism	**Status**
Gleditsia assamica Bor.	Fabaceae	T	700–1400	SF	N-E India	NE	VU
Saraca asoca (Roxb.) de Wilde	Fabaceae	T	<500	PF	Sri Lanka		VU
Sophora wightii Baker	Fabaceae	S	50–1400	PF	South India, Sri Lanka		EN
Gentiana quadrifaria Bl.	Gentianaceae	H	1000–1800	G	Himachal Pradesh, Jammu & Kashmir, Punjab, Uttarpradesh, Sikkim		VU
Gynocardia odorata R.Br.	Flacourtiaceae	T	500–1000	PF	Indo Burma, N-E India	NE	LC
Illichium griffithii Hk.f. &Th.	Illiaceae	T	1200–1500	PF	Bhutan, N-E India, Hongkong, Vietnam		CR
Ixonanthes khasiana Hk.f.	Ixonanthaceae	H	1000–1500	PF	Meghalaya	E	VU
Engelhardtia spicata Leschn. ex Blume	Juglandaceae	T	50–1900	PF, SF	N-E India, China, Bhutan upto Vietnam		LC
Cinnamomum tamala (Buch.Ham.) Nees	Lauraceae	T	1300–1600	PF, SF	Tropical and Subtropical Himalaya	NE	VU
Magnolia griffithii Hk.f. & Th.	Magnoliaceae	T	100–700	PF	Assam, Myanmar	NE	DD
Michelia panduana Hk.f. & Th.	Magnoliaceae	T	1000–1500	PF	N-E India	NE	VU
Aglaia edulis A. Grey	Meliaceae	T	300–700	PF	Bengal, N-E India, Bornea, Fiji Island		NT
Aphanamixis polystachya (Wall.) Parker	Meliaceae	T	50–500	PF	Wide distribution		LC
Toona ciliata Roem.	Meliaceae	T	100–700	PF, SF	Wide distribution		LC
Osbekia capitata Benth.	Melastomaceae	H	1000–2000	G	East Bhutan, Meghalaya	NE	VU
Cyclea debiliflora Miers	Menispermaceae	C	600–1200	PF	Meghalaya	E	EX
Mitrastemon yamamatoi (Makino) Makino	Mitrastemonaceae	P	1200–1500	SA	Meghalaya, Thailand		EN
Embelia ribes Burm.f.	Myrsinaceae	C	1000–1500	PF	Indo-Malaya, throughout India		DD
Nepenthes khasiana Hk.f.	Nepenthaceae	S	200–1000	PF,RA,G	Meghalaya	E	CR
Dendrobium nobile Lindl.	Orchidaceae	E	1200–1500	PF	N-E India, Bhutan, Nepal, Thailand, China		EN
Calanthe anthropophora Ridl.	Orchidaceae	H	100–500	RA	Meghalaya, Thailand		EN
Cymbidium eburneum Lindl.	Orchidaceae	E	700–1500	PF	N-E India & Eastern Himalayas	NE	VU
Diplomeris pulchella D. Don.	Orchidaceae	H	100–1300	SA	Meghalaya, Thailand		VU
Flickingeria fugax (Reichb.f.) Seidn.	Orchidaceae	E	1200–1500	PF	Entire India, Burma, Thailand, Java, Ceylon		EN
Gastorchilus calceolaris D.Don.	Orchidaceae	E	1000–1500	PF	Meghalaya, Sikkim, Bhutan, Nepal, Thailand, Burma and China		CR
Paphiopedilum insigne (Wall.) Pfitz.	Orchidaceae	H	1000–1400	SA	Meghalaya	E	VU
Paphiopedilum venustum (Wall.) Pfitz.	Orchidaceae	H	1000–1400	SA	Bangladesh, Nepal, Meghalaya, Sikkim	NE	VU
Pleione lagenaria Lindl.	Orchidaceae	E	1000–1500	PF	N-E India	NE	EX
Pleione maculata (Lindl.) Lindl.	Orchidaceae	E	1200–>1500	PF	N-E India, Bhutan, Nepal, Thailand		EN
Zeuxine pulchra King & Pantl.	Orchidaceae	E	>1500	PF	Meghalaya, Sikkim	NE	EN
Clematis apiculata Hk.f. & Th.	Ranunculaceae	C	1000–1500	PF	Meghalaya	E	EN
Prunus ceylanica (Wt.) Miq.	Rosaceae	T	200–500	PF	SriLanka, Indo-Malaya, South & N-E India		EN
Canthium dicoccum (Gaert.) T.&T.	Rubiaceae	T	600–700	PF	Sri Lanka		VU
Ophiorrhiza subcapitata Hk. f.	Rubiaceae	H	900–1300	SA	Meghalaya	E	EN
Ophirrhiza hispida Hk.f.	Rubiaceae	H	90–1800	SA	N-E India & Burma	NE	EN
Ophirrhiza tingens Clarke ex. Fischer	Rubiaceae	H	150–1800	RA	N-E India	NE	VU
Ophirrhiza wattii C.E.C. Fisch.	Rubiaceae	H	600–1200	SA	N-E India	NE	EN
Euodia lunuankenda (Gaertn.) Merr.	Rutaceae	T	200–1200	PF	Tamil Nadu, N-E India		EN
Dimocarpus longan Lour.	Sapindaceae	T	200–500	PF	China		NT
Saurauia punduana Wall.	Saurauiaceae	T	1000–1500	PF,SF,PiF	China		CR
Ailanthus integrifolia Lamk.	Simaroubaceae	T	300–700	PF	India, Indonesia		LC
Brucea mollis Wall. ex. Kurz	Simaroubaceae	S	1200–1700	PF	South-east Asia, N-E India, Andamans		NT
Heritiera macrophylla Kurz	Sterculiaceae	T	50–300	PF	Wide distribution		LC
Sterculia khasiana Debbarman	Sterculiaceae	T	600–1300	PF	Meghalaya	E	EX
Dendroglossa minutula (Fe´e) Copel	Polypodiaceae	H	100–1200	SA	Meghalaya	E	EN
Adinandra griffithii Dyer	Ternstroemiaceae	T	1000–1300	PF,	Meghalaya	E	EN
Tetrameles nudiflora R. Br.	Tetramelaceae	T	<500	SF	Throughout Asia		LC
Taxus baccata L.	Taxaceae	T	>1400	PF	World wide		CR
Valeriana hardwickii Wall.	Valerianaceae	H	1200–1700	PF, PiF	Pakistan, Burma, Ceylon		VU
Valeriana jatamansii Jones	Valerianaceae	H	1200–1700	PF, PiF	Temperate Himalayas	NE	VU

Abbreviations: T - Tree, S - Shrub, H - Herb, C - Climber, E - Epiphyte, P - Parasite; PF– Primary forest, SF–Secondary forest, PiF– Pine forest, SA–Shady area under forest or near stream, RA–Rocky areas, G–Grassland, E–Endemic, NE– Near Endemic; EX– Extinct, CR– Critically Endangered, EN– Endangered, VU– Vulnerable, NT– Near threatened, LC– Least Concern and DD– Data deficient.