

Impact of Anthropogenic Disturbance on Population Structure and Regeneration Status of Trees in Subtropical Humid Forest of Meghalaya, North-east India

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ABSTRACT

The present study was carried out to assess the impact of anthropogenic disturbances of mild intensity on population structure and regeneration status of trees in two disturbed and undisturbed stands of subtropical humid forests, represented by Ialong and Raliang sacred groves in Jaintia hills of Meghalaya, northeast India. The woody species (>5cm dbh) richness in 0.5 ha study plots increased from 80–82 in the protected stands to 92–93 in the unprotected stands of the two groves. There was a marginal decrease in tree density in unprotected stand at Ialong but at Raliang, density was more in the unprotected stand compared to the protected forest. The density distribution in different diameter classes revealed that the disturbance of mild intensity led to a decrease in the number of individuals of usable size (>26 cm dbh). The seedling density was significantly higher in the protected stands both at Raliang and Ialong. Compared to the seedling density, the sapling density was very low both in the protected and unprotected stands. The age structure of the tree population in the four stands reveals that ca. 3–7% of the total seedlings were able to reach up to the sapling stage and 12–33% of saplings could attain adulthood (>5cm dbh).

Key words: Tree regeneration, population structure, disturbance, humid forests, northeast India.

Introduction

About 50 million forest dwellers in India live in or along the forest fringes and depend on forest resources for food security, health care, construction materials and cash income (NCHSE 1987). The availability of timber, edible, medicinal and ornamental plants in wild is progressively declining because of their over-exploitation and conversion of natural forests into man managed systems and degraded land. Vegetation cutting not only results into compositional and structural changes in the forest community, it also causes disruption of ecological processes and loss of economic species and their viable size (Schmidt-Vogt, 1998).

Meghalaya, a hilly state in north-east India (25°02' to 26°10' N latitude and 89°45' and 92°45' E longitude covers an area of 22,429 sq. km), supports humid to moist tropical and subtropical forests. These forests are rich in plant diversity (Khan *et al.*, 1997) and exhibit complex community structure (Jamir and Pandey, 2003; Upadhaya *et al.*, 2003). They are under intense biotic pressure due to large-scale shifting agriculture and other human activities. As a result, the forests have been fragmented in to patches of different sizes ranging from 70 sq. km to 0.1 sq. km (Tripathi, 2002). Some undisturbed forest patches (0.1 ha to 400 ha) however, are still found in the state due to religious beliefs of the indigenous tribes. These are popularly known as '*sacred groves*'. Ecologically the sacred groves represent the climax vegetation of the area, which ranges from moist deciduous forests at lower elevation to subtropical semi-evergreen to evergreen forest in the precipitous zone at higher elevation between 1200–1900 m a.s.l. A number of ecological studies have been carried out in the sacred groves of Meghalaya (Barik *et al.*, 1996; Khan *et al.*, 1986; Khiewtam and Ramakrishnan, 1993; Jamir and Pandey, 2003; Upadhaya *et al.*, 2003) focusing on biodiversity, community structure and regeneration of tree species. Due to increasing human population, the pressure on the forest in the state has increased many fold leading to encroachment in the sacred groves by the indigenous tribes themselves for their timber and fuel wood needs. The present study based on the protected and disturbed stands of the two sacred groves in the Jaintia hills of Meghalaya, analyses the implications of selective tree felling and fuel wood collection on population structure and regeneration status of woody species.

Materials and Methods

Study sites and climate

The study was conducted at Ialong and Raliang in Jaintia hills district of Meghalaya in north-east India. Ialong is located about 8 km east (latitude 25°28' N, longitude 92°16' E, altitude 1350 m a.s.l.), and Raliang (latitude 25°30' N, longitude 92°28' E, altitude of 1300 m a.s.l) is 28 km from the Jowai town of Jaintia hills district. The forests at Ialong and Raliang have the status of sacred groves and locally called as '*Khloo Blai*' (religious forest) and '*Khloo Lyngdoh* or '*Khloo Poh Lyngdoh*' (forest taken care by the *Lyngdoh* or preist) respectively. These groves are under the control of Jowai and Raliang Dolloiship (chief of the area) respectively and are well protected on account of strong religious beliefs of the Jaintia tribe. These groves represent the remnant of subtropical humid forest vegetation of the area. A portion of each of the two sacred groves covering an area of 20–30 ha is well protected and has the status of sacred groves while another portion (30–40 ha) is open for the use of the people (village reserve forest) residing in nearby village to meet their timber and fuel wood requirements.

Annual rites and rituals are performed regularly in these groves by the local people. At Ialong even in the unprotected stand all rites and rituals are held regularly. Felling of trees or collection of fallen trees and branches for timber and fuelwood are not allowed from the protected stand. However, the '*Kabariad*' (local herbalist) are exempted from such restrictions. Extraction for fuel wood and timber is allowed from the village reserve forest.

The climate of the area is monsoonic and has distinct wet and dry seasons in a year. The wet season extends from April to October followed by a short dry period from November to March. During wet season monthly rainfall ranges from 131 mm to 1557 mm, while in dry period it is usually <50 mm per month. The annual rainfall was 5950 mm during the study period (2000–2001). The mean monthly temperature varied from a maximum of 26°C in the month of April to a minimum of 5°C in January (Upadhaya, 2002).

Methodology

Based on disturbance index proposed by Rao *et al.* (1990) the forest stands at Ialong and Raliang were considered as undisturbed

(disturbance index 0%) and disturbed (disturbance index 20%). Quantitative study of woody species (≥ 5 cm dbh) was carried out during 1999–2001 by randomly laying fifty quadrats of 10 m \times 10 m in the protected and disturbed stands of both the groves. Climbers having ≥ 5 cm dbh were also enumerated. Saplings (< 5 cm dbh and > 30 cm height) were recorded in thirty 5 m \times 5 m and seedlings (< 30 cm height) in 1 m \times 1 m subplots in each stand. The collected plant specimens were identified with the help of the local floras (Balakrishnan, 1981–1983; Haridasan and Rao, 1985–1987; Kanjilal *et al.*, 1934–40). The Herbaria of Botanical Survey of India, Eastern Circle, Shillong and Herbaria at Botany Department, NEHU, Shillong were consulted for correct identification of plant specimens. The nomenclature of the species follows the regional flora. Frequency, density, basal area of woody species were determined according to Mueller-Dombois and Ellenberg (1974). The tree population structure was analyzed based on density-diameter distribution pattern and regeneration status was assessed on the basis of density of seedlings, saplings and adult trees.

Results

Species richness

In 0.5 ha area of the protected forest stand at Raliang and Ialong, there were 80 and 82 species, respectively. The corresponding values for the unprotected stands were 92 and 93 species (Table 1). At both the places disturbance increased tree species richness in the forest, but their density did not exhibit a consistent trend; it increased at Ialong and decreased at Raliang. Shannon-Wiener's diversity index computed using proportional number varied from a minimum of 3.42 in Ialong protected stand to a maximum of 3.87 in Raliang unprotected stand. Evenness index varied from 0.53 to 0.61 in all the stands. Secondary species in the unprotected stands of both the groves played a major role in increasing species diversity and evenness in the community (Table 1).

Tree regeneration

Tree seedling density was significantly higher in the protected stands than the unprotected stands at both the sites (Table 1). At Ialong *Microtropis discolor* and *Pseudostreblus indica* seedlings

Table 1. Stand structure and diversity of woody species in the protected and unprotected stands at Ialong and Raliang

Variables	Ialong		Raliang	
	Protected	Unprotected	Protected	Unprotected
Shannon diversity index (H)	3.42	3.78	3.55	3.87
Evenness index	0.53	0.61	0.56	0.61
Simpson dominance index	0.067	0.047	0.052	0.034
Number of tree species	82	92	80	93
Tree density (per 100 m ²)	15	13	9	13
Saplings density (per 100 m ²)	46	41	76	57
Seedlings density (per 100 m ²)	1410	955	2300	775
Tree basal area (m ² ha ⁻¹)	57.46	49.64	71.44	36.52

formed a carpet on the forest floor in the protected stand during rainy season. In the protected stand at Raliang, seedlings of *Actinodaphne obovata*, *Knema angustifolia*, *Sarcosperma griffithii*, *Prunus jenkinsii* and *Neolitsea cassia* were abundant. In the unprotected stands, *Prunus jenkinsii*, *Persea odoratissima*, *Acer laevigatum* and *Sarcosperma griffithii* were abundant at Raliang and *Pithecellobium monadelphum*, *Persea odoratissima*, *Engelhardtia spicata* and *Castanopsis purpurella* were abundant at Ialong (Table 2).

Seedlings of *Acer laevigatum* were common in small canopy gaps while those of *Engelhardtia spicata* and *Betula alnoides* were observed in large gaps and periphery of the forest. Seedlings of *Pithecellobium monadelphum*, *Castanopsis purpurella* and *Persea odoratissima* at Ialong and *Sarcosperma griffithii*, *Actinodaphne obovata* and *Neolitsea cassia* at Raliang were equally abundant both in the protected and unprotected stands.

As compared to the seedling density, the sapling density was drastically low, both in the protected and unprotected stands (Table 2). *Camellia caudata*, *Microtropis discolor*, *Castanopsis purpurella* and *Pithecellobium monadelphum* were dominant at Ialong, and *Actinodaphne obovata*, *Dysoxylum gobara* and *Castanopsis purpurella* were abundant in the Raliang protected stand. Saplings of *Castanopsis purpurella* and *Pithecellobium monadelphum* were recorded in the unprotected stand at both the places. *Acer laevigatum*, *Castanopsis purpurella*, *Engelhardtia spicata*, *Helicia nilagirica*, *Lindera*

Table 2. Sapling (number ha⁻¹) and seedling (number 100 m⁻²) density in the protected and unprotected stands at Ialong and Raliang

Name of species	Ialong				Raliang			
	Protected		Unprotected		Protected		Unprotected	
	Sapling	Seedling	Sapling	Seedling	Sapling	Seedling	Sapling	Seedling
<i>Acer lacvigatum</i>	40	160	80	-	60	105	400	125
<i>Acer oblongum</i>	-	-	-	-	-	-	80	-
<i>Actinodaphne obovata</i>	-	-	-	-	1380	580	120	60
<i>Betula alnoides</i>	-	-	-	50	-	-	-	-
<i>Camellia caduca</i>	-	-	80	45	-	-	-	-
<i>Camellia caudata</i>	760	115	300	-	-	-	-	-
<i>Caryota urens</i>	-	-	-	-	60	20	-	-
<i>Castanopsis indica</i>	120	-	-	-	-	-	-	-
<i>Castanopsis purpurella</i>	540	40	680	50	620	-	600	75
<i>Castanopsis tribuloides</i>	220	-	120	-	-	-	-	-
<i>Cinnamomum glanduliferum</i>	160	-	40	-	-	-	-	-
<i>Cinnamomum taniata</i>	-	-	-	-	120	-	20	-
<i>Citrus latipes</i>	60	-	180	-	20	-	-	-
<i>Cryptocarya floribunda</i>	-	-	-	-	140	-	60	-
<i>Diospyros kaki</i>	40	-	60	-	-	-	-	-
<i>Drymicarpus racemosus</i>	-	-	-	-	100	-	20	-
<i>Dysoxylum gobara</i>	-	-	-	-	760	15	180	-
<i>Elaeocarpus sikkimensis</i>	-	-	-	-	280	-	300	-
<i>Engelhardtia spicata</i>	100	20	380	110	140	15	120	-

<i>Euonymus attenuatus</i>	-	-	-	-	80	-	-	-
<i>Fissistigma verrucosum</i>	-	-	-	-	-	5	40	-
<i>Garcinia tincoria</i>	20	-	-	-	-	-	20	-
<i>Helicia nilagirica</i>	420	25	220	85	260	5	400	25
<i>Ilex embeloides</i>	-	-	-	-	60	-	-	-
<i>Knema angustifolia</i>	-	-	-	-	340	260	-	-
<i>Lindera latifolia</i>	80	-	260	-	520	20	180	-
<i>Lindera reticulata</i>	-	-	-	-	100	-	40	-
<i>Lithocarpus elegans</i>	80	-	-	-	360	10	420	-
<i>Lithocarpus fenestrata</i>	20	-	-	-	40	-	-	-
<i>Litsea citrata</i>	-	-	-	-	60	-	120	-
<i>Macaranga denticulata</i>	-	-	160	-	20	-	380	-
<i>Macropanax dispermus</i>	40	5	-	-	80	-	-	-
<i>Munglietia insignis</i>	-	-	-	-	20	-	-	-
<i>Microtropis discolor</i>	620	625	60	90	-	-	-	-
<i>Myrica esculenta</i>	-	-	20	-	20	-	-	-
<i>Myrsine semmiserrata</i>	-	-	40	-	-	-	-	-
<i>Neolitsa cassia</i>	-	-	-	-	460	185	100	105
<i>Persea bomboeyana</i>	-	-	180	-	-	-	-	-
<i>Persea odoratissima</i>	220	40	280	205	220	5	380	170
<i>Phoebe lanceolata</i>	100	-	-	-	-	-	-	-
<i>Pithecellobium monadelphum</i>	420	100	500	320	380	-	1120	-
<i>Podocarpus nerifolia</i>	-	-	-	-	100	5	40	-

contd....

Table 2 ... contd.

Name of species	Ialoung				Rafiang			
	Protected		Unprotected		Protected		Unprotected	
	Sapling	Seedling	Sapling	Seedling	Sapling	Seedling	Sapling	Seedling
<i>Prunus jenkinsii</i>	40	15	-	-	380	390	160	120
<i>Pseudostrebus indica</i>	20	200	-	-	-	-	-	-
<i>Pyralia edulis</i>	60	-	-	-	-	-	-	-
<i>Quercus serrata</i>	-	-	40	-	40	-	-	-
<i>Quercus griffithii</i>	20	-	40	-	-	-	-	-
<i>Rhododendron arboreum</i>	-	-	40	-	-	-	-	-
<i>Rhus acuminata</i>	160	-	120	-	-	-	100	-
<i>Sapindus rarak</i>	-	-	-	-	60	-	80	-
<i>Sarcosperma griffithii</i>	-	-	-	-	180	665	100	95
<i>Schefflera elata</i>	20	-	-	-	-	-	-	-
<i>Schefflera hypoleuca</i>	80	-	-	-	-	-	40	-
<i>Schinia khasiana</i>	-	-	-	-	20	-	-	-
<i>Schinia wallichii</i>	-	-	160	-	-	-	-	-
<i>Styrax serrulatum</i>	20	-	-	-	40	-	40	-
<i>Syzygium tetragonum</i>	100	65	60	-	40	15	-	-
<i>Wendlandia wallichii</i>	-	-	-	-	40	-	-	-
Total	4580	1410	4100	955	7600	2300	5660	775

- indicates absence

latifolia, *Pithecellobium monadelphum* and *Persea odoratissima* were common in all the four stands, whereas *Castanopsis indica*, *Pseudostreblus indica*, *Pyrularia edulis*, *Schffelera elata* were restricted only to the protected stand at Ialong. Similarly, *Caryota urens*, *Ilex embeloides*, *Knema angustifolia* and *Euonymus attenuatus* saplings were restricted only to Raliang protected stand. Saplings of some species such as *Camellia caduca*, *Myrsine semiserrata*, *Persea bombocyania*, *Rhododendron arboreum* and *Schinus molle* were restricted to the unprotected stand at Ialong, while those of *Acer oblongum*, *Fissistigma verrucosum* and *Litsea citrata* were present only in Raliang unprotected stand (Table 2).

Age structure of woody species

The overall age-structure of tree population irrespective of the species, as depicted by the number of seedlings, saplings and adult trees, was similar in all the four stands. In all stands there was a preponderance of seedlings, but the sapling population was quite small. The decrease in population density from the sapling stage to adult tree was gradual. Only 3.25–7.03 percentage of seedlings could reach up to saplings stage (Table 3). In other words about 93–97% of the seedlings were eliminated during the course of their establishment and growth. Saplings represented a more stable juvenile stage as compared to seedlings since 12–33% of the saplings were able to reach adult hood (>5 cm dbh).

Population density and regeneration of economically important species

The density of plant species with economic value is given in Table 4. The data furnished in the table suggests that there are large number of useful species in these forests that have multiple uses.

Table 3. Percentage of seedlings into saplings and adult trees in the protected and unprotected stands at Ialong and Raliang

Sites	Stands	Sapling as % of seedling	Adult as % of saplings
Ialong	Protected	3.25	32.23
	Unprotected	4.29	32.68
Raliang	Protected	3.30	12.29
	Unprotected	7.03	23.11

Table 4. Population density (≥ 5 cm dbh; individuals ha^{-1}) of species having economic value in the protected and unprotected stands of Jalong and Raliang sacred forest

Name of species	Jalong		Raliang		Uses						
	Protected	Unprotected	Protected	Unprotected	Construction	Food	Medicine	Ornament	Artistry	Fire wood	Fencing
<i>Acer laevigatum</i>	6	2	26	20	X	-	-	-	-	-	-
<i>Acer oblongum</i>	-	-	2	-	X	-	-	-	-	-	-
<i>Actinodaphnæ obosuta</i>	-	-	108	2	X	-	X	-	-	-	-
<i>Alseodaphnæ petiolaris</i>	6	-	6	2	X	-	-	-	-	-	-
<i>Betula albaoides</i>	12	12	4	4	X	-	-	-	-	X	-
<i>Castanopsis indica</i>	10	8	-	-	X	X	-	-	X	X	-
<i>Castanopsis purpurella</i>	62	224	14	130	X	X	-	-	X	X	-
<i>Castanopsis tribuloides</i>	30	28	-	-	X	-	-	-	-	X	-
<i>Cinnamomum glanduliferum</i>	16	28	-	10	X	-	-	-	X	X	-
<i>Cinnamomum glaucascence</i>	-	-	2	-	X	-	-	-	-	-	-
<i>Drymiocarpus racemosus</i>	-	-	20	8	X	-	-	-	-	X	-
<i>Elaeocarpus sikkimensis</i>	-	-	2	18	X	-	-	-	-	X	-
<i>Engelhardtia spicata</i>	40	56	8	24	X	-	-	-	-	X	-
<i>Eoodia tricolora</i>	-	10	-	4	-	-	-	X	-	-	-
<i>Garcinia tinctoris</i>	2	-	4	-	-	X	-	-	-	-	-
<i>Knema angustifolia</i>	-	-	28	-	X	-	-	-	-	-	-

<i>Lithocarpus elagans</i>	28	12	14	82	X	-	-	-	-	X	-
<i>Lithocarpus fenestrata</i>	12	6	2	2	X	-	-	-	-	X	-
<i>Lithocarpus</i> sp.	8	-	2	8	-	-	-	-	-	X	-
<i>Michelia doisopa</i>	-	-	2	-	X	-	-	-	-	-	-
<i>Neolitsea cassia</i>	-	-	64	12	X	-	-	-	-	X	-
<i>Pearsea gamblei</i>	-	-	4	-	X	-	-	-	-	X	-
<i>Pearsea odoratissima</i>	18	14	10	10	X	-	-	-	-	X	-
<i>Pinus kesiya</i>	2	6	-	4	X	-	-	X	-	-	-
<i>Podocarpus nerifolia</i>	-	-	2	-	X	-	X	-	-	-	-
<i>Prunus jenkinsii</i>	20	4	78	18	X	-	-	-	-	X	-
<i>Pseudostrebius indica</i>	48	-	-	-	-	-	-	-	-	-	-
<i>Quercus serrata</i>	2	-	-	-	X	-	-	-	-	X	-
<i>Sarcosperma griffithii</i>	-	-	116	44	X	-	-	-	-	-	-
<i>Schinus khasiana</i>	-	-	-	8	X	-	-	-	-	X	-
<i>Schinus wallichii</i>	20	88	4	66	X	-	-	-	-	X	-
<i>Spondias axillaris</i>	-	8	2	10	X	-	-	-	-	-	-
<i>Syzygium tetragonum</i>	60	22	14	12	X	-	-	-	-	X	-
<i>Caryota urens</i>	-	-	8	2	-	-	-	-	X	-	X
<i>Cinnamomum tamala</i>	-	-	4	6	-	-	-	-	-	-	-
<i>Citrus latipes</i>	8	52	6	-	-	-	X	-	-	-	-
<i>Diospyros kaki</i>	8	32	2	10	-	-	-	-	-	-	-
<i>Dyconia indica</i>	-	6	-	-	-	-	X	-	-	-	-
<i>Dysoxylon gobara</i>	-	-	62	26	-	-	X	-	-	-	-
<i>Erythrina arboresece</i>	2	4	-	-	-	-	-	-	-	-	X

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Table 4 ... contd.

Name of species	Ialung		Raliang		Construction	Food	Medicine	Ornament	Artsry	Fire wood	Fencing
	Protected	Unprotected	Protected	Unprotected							
<i>Eurya acuminata</i>	4	2	-	4	x	-	-	-	-	-	-
<i>Helicia nilagirica</i>	62	32	28	76	x	-	-	-	-	-	-
<i>Litsea citrata</i>	-	4	-	16	-	-	x	-	-	-	-
<i>Macaranga denticulata</i>	-	4	4	12	-	-	-	-	-	x	-
<i>Mangletia insignis</i>	2	-	8	6	-	-	-	x	-	-	-
<i>Myrica esculanta</i>	6	26	2	32	-	x	x	-	-	-	-
<i>Myrsine semmirerata</i>	14	4	2	4	x	-	-	-	-	-	-
<i>Persea bombocyania</i>	4	14	2	2	-	-	-	-	-	x	-
<i>Persea duthiei</i>	4	-	-	-	x	-	-	-	-	-	-
<i>Persea purviflora</i>	-	2	4	12	x	-	-	-	-	-	-
<i>Quercus griffithii</i>	2	6	-	-	x	-	-	-	-	x	-
<i>Rhododendron arboreum</i>	2	8	-	-	x	-	-	-	-	-	-
<i>Rhus acuminata</i>	36	50	-	38	-	-	-	-	-	-	-
<i>Vaccinium sperengelii</i>	4	4	-	-	x	-	-	-	-	-	-
<i>Viburnum simonsii</i>	-	12	-	-	-	x	-	-	-	-	-
<i>Camellia caduca</i>	-	26	-	-	x	-	-	-	-	-	-
<i>Camellia caudata</i>	136	48	-	-	x	-	-	-	-	-	-

The number of seedling and sapling of the economic species in the protected stands of both the forests was higher as compared to the unprotected stands (Fig. 1). However, the density of such species was high in the first two diameter classes (i.e. 5–15, 16–25) in both the unprotected stands as compared to the protected stands. The density of such species in the last four diameter classes (i.e. 36–45, 46–55, 56–65 and >65 cm) was almost half in the unprotected stands indicating lack of viable sizes in the unprotected stand.

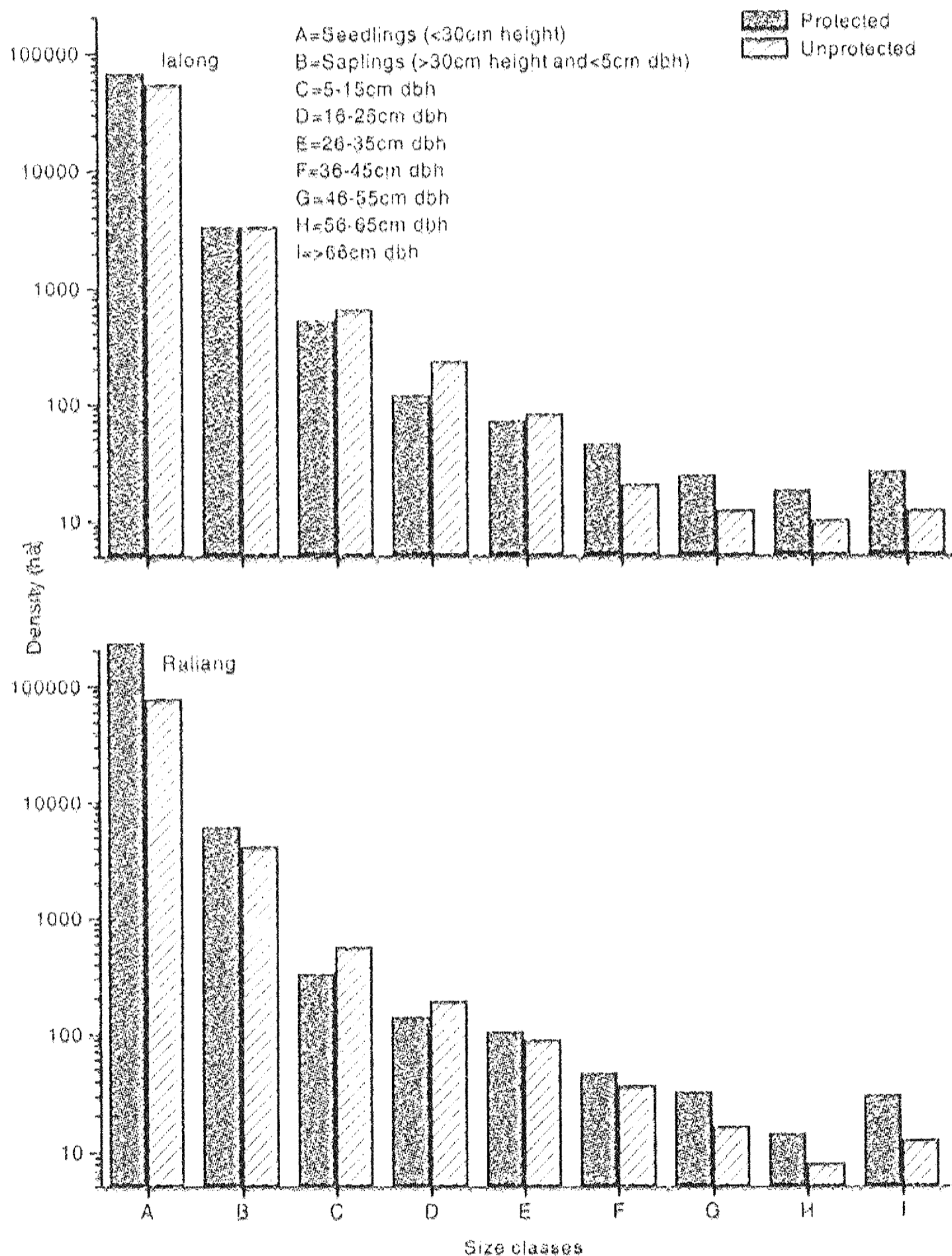


Fig. 1. Size-class representation of economically important species in protected and unprotected stands of lalong and Raliang sacred forests.

Discussion

The increase in species richness in the unprotected stands of both the forests was primarily due to colonization by fast growing secondary species like *Corylopsis himalayana*, *Litsea citrata*, *Lyonia ovalifolia* and *Saurauria nepaulensis* in the open gaps created due to selective cutting of trees. Secondly, moderate disturbance favours both the competitive and those species that tolerate disturbance to co-exists (Connell, 1978; Collins *et al.*, 1995). This finding is similar to those reported by Quigley and Platt (2003), who observed rapid recovery of damaged trees and release of smaller trees in seasonal forests damaged by hurricane. Further, the studies of Connell (1978), Sousa (1979), Paine and Levin (1981) and Hobbie *et al.* (1994) clearly demonstrated that maximal species diversity occurs under intermediate disturbance regime.

The population structure of trees of economic importance in the two sacred groves indicates a low abundance of the older trees. Further, the number of trees belonging to >65 cm dbh class was smaller (1%) in the unprotected stands as compared to 3–4% in the protected stands. This may be the result of selective felling of mature trees by the villagers for timber and construction purposes. Selective extraction of trees led to better tree regeneration either through coppice or new recruitments or both in the unprotected stands where population density of young individuals (5–15 cm and 16–25 cm dbh) was high. The density of trees beyond 16–25 cm dbh class gradually decreased indicating the extraction of mature trees (>26 cm dbh) in the forest. Selective cutting of straight boles of some species like *Camellia caudata*, *Helicia nilagirica* and *Syzygium tetragonum* for construction purposes and use as poles by villagers was the main reason for the lower stem density in lalong unprotected stand. At Raliang large trees of *Actinodaphne obovata*, *Sarcosperma griffithii*, *Neolitsea cassia* and *Prunus jenkinsii* were selectively felled few years ago for construction purposes. This resulted into creation of canopy gaps leading to colonization by shade intolerant species such as *Castanopsis purpurella*, *Engelhardtia spicata*, *Lithocarpus elagans* and *Schima wallichii* whose density had markedly increased in the disturbed stand. Similar change in age-structure of population in the forest community due to various disturbances has also been reported by Primack *et al.* (1985) and Khan *et al.* (1986).

The sapling/seedling and mature tree/sapling ratios indicated a much greater loss of individuals during the period of conversion of seedlings to saplings which is a more vulnerable stage in the life cycle of a species as compared to the period during which the saplings developed into the adult trees. High mortality and low growth rate are typical for juvenile of rainforest trees due to low understorey light level, exposure to physical and biotic disturbances and short-term water deficits (Augsperger, 1984; Kobe, 1999; Davies *et al.*, 1999). The perpetuation of a species depends on the presence of adequate number of individuals of different growth phases or developmental phases of that species.

Commercial logging and other human disturbances have adversely affected the world's tropical forests. Chapman and Chapman (1997) reported lower sapling density in heavily logged tropical forest at Kebale National Park, Uganda. Movement of people inside the protected parts of Ialong and Raliang sacred grove was strictly prohibited, whereas there was free movement of the local people and their cattle in the unprotected stand, which may be the reason for low seedling density in the unprotected portion of the sacred groves.

Effects of man-made disturbance such as selective felling of trees have often been equated with natural gap forming process (Denslow, 1980). The impact on seedling and sapling populations during the mechanical felling of trees and the hauling of logs by mechanical means is usually harsher than the impacts of gaps created by natural forces (Chandrashekara and Ramakrishnan, 1993). The reduction in seedling and sapling density in the unprotected stand of the sacred groves could be ascribed to the impact of tree felling in this stand.

Greater diversity of economically useful plants especially the edible ones were observed in the disturbed stands of both the groves. This finding agrees to that of Kunstaster (1978), Kunstadter *et al.* (1978) and Schmidt-Vogt (1998) from Thailand who reported greater diversity of economically-useful plants in the secondary vegetation after jhum cultivation that increases diversity of habitats in the area and thus supplies useful plants. However, the availability of useful plants depends on different successional stages (Schmidt-Vogt, 1998) like early successional stages dominated by grasses, herbs are rich in medicinal plants, and secondary forests supply mainly edible products as in the present study. Although

there is no shortage of economically-useful species, there may be a lack of usable sizes as reflected by less number of individuals in higher dbh class in the disturbed stands of both the forests.

The present study suggests that mildly disturbed forests may result in greater species diversity than most reforestation projects and sometimes a greater incidence of useful plants than primary forest. However, this may not be true for all the systems and is dependant on the degree of disturbance that was about 20% in the unprotected stands of both the forests (Upadhaya *et al.*, 2004). In spite of disturbances, presence of large number of young (5–15 cm dbh) individuals indicates that disturbance has not adversely affected tree regeneration in the disturbed stands. Anthropogenic disturbances have led to an increase in species richness due to colonization by secondary as well as light demanding species in the unprotected stands. Though the richness of species having economic importance had increased, population studies indicate that usable/viable sizes had decreased. This practice by the local people has persisted for many decades and is one of the important management tools because of which the sacred groves are well preserved. In Meghalaya, village reserve forests (*Law shmong*), and '*Law Adong*' (forest where extraction is mostly for funeral purposes) are very common in the vicinity of the villages. Such man-managed forests guarantee not only a high-quality forest cover, but also provide scope for generating cash income.

Acknowledgements

The authors are thankful to the Ministry of Environment and Forests, Government of India, New Delhi for financial assistance in the form of a research project (Sanction No. 14/28/95-RE), and to the Dolloi of Raliang and Headman of Ialong for granting us permission to work in these forests.

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