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Tree assemblages and diversity patterns in Tropical Juri Forest, Bangladesh

Swapan Kumar Sarker · Muhammad Nur-Un-Nabi · Md. Mohasinul Haque · Mahmuda Sharmin · Sanjay Saha Sonet · Sourav Das · Niamjit Das

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Abstract Juri is a biodiversity-rich primary forest in Bangladesh, which remains ecologically unexplored. We identified tree species and examined the richness, alpha (α) diversity and floristic similarity patterns within the identified communities. Vegetation and environmental data were sampled in 120 (0.04 ha) study plots. Tree communities were delimited by two-way indicator species analysis (TWINSPAN). In total, 78 tree species of 35 families and 58 genera were identified. TWINSPAN identified six tree communities: A—*Tricalysia singularis*; B—*Kydia calycina-Castanopsis tribuloides*; C—*Polyalthia simiarum-Duabanga grandiflora*; D—*Ficus roxburghii*; E—*Artocarpus lacucha*; F—*Artocarpus lacucha.* Mean richness, Shannon and Gini-Simpson indices were highest for the *Polyalthia simiarum-Duabanga grandiflora* community, while *Ficus roxburghii* showed lowest diversity. Significant differences ($p = 0.05$) in three diversity indices were recorded between *Polyalthia simiarum-Duabanga grandiflora* and *Ficus roxburghii.* Tree compositional similarity was greatest between *Kydia calycina-Castanopsis tribuloides* and *Polyalthia simiarum-Duabanga grandiflora* (0.712).

Keywords Two-way indicator species analysis (TWINSPAN) · Richness index · Shannon index · Gini-Simpson index · Tropical forest · Conservation

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S. K. Sarker (✉) · M. Nur-Un-Nabi · Md. Mohasinul Haque · M. Sharmin · S. S. Sonet · S. Das · N. Das
Department of Forestry and Environmental Science, Shahjalal University of Science & Technology, Sylhet 3114, Bangladesh
e-mail: swapan_sust@yahoo.com

Introduction

Distinguishing plant communities has been central to vegetation science for decades (Jongman et al. 1995; Kashian et al. 2003; Habib et al. 2011). There is growing interest in describing plant community structure and diversity patterns in fragmented and degraded tropical forests (Laurance and Bierregaard 1997; Myers et al. 2000; Gillespie et al. 2004; da Silva et al. 2011) because this has implications for conservation of species and habitats (John et al. 2007; Toledo et al. 2011). Current knowledge of vegetation distributions in species-rich communities is almost exclusively derived from neo-tropical forests (Condit et al. 2002; Li et al. 2009; Condit et al. 2011), while Oriental forests have received less attention. As a result, spatial structure, species-habitat associations, diversity patterns and the mechanisms of species coexistence in Oriental forest ecosystems remain poorly understood despite their richness of floristic diversity and their vulnerability to intense anthropogenic disturbance and climate change (Toledo et al. 2011).

The forests of Bangladesh are now subject to unprecedented threat, not only from deforestation and fragmentation, but also from climate change (FAO 1998; Barua et al. 2010; Sarker et al. 2011). Thus, the issue of conserving the remaining remnant forests has become a priority. Bangladesh government, a signatory to the convention on biological diversity (CBD) has assigned high conservation priority to the remaining natural forests in the country. But, successful conservation requires detailed knowledge of floristic composition and diversity, ecology, and distribution of plant communities (Sarker et al. 2013a). Unfortunately, there is limited knowledge of tree species distribution in the remnant primary forests in north-eastern Bangladesh. Greater understanding of patterns of tree distribution in forest landscapes can guide habitat mapping and design of conservation strategies such as identification and protection of rare or severely degraded tree communities.

Our study area, Juri Natural Forest (JNF), is a biodiversity-rich primary forest in northeast Bangladesh, and represents both tropical evergreen and deciduous vegetations. It is an inaccessible forest situated along the Indo–Burma Biodiversity Hotspot (Myers et al. 2000; Sarwar and Araki 2010). Tree species composition of this forest has been severely degraded by both anthropogenic disturbances (e.g., agricultural expansion, illegal felling, industrial logging, human settlement, fire and grazing) and environmental stresses (e.g., prolonged drought, soil erosion, periodic flooding and catastrophic events) (Dewan 2009; Barua et al. 2010; Rahman et al. 2010). Most studies (IUCN 2004; Uddin and Hassan 2011) of the north-eastern hill forests of Bangladesh have yielded qualitative rather than quantitative descriptions of floristic composition and tree species diversity. In the present study, we identified tree communities, and examined the species richness, alpha (α) diversity and floristic similarity patterns within and between these communities in relation to habitat characteristics with implications for conservation.

Materials and methods

Study site

JNR is a remnant natural forest in the Patharia Hill Reserve, northeast Bangladesh (Islam et al. 2008). The forest is under the jurisdiction of Moulivibazar Forest Range 1 under Sylhet Forest Division and represents the natural vegetations of the Lathitila forest beat (24°33′559″N and 92°13′386″E, 2,279.91 ha). The topography of the area varies from medium to steep slopes and hillocks of varying elevation with undulating valleys and streams. Several channels with many tributaries drain the forest (IUCN 2004). The hilly areas of JNF are composed of upper tertiary rocks. Sediments are generally well weathered and limestone is also found at high elevations, sometimes cemented with secondary ironstones (Islam et al. 2008). Soils vary from clay to sandy-loamy with low pH. The soil texture consists of yellowish to dark grey granules. Accumulation of humus on the topsoil is limited by rapid decomposition of debris under moist warm tropical conditions (Hassan 1994; IUCN (International Union for Conservation of Nature) 2004). JNF lies within the monsoon climate zone. The annual average temperature is maximum 33.2 °C and minimum 13.6 °C and total rainfall is 3,334 mm. Relative humidity remains high (75–90 %) most of the year and is highest from May to October. Humidity dips below 80 % from November to April (BMD 2012). The forest is generally classified as tropical semi-evergreen (Muzaffar et al. 2007). The most common evergreen trees of this forest are *Cinnamomum tamala*, *Amoora wallichi*, *Vitex pinnata*, and *Palaquium polyanthum*. Common deciduous trees are *Syzygium ramosissimum*, *Cleistocalyx operculatus*, *Albizia procera*, *Anthocephalus chinensis*, and *Bombax insigne*. (Islam et al. 2008).

Sampling strategy

Field work was conducted during October–December 2012. During early reconnaissance we observed that forest species composition varied along an elevation gradient (18–100 m). Therefore, sampling plots were demarcated in two steps. At first, hills of the forest were stratified into elevation categories: foothill to mid-hill, mid-hill; and mid-hill to hill-top. Elevation percentage ranging 0–30 %; 30–70 % and 71–100 % were used to denote foothill to mid-hill, mid-hill; and mid-hill to hill-top, respectively. After that, sampling was arbitrary but without preconceived bias (McCune and Grace 2002) in each elevation range. Species-area curve was used to determine the number of plots sampled in each elevation range. Sampling plots measured 20 m × 20 m and numbered 120 in total to represent the tree vegetation in JNF.

Tree and environmental data collection

Trees of diameter at breast height (DBH, 1.3 m) >7.6 cm were identified to species level. A representative voucher was collected from each species in each plot for identification and deposition in the Forestry and Environmental Science Laboratory in Shahjalal University of Science and Technology, Sylhet, Bangladesh. Environmental data were recorded in each plot. Soil pH, moisture content (%) and elevation (masl) data were considered as environmental variables and measured. Measurements of soil pH and moisture were taken by digital soil pH and moisture meter from the four corners of each plot, and mean values of soil pH and soil moisture content were recorded. Elevations were estimated by hand-held digital GPS (Global Positioning System).

Data analysis

Tree community classification

Tree community types were delimited by two-way indicator species analysis (TWINSPAN) using the software WinTWINS 2.3 (Hill 1979; modified by ter Braak 1987). This tool was chosen mainly for two reasons; first, it is based on ordination, i.e., correspondence analysis, which should result in a classification based on floristic composition. Second, due to the noise-reducing effect of ordination, the divisive algorithm should be less noise-sensitive than agglomerative algorithms (Gauch 1982). This was desirable since much of the floristic variation in the data could be considered noise (Ejrnæs and Bruun 2000).

TWINSPAN has been widely criticized, but it is still used by many ecologists, partly because there is no clearly improved and accepted alternative (Kent 2006). It continues to be used for the classification of ecological data sets (Klinka et al. 2002; Carter et al. 2006) despite problems found in experiments using artificially produced data (Belbin and McDonald 1993). In this study, TWINSPAN was applied using default options for minimum group size for division (5); maximum number of indicator species per division (7); pseudo-species cut levels 0, 0.05, 0.1, 0.2. Four levels of division were used. The first two indicator species were used to name the respective community.

Diversity and composition

Alpha diversity (Whittaker 1972) was calculated for each community by using three indices: species richness index, Shannon diversity index (H′) and Gini-simpson diversity index (D′). Species richness was calculated as the number of species found in each plot. The Shannon diversity index accounts for both common and rare species, while the Gini-simpson index is more sensitive to common species (Hill 1973; Magurran 2004). Indices were calculated by using Biodiversity R package (Kindt and Coe 2005) in R software version 2.10.1 (R Development Core Team 2010). Post hoc pair wise Tukey's HSD mean separation test and homogeneity of variance test ($p = 0.05$) were used to assess the significance of differences between diversity indices. This analysis was performed by using SPSS 11.5. The Morisita-Horn index based on a two-way probabilistic approach (Chao et al. 2008) was used to determine the compositional similarity between communities. Despite its greater sensitivity to common species, this abundance-based index gives the most satisfactory results to deal with bias (Chao et al. 2008). A bootstrap approach was taken by using the software SPADE (Chao and Shen 2010) to calculate the 95 % confidence interval based on 200 simulations to measure compositional similarity.

Results

Community classification

In total, 78 tree species of 35 families and 58 genera were identified (Appendix Table 5). TWINSPAN classified 120 sample plots into six tree community types (Fig. 1):

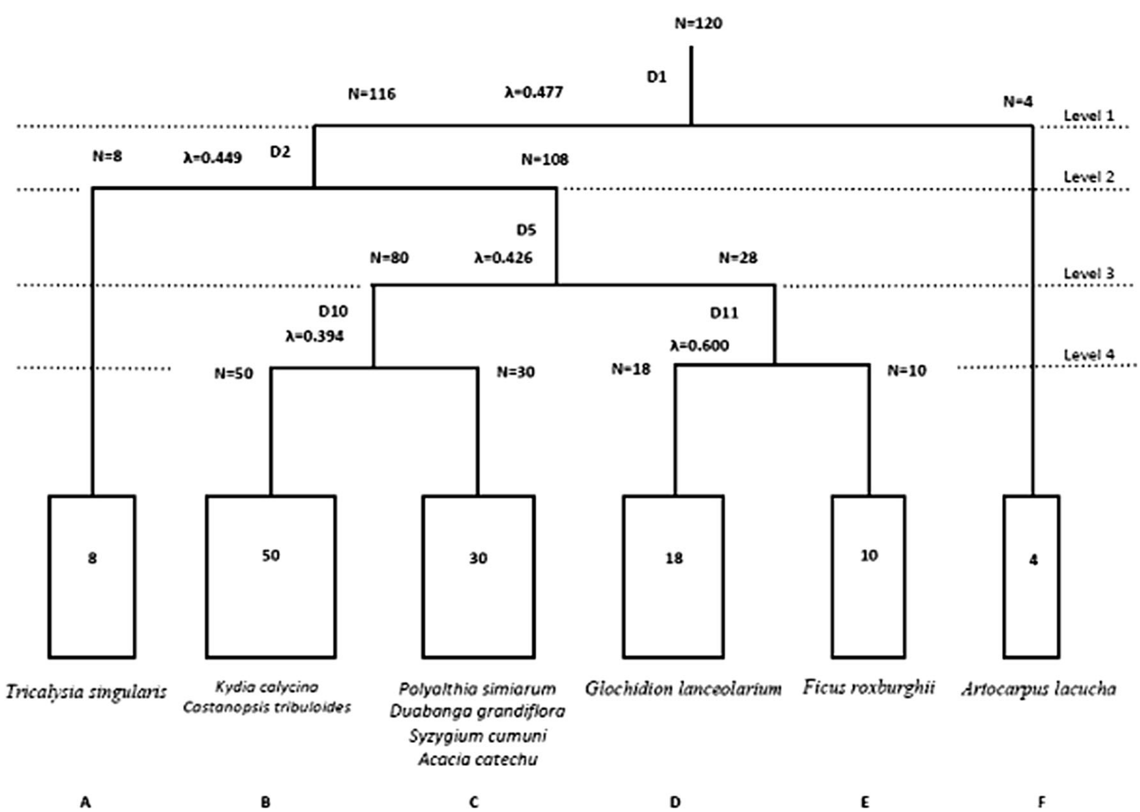

Fig. 1 Tree communities identified by TWINSPAN. Sample plots (N), indicator species and respective eigenvalues (λ) of each division are indicated. The numeric values mentioned in the box are the total sample plots for a certain community

A—*Tricalysia singularis*; B—*Kydia calycina-Castanopsis tribuloides*; C—*Polyalthia simiarum-Duabanga grandiflora*; D—*Ficus roxburghii*; E—*Artocarpus lacucha*; and F—*Artocarpus lacucha*. Summary of the communities is given in Table 1.

Community type A: *Tricalysia singularis*

Tricalysia singularis was the community at lower elevations in JNF. It was sampled by 8 sample plots and 15 tree species were recorded, mostly on the foothill. Mean elevation of the study plots of this community was 20.5 masl. The soil was moderately acidic with a mean pH 4.40 (±0.33). This community had the lowest tree density (181 ha^{-1}) of all communities. Common species included *Artocarpus chama, Michelia oblonga, Pterocarpus indicus, Bombax insigne, Tricalysia singularis* and *Gurea paniculata*.

Community type B: *Kydia calycina-Castanopsis tribuloides*

This was the characteristic community of the mid-hill sites and had the highest number of sample plots (50) and tree species (48). This community also contained the maximum number of unique species (12). Examples include, *Garcinia cowa*, *Bixa orellana*, *Cynometra polyandra*, *Syzygium praecox*, *Baccaurea ramiflora*, and *Eclipta alba*. Mean elevation and soil pH of this community were 40 masl and 4.41, respectively. *Kydia calycina*, *Lophopetalum wightianum*, *Carallia brachiata*, *Ficus roxburghii*, *Gurea paniculata*, and *Castanopsis tribuloides* were common species of this community type.

Community type C: *Polyalthia simiarum-Duabanga grandiflora*

This community harbored 47 tree species in 30 sample plots and contained 4 indicator species (*Polyalthia simiatum*, *Duabanga grandiflora*, *Syzygium cumuni* and *Acacia catechu*). The plots were distributed from mid-hill to hill-top at elevations up to 100 masl. A distinguishing attribute of this community was the highest soil acidity (mean pH of 4.37 ± 0.38) of all sampled communities. Common species included *Lophopetalum wightianum*, *Polyalthia simiarum, Duabanga grandiflora*, *Vitex pinnata*, *Kydia calycina*, and *Gurea paniculata*.

Community type D: *Glochidion lanceolarium*

Glochidion lanceolarium community (18 sample plots) occurred in the drier foothill to mid-slope habitat of JNF and had very low average soil moisture content (45 %). Mean soil pH was 4.53. *Elaeocarpus floribundus,*

Table 1 Summary of the community types with their indicator species and environmental conditions

Types	Indicator species	Plot no.	Habitat	No. of species	No. of unique species	No. of family	No. of genus	Abundance	Density (ha^{-1})	Soil pH	Moisture content (%)	Elevation (masl)
A	*Tricalysia singularis*	8	Foothill	15	5	13	14	29	181	4.40 ± 0.33	52.50 ± 14.79	20.50 ± 4.33
B	*Kydia calycina, Castanopsis tribuloides*	50	Mid-slope	48	12	28	38	227	236	4.40 ± 0.33	51.71 ± 12.39	40.04 ± 23.88
C	*Polyalthia simiarum, Duabanga grandiflora, Syzygium cumuni, Acacia catechu*	30	Mid slope- hill top	47	11	28	41	207	272	4.37 ± 0.38	54.52 ± 10.96	47.94 ± 29.47
D	*Glochidion lanceolarium*	18	Drier foothill- mid slope	28	4	21	26	68	213	4.53 ± 0.30	44.75 ± 18.25	40.25 ± 21.56
E	*Ficus roxburghii*	10	Eroded foothills along stream	8	2	6	7	25	208	4.43 ± 0.52	53.33 ± 24.94	19.66 ± 2.35
F	*Artocarpus lacucha*	4	Shady moist mid-slopes	9	1	8	9	20	250	4.80 ± 0.70	66.5 ± 6.5	48 ± 23

Before and after "±": mean values and standard deviation of environmental parameters

Table 2 Descriptive statistics and multiple comparisons of different diversity indices in the forest communities

Community types	Richness (E)			Shannon (H′)			Gini-Simpson (D′)		
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE
Tricalysia singularis	4.25	0.95	0.47	1.43	0.09	0.05	0.74	0.02	0.01
Kydia calycina-Castanopsis tribuloides	6.04	2.07	0.42	1.57	0.42	0.09	0.75	0.12	0.03
Polyalthia simiarum-Duabanga grandiflora	7.36^{a*}	1.18	0.46	1.86^{a*}	0.36	0.08	0.81^{a*}	0.10	0.02
Glochidion lanceolarium	6.36	0.09	0.41	1.48	0.34	0.12	0.73	0.11	0.04
Ficus roxburghii	3.33^{b*}	0.57	0.33	1.05^{b*}	0.22	0.13	0.60^{b*}	0.10	0.06
Artocarpus lacucha	5.50	0.70	0.50	1.62	0.14	0.10	0.79	0.03	0.02

SD standard deviation, *SE* standard error

^{a*} and ^{b*} means difference is significant at the 0.05 level

Duabanga grandiflora, Illex godajam, Gurea paniculata, Glochidion lanceolarium, and *Garcinia xathocymus* were common trees in this community.

Community type E: *Ficus roxburghii*

Ficus roxburghii community included 10 sample plots and supported the lowest number of species. It occurred on eroded foothill sites along stream channels. Mean elevation of this community type was 19.66 masl. Common species were *Syzygium fruticosum, Ficus roxburghii, Spondias pinnata, Terminalia bellirica,* and *Elaeocarpus floribundus.*

Community type F: *Artocarpus lacucha*

This community occurred at high elevations with moist soil. It had the lowest number of sample plots (4). This community appeared at 25–71 masl and was comprised of nine species. *Cleistocalyx operculatus* was the only unique species. *Carallia brachiata*, *Polyalthia simiarum*, *Glochidion lanceolarium*, *Ficus roxburghii*, *Vitex pinnata*, and *Palaquium polyanthum* were common species.

Tree diversity and composition

Mean richness and Shannon and Gini-Simpson indices were highest for the *Polyalthia simiarum-Duabanga grandiflora* community while *Ficus roxburghii* showed lowest alpha diversity (Table 2; Fig. 2). Differences in all diversity indices were significant ($p = 0.05$) between *Polyalthia simiarum-Duabanga grandiflora* and *Ficus roxburghii* community types. The homogeneity of variance test confirmed the results of Tukey's HSD test (Table 3).

Greatest pair-wise compositional similarity was recorded between communities *Kydia calycina-Castanopsis tribuloides* and *Polyalthia simiarum-Duabanga grandiflora* (0.712) followed by *Polyalthia simiarum-Duabanga grandiflora* and *Glochidion lanceolarium* (0.631) (Table 4). Average similarity between all communities was 0.34.

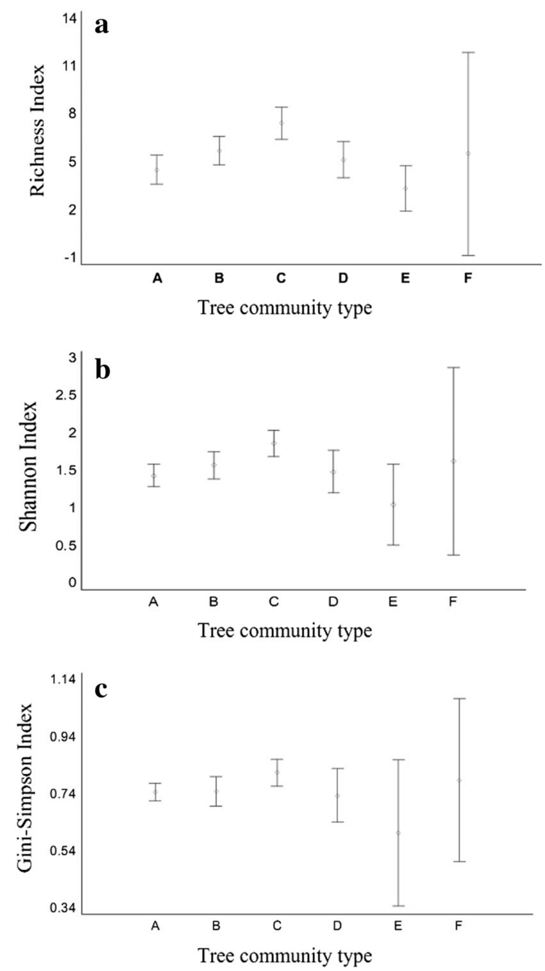

Fig. 2 Mean intervals of richness index (**a**), Shannon (**b**) and Gini-Simpson (**c**) diversity indices

Discussion

Tree communities

Several studies have documented the influence of topography and soil heterogeneity on species composition and

Table 3 Homogeneity of variance test

Community types	Richness(E) subset for alpha = 0.05		Shannon (H′) subset for alpha = 0.05		Gini-Simpson(D′) subset for alpha = 0.05	
	1	2	1	2	1	2
*Ficus roxburghii**	3.33	–	1.04	–	0.60	–
Kydia calycina-Castanopsis tribuloides	4.25	4.25	1.43	1.43	0.73	0.73
Tricalysia singularis	5.50	5.50	1.48	1.48	0.74	0.74
Glochidion lanceolarium	6.04	6.04	1.56	1.56	0.74	0.74
Artocarpus lacucha	6.37	6.37	1.62	1.62	0.78	0.78
*Polyalthia simiarum-Duabanga grandiflora**	–	7.36	–	1.86	–	0.8135

* Indicates significantly different ($p = 0.05$) community in terms of Shannon (H′) Gini-Simpson diversity (D′) and Richness diversity index

Table 4 Pair wise (C22) and simultaneous (C26) Comparison of communities by Morisita-Horn index (Bootstrap SE in parentheses is based on 200 replications)

	Estimate	95 % confidence interval	
		Minimum	Maximum
Estimator C22			
A			
B	0.600[a] (0.119)	0.367	0.833
C	0.413 (0.090)	0.237	0.589
D	0.490 (0.112)	0.271	0.710
E	0.080[a] (0.071)	0.000[b]	0.218[b]
F	0.282 (0.122)	0.043	0.521
B			
C	0.712[a] (0.063)	0.588	0.836
D	0.562 (0.092)	0.381	0.743
E	0.107[a] (0.033)	0.042	0.172
F	0.416 (0.092)	0.237	0.595
C			
D	0.631[a] (0.093)	0.449	0.813
E	0.174[a] (0.054)	0.067	0.280
F	0.414 (0.120)	0.179	0.650
D			
E	0.272[a] (0.100)	0.076	0.467
F	0.486[a] (0.110)	0.271	0.701
E			
F	0.212[a] (0.118)	0.000[b]	0.444[b]
Estimator C26	0.348 (0.036)	0.278	0.418

[a] Indicates the highest and lowest values; C_{22}: A similarity measure of comparing 2 communities based on shared information between any two communities; C_{26}: A similarity measure of comparing 6 communities based on shared information between any two communities

[b] If the lower bound is less than 0, it is replaced by 0; if the upper bound is greater than 1, it is replaced by 1

diversity in tropical forests (Valencia et al. 2004; John et al. 2007; Jones et al. 2008). JNF is a complex hill ecosystem in Bangladesh with remarkable variation in soil properties (Hassan 1994). Thus, despite a narrow elevation gradient, a high degree of variability in tree species composition is expected between different landforms in the forest. Previous studies (IUCN 2004; Sarker et al. 2013b; Uddin and Hassan 2011) mentioned the influence of topography in structuring plant assemblages in the northeastern hill forests of Bangladesh. We also observed that the identified tree communities varied by topography. *T. singularis* community occurred on foothill sites with moderate soil acidity. *K. calycina—C. tribuloides* community occurred on mid-slopes with moderate soil acidity. *P. simiarum—D. grandiflora* community spread over mid-hills to hill-tops where soils were strongly acidic. *G. lanceolarium* community comprised tree species that naturally occurred between drier foot-mid hill sites. *F. roxburghii* was the characteristic community of eroded foothills near stream channels. *A. lacucha* community occurred on shady mid-slopes with moist soils.

Almost all tree communities contained several unique species and a number of species common in the southeastern hill forests of Bangladesh. *K. calycina—C. tribuloides* community had the highest number of unique species and several tree species of this community such as *Bombax insigne, Gurea paniculata, Michelia oblonga, G. lanceolarium,* are also common in the moderately sloped hill forests of the southeastern zone (Ahmed and Hassan 2008). *G. lanceolarium* community included three unique species namely *Amoora wallichi, Lagerstroemia indica* and *Albizia procera*. These are evergreen trees of lowland forest (Ahmed and Hassan 2008). But these species can also survive at mean elevation of 40.25 m (±21.56) in JNF. *F. roxburghii* community experiences flush flood during the monsoon and this community mostly supports tree species that can survive waterlogged conditions (Ahmed and Hassan 2008; Sarker et al. 2013b). Examples include *F. roxburghii, Syzygium fruticosum* and *A. chaplasha*. Soil acidity of the six communities usually increased with increasing elevation (Smith et al. 2002). Differences in tree species composition were detectable along this pH gradient. Both pH and elevation can influence community composition by affecting species richness (Lobo 2001) as well as ground-level species composition and diversity (Stehn et al. 2011).

Community diversity and compositional similarity

Alpha diversity patterns were associated with topographical variation. For example, tree alpha diversity was highest on the mid-hill to uphill sites (dominated by *P. simiarum-D. grandiflora* community) while diversity was lowest on the eroded foothill sites (dominated by *T. singularis* community) (Table 2). Apart from topographical variation, several other factors (e.g., dispersal, biotic interaction, and disturbance) might be responsible for variations in diversity as is typical in tropical forest (Hubbell 2001; Vellend 2010).

The abundance-based Morisita-Horn index, which is more sensitive to most common species (Chao et al. 2008), revealed that communities of the shady moist sites (e.g., *K. calycina—C. tribuloides* and *P. simiarum—D. grandiflo*ra) were compositionally most similar. In contrast, foothill communities (e.g., *T. singularis* and *F. roxburghii*) were dissimilar. Nevertheless, we observed low averages in pair-wise compositional similarity (Table 4), suggesting tree communities in the study area were highly diverse and require highest conservation priority.

Conservation implications

Classification of vegetation communities has become increasingly an important tool for conservation management in the tropics (Whittaker 1962; Cowardin et al. 1979; Pinto et al. 2005). The results of this study have implications for the conservation and restoration of remnant natural vegetation of Juri Forest. Our classification of the tree communities based on topography will enhance Bangladesh Forest Department's ability to identify the most important sites for implementing future conservation works.

We recorded many national red-listed species (17) (Table 5 in "Appendix" section) (Bangladesh National Herbarium 2001) and these plant species were found throughout the forest. Of these four species (*Alstonia scholaris*, *Intsia bijuga*, *Lophopetalum wightianum* and *Pterocarpus indicus*) are globally threatened (IUCN 2013). Mid-hill and mid-hill to hill-top were the priority sites for conservation because they supported highly species-rich communities (e.g., *K. calycina–C. tribuloides* and *P. simiarum–D. grandiflora*). These two communities together accounted for 85 % of tree species and 65 % of red listed tree species in the forest. In comparison, communities of the low elevation sites were comparatively species-poor. These sites have been subjected to frequent human disturbance (e.g., grazing, fire, settlement, and illegal felling) and habitat alteration (Sarker et al. 2013b). Hence, these sites require immediate restoration. Our information on the communities and sites can be used as reference for future management, restoration and conservation of JNF.

Conclusion

JNF is a conservation priority area in Bangladesh and houses numerous nationally and globally red-listed tree species. We identified six tree community types in JNF and they occupied distinct topographical locations. Tree diversity patterns within the communities were also associated with topographical variation. In terms of composition, communities of the shady moist sites were highly similar and foothill communities were dissimilar. Low overall average pair-wise compositional similarity between the communities indicates that the tree communities were diverse. Communities of the mid-hill to uphill sites are priority sites for conservation because they support high diversity. Eroded foot hill sites with low diversity are subjected to frequent human and environmental perturbations and require immediate restoration.

Ecological information on tree communities and tree diversity patterns among and within communities are required for successful ecological restoration and conservation. Hence, the vegetation and environmental data collected, and the findings of this study can be used by conservation agencies (e.g., Bangladesh Forest Department, IUCN) in implementing site specific conservation strategies for JNF. Above all, the numerical research approach could be a basis for vegetation mapping, monitoring and assessing site qualities.

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Appendix

See appendix Table 5.

Table 5 Name of the tree species with vernacular, scientific, family and genus name in six communities

Family	Genus	Scientific name	Vernacular name	Representing community types
Anacardiaceae	Spondias	*Spondias pinnata* (L.f.) Kurz[R]	Amra	B, C, E
	Bouea	*Bouea oppositifolia* (Roxb.) Meissner	Moyam	A, C
	Holigarna	*Holigarna longifolia* Roxb.[R]	Jawa	C
Annonaceae	Polyalthia	*Polyalthia simiarum* Hook.f. & Thom.	Cchami	B, C, D, F
Apocynaceae	Alstonia	*Alstonia scholaris* (L.) R.Br.[GR]	Chatni	B, C
Aquifoliaceae	Illex	*Illex godajam* Colebr. *ex* Hook.f.	Modori	B, C, D
Asteraceae	Eclipta	*Eclipta alba* (L.) Hassk.	Bongra	B
Bignoniaceae	Oroxylum	*Oroxylum indicum* (L.) Kurz[R]	Thona	B, C, D
Bixaceae	Bixa	*Bixa orellana* L.	Lotkon	B
Bombacaceae	Bombax	*Bombax ceiba* Burm.f.	Shimul	A
Burseraceae	Protium	*Protium serratum* (Wall. *ex* Coelbr.) Engl.	Gutgutiya	C
Caesalpiniaceae	Cassia	*Cassia fistula* L.	Sonalu	D
	Malintoa	*Cynometra polyandra* Roxb.	Ping	B
	Haematoxylon	*Intsia bijuga* (Colebr.) O.Kuntze[GR]	Mondol	C
Capparaceae	Crataeva	*Crataeva nervosa* L.	Bonak	B, C, D, F
Celastraceae	Lophopetalum	*Lophopetalum wightianum*.[GR]	Shutrong	B, C
Cluciaceae	Garcinia	*Garcinia cowa* Roxb. *ex* DC.[R]	Kao	B
		Garcinia xathocymusi Hook.f. *ex* T.Anders.[R]	Dephol	B, D
Combretaceae	Terminalia	*Terminalia bellirica* (Gaertn.) Roxb.[R]	Bohera	B, E
		Terminalia chebula Retz.	Horitoki	B
Datiscaceae	Bombax	*Bombax insigne* Wall.[R]	Toirol	A, B, C
Ehretiaceae	Ehretia	*Ehretia serrata* Roxb.	Kalahuja	C
Elaeocarpaceae	Elaeocarpus	*Elaeocarpus floribundus* Blume	Belfoi	B, C, D, E
Euphorbiaceae	Baccaurea	*Baccaurea ramiflora*.[R]	Bubi	B
	Bischofia	*Bischofia javanica* Blume	Joki	B, C
	Phyllanthus	*Emblica officinalis* Gaertn.	Amloki	B
	Glochidion	*Glochidion lanceolarium* (roxb.) Voigt	Kakra	A, B, C, D, F
		Glochidion sphaerogynum (Muell.-Arg) Kurz	Kai angla	B, C
	Jatropha	*Jatropha curcas* L.	Verenda	C
	Macaranga	*Macaranga denticulata* (Blume) Muell.-Arg.[R]	Jagua	C, D
	Mallotus	*Mallotus albus* (Roxb.) Muell.-Arg.	Malori	C
		Mallotus roxburghianus Muell.-Arg.	Gulli	B, D
	Stereospermum	*Stereospermum colais* (Bauch.-Ham. *ex* Dillw.) Mabberley	Pahari awal	B
Fabaceae	Pterocarpus	*Pterocarpus indicus* Willd.[GR]	Padok	A
Fagaceae	Arachis	*Arachis hypogaea* L.	Kath badam	C
	Castanopsis	*Castanopsis tribuloides* (Smith) A.DC.	Hingra	B, C, D, F
	Lithocarpus	*Lithocarpus elegans* var.elegans (Blume) Hatus. *ex* Soepad.	Ramkota	B, D
Lauraceae	Cinnamomum	*Cinnamomum cecicodaphne* Meiss.	Gondroi	C, D
	Cassytha	*Cinnamomum tamala* Ness & Eberm.	Huara	A
Leguminosae	Albizia	*Albizia procera* (Roxb.) Benth.	Sada Koroi	D
	Cassia	*Cassia fistula* L.[R]	Sonalu	D
Lythraceae	Lagerstroemia	*Lagerstroemia indica* L.	Foris	D
		Lagersroemia speciosa (L.) Pers.	Jarul	B
	Lawsonia	*Lawsonia intermis* L.	Henna	C
Magniliaceae	Michelia	*Michelia oblonga* Wall. *ex* Hook.f. & Thoms.	Sundi	A, C

Table 5 continued

Family	Genus	Scientific name	Vernacular name	Representing community types
Malvaceae	Kydia	*Kydia calycina* L.	Patha	A, B, C, D
Meliaceae	Aglaia	*Amoora wallichi* King	Rongi rata	D
	Chisocheton	*Chisocheton paniculatus* Hiern	Kalikura	B, D
		Gurea paniculata Roxb.	Rata	A, B, C, D
Mimosaceae	Acacia	*Acacia catechu* (L.f) Willd.	Katha	B, C
	Albizia	*Albizia chinensis* (Osb.) Merr.	Koroi	C
		Albizia lebbeck (L.) Benth. & Hook.[R]	Shiris	B, C
		Albizia procera (Roxb.) Benth.	Sada koroi	D
Moraceae	Artocarpus	*Artocarpus chama* Buch.-Ham. *ex* Wall	Cham kathal	A
		Artocarpus chaplasha Roxb.	Chapalish	E
		Artocarpus lacucha Buch.Ham	Dewa	B, C, E, F
	Ficus	*Ficus roxburghii* Wall. *ex* Miq.	Dumur	A, B, C, D, E, F
	Streblus	*Streblus asper* Lour.	Sheora	B, C
Myrtaceae	Cleistocalyx	*Cleistocalyx operculatus* (Roxb.) Merr. & L.M. Perry var. Paniala (Roxb.) P. Chantaranothia & J. Parn.	Goda jam	F
	Psidium	*Psidium guajava* L.	Peyara	C
	Syzygium	*Syzygium cumuni* (L.) Skeels	Jam	B, C, D
		Syzygium cymosum DC.	Jonki jam	A
		Syzygium fruticosum DC.	Khudi jam	E
		Syzygium praecox (Roxb.) Rathakr.& N. C. Nair	Poora jam	B
		Syzygium ramosissimum (Blume) Balakrishnan	Khor jam	B
Rhizophoraceae	Carallia	*Carallia brachiata* (Lour.) Merr.	Mathang	B, D, F
Rubiaceae	Neonauclea	*Adina sessilifolia* (Roxb.) Hook.f	Kom	A, B, D
	Neolamarckia	*Anthocephalus chinensis* (Lamk.) A. Rich. *ex*	Kodom	C, E
	Discospermum	*Tricalysia singularis* K. Schum.	Pakihara	A, B, C, D
Sapotaceae	Palaquium	*Palaquium polyanthum* Engl.	Korta	B, C, D, F
Sonneratiaceae	Withania	*Duabanga grandiflora* (Roxb.) *ex* DC.) Walp.	Ramdala	C, D
Sterculiaceae	Pterospermum	*Pterospermum acerifolium* (L.) Willd.[R]	Moskond	B, C
	Sterculia	*Sterculia villosa* Roxb. *ex* Smith.[R]	Udal	C
Ternstroemicaceae	Eurya	*Eurya acuminate* DC.	Chagoler bodi	B, C, D
Verbenaceae	Vitex	*Vitex pinnata* L.	Awal	A, B, C
–	–	–	Guiya*	B
–	–	–	Japa*	B, C
–	–	–	Macher kata*	C, D
–	–	–	Orisonko*	B, C
–	–	–	Ramai awal*	B, C

* Unidentified tree species, R Red listed species, GR IUCN Red listed species

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