ISSN (Online): 2349-1183; ISSN (Print): 2349-9265
TROPICAL PLANT RESEARCH
The Journal of the Society for Tropical Plant Research

5(2): 233–242, 2018
DOI: 10.22271/tpr.2018.v5.i2.030

Research article

Comparative study on structural composition and community association of Nambor Wildlife Sanctuary and its South-Westward extended Bornewria forest, Assam, India

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[Accepted: 27 August 2018]

Abstract: Knowledge of species composition and diversity are of utmost importance, not only to understand the structure of a forest community but also for planning and implementation of conservation strategy of the community. An extensive field study was undertaken to ascertain the structural composition, species diversity and community association of two forest sites *i.e.* Nambor Wildlife Sanctuary (NWLS) and its South-Westward extended Bornewria forest of Assam, India. The forests represent Tropical moist semi-evergreen and moist mixed deciduous type. The entire area was embraced with a fragmented block of Gondowana formation. A total of 261 plant species were observed from the two forests sites in floristic assessment. Out of which 247 species were recorded from NWLS and in Bornewria forest 136 were enumerated. The overexploitation and shifting cultivation adversely affected the total forested area and species composition of Bornewria forest. Phytosociological studies showed that *Vatica lanceaefolia* (15.47) followed by *Magnolia hodgsonii* (10.97), *Castanopsis hystrix* (10.02) and *Mesua ferrea* (9.56) were dominated in NWLS. However, in case of Bornewria forest, *Hydnocarpus kurzii* expressed its dominance with highest IVI values (15.98), followed by *Dysoxylum excelsum* (13.52), *Mesua ferrea* (12.37) and *Stereospermum tetragonum* (11.87). Plant species diversity was quantitatively higher in NWLS in comparison to Bornewria forest because of ecological destabilization and disturbance in their natural abode. Study on regeneration status of NWLS revealed that 67.42% trees were naturally regenerated. *Mesua ferrea* and *Vatica lanceifolia* were the most ecologically successful species with IVI of 7.66 and 5.27 in the seedling stage. In Bornewria forest site 42 regenerating tree individuals were recorded. The maximum quantity of seedlings of *Hydnocarpus kurzii* was noticed in the forest which showed mass regeneration status of the species. Both the forest desires to curb the anthropogenic disturbance, so that protect the integrity of the forest.

Keywords: Phytosociological studies - Plant inventory - Regeneration - Species diversity.

[Cite as: Barua KN, Gogoi G & Hazarika P (2018) Comparative study on structural composition and community association of Nambor Wildlife Sanctuary and its South-Westward extended Bornewria forest, Assam, India. *Tropical Plant Research* 5(2): 233–242]

INTRODUCTION

Floristic composition of vegetation and species diversity reflect the gene pool and adaptation potential of the community (Odum 1971). Knowledge of species composition and diversity of tree species is of great importance not only to understand the structure of a forest community but also for planning and implementation of conservation strategy of the community (Bajpai *et al.* 2012, Malik 2014, Malik & Bhatt 2015, Masens *et al.* 2017). It is a prerequisite for the foresters to understand the structural attributes of the forest for better silviculture and management practices. In forest management, regeneration study not only reflects the current status but also gives an idea about the possible changes in forest composition in the future (Mishra *et al.* 2013, Sharma *et al.* 2014, Hanief *et al.* 2016, Malik & Bhatt 2016). Survival and growth of seedlings/saplings

Received: 11 April 2018 Published online: 31 August 2018
https://doi.org/10.22271/tpr.2018.v5.i2.030

determine the successful regeneration of the species which is one of the most important steps toward achieving long-term sustainability of forests (Saikia & Khan 2013, Malik 2014, Malik & Bhatt 2016).

However, the structure and nature of the plant community are determined by the species composition and their ecological amplitude. The quantitative characters are very important in the analysis of comparative community structure of different forest stands. Study of community structure in the natural forests of various climatic zones of the country have been done by different authors in the recent past (Nath *et al*. 2000, Pande *et al.* 2001, Pandey & Shukla 2003, Galav *et al*. 2005, Naithani *et al.* 2006, Khatri *et al*. 2009, Sarkar & Devi 2014, Naidu & Kumar 2016, Bajpai *et al.* 2017). The species diversity and community structure of Nambor Wildlife Sanctuary and Bornewria forest of Assam have not been explored well and a very little information is available so far (Prasad 2001). Therefore, the present study was carried out on structural composition, diversity and community association of the two forest sites.

MATERIALS AND METHODS

Study site

Two natural forest stands Nambor Wildlife Sanctuary (NWLS) (primary) and Bornewria forest (secondary) geographically located at latitude of 26.36° N; longitude of 93.86° E and latitude of 26.24° N; longitude of 93.82° E respectively were selected for the present study in Karbi Anglong Autonomous District Council of Assam (Fig. 1). The forests are classified as Moist Semi-Evergreen Forest mixed with East Himalayan Moist Mixed Deciduous Forest (Champion & Seth 1968). The entire area is of great importance in paleohistorical point of view as it comprises a fragmented block of Gondowana formation. The total forested area of NWLS is 37.0 km^2. Bornewria is a South-west ward extended part of original Nambor reserve forest now converted to a secondary denuded one. Over a period, Bornewria forest has been adversely affected by shifting cultivation (*Jhum*), an age-old ecologically hazardous traditional cultivation practice. With the rapid shortening of the fallow cycle, the farmers shift towards the forested land and forest has been deforested gradually. Invasion of secondary species such as *Hydnocarpus kurzii* (King) Warb., *Dysoxylum excelsum* Blume, *Stereospermum tetragonum* DC. etc. changes the original forest scenario.

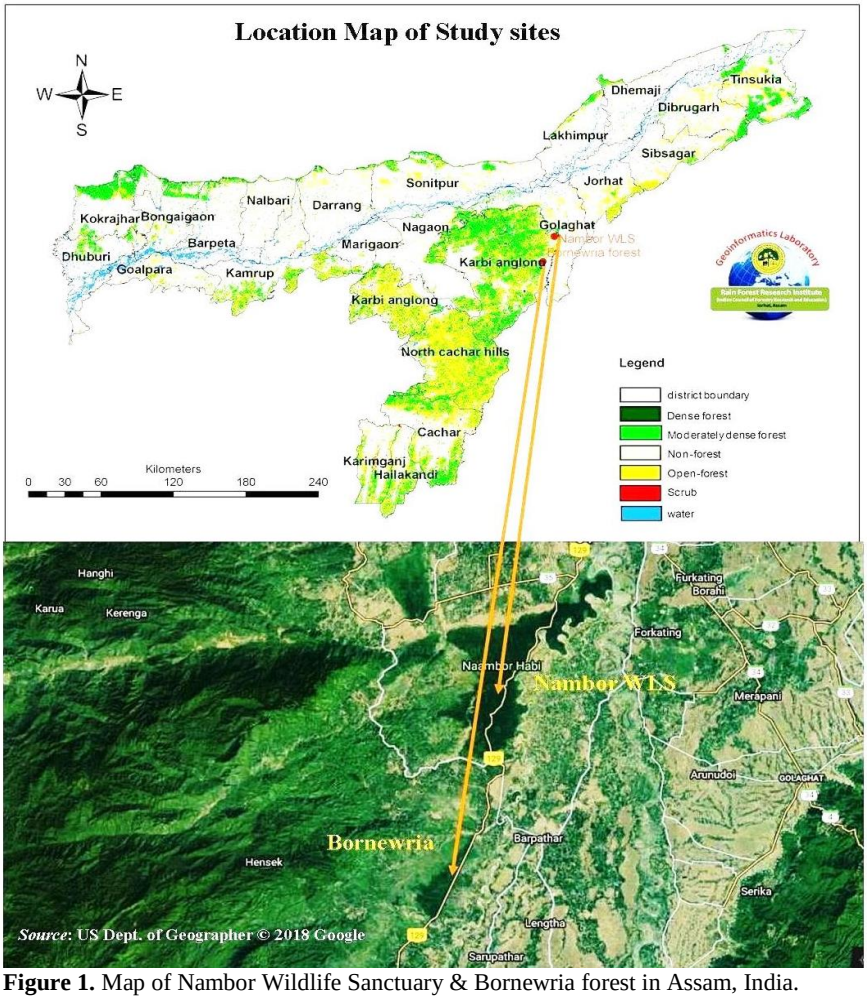

Figure 1. Map of Nambor Wildlife Sanctuary & Bornewria forest in Assam, India.

The climate is the typically humid sub-tropical type and receiving nearly 1200 mm total average annual rainfall. The soil comprises old alluvial and red laterite type. The texture is sandy loam, soil pH ranges from 4.8 to 6.31 and soil reaction is acidic. The highest relative humidity was observed to be 90.4% (in the month of August). The average maximum temperature varies from 28.65–31.24 °C and average minimum temperature from 14.67–19.38 °C.

Methodology

Phytosociological studies of the two selected forest stands were carried out by randomly laying quadrats of 10m × 10m, 5m × 5m and 1m × 1m for trees, shrubs/saplings and herbs/seedlings replicated with 40, 80 and 160 numbers of quadrats respectively for each site. The species were categorized as a tree (>3 m height), shrub (height above 0.5 to 3 m) and herb (less than 0.5 m) height (Khan 1961). The size and the number of sampling quadrats were determined following Mishra (1968) and Kershaw (1973). Species diversity (H') was calculated by using Shannon and Wiener formula (Shannon & Wiener 1963). The concentration of dominance values was assessed by Simpson's index (Simpson 1949). The similarity coefficient for common and rare species was calculated by following Sorenson and Jaccard's coefficient (Magurran 1988). Motyka's index (%) was calculated by following formula IS_{mo} =2MW/MA+MB X 100 that expresses the similarity percentage for each pair of vegetation types

Sorensen Co-efficient Ss = 2a/(2a+b+c)

Jaccard's Co-efficient Sj = a/(a+b+c)

Where a = Number of species occurring in both sample.

b = Species occurring only in sample B

c = Species occurring only in sample A.

Identification of the plant species was done with the help of floras (Kanjilal *et al*. 1934–40, Hooker 1872–97) and by consulting herbaria of Botanical Survey of India, Eastern Regional Centre, Shillong and Central National Herbarium, Howrah. The nomenclature of each plant species was confirmed with the help of databases like 'The Plant List' and 'Tropicos'. The abundance to frequency ratio (A/F) of different species was computed to define the distribution pattern of the species (Whitford 1949). This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution (Cottam & Curtis 1956).

RESULTS AND DISCUSSION

Plant Inventory

A total of 261 plant species were found distributed in both the forests during floristic assessment. Out of which Nambor Wildlife Sanctuary (NWLS) was comprised of 247 species belong to 75 families and 179 genera. On the other hand, Bornewria forest was comprised of 136 species belong to 54 families and 110 genera. The breakup of the families, genera, species, dicotyledonous, monocotyledon, ferns and Gymnosperms are shown in table 1. A total of 30 fern and fern allies were recorded from Nambor WLS whereas, only 10 fern and fern allies were recorded in the Bornewria forest. Fern and fern allies like *Adiantum caudatum* L., *Angiopteris* sp., *Lygodium flexuosum* (L.) Sw., *Polypodiodes amoena* (Wall. ex Mett.) Ching, *Pteris cretica* L., *Sphaerostephanos unitus* (L.) Holttum and *Stenochlaena palustris* (Burm. f.) Bedd. were found in both the habitats. *Gnetum gnemon* L., a highly evolved gymnosperm species distributed in the lower strata of both the forests and established as an important component of the vegetation that reflects the old land history of this region.

Table 1. Plant inventory of Nambor Wildlife Sanctuary and Bornewria forest of Assam.

	Dicots		Monocots		Ferns		Gymnosperms		
	Numbers	%	Numbers	%	Numbers	%	Numbers	%	Total
Nambor WLS									
Families	49	65	9	12	16	21	1	1.33	75
Genera	120	67.04	34	18.99	24	13.41	1	0.56	179
Species	165	66.80	51	20.65	30	12.14	1	0.40	247
Bornewria Forest									
Families	40	74.07	8	14.81	5	9.26	1	1.85	54
Genera	78	71.56	21	19.26	10	9.17	1	0.91	110
Species	100	73.53	25	18.38	10	7.35	1	0.73	136

Artocarpus chama Buch.-Ham., *Mesua ferrea* L., *Morus macroura* Miq., *Phoebe goalparensis* Hutch., *Aglaia spectabilis* (Miq.) S.S.Jain & S.Bennet etc. were the predominant species in moist semi-evergreen forest. Other trees like *Haldina cordifolia* (Roxb.) Ridsdale, *Lagerstroemia speciosa* (L.) Pers., *Albizia procera*

(Roxb.) Benth., *Bombax ceiba* L., *Schima wallichii* Choisy, *Stereospermum tetragonum* etc. along with vascular climbers and epiphytes were common plant species of the moist mixed deciduous forest.

The upper canopy was predominated by deciduous tree species whose leafless period is short *viz*. *Alstonia scholaris* (L.) R. Br., *Artocarpus chama*, *Mallotus nudiflorus* (L.) Kulju & Welzen, *Morus macroura*, *Stereospermum tetragonum*, *Tetrameles nudiflora* R. Br., *Zanthoxylum budrunga* (Roxb.) DC. etc. Whereas, middle and lower canopy were of more or less evergreen character. In the middle canopy, trees like *Elaeocarpus sikkimensis* Mast., *E. tectorius* (Lour.) Poir., *Canarium resiniferum* Bruce ex King, *Castanopsis hystrix* Hook. f. & Thomson ex A. DC., *Machilus gamblei* King ex Hook. f., *Vatica lanceifolia* (Roxb.) Blume, *Mesua ferrea* with evergreen characteristic were found predominant in the primary forest.

The lower canopy vegetation is mainly influenced by the size of seedling population and survivability. The Density of trees in a forest is largely depending upon the response of the tree seedlings to the prevailing microenvironment. The present observation noted that the seed germination and survival percentage of *Hydnocarpus kurzii*, *Vatica lanceifolia*, *Mesua ferrea*, *Litsea laeta* (Wall. ex Nees) Hook.f. etc. were maximum and found well established in the forest floor. Better establishment of the tree seedlings was recorded in the primary forest strand near the periphery rather than the core areas that may be due to the lack of threshold light intensity available to the seedlings (Whitmore 1975, Abbott 1984, Primack *et al*. 1985).

Orchids are susceptible and selective for their habitats. The humid forest of NWLS has cradled the rich heritage of both terrestrial and epiphytic orchids. A total of 23 orchid species were recorded and *Acampe papillosa* (Lindl.) Lindl., *Bulbophyllum* spp. *Calanthe sylvatica* (Thouars) Lindl., *Dendrobium acinaciforme* Roxb., *D. lituiflorum* Lindl., *D. anceps* Sw., *D. lindleyi* Steud., *Eria lasiopetala* (Willd.) Ormerod, *Gastrochilus calceolaris* (Buch.-Ham. ex Sm.) D.Don, *G. inconspicuus* (Hook.f.) Kuntze, *Oberonia mucronata* (D.Don) Ormerod & Seidenf., *Zeuxine gracilis* (Breda) Blume were the dominant orchids in both the site. An endangered spectacular orchid *Anoectochilus brevilabris* Lindl. (Jewel orchid) also reported their occurrence in the dense damp forest floor of the primary forest, but now severely influenced by biotic interference. In Bornewria forest (Secondary forest) found only 12 tropical orchids. The ecological destabilization due to various anthropogenic factors a number of orchid species have been on the verge of disappearance.

A total of 35 species of climbers and scandent shrubs were recorded in the primary natural forest which are the curious botanical wealth of this forest. Whereas, only 20 species of climbers and scandent shrubs were found in the secondary forest. *Abrus precatorius* L., *Aristolochia saccata* Wall., *Beaumontia grandiflora* Wall., *Dioscorea* spp., *Dischidia major* (Vahl) Merr., *Dischidia major* (Vahl) Merr., *Licuala peltata* Roxb. ex Buch.-Ham., *Piper* spp., *Pothos* spp., *Smithia grandis* Baker, *Tacca integrifolia* Ker Gawl. etc. were the species of climbers and scandent shrubs found in the primary forest that twisted or straggled the trees which bear the characteristic of the moist evergreen forest. Some common climbers and plants of straggling habit found dominated in the secondary forest were *Dalhousea bracteata* Grah., *Mikania micrantha* Kunth., *Mimosa rubicaulis* Lam., *M. himalayana* Gamble, *Piper griffithii* C. DC., *Pothos scandens* L., *Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb., etc.

Vegetation Analysis

Phytosociological studies in the primary natural forest showed that *Vatica lanceaefolia* (Roxb.) Blume (15.47) was the predominant tree species followed by *Magnolia hodgsonii* (Hook.f. & Thomson) H.Keng (10.97), *Castanopsis hystrix* (10.02) and *Mesua ferrea* (9.56). However, in case of secondary forest *Hydnocarpus kurzii* expressed its dominancy with highest IVI values (15.98), which was followed by *Dysoxylum excelsum* (13.52), *Mesua ferrea* (12.37) and *Stereospermum tetragonum* (11.87) (Table 2).

Gnetum gnemon (IVI 22.64) was found dominant in the shrub layer of primary forest followed by *Phlogacanthus curviflorus* (Wall.) Nees (IVI 17.38), which is highly medicinal. Maximum number of saplings of *Hydnocarpus kurzii* (IVI 15.14) followed by *Litsea laeta* (IVI 13.01) and *Mesua ferrea* (11.85) etc. were found in the secondary forest. The floor of the primary forest was found covered by the herbaceous species like *Cheilocostus speciosus* (J.Koenig) C.D.Specht, *Oplismenus compositus* (L.) P.Beauv., *Curculigo orchioides* Gaertn., *Alpinia nigra* (Gaertn.) Burtt, *Selaginella biformis* A. Braun ex Kuhn, *Setaria palmifolia* (J.Koenig) Stapf, *Setaria pumila* (Poir.) Roem. & Schult., *Cyperus pilosus* Vahl, etc. On the other hand, in the secondary forest the edible fern species *Diplazium esculentum* (Retz.) Sw. (IVI 24.25) was found dominated in ground strata followed by *Colocasia* esculenta (L.) Schott (IVI 19.69) and *Cheilocostus speciosus* (IVI 15.94) (Table 2).

As reported by Knight (1975) the value of Diversity Index varies from 5.06–5.40 for tropical forest. The present study showed that Diversity index (H') of the primary forest were 5.7, 4.727, 4.1 for trees, shrubs/saplings and herbs/seedlings respectively, which was found within the range. On the other hand, the

Table 2. Importance value index (IVI) of Nambor Wildlife Sanctuary and Bornewria forest. [Tree- >3 m, Shrub- 0.5–2 m, Herb- <0.5 m hight]

SN	Name of species	Nambor WLS			Bornewria forest		
		Tree	Shrub	Herb	Tree	Shrub	Herb
1	*Abacopteris lakhimpurensis* Ching			2.81			5.61
2	*Abroma augusta* (L.) L.f.	0.69	2.21				
3	*Acanthus leucostachyus* Wall. ex Nees			5.22			
4	*Achyranthes aspera* L.			5.19			
5	*Actinodaphne obovata* (Nees.) Blume	2.12	2.5	5.5			
6	*Aesculus assamica* Griff.	1.35	1.45				
7	*Aglaia cucullata* (Roxb.) Pellegr.	2.91	1.61		1.09	1.33	
8	*Alangium chinense* (Lour.) Harms	1.59		0.71	3.18		
9	*Albizia procera* (Roxb.) Benth.				2.62		
10	*Alpinia nigra* (Gaertn.) Burtt			12.47		3.67	3.15
11	*Alstonia scholaris* (L.) R. Br.	0.77	1.27	3	5.95	3.84	
12	*Amischotolype gracilis* (Ridl.) I.M. Turner			10			
13	*Antidesma bunius* (L.) Spreng.				1.09		
14	*Antidesma montanum* Blume				3.07	3.42	
15	*Artocarpus chama* Buch.-Ham	2.24	1.61	3.42	11.15	1.91	
16	*Artocarpus lacucha* Buch.-Ham.	2.18	0.99			1.91	
17	*Baccaurea ramiflora* Lour.	3.83	4.55		5.33	5.64	
18	*Balakata baccata* (Roxb.) Esser	3.22	3.15		7.08		
19	*Bauhinia malabarica* Roxb.		6.99	2.04	3.93	1.14	4.12
20	*Benkara fasciculata* (Roxb.) Ridsdale					2.6	
21	*Bischofia javanica* Blume	3.66	1.23		1.64	2.27	
22	*Blumea lacera* (Burm.f.) DC.			3.36			
23	*Boehmeria glomerulifera* Miq.	1.95					
24	*Boehmeria nivea* (L.) Gaudich.			2.39			
25	*Bombax ceiba* L.	3.63			7.79		
26	*Bridelia retusa* (L.) A.Juss.		1.49		2.71		
27	*Bridelia stipularis* (L.) Blume	1.51					
28	*Butea monosperma* (Lam.) Taub.	1.32					
29	*Calanthe sylvatica* (Thouars) Lindl.			5			
30	*Callicarpa arborea* Roxb.	4.01	1.51		3.12		
31	*Callicarpa longifolia* Lamk.		5.4			2.79	
32	*Canarium resiniferum* Bruce ex King	3.5			3.96		
33	*Carex indica* L.			5.66			
34	*Castanopsis indica* (Roxb. ex Lindl.) A.DC.	2.36					
35	*Castanopsis armata* (Roxb.) Spach.	5.47	3.75	1.62		8.65	2.49
36	*Castanopsis hystrix* Hook. f. & Thomson ex A. DC.	10	5.12	0.78	5.94	1.89	
37	*Castanopsis tribuloides* (SM.) A.DC.	1.56					
38	*Catunaregam spinosa* (Thunb.) Tirveng.	1.39	1.95				
39	*Chloranthus elatior* R. Br.			0.78			
40	*Chromolaena odorata* (L.) R.M.King & H.Rob.					6.75	5.17
41	*Chrysophyllum roxburghii* G.Don	1.7					
42	*Chrysopogon zizanioides* (L.) Roberty			2.62			
43	*Chukrasia tabularis* A.Juss.	3.24	2.1	2.44	2.91	3.91	
44	*Cinnamomum glanduliferum* (Wall) Meissn.	0.87	5.66				
45	*Cinnamomum glaucescens* (Nees) Hand-Mazz.	4.69	2.55		2.12	4.53	
46	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	3.94	4.26	1.69	3.26	4.64	
47	*Clerodendrum indicum* (L.) Kuntze		0.89			5.23	
48	*Clerodendrum laevifolium* Blume		3.07				
49	*Clerodendrum glandulosum* Lindl.					3.64	
50	*Clerodendrum infortunatum* L.		2			6.51	
51	*Coffea benghalensis* B.Heyne ex Schult.		5.7	1.78		3.81	
52	*Colocasia esculenta* (L.) Schott			4.39			19.7
53	*Combretum decandrum* Jacq.	1.17	1.97				
54	*Cordia dichotoma* G. Forst.	0.72	2.85		4.36		
55	*Cordia myxa* L.	2.85					
56	*Cheilocostus speciosus* (J.Koenig) C.D.Specht			16.67			15.9
57	*Croton joufra* Roxb.	3.88			1.31		

58	*Croton caudatus* Geiseler					5.61	3.1
59	*Croton persimilis* Mull. Arg.	1.58	1.69		3.47	4.38	
60	*Croton tiglium* L.	0.74			2.46		
61	*Curculigo orchioides* Gaertn.			13.39			2.38
62	*Curcuma zerumbet* Roxb.			5			3.27
63	*Cyperus pilosus* Vahl.			3.32			2.81
64	*Dalbergia stipulacea* Roxb.						0.92
65	*Dalhousiea bracteata* (Roxb.) Benth.					3.96	1.97
66	*Delima sarmentosa* L.						3.25
67	*Dicliptera chinensis* (L.) Juss.			1.24			
68	*Dillenia indica* L.	5.29	2.69	2.68	6.46	6.38	1.34
69	*Dillenia pentagyna* Roxb.	4.3	1.48		1.33	5.34	
70	*Diplazium esculentum* (Retz.) Sw.						24.3
71	*Drimycarpus racemosus* (Roxb.) Hook f. ex Marc.						3.81
72	*Duabanga grandiflora* (Roxb.ex DC.) Wall.	2.76	1.22		3.38		
73	*Dysoxylum excelsum* Blume	7.93	3.35	0.78	13.52	6.43	
74	*Elaeocarpus sphaericus* (Gaertn.) K. Schum	1.99	1.09	0.83			
75	*Elaeocarpus rugosus* Roxb. ex G.Don	2.66					
76	*Elaeocarpus sikkimensis* Mast.	1.9					
77	*Elaeocarpus tectorius* (Lour.) Poir.	5.32	2.88	0.71	3.36	0.89	
78	*Erythrina stricta* Roxb.	0.78			2.06		
79	*Eurya japonica* Thunb.	2.63	2.81	1.94			
80	*Eurya acuminata* DC.	3.09	7.87			5.55	
81	*Evodia meliifolia* (Hance ex Walp.) Benth.	3.31	1.03		1.94		
82	*Ficus hispida* L.f.				3.54	3.4	3.05
83	*Ficus racemosa* L.			0.97	2.05		
84	*Ficus religiosa* L.	1.09			1.41	1.23	
85	*Ficus sarmentosa* Buch-Ham. ex Sm.	2.49	1.03		3.12	1.18	
86	*Ficus nervosa* B.Heyne ex Roth	3.75	6.52				
87	*Fimbristylis bisumbellata* (Forsk.) Bubani			2.75			
88	*Floscopa scandens* Lour.			3.56			
89	*Flueggea virosa* (Roxb. ex Willd.) Royle	1.78	3	3.27	2.84	1.33	
90	*Garcinia cowa* Roxb. ex Choisy		1.87		1.85	1.91	1.16
91	*Garcinia xanthochymus* Hook.f. ex T.Anderson	3.77			2.4		
92	*Girardinia palmata* (Forssk.) Gaudich.			1.43			
93	*Globba multiflora* Wall. ex Baker			7.72			
94	*Glochidion ellipticum* Wight	1.54					
95	*Glycosmis pentaphylla* (Retz.) DC.		3.23			10.6	2
96	*Gmelina arborea* Roxb.	1.61			1.77		
97	*Gnetum gnemon* L.		22.64	8.45		12.6	3.11
98	*Gomphostemma parviflorum* Wall. ex Benth.		0.96				
99	*Grewia multiflora* Juss.	1.95	1.18		4.6	3.07	
100	*Haldina cordifolia* (Roxb.) Ridsdale				4.91		
101	*Hedychium spicatum* Sm.			6.18			1.03
102	*Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult.			1.07			
103	*Hydnocarpus kurzii* (King) Warb.	3.95	2.03	1.11	15.98	15.1	29.6
104	*Justicia procumbens* L.			4.38			
105	*Knoxia sumatrensis* (Retz.) DC.			5.96			5.19
106	*Kydia calycina* Roxb.	4.81	1.55		4.77	1.14	
107	*Lagerstroemia speciosa* (L.) Pers.	5.33	1.43	2.08	3.67		
108	*Lantana camara* L.					4.28	
109	*Leea asiatica* (L.) Ridsdale		7.91			1.14	
110	*Leea indica* (Burm. f.) Merr.		5.5			5.67	
111	*Lepidagathis incurva* Buch Ham. ex D. Don.			1.37			
112	*Litsea monopetala* (Roxb.) Pers.	2.1	4.96	2.74	3.65	5.05	
113	*Litsea glutinosa* (Lour) Robin.				3.21	5	1.21
114	*Litsea laeta* (Wall. ex Nees) Hook.f.	3.7	3.28	0.78	6.01	13	6.56
115	*Litsea salicifolia* (Roxb. ex Nees) Hook. F.					4.35	
116	*Litsea lancifolia* (Roxb. ex Nees) Fern.-Vill.	3.49	5.02	2.43	4.18	4.97	2.5
117	*Litsea nitida* (Roxb.) Hook. f.	0.68	5.02		7.41	5.89	1.15

118	*Macaranga peltata* (Roxb.) Muel. Arg.				8.11	2.95	2.46
119	*Machilus gamblei* King ex Hook. f.	4.86		0.78			
120	*Magnolia griffithii* Hook. f. & Thomson	2.6	3		3.07		
121	*Magnolia hodgsonii* (Hook. f. & Thomson) H. Keng	11	5.5	2.54	10		
122	*Magnolia insignis* Wall.	1.15		2.72	3.79	2.06	2.86
123	*Magnolia mannii* (King) Figlar	3.93	6.97				
124	*Magnolia montana* (Blume) Figlar	2.95					
125	*Magnolia pterocarpa* Roxb.	1.67					1.91
126	*Magnolia champaca* (L.) Baill. ex Pierre	1.21					
127	*Mallotus nudiflorus* (L.) Kulju & Welzen	1.63	2.42		3.48		
128	*Mallotus philippensis* (Lamk.) Mull. Arg	3.56	5	3.29	3.08	1.06	
129	*Mangifera indica* L.	1.4			1.66	2.18	1.07
130	*Mangifera sylvatica* Roxb.	1.83					
131	*Mansonia dipikae* Purkayastha	4.19	5.58	1.65	2.97	7.28	7.59
132	*Melastoma malabathricum* L.					2.37	
133	*Merremia umbellata* (L.) Hallier f.						3.33
134	*Mesua ferrea* L.	9.56	6.21	7.66	12.37	11.9	6.54
135	*Mikania micrantha* Kunth.						8.89
136	*Mimosa pudica* L.						2.07
137	*Mimosa himalayana* Gamble					3.19	3.09
138	*Morus macroura* Miq.	2.84		1.76	3.82	1.61	
139	*Mussaenda roxburghii* Hook. f.		3.59			1.71	1.96
140	*Nelsonia canescens* (Lam.) Spreng.			6.38			
141	*Neolamarckia cadamba* (Roxb.) Bosser	4.32	1.73		2.85	1.33	
142	*Ocotea lancifolia* (Schott) Mez	2.92	6.17	2.82	2.59	2.05	2.89
143	*Oplismenus burmanni* (Retz.) P.Beauv.			3.24			
144	*Oplismenus compositus* (L.) P. Beauv.			15.61			12.3
145	*Oroxylum indicum* (L.) Kurz	1.33	2.67		2.59		
146	*Oxalis corniculata* L.						1.07
147	*Oxyceros longiflorus* (Lam.) T.Yamaz.					6.49	
148	*Oxyspora paniculata* (D. Don) DC.		8.28				
149	*Panicum repens* L.			5.94			
150	*Phlogacanthus curviflorus* (Wall.) Nees		17.38	7.03			
151	*Phoebe goalparensis* Hutch.	2.45					
152	*Phyllanthus fraternus* G.L.Webster	0.68	2.56				
153	*Piper griffithii* C. DC.			2.12			13
154	*Polygonum barbatum* L.			5.87			4.77
155	*Pothos scandens* L.						2.83
156	*Premna latifolia* Roxb.	3.16			4.15	1.02	
157	*Psychotria calocarpa* Kurz			1.92			
158	*Pteridium equilinun* (L.) Kuhn.			2.43			4.43
159	*Pteris cretica* L.			1.8			3.36
160	*Quercus semiserrata* Roxb.	1.05					
161	*Rhamnus napalensis* (Wall.) M.A. Lawson		2.5			4.51	
162	*Schima wallichii* Choisy				5.06		
163	*Schoenoplectiella juncoides* (Roxb.) Lye			2.27			
164	*Selaginella biformis* A.Braun ex Kuhn			7.34			
165	*Setaria palmifolia* (J.Koenig) Stapf			5.78			7.26
166	*Setaria pumila* (Poir.) Roem. & Schult.			3.79			12.9
167	*Sida cordifolia* L.						2.84
168	*Smilax zeylanica* L.						2.11
169	*Smithia grandis* Baker						2.54
170	*Spermacoce articularis* L.f.						3.03
171	*Sphaerostephanos unitus* (L.) Holttum						6.47
172	*Stephania japonica* (Thunb.) Miers						4.87
173	*Sterculia villosa* Roxb.	4.57	5.07	1.94			
174	*Stereospermum tetragonum* DC.	4.75	3.1		11.87	2.14	4.4
175	*Strobilanthes adnatus* C.B.Clarke			3.75			
176	*Syzygium fruticosum* DC.		3.6				
177	*Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult.		2.35	2.39		2.87	1.44

178	*Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre	0.75	0.5		3.53	3.98	
179	*Terminalia myriocarpa* Van Heurck & Mull.Arg.	1.7	1.22				
180	*Terminalia bellirica* (Gaertn.) Roxb.	4.33	1.18				
181	*Terminalia chebula* Retz.	3.27	1.1	2.41	3.15	1.33	1.15
182	*Tetrameles nudiflora* R.Br.	5.65	3.96		3.12	1.06	
183	*Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb.		1.77			4.2	
184	*Toona ciliata* M. Roem.	3.09	2.19	2.09	0.96	1.33	
185	*Triadica cochinchinensis* Lour.	8.64	3.27	3.75	5.47	6.73	1.4
186	*Urena lobata* L.						3.95
187	*Vatica lanceaefolia* (Roxb.) Blume	15.5	6.08	5.27	1.85	5.15	
188	*Vitex peduncularis* Wall. ex Schaue	1.6	2.08				
189	*Wrightia coccinea* Roxb. ex Hornem.	1.26					
190	*Zanthoxylum budrunga* (Roxb.) DC.	1.83			2.29		
191	*Ziziphus jujuba* Mill.	1.38	1.35				0.92

diversity index of secondary forest were found 4.760 4.491 and 4.016 respectively. The values of plant species diversity of primary natural forests were always higher in comparison to the secondary forest which indicates high species richness considering the population of individual species. Concentrations of Dominance (CD) of the primary forest were found 0.027, 0.042 and 0.046 for trees, shrubs/saplings and herbs/seedlings respectively whereas, 0.031, 0.0369 and 0.062 for the secondary forest (Table 3). Species diversity and concentration of dominance are generally inversely related.

Table 3. Diversity Index (H') and Concentration of dominance (CD) of different canopy height in Nambor Wildlife Sanctuary and Bornewria forest. [Tree- >3 m, Shrub- 0.5–2 m, Herb- <0.5 m hight]

Indices	Nambor WLS			Bornewria forest		
	Tree	**Shrub**	**Herb**	**Tree**	**Shrub**	**Herb**
H'	5.736	4.727	4.1	4.760	4.491	4.016
CD	0.027	0.042	0.046	0.031	0.0369	0.062

Similarity coefficients of both the Nambor and Bornewria Forest were calculated and compared (Table 4). The Sorenson's similarity co-efficient (0.3772) was found higher than Jaccard's co-efficient (0.2324). Motyka's similarity index was found 60.57% between the forest sites (Table 4). The contagious trend of the distribution pattern of plant species was found in both the forests, which has also been reported by Kershaw (1973) and Greig-Smith (1957).

Table 4. Similarity co-efficient of studied natural forest.

SN	Similarity Indices	Nambor WLS	Bornewria Forest
1	Sorenson,s co-efficient (Ss)	0.3772	
2	Jaccard's co-efficient (Sj)	0.2324	
3	Motyka's index	60.57	

Regeneration performance of a tree species is characterized by its population constitution in different life phases *i.e.* tree, sapling and seedling (Pokhriyal *et al.* 2010) as well as depends upon the existence of a sufficient number of seedlings and saplings. In NWLS out of 89 reported tree species, 60 species were found regenerated naturally *i.e.* regeneration percentage 67.42%. *Mesua ferrea* and *Vatica lanceaefolia* were found the most ecologically successful species with IVI of 7.66 and 5.27 respectively in the seedling stage. Whereas, in Bornewria forest out of 62 tree species, 42 species were found regenerated naturally *i.e.* regeneration percentage 67.74%. So, the regeneration percentage in both the forests was found almost similar. A maximum number of seedlings of *Hydnocarpus kurzii* (IVI 29.62) was found in the Bornewria forest which showed mass regeneration status of the species. Seedling diversity was found poor in the Bornewria forest. According to Mishra *et al.* (2008) higher numbers of saplings and trees in comparison to seedlings, point out the ability of the forest to recruit more seedlings.

CONCLUSION

The assessment of structural composition and plant species diversity of two forest sites have indicated that, Nambor Wildlife Sanctuary (NWLS) (Primary forest) was found richer than Bornewria forest (Secondary forest) in plant diversity. Numbers of plant species were declined in the Bornewria forest because of ecological destabilization and disturbance in their natural abode.

ACKNOWLEDGMENTS

The authors would like to express deep sense of gratitude and sincere thanks to Director, Rain Forest Research Institute, Jorhat whose advice and encouragement were vital. The authors also grateful to the State Forest Department of Assam, Divisional Forest Officer Golaghat and the staff for permits to work in the Forest as well as their support and co-operation.

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