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Effect of Disturbance on Diversity and Distribution of Herbaceous Vegetation in Nokrek Biosphere Reserve, Meghalaya, North-East India

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ABSTRACT

The phyto-sociological investigation on herbs was carried out in core zone (undisturbed) and buffer zone (disturbed) of the Nokrek Biosphere Reserve, Meghalaya, North-East India. The field study and vegetation analysis were conducted following the standard methods. The findings reveal that disturbance leads to change in phyto-soiological attributes from core to buffer zone. The buffer zone possessed more species richness and density in comparison to core zone, indicating disturbance supporting diversity of herbaceous species. The dominant species and family no longer maintained their dominance, as species *Elatostema sessile* of core zone was replaced by *Pteris quadriaurita* in buffer zone and family Urticaceae was replaced by Asteraceae. The shift in position is highly linked with disturbance. Despite more number of families, the number of monospecific family was high in buffer zone, stating elimination of some sensitive species on one hand and introduction of some species from neighboring habitat on other hand. The species richness index and Shannon diversity index were high in buffer zone and Simpson index followed a reverse trend in results with respect to Shannon diversity index. This could be attributed due to small gaps and open canopy in buffer zone, facilitating herbaceous vegetation. The normal dominance - distribution curve in both zones showing stability and complexity of community.

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INTRODUCTION

Biological diversity is the variety and variability among living organisms and the ecological complexes in which they occur and encompasses community diversity, species diversity and genetic diversity (Anon 2002). Biodiversity is presently critical since we live in an era of Mass Holocene Extinction, a period of species loss caused by man and unrivalled in rate of species loss. The extinction of a species is almost always related to destruction of habitat.

Human beings live close to nature and natural resources and have always been an integral part of the ecosystem. From the beginning of human society, each tribe or community develop its own ways of utilizing and managing the community and natural resources. Indigenous people live at the mercy of nature. Nature was seemingly inexhaustible reservoir, providing humans with everything they needed, whilst at the same time offering vast spaces for the disposal of pollutants and wastes. The direct and indirect impacts of human activities on natural environment constitute a threat to the future of the biological diversity.

Biodiversity has attracted world attention because of the growing awareness of its importance on one hand and the anticipated massive depletion / loss on the other hand (Singh 2002). It may thus be assumed to be a synonym for Life on Earth, variety of life and its processes. Globally concerns are raised over the rapid loss of biodiversity in all its forms and at all levels. Human disturbance in tropical forests is not simply a phenomenon of the colonial and modern eras, but dates back to early human occupation in tropical regions (Denevan 1976).

In early 1970's the UNESCO promoted the concept of Biosphere Reserve to minimize the conflict between local communities and protected area managers. By 1971 UNESCO launched the Man and Biosphere (MAB) program. There are over 500 Biosphere Reserves in 100 countries. Through Man and Biosphere (MAB) program, UNESCO has been promoting regional and international cooperation. In addition, they are a concrete means for countries to implement Agenda 21, the Convention on Biological Diversity (CBD).

Biosphere Reserves are potential *in-situ* conservation sites and are major vegetation protected against disturbance to act as reference area for natural vegetation. The Biosphere Reserves were set up to conserve biodiversity at all levels from sub-specific to landscape, to conduct research and monitor as part of a larger international network and to improve the quality of life for the local communities living in and around the Biosphere Reserves. The idea behind formation of Biosphere Reserve is to inter relate biodiversity conservation and sustainable development.

Article 2 of the Statutory Framework for the World Network of Biosphere Reserve intends to fulfil three basic functions namely, Conservation function Development function and Logistic function (Schaaf 2002), which are complimentary and mutually reinforcing.

The government of India has established 18 Biosphere Reserves (Anon 2009) categories roughly corresponding to IUCN category V protected areas, which protect larger areas of natural habitat and often include one or more National Parks and preserves, along buffer zones that are open to some economic uses. Protection is granted not only to the flora and fauna of the protected region, but also to the human communities who inhabit these regions and their ways of life. Eight of the 15 Biosphere Reserves are approved by UNESCO and the Nokrek Biosphere Reserve of Meghalaya is one of its kinds in North-East India.

Disturbance has been the main factor in the ecological system and there has been greater emphasis on the human dimensions of ecological process (Ramakrishnan 2002). The effect of human activities on species diversity is an issue that has considerable ecological interest from both at a theoretical and applied standpoint. Historically, high extinction rate is associated with human activities (Wilson 1998). The value and importance of vegetation in our planet functioning is clearly reflected in multilateral agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD).

The available literature depicts that scientists have paid commendable attention on biodiversity exploration at global level. In India, plant diversity and community attributes have been studied desirably (Singh et al. 2011, 2012, Kumar et al. 2012, Singh and Mudga 2000). In fact, there is paucity of information on impact assessment with regards to North-East India, particularly in terms of herbaceous vegetation. In view of this, the present study has been carried out in Nokrek Biosphere Reserve to assess the impacts of anthropogenic disturbance on diversity and distribution of herbaceous species taking into account core and buffer zone.

Study area

The word Meghalaya literally means the Abode of Clouds in Sanskrit. Meghalaya is one of the eight sister states of India with an area of 22,429 sq km. It

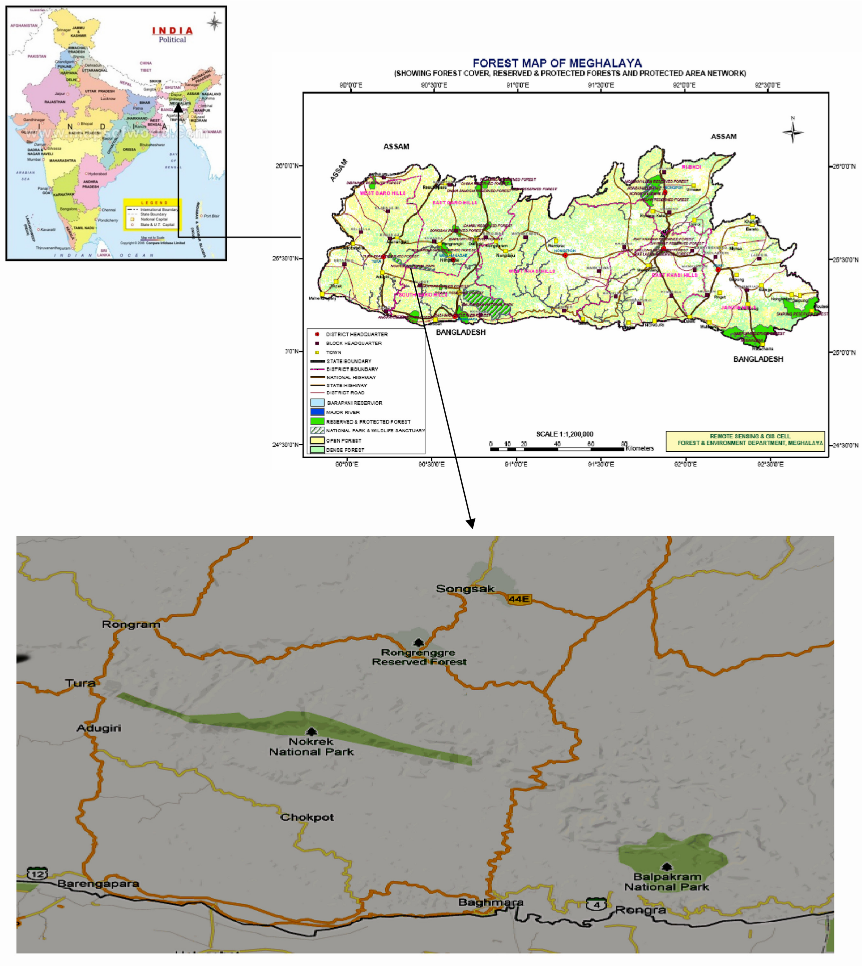

Fig. 1. Location of Nokrek Biosphere Reserve, Meghalaya, India.

is situated in the north eastern region of India and lies between 24º58´ N to 26º07´N latitudes and 89º48´E to 92º51´ E longitudes.

The Nokrek Biosphere Reserve (NBR) is located on Tura range of mountain system which is a part of Meghalaya plateau, overlapping with parts of three districts, i.e. East, West and South Garo Hills. It lies between 25º 20´ to 25º29´ N latitude and 90º13´ to 90º35´ E longitude (Fig. 1). The area was declared as the Nokrek Biosphere Reserve (NBR) on September 1st, 1988 and the core area as the National Park on 23rd December 1997. The Nokrek Biosphere Reserve was recognized by the UNESCO's World Network of Biosphere Reserve on 26th May, 2009 (Anon 2010). It has an average altitude of 600 m ; the highest point being the Nokrek peak 1412 m (Momin 2002, Nath 2004). The temperature ranges from 3ºC to 30ºC with rainfall > 3,000 mm. The reserve spreads over an area of approximately 820 sq km of which 47.48 sq km is the Nokrek National Park (NNP) which constitutes the core area of the Nokrek Biosphere Reserve. The Nokrek National Park area remains comparatively undisturbed, consisting of primary evergreen forests and is accessible only on foot.

MATERIALS AND METHODS

The field study was carried out during 2014 to 2017 and vegetation analysis was done following the methods as described by Misra (1968), Mueller-Dombois and Ellenberg (1974). The field data were used for computing various phyto-sociological attributes namely Frequency, Density, Abundance, Basal area, IVI and various diversity indices. The distribution pattern of species was determined by computing Whitford index (Whitford 1949, Pielou 1969).

One hectare sample plot was demarcated in each core and buffer zones and quadrat method (1 m × 1 m size) was employed for field study. A total of 100 quadrats each in core and buffer zone were laid randomly. Plant specimen were collected and mounted on herbarium sheets following Jain and Rao (1977). The specimen identification was performed with the help of herbarium of Botanical Survey of India, Shillong. The identification of species was cross-checked through floras (Haridasan and Rao 1985, Kanjilal et al. 1934–40).

RESULTS

Phyto–sociological attributes

The findings of present investigation reveal that altogether a total of 77 herbaceous species belonging to 63 genera and 39 families were recorded. Of this, the core zone harbors 44 species from 34 genera and 23 families and buffer zone had 52 species belonging to 44 genera and 29 families. Moreover, buffer zone also possessed high density (914 individuals per 100 m^2) than core zone (889 individuals per 100 m^2 (Table 1).

Diversity and dominance of species

The Shannon diversity index was found higher in the buffer zone (3.21) than core zone (3.10). On the contrary, Simpson dominance index showed a reverse trend in result and value was high in core zone (0.10) than buffer zone (0.08). The Margalefs index of species richness was also found to be higher in the buffer zone (7.48) than in the core zone (6.33) (Margalef 1958). However, both zones possessed same value (0.82) of evenness index (Table 1) (Shannon and Weiner 1963).

Table 1. Phytosociological attributes of herbs in core and buffer zone.

Parameters	Core zone	Buffer zone
Number of family	23	29
Number of genera	34	44
Number of species	44	52
Herb density (individuals per 100 m^2)	889	914
Shannon diversity index	3.10	3.21
Simpson dominance index	0.10	0.08
Margalef index of species	6.33	7.48
Evenness index	0.82	0.82

In core zone, the most dominant (IVI–40.48 and density-247 individuals per 100 m^2) species was *Elatostema sessile* and was followed by *Urtica dioica* (IVI-12.58) and (density-66 individuals per 100 m^2). On other hand, in buffer zone, the dominant species was *Pteris quadriaurita* (IVI–35.47 and density–212 individuals per 100 m^2) and it was followed by *Selaginella* sp. (IVI–15.03 and density–45 individuals per 100 m^2) and *Molineria latifolia* (IVI–13.93 and density-58 individuals per 100 m^2) (Tables 2—4). All herbaceous species in both zones followed contagious distribution pattern. The normal dominance-distribution curve in both zones indicates stability of the community (Table 4, Figs. 2 and 3).

Species similarity index

The species similarity index between core and buffer zone was computed as 39.58 which is rather low. A total of 19 species were common in both zones, however 25 species were restricted to core zone and 33 species confined to buffer zone (Tables 2 and 3).

Diversity-dominance of family

The dominant family in the core zone was Urticaceae with 10 species (23% species) and followed by Araceae with 4 species (9% species). The number of monospecific families amounting to 14 (28% species). In the buffer zone, Asteraceae was the most dominant family with 9 species (17% species) and it

Table 2. Community structure of herbs in the core zone.

Sl. No.	Scientific name	Family	D Per 100 m^2	F (%)	A (%)	IVI	A/F ratio
1	*Aletris gracilis* Lendle	Liliaceae	9	4	2.25	2.60	0.56
2	*Alpinia galanga* ((L.) Sw.	Zingiberaceae	8	3	2.67	2.09	0.89
3	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae	7	2	3.50	1.58	1.75
4	*Arisaema album* N. E. Br	Araceae	2	1	2.00	0.62	2.00
5	*Asplenium nidus* L.	Aspleniaceae	15	3	5.00	2.88	1.67
6	*Blumea myriocephala* D.C	Asteraceae	9	4	2.25	2.60	0.56
7	*Boehmeria macrophylla* Hornem.	Urticaceae	14	6	2.33	3.96	0.39
8	*Boehmeria platyphylla* D. Don	Urticaceae	21	7	3.00	5.14	0.43
9	*Cardamine indica* L.	Brassicaceae	10	3	3.33	2.32	1.11
10	*Caulokaempferia scunda* (Wall) Carsen	Zingiberaceae	5	2	2.50	1.36	1.25
11	*Colocasia antiquorum* Schott	Araceae	8	3	2.67	2.09	0.89
12	*Colocasia esculenta* (L.) Schott	Araceae	10	6	1.67	3.51	0.28
13	*Costus speciosus* Koen ex. Retz.	Costaceae	36	9	4.00	7.62	0.44
14	*Curcuma* sp.	Zingiberaceae	8	3	2.67	2.09	0.89
15	*Davallia trichomanoides* Blume	Davalliaceae	5	2	2.50	1.36	1.25
16	*Dioscorea* sp.	Dioscoreaceae	9	2	4.50	1.81	2.25
17	*Disporum cantoniense* (Lour.) Merr.	Convallariaceae	9	3	3.00	2.20	1.00
18	*Elatostema sessile* J. R. Forst & G. Forst.	Urticaceae	247	32	7.72	40.48	0.24
19	*Elephantopus scaber* L.	Asteraceae	23	8	2.88	5.76	0.36
20	*Girardinia diversifolia* (Link) Friis	Urticaceae	4	3	1.33	1.64	0.44
21	*Impatiens chinensis* L.	Balsaminaceae	38	17	2.24	11.02	0.13
22	*Impatiens porrecta* Hook. F. & Th.	Balsaminaceae	19	4	4.75	3.72	1.19
23	*Impatiens trilobata* Colebr.	Balsaminaceae	39	15	2.60	10.34	0.17
24	*Laportea crenulata* Gaud	Urticaceae	14	6	2.33	3.96	0.39
25	*Molineria capitulata* (Lour.)	Hypoxdaceae	30	7	4.29	6.15	0.61
26	*Molineria latifolia* (Dryand. ex W. T. Aiton) Herb. ex Kurz	Hypoxdaceae	24	5	4.80	4.68	0.96
27	*Oxalis corniculata* L.	Oxalidaceae	13	5	2.60	3.45	0.52
28	*Paederia foetida* L.	Poaceae	2	1	2.00	0.62	2.00
29	*Panax* sp.	Araliaceae	5	4	1.25	2.15	0.31
30	*Peliosanthes teta* Andrews	Convallariaceae	10	4	2.50	2.71	0.63
31	*Persicaria capitata* (Buch.-Ham. ex D. Don) H. Gross	Polygonaceae	5	4	1.25	2.15	0.31
32	*Phrynium capitatum* Willd.	Marantaceae	16	6	2.67	4.18	0.44
33	*Polygonum chinensis* L.	Polygonaceae	10	3	3.33	2.32	1.11
34	*Pouzolzia hirta* (Blume) Blume ex Hassk.	Urticaceae	9	2	4.50	1.81	2.25
35	*Pouzolzia viminea* (Blume) Wedd	Urticaceae	30	9	3.33	6.95	0.37
36	*Pteris grandifolia* L.	Pteridaceae	14	8	1.75	4.75	0.22
37	*Pteris* sp.	Pteridaceae	40	12	3.33	9.26	0.28
38	*Ruellia prostrata* Poir.	Acanthaceae	9	3	3.00	2.20	1.00
39	*Scoparia dulcis* L.	Scrophulari-aceae	10	4	2.50	2.71	0.63
40	*Selaginella decipiens* Warb	Selaginellaceae	10	6	1.67	3.51	0.28
41	*Solanum* sp.	Solanaceae	4	3	1.33	1.64	0.44
42	*Urtica dioica* L.	Urticaceae	66	13	5.08	12.58	0.39
43	*Urtica incisa* Poir.	Urticaceae	8	2	4.00	1.69	2.00
44	*Urtica urens* L.	Urticaceae	5	3	1.67	1.75	0.56

Table 3. Community structure of herbs in buffer zone.

Sl. No.	Scientific name	Family	D	F	A	IVI	A/F ratio
1	*Ageratina adenophora* (Spren g.) R.M.King & H. Rob.	Asteraceae	18	11	1.64	5.94	0.15
2	*Amomum maximum* Roxb.	Zingiberaceae	8	2	4.00	1.60	2.00
3	*Ageratina* sp.	Asteraceae	39	8	4.88	7.16	0.61
4	*Ageratum conyzoides* (L.)	Asteraceae	40	17	2.35	10.51	0.14
5	*Aletris gracilis* Rendle	Nartheciaceae	5	3	1.67	1.63	0.56
6	*Allium tuberosum* Rottler ex Spreng.	Amaryllidaceae	3	1	3.00	0.69	3.00
7	*Alpinia galanga* (L.) Willd.	Zingiberaceae	3	2	1.50	1.05	0.75
8	*Amomum subulatum* Roxb.	Zingiberaceae	6	3	2.00	1.74	0.67
9	*Anisomeles malabarica* (L.) R. Br. ex Sims	Lamiaceae	4	3	1.33	1.52	0.44
10	*Arisaema album* N. E. Br	Araceae	7	3	2.33	1.85	0.78
11	*Bidens pilosa* L.	Asteraceae	18	4	4.50	3.41	1.13
12	*Carex crinita* Lam.	Cypernum	13	3	4.33	2.51	1.44
13	*Colocasia antiquorum* Schott	Araceae	3	1	3.00	0.69	3.00
14	*Colocasia esculenta* (L.) Schott	Araceae	7	2	3.50	1.49	1.75
15	*Commelina paludosa* Blume	Commelinaceae	10	3	3.33	2.18	1.11
16	*Crassocephalum crepidioides* (Benth.) S. Moore	Asteraceae	14	5	2.80	3.34	0.56
17	*Curcuma amada* Roxb	Zingiberaceae	12	3	4.00	2.40	1.33
18	*Dioscorea bulbifera* L.	Dioscoreaceae	16	12	1.33	6.08	0.11
19	*Dryopteris affinis* Fraser-Jenk.	Dryopteridaceae	11	3	3.67	2.29	1.22
20	*Elatostema sessile* J. R. Forst. & G. Forst.	Urticaceae	63	10	6.30	10.50	0.63
21	*Elephantopus scaber* Linn.	Asteraceae	3	1	3.00	0.69	3.00
22	*Eleutheranthera ruderalis* (Sw.) Sch.Bip.	Asteraceae	9	2	4.50	1.71	2.25
23	*Eryngium foetidum* L.	Apiaceae	3	1	3.00	0.69	3.00
24	*Hautounia cordata*	Pip2raceae	5	2	2.50	1.27	1.25
25	*Hedychium coccinum* Smith	Zingiberaceae	9	2	4.50	1.71	2.25
26	*Paederia foetida* L.	Poaceae	2	1	2.00	0.58	2.00
27	*Hydrocotyle javanica* Thunb.	Apiaceae	34	3	11.33	4.80	3.78
28	*Impatiens chinensis* L.	Balsaminaceae	10	5	2.00	2.90	0.40
29	*Impatiens porrecta* Hook. F. & Th.	Balsaminaceae	5	2	2.50	1.27	1.25
30	*Impatiens trilobata* Colebr.	Balsaminaceae	22	6	3.67	4.57	0.61
31	*Jasminum nervosum* Lour.	Oleaceae	3	1	3.00	0.69	3.00
32	*Ludwigia octovalvis* subsp. ses siliflora (Micheli) P. H. Raven	Onargaceae	3	1	3.00	0.69	3.00
33	*Molineria capitulata* (Lour.) Herb	Hypoxidaceae	30	11	2.73	7.25	0.25
34	*Molineria latifolia* (Dryand. ex W. T.Aiton) Herb. ex Kurz	Hypoxidaceae	58	21	2.76	13.93	0.13
35	*Oxalis corniculata* L.	Oxalidaceae	12	3	4.00	2.40	1.33
36	*Peliosanthes teta* Andrews	Convallariaceae	4	3	1.33	1.52	0.44
37	*Phrynium capitatum* Willd.	Marantaceae	19	7	2.71	4.61	0.39
38	*Phyllanthus urinaria* L.	Phyllanthaceae	2	1	2.00	0.58	2.00
39	*Pilea umbrosa* Blume	Urticaceae	12	5	2.40	3.12	0.48
40	*Plantago major* L.	Plantaginaceae	3	1	3.00	0.69	3.00
41	*Prismatomeris albidiflora* Thw aites	Rubiaceae	6	4	1.50	2.10	0.38
42	*Pteris quadriaurita* Retz	Pteridaceae	212	34	6.24	35.47	0.18
43	*Pteris* sp.	Pteridaceae	49	15	3.27	10.78	0.22
44	*Saccharum spontaneum* Linn.	Poaceae	8	3	2.67	1.96	0.89
45	*Scoparia dulcis* L.	Scrophulariaceae	8	2	4.00	1.60	2.00
46	*Selaginella* sp.	Selaginellaceae	45	28	1.61	15.03	0.06
47	*Sida rhombifolia* L.	Malvaceae	3	2	1.50	1.05	0.75
48	*Thysanolaena maxima* (Roxb.) Kuntze.	Poaceae	17	4	4.25	3.30	1.06
49	*Vernonia silhetensis* (DC.) Craib	Asteraceae	7	3	2.33	1.85	0.78
50	*Vernonia volkameriifolia* DC.	Asteraceae	4	2	2.00	1.16	1.00
51	*Viola betonicifolia* Sm.	Violaceae	3	1	3.00	0.69	3.00
52	*Zingiber zerumbet* Sm.	Zingiberaceae	4	1	4.00	0.80	4.00

Table 4. Species ranking (based on IVI) in core and buffer zone.

Species rank	Species (core zone)	IVI	Species (buffer zone)	IVI
1	*Elatostema sessile* J.R.Forst. & G. Forst.	40.48	*Pteris quadriaurita* Retz	35.47
2	*Urtica dioica* L.	12.58	*Selaginella* sp.	15.03
3	*Impatiens chinensis* L.	11.02	*Molineria latifolia* (Dryand. ex W. T. Aiton) Herb. ex Kurz	13.93
4	*Impatiens trilobata* Colebr.	10.34	*Pteris* sp.	10.78
5	*Pteris* sp.	9.26	*Ageratum conyzoides* (L.)	10.51
6	*Costus speciosus* Koen ex. Retz.	7.62	*Elatostema sessile* J. R. Forst. & G. Forst.	10.50
7	*Pouzolzia viminea* (Blume) Wedd	6.95	*Molineria capitulata* (Lour.) Herb	7.25
8	*Molineria capitulata* (Lour.) Herb	6.15	*Ageratina* sp.	7.16
9	*Elephantopus scaber* L.	5.76	*Dioscorea bulbifera* L.	6.08
10	*Boehmeria platyphylla* D. Don	5.14	*Ageratina adenophora* (Spreng.) R.M.King & H. Rob.	5.94
11	*Pteris grandifolia* L.	4.75	*Hydrocotyle javanica* Thunb.	4.80
12	*Molineria latifolia* (Dryand. ex W. T. Aiton) Herb. ex Kurz	4.68	*Phrynium capitatum* Willd.	4.61
13	*Phrynium capitatum* Willd.	4.18	*Impatiens trilobata* Colebr.	4.57
14	*Boehmeria macrophylla* Hornem.	3.96	*Bidens pilosa* L.	3.41
15	*Laportea crenulata* Gaud	3.96	*Crassocephalum crepidioides* (Benth.) S. Moore	3.34
16	*Impatiens porrecta* Hook. F. & Th.	3.72	*Thysanolaena maxima* (Roxb.) Kuntze.	3.30
17	*Colocasia esculenta* (L.) Schott	3.51	*Pilea umbrosa* Blume	3.12
18	*Selaginella decipiens* Warb	3.51	*Impatiens chinensis* L.	2.90
19	*Oxalis corniculata* L.	3.45	*Carex crinita* Lam.	2.51
20	*Asplenium nidus* L.	2.88	*Curcuma amada* Roxb	2.40
21	*Scoparia dulcis* L.	2.71	*Oxalis corniculata* L.	2.40
22	*Peliosanthes teta* Andrews	2.71	*Dryopteris affinis* Fraser-Jenk.	2.29
23	*Aletris gracilis* Lendle	2.60	*Commelina paludosa* Blume	2.18
24	*Blumea myriocephala* D.C	2.60	*Prismatomeris albidiflora* Thwaites	2.10
25	*Polygonum chinensis* L.	2.32	*Saccharum spontaneum* Linn.	1.96
26	*Cardamine indica* L.	2.32	*Arisaema album* N. E. Br	1.85
27	*Disporum cantoniense* (Lour.) Merr.	2.20	*Vernonia silhetensis* (DC.) Craib	1.85
28	*Ruellia prostrata* Poir.	2.20	*Amomum subulatum* Roxb.	1.74
29	*Panax* sp.	2.15	*Eleutheranthera ruderalis* (Sw.) Sch. Bip.	1.71
30	*Persicaria capitata* (Buch.-Ham. ex D. Don) H. Gross	2.15	*Hedychium coccinum* Smith	1.71
31	*Colocasia antiquorum* Schott	2.09	*Aletris gracilis* Rendle	1.63
32	*Alpinia galanga* (L.) Sw.	2.09	*Scoparia dulcis* L.	1.60
33	*Curcuma* sp.	2.09	*Amomum maximum* Roxb.	1.60
34	*Dioscorea* sp.	1.81	*Peliosanthes teta* Andrews	1.52
35	*Pouzolzia hirta* (Blume) Blume ex Hassk.	1.81	*Anisomeles malabarica* (L.) R. Br. ex Sims	1.52
36	*Urtica urens* L.	1.75	*Colocasia esculenta* (L.) Schott	1.49
37	*Urtica incisa* Poir.	1.69	*Impatiens porrecta* Hook.f. & Th.	1.27
38	*Girardinia diversifolia* (Link) Friis	1.64	*Hautounia cordata*	1.27
39	*Solanum* sp.	1.64	*Vernonia volkameriifolia* D. C.	1.16
40	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	1.58	*Alpinia galanga* (L.) Willd.	1.05
41	*Caulokaempferia scunda* (Wall) Carsen	1.36	*Sida rhombifolia* L.	1.05
42	*Davallia trichomanoides* Blume	1.36	*Zingiber zerumbet* Sm	0.80
43	*Paederia foetida* L.	0.62	*Eryngium foetidum* L.	0.69
44	*Arisaema album* N.E. Br	0.62	*Allium tuberosum* Rottler ex Spreng.	0.69
45			*Colocasia antiquorum* Schott	0.69
46			*Elephantopus scaber* Linn.	0.69
47			*Plantago major* L.	0.69
48			*Jasminum nervosum* Lour.	0.69

Table 4. Continued.

Species rank	Species (core zone)	IVI	Species (buffer zone)	IVI
49			*Ludwigia octovalvis* subsp. sessiliflora (Micheli) P. H. Raven	0.69
50			*Viola betonicifolia* Sm.	0.69
51			*Phyllanthus urinaria* L.	0.58
52			*Paederia foetida* L.	0.58

was followed by and Zingiberaceae with 6 species (12% species). The 20 families were monospecific and contributing 40% species (Table 5 and Fig. 2). The diversity-distribution curve showed stability in terms of families in both zones (Fig. 4).

DISCUSSION

The high species richness with more number of genera and families in the buffer zone could be linked with disturbance, as disturbance supports herbs and shrubs due to open canopy that may also lead to high density. The Simpson dominance index exhibited reverse trend in results with Shannon index of diversity, as it is always found in natural vegetation. The high value of evenness index in both the zones argued uniform distribution of species. A positive and significant correlation was established between density and Shannon diversity index in both the core zone (0.927) and buffer zone (0.992) ; density and Simpson dominance index indices as 0.960 (core zone) and 0.966 (buffer zone) (Simpson 1949). *Elatostema sessile*, the dominant species in core zone was replaced by *Pteris quadriaurita* in buffer zone. Similarly, Urticaceace, the dominant family in the core zone was replaced by Asteraceace in buffer zone. Moreover, the number of monospecific families was high in buffer zone. The shift in position of species and families and more number of monospecific families in buffer zone could be attributed due to disturbance, as certain species and families are sensitive to the disturbance and eliminated from the habitat. Surprisingly, some species and families introduced in the buffer zone making more diverse than core zone. In fact, gaps created due to disturbance and exposed canopy favor survival and growth of certain species and facilitate introduction of some families and species.

Very low species similarity index could be linked with disturbance that may cause alteration in botanical composition, as changes in edapho-climateic conditions resulting into introduction and/or elimination of species. The species common in both zones possessed high tolerance towards disturbance and play significant role in functioning of the ecosystem. The species restricted to core zone appeared to

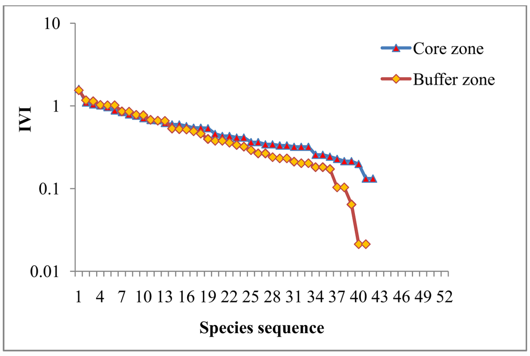

Fig. 2. Species dominance-distribution curve in core zone and buffer zone.

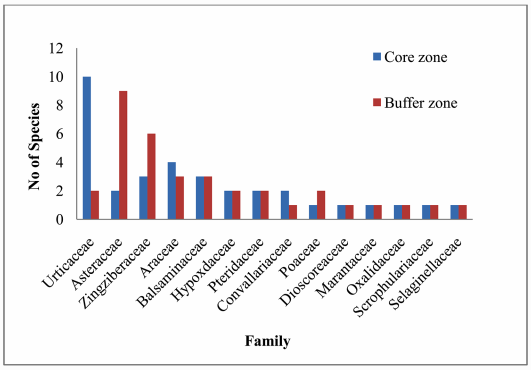

Fig. 3. Family-wise distribution of species in core zone and buffer zone.

Table 5. Family ranking in the core zone and buffer zone.

Family rank	Core zone Family	Core zone No. of species	Buffer zone Family	Buffer zone No. of species
1	Urticaceae	10	Asteraceae	9
2	Araceae	4	Zingiberaceae	6
3	Balsaminaceae	3	Apiaceae	3
4	Zingiberaceae	3	Araceae	3
5	Asteraceae	2	Balsaminaceae	3
6	Convallariaceae	2	Hypoxidaceae	2
7	Hypoxdaceae	2	Poaceae	2
8	Polygonaceae	2	Pteridaceae	2
9	Pteridaceae	2	Urticaceae	2
10	Acanthaceae	1	Amaryllidaceae	1
11	Araliaceae	1	Commelinaceae	1
12	Aspleniaceae	1	Convallariaceae	1
13	Brassicaceae	1	Cypernum	1
14	Costaceae	1	Dioscoreaceae	1
15	Dioscoreaceae	1	Dryopteridaceae	1
16	Liliaceae	1	Lamiaceae	1
17	Marantaceae	1	Malvaceae	1
18	Oxalidaceae	1	Marantaceae	1
19	Poaceae	1	Nartheciaceae	1
20	Scrophulariaceae	1	Oleaceae	1
21	Selaginellaceae	1	Onargaceae	1
22	Solanaceae	1	Oxalidaceae	1
23	Davalliaceae	1	Phyllanthaceae	1
24			Piperaceae	1
25			Plantaginaceae	1
26			Rubiaceae	1
27			Scrophulariaceae	1
28			Selaginellaceae	1
29			Violaceae	1

have greater ecological amplitude and are sensitive to disturbance. Moreover, the species absent in buffer zone appear to be more vulnerable to disturbance. The species confined to buffer zone indicating high tolerance limit towards disturbance. The normal diversity-distribution curves for species and family indicate stability and complexity of community. The earlier workers (Laloo et al. 2006, Mishra 2009, 2011, 2012, 2013, Mishra and Jeeva 2012, Mishra and Laloo 2006, Mishra et al. 2003, 2004, 2005) have also reported a similar trend in results from the sacred groves and sub-tropical forests of Meghalaya, North-East India. Some commendable researches (Sangma and Mishra 2017, Singh et al. 2011, (2014, 2015 a, b Sunar and Mishra 2017, Sorensen 1948) have also been conducted on the line of the present investigation in the state of Mizoram and findings of the present study are in conformity with the earlier works done so far.

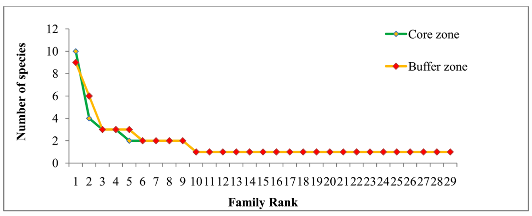

Fig. 4. Family dominance-distribution curvein core zone and buffer zone.

CONCLUSION

Findings of present investigation reveal that there is a drastic change in botanical composition of herbaceous species from core zone to buffer zone of Nokrek Biosphere Reserve. The buffer zone possessed high species richness, number of genera and families than core zone. The density species richness index and diversity index were also reported high in buffer zone. In both zones species were evenly distributed and majority of species possessed contagious distribution pattern. The disturbance does not impact stability and complexity of herbaceous species, as log normal dominance-distribution curve was established in both zones. The species and families no longer maintained their dominance from core zone buffer zone. The buffer zone possessed more number of families showing diverse vegetation and also had greater number of monospecific families indicating loss of some disturbance-sensitive species from certain families.

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