Research article

Phytosociological and floristic evaluation of Kuldiha Wildlife Sanctuary, Odisha, India

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Abstract: The present paper documents the findings of phytosociological attributes which have been carried out in tropical moist deciduous forest of Kuldiha Wildlife Sanctuary, Odisha, India. The main objectives of this study are to identify, characterize and classify the vegetation community which is naturally distributed in the forest reserve. The vegetation sampling and data analysis were done following standard procedures. One hundred and eight plant species belonging to 38 families in the form of 38 species of trees, 38 species of shrubs and 32 species of herbs are documented. The most common plant species based on importance value in tree, shrub and herb layers are *Terminalia tomentosa* (IVI-292.27), *Shorea robusta* (RVI-50.89) and *Croton roxburghii* (RVI- 17.11) respectively. Euphorbiaceae is found to be most dominant family. The incidence of fire, livestock grazing and other anthropogenic disturbance are responsible for depletion of the old and uneven age structure of forest. This study provides baseline information on the dry forests of Kuldiha Wildlife Sanctuary. Appropriate conservation and management can considerably improve the botanical value of Kuldiha Wildlife Sanctuary, and consequently their value for other life forms.

Keywords: Dry deciduous forest - IVI - Long-term management - Sustainable utilization - Vegetation community.

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INTRODUCTION

Plant species diversity is complex in nature and its structure and composition differs from place to place because of varying climatic condition and topography (Raturi 2012). Compared to the other ecosystems, tropical forest ones, the most complex of all the terrestrial ecosystems are harshly exploited ecosystems of the biosphere (Bahuguna 1999). It covers 7 % of the earth's land surface, but harbors more than half of the world's plant and animal biodiversity (Wilson 1988). Despite its direct services for sustainable human life, they are disappearing at an overall rate of 0.8 to 2 % per year (May & Stumpf 2000, Sagar *et al.* 2003) and particularly dry deciduous forests are the most disturbed and least protected ecosystems on the earth (Murphy & Lugo 1986). Even with a national policy aimed at conserving and improving nature, biodiversity is still decreasing. In addition to eutrophication, acidification and desiccation; habitat destruction, deforestation, human settlements, globalization, agricultural expansion, and other infrastructure related to development over the last century have accelerated the rapid decline of tropical forests throughout the world, which in turn bring about negative impacts on biodiversity, climate change, ecological services, soil productivity and the livelihoods of forest dwelling as well as rural people (Myers 1992, Raghubanshi & Tripathi 2009). Biodiversity has become the issue of global attention because of growing awareness of its importance on the one hand as ecosystem energy and on the other hand it allows building complex tropical networks and functions as insurance for ecosystem stability and resilience (Gaston & Spicer 2004). The health of ecosystems, especially in mountainous regions, is closely allied to its plant biodiversity (Schafer 2011) and vegetation classification is therefore the first step towards ecosystem conservation. Such studies may become a vital tool in the estimation of the level of adaptation to the

environment and their ecological significance (Pascal & Pelissier 1996). Phytosociological analysis indicates the organization and structure of plant diversity which determines the distribution pattern of individuals among the species in a particular habitat. In connection to this, Warger & Morrel (1976) noted that phytosociological analysis is important for understanding the functioning of any community. It provides useful basic data for ecology, geography, landscape science, conservation and environmental science because the data represent integrated units in vegetation systems (Fujiwara 1987). Intensive studies concerning the phytosociology of the tropical forests of India and also other parts of the world (Timilsina *et al.* 2007, Wahab *et al.* 2008, Tripathi & Singh 2009, Slimani *et al.* 2010, Tel *et al.* 2010, Badshah *et al.* 2010, Bhat *et al.* 2011, Hegde *et al.* 2011, Bajpai *et al.* 2012, Dangwal *et al.* 2012, Sahu *et al.* 2012, Verma *et al.* 2013, Ahmed & Sharma 2014, Jehad *et al.* 2014, Srinivasa *et al.* 2014, Pradhan & Rahman 2015, Knight 2015, Sundarapandian & Subbiah 2015, Shahid & Joshi 2016, Bajpai *et al.* 2017, Iyagin & Adekunle 2017, Masens *et al.* 2017, Shiferaw *et al.* 2018) have been highlighted. A perusal of literature reveals that phytosociological studies in different parts of Odisha are well studied (Sahu *et al.* 2007, Ekka & Behera 2011, Behura *et al.* 2015, Nayak *et al.* 2016, Paul 2017). In this context, there have, however, been no reports in Kuldiha Wildlife Sanctuary, Odisha, India. In the present investigation an attempt has been made to document the structure of plant communities, composition and diversity of tropical moist deciduous forest of Kuldiha Wildlife Sanctuary, Odisha, India which will help in management and conservation of forest vegetation in future.

MATERIALS AND METHODS

Study site

Figure 1. Location of study area.

Kuldiha Wildlife Sanctuary (21° 20' N to 21° 30' N latitude and 86° 30' E to 86° 45' E longitude) is situated in Baleswar district of Odisha, India (Fig. 1). It spreads over 2505 km² and is linked with the Similipal Biosphere Reserve of Mayurbhanj district through the Sakhuapada and Nato Hill ranges. The landscape is hilly with moderate to steep slopes having ranges of altitude between 169 to 682 m. The maximum temperature in the warmest month and the minimum temperature in the coldest month are 42°C and 6°C, respectively. The mean annual rainfall is 1,568mm. Ecologically the sanctuary falls within the Biogeographic zone of Deccan Plateau and within the Biogeographic Province of Chhotanagpur Plateau (Rodger & Panwar 1988). Three small rivers, Tangna, Kamala and Usatal nala are the main water sources of the sanctuary. Adjoining to Nilagiri forest in the north and Mayurbhanj forest in the west, the vegetation of the sanctuary is mostly tropical deciduous forest type (Champion & Seth 1968). The rock of the sanctuary comprises with khondolite (grayish or reddish-brown in

colour), Pyroge granites (dark in colour), charnockite (greenish grey in colour) and garnetiferous Granites. A good exposure of laterite has been found in the south-west portion of the sanctuary. This is an alternation product of khondolites. Alluvial soil is restricted to bank of nallas, rivers, and other water sources.

Data collection

Phytosociological studies were carried out during June 2016 to May 2017 to cover all spectrum of vegetation. The surveys of area have been done by sampling method. Vegetation surveys were carried out by quadrat methods (Misra 1968). For this purpose the entire area of 100 ha was divided into 10 segments. In each segment a sampling area of 400 m² with length and breadth of 20 m and 20 m respectively were measured. All plants above 3 m tall were recorded by measuring girth at breast height (GBH) species wise. For bushes, shrubs (less than 3 m tall) a sampling area of 25 m² (5 m × 5 m) was nested inside the aforementioned 400 m² plot. The sampling plot of 1 m² (1 m × 1 m) area was also nested inside the 25 m² plots to make inventory of all herbaceous vegetation (Fig. 2).

Figure 2. Sample plot structure, used in the study.

The vegetation data were quantitatively analysed following standard procedures (Curtis & McIntosh 1950, Philips 1959, Misra 1968). Girth was measured using 2 m tape. Height of small trees and shrubs was measured using a 5 m graded pole. When the height exceeded 5 m it was estimated visually. For calculating the basal area of multi-stemmed trees, the girth of each stem was measured individually and added up. The economic uses of plant species if any were discussed with the local people. Plant samples were identified or confirmed with available regional floras (Haines 1925, Saxena & Brahmam 1996). Phytosociological parameters indicated below were analyzed by the following methods and formulas (Curtis 1959, Misra 1968).

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates studied}}$$

$$\text{Frequency (\%)} = \frac{\text{Number of quadrates in which the species occurred}}{\text{Total number of quadrates studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates in which the species occurred}}$$

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Total density of all the species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Number of sample plots with a sighting of a species}}{\text{Total number of sample plots}} \times 100$$

$$\text{Relative Abundance} = \text{Relative Frequency} + \text{Relative Density}$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of a species}}{\text{Total basal area for all species}} \times 100$$

$$\text{IVI} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance}$$

For non-timber species the importance value is called Relative Importance Value (RVI) and calculated as followed:

$$\text{RVI} = \text{Relative Frequency} + \text{Relative Density}$$

RESULTS AND DISCUSSION

Figure 3. Plot wise distribution of plant diversity in Kuldiha Wildlife Sanctuary, Baleswar, Odisha.

Table 1. Phytosociological analysis of tree species in Kuldiha Wildlife Sanctuary, Baleswar, Odisha.

S. N.	Botanical Name	Local Name	NOI	NPSO	D	RD	F	RF	AB	CV	RCV	IVI	AB/F
1	<i>Emblica officinalis</i>	Aonla	4	3	0.4	1.55	30	29.707	1.33	584229.1	8.510	39.764	0.044
2	<i>Terminalia tomentosa</i>	Asana	60	9	6.0	23.26	90	89.108	6.67	12349795	179.905	292.270	0.074
3	<i>Terminalia bellerica</i>	Bahada	4	3	0.4	1.55	30	29.702	1.33	2059774	30.005	61.259	0.040
4	<i>Ziziphus oenoplia</i>	Borakoli	3	2	0.3	1.16	20	19.801	1.50	492542.4	7.175	28.139	0.075
5	<i>Buchanania lanzan</i>	Char	1	1	0.1	0.39	10	9.900	1.00	218541.8	3.183	13.472	0.100
6	<i>Oroxylum indicum</i>	Phanphena	6	3	0.6	2.33	30	29.702	2.00	735122.2	10.708	42.737	0.067
7	<i>Anogeissus latifolia</i>	Dhaura	22	7	2.2	8.53	70	69.306	3.14	8381885	122.103	199.937	0.045
8	<i>Polyalthia cerasoides</i>	Gandhasal	5	4	0.5	1.94	40	39.603	1.25	484262.4	7.054	48.596	0.031
9	<i>Mitragyna parvifolia</i>	Godikoima	2	1	0.2	0.78	10	9.900	2.00	279752.7	4.075	14.751	0.200
10	<i>Randia dumetorum</i>	Patua	5	2	0.5	1.94	20	19.801	2.50	1088583	15.857	37.597	0.125
11	<i>Terminalia chebula</i>	Harida	5	4	0.5	1.94	40	39.603	1.25	1491308	21.724	63.266	0.031
12	<i>Syzygium cumini</i>	Jamu	1	1	0.1	0.39	10	9.900	1.00	306795.9	4.469	14.757	0.100
13	<i>Bridellia retusa</i>	Kashi	12	6	1.2	4.65	60	59.405	2.00	8521081	124.130	188.188	0.033
14	<i>Diospyros melanoxylon</i>	Kendu	2	2	0.2	0.78	20	19.801	1.00	479686.5	6.987	27.565	0.050
15	<i>Casearia elliptica</i>	Khakada	3	2	0.3	1.16	20	19.801	1.50	407993.5	5.943	26.908	0.075
16	<i>Diospyros malabarica</i>	Kala kendu	1	1	0.1	0.39	10	9.900	1.00	384844.8	5.606	15.894	0.100
17	<i>Xylia xylocarpa</i>	Kongada	3	1	0.3	1.16	10	9.900	3.00	928339.9	13.524	24.587	0.300
18	<i>Hollarhena antydysenterica</i>	Kuluchi	3	2	0.3	1.16	20	19.801	1.50	487344	7.099	28.064	0.075
19	<i>Careya arborea</i>	Kumbhi	2	2	0.2	0.78	20	19.801	1.00	515903.2	7.515	28.092	0.050
20	<i>Protium seeatum</i>	Rimuli	1	1	0.1	0.39	10	9.900	1.00	218541.8	3.184	13.472	0.100
21	<i>Haldinia cordifolia</i>	Kurma	3	2	0.3	1.16	20	19.801	1.50	728775.3	10.616	31.581	0.075
22	<i>Schleichera oleosa</i>	Kusuma	7	5	0.7	2.71	50	49.504	1.40	5961148	86.839	139.057	0.028
23	<i>Madhuca indica</i>	Mahula	2	2	0.2	0.78	20	19.801	1.00	1116914	16.270	36.847	0.050
24	<i>Antidesma acidum</i>	Nunannunia	1	1	0.1	0.39	10	9.900	1.00	253388.1	3.691	13.979	0.100
25	<i>Dalbergia latifolia</i>	Pahadia sisso	2	1	0.2	0.78	10	9.900	2.00	221521.3	3.227	13.903	0.200
26	<i>Butea parviflora</i>	Palasha	1	1	0.1	0.39	10	9.900	1.00	0	0	10.288	0.100
27	<i>Millusa velutina</i>	Parashi	12	4	1.2	4.65	40	39.603	3.00	3227790	47.020	91.275	0.075
28	<i>Pterocarpus marsupium</i>	Piasal	1	1	0.1	0.39	10	9.900	1.00	95936.5	1.397	11.686	0.100
30	<i>Antidesma ghaesembilla</i>	Matha saga	12	4	1.2	4.65	40	39.603	3.00	2152429	31.355	75.610	0.075
31	<i>Croton roxburghii</i>	Putuli	1	1	0.1	0.39	10	9.900	1.00	47143.48	0.687	10.975	0.100
32	<i>Shorea robusta</i>	Sal	54	9	5.4	20.93	90	89.108	6.00	11010969	160.402	270.441	0.067
33	<i>Lagerstroemia parviflora</i>	Sidha	3	2	0.3	1.16	20	19.801	1.50	556303.7	8.103	29.068	0.075
34	<i>Albizia lebbeck</i>	Sirisa	3	3	0.3	1.163	30	29.702	1.00	593628	8.647	39.513	0.033
35	<i>Dalbergia sisso</i>	Sisso	4	2	0.4	1.55	20	19.801	2.00	413417.6	6.022	27.374	0.100
36	<i>Cassia fistula</i>	Sunari	1	1	0.1	0.39	10	9.900	1.00	26446.1	0.385	10.673	0.100
37	<i>Soymida febrifuga</i>	Rohini	1	1	0.1	0.39	10	9.900	1.00	55571.59	0.809	11.098	0.100
38	<i>Zizyphus mauritiana</i>	Barkoli	2	1	0.2	0.78	10	9.900	2.00	120072.4	1.749	12.425	0.200

Note: NOI- Number of individuals, NPSO- Number of plots in which species occurred, D- Density, RD- Relative density, F- Frequency, RF- Relative frequency, AB- Abundance, CV- Coverage, RCV- Relative coverage, IVI- Importance value index.

Table 2. Phytosociological analysis of shrub species in Kuldiha Wildlife Sanctuary.

S. N.	Botanical Name	Local Name	NOI	NPSO	D	RD	F	RF	AB	AB/F	RVI
1	<i>Emblca officinalis</i>	Anla	6	1	0.6	1.333	10	1.14	6.00	0.600	2.469
2	<i>Combretum roxburghii</i>	Atundi	10	4	1.0	2.222	40	4.55	2.50	0.062	6.767
3	<i>Aegle marmelos</i>	Bela	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
4	<i>Flacourtia jangomas</i>	Boinchakoli	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
5	<i>Buchanania lanzan</i>	Char	7	3	0.7	1.555	30	3.41	2.33	0.077	4.964
6	<i>Dillenia pentagyna</i>	Rai	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
7	<i>Ageratum conyzoides</i>	Dahanimari	14	2	1.4	3.111	20	2.27	7.00	0.350	5.383
8	<i>Acacia pennata</i>	Dantari	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
9	<i>Flemingia chapper</i>	Rani dant kathi	2	1	0.2	0.444	10	1.14	2.00	0.200	1.580
10	<i>Nyctanthes arbor-tristis</i>	Gangasiuli	6	2	0.6	1.333	20	2.27	3.00	0.150	3.606
11	<i>Pterospermum acerifolium</i>	Giringa	4	1	0.4	0.888	10	1.14	4.00	0.400	2.025
12	<i>Clerodendrum viscosum</i>	Gobra	4	3	0.4	0.888	30	3.41	1.33	0.044	4.297
13	<i>Syzygium cumini</i>	Jamu	4	3	0.4	0.888	30	3.41	1.33	0.044	4.297
14	<i>Mallotus philippensis</i>	Kamalagundi	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
15	<i>Ziziphus oenopila</i>	Kankoli	6	3	0.6	1.333	30	3.41	2.00	0.066	4.742
16	<i>Diospyros melanoxylon</i>	Kendu	8	3	0.8	1.777	30	3.41	2.67	0.088	5.186
17	<i>Casearia elliptica</i>	Khakada	4	3	0.4	0.888	30	3.41	1.33	0.044	4.297
18	<i>Mimosa himalayana</i>	Khirkichikanta	6	1	0.6	1.333	10	1.14	6.00	0.600	2.469
19	<i>Zyzyphus xylopyrus</i>	Barokoli	2	1	0.2	0.444	10	1.14	2.00	0.200	1.580
20	<i>Xylia xylocarpa</i>	Kongada	2	1	0.2	0.444	10	1.14	2.00	0.200	1.580
21	<i>Hollarhena antidyeseaterica</i>	Kulchi	24	6	2.4	5.333	60	6.82	4.00	0.066	12.15
22	<i>Haldinia cordifolia</i>	Kurma	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
23	<i>Schleichera oleosa</i>	Kusuma	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
24	<i>Madhuca indica</i>	Mahula	10	3	1.0	2.222	30	3.41	3.33	0.111	5.631
25	<i>Helicteres isora</i>	Modimudica	5	3	0.5	1.111	30	3.41	1.67	0.055	4.520
26	<i>Smilax zeylanica</i>	Mutri	3	2	0.3	0.666	20	2.27	1.50	0.075	2.939
27	<i>Butea supeba</i>	Noi palaso	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
28	<i>Cleistanthus collinus</i>	Koarada	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358
29	<i>Gardenia gummifera</i>	Bhurudu	2	1	0.2	0.444	10	1.14	2.00	0.200	1.580
30	<i>Butea parviflora</i>	Polash	4	2	0.4	0.888	20	2.27	2.00	0.100	3.161
31	<i>Bauhinia vahlii</i>	Siali	20	5	2.0	4.444	50	5.68	4.00	0.080	10.12
32	<i>Albizia lebbek</i>	Sirisha	2	1	0.2	0.444	10	1.14	2.00	0.200	1.580
33	<i>Cassia fistula</i>	Sunari	8	2	0.8	1.777	20	2.27	4.00	0.200	4.050
34	<i>Shorea robusta</i>	Sal	183	9	18.3	40.666	90	10.23	20.33	0.225	50.89
35	<i>Cycas circinalis</i>	Veru	2	2	0.2	0.444	20	2.27	1.00	0.050	2.717
36	<i>Randia dumetorum</i>	Potua	2	2	0.2	0.444	20	2.27	1.00	0.050	2.717
37	<i>Croton roxburghii</i>	Putuli	87	7	8.7	19.333	70	7.95	12.43	0.177	27.28
38	<i>Lantana camara</i>	Putush	1	1	0.1	0.222	10	1.14	1.00	0.100	1.358

Note: NOI- Number of individuals, NPSO- Number of plots in which species occurred, D- Density, RD- Relative density, F- Frequency, RF- Relative frequency, AB- Abundance, RVI- Relative value index.

All over the world, plant biodiversity in terrestrial ecosystems have diverse biological communities due to their rapidly changing landscape and geo-climatic history (Herben *et al.* 2003, Fosaa 2004). The distribution pattern of plant species in an ecosystem is always representative of the function of that system because it signifies the nature of its biomass (Enquist 2002, Myklestad & Sætersdal 2004). In an ecosystem plant species assemble in a definite fashion and hence can assist in vegetation quantification and evaluation. Thus knowledge of floristic composition of natural ecosystems and habitat types is a key factor for improving the long-term management of natural resources (Mucina 1997, Ewald 2003, Kumar *et al.* 2015). During the study period a total of 108 plant species belonging to 38 families of vascular plants were recorded. Plot wise distribution of species is depicted in figure 3. The floristic composition of the reserve forest reveals 38 species in the upper storey, 38 species in the middle storey and 32 species in the ground flora (Table 1, 2 & 3). The findings of the present study are comparable with that of different ecosystems under tropical climates (Bhadra *et al.* 2010, Behera *et al.* 2012, Jaykumar & Nair 2012, Mishra *et al.* 2013, Rabha 2014, Bajpai *et al.* 2015, Borah *et al.* 2016, Barua *et al.* 2018). Krishnamurthy *et al.* (2010) reported 46 species from a tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka. Sahu *et al.* (2012) recorded 57 species in dry deciduous forests of Eastern Ghats. Studies of Thakur (2015) in tropical dry deciduous forest in Sagar district reported total 36 trees, 8 shrubs and 34 herbs. Pradhan & Rahaman (2015) recorded a total of 65 species belong to 36 families from three tropical dry deciduous forests of Birbhum District, West Bengal. Working on phytosociology of Hulikal

state forest Vinayaka & Krishnamurthy (2016) reported a total of 231 plant species out of which 96 are trees followed by 53 herbs, 51 shrubs and remaining 31 are climbers. Sukumaran *et al.* (2018) has been recorded 36 trees, 18 shrubs, 26 herbs and 22 climbers in Muppuram sacred grove of Kollencode, Tamilnadu.

Table 3. Phytosociological analysis of herb species in Kuldiha Wildlife Sanctuary.

S. N.	Botanical Name	Local Name	NOI	NPSO	D	RD	F	RF	AB	AB/F	RVI
1	<i>Hemidesmus indicus</i>	Anantamula	5	2	0.5	2.688	20	0.25	2.50	2.935	0.125
2	<i>Combretum roxburghii</i>	Atundi	10	4	1.0	5.376	40	0.49	2.50	5.870	0.062
3	<i>Urginea indica</i>	Banapiaja	1	1	0.1	0.537	10	0.12	1.00	0.661	0.100
4	<i>Flacourtia jangomas</i>	Boinchakoli	6	3	0.6	3.225	30	0.37	2.00	3.596	0.067
5	<i>Buchanania lanzan</i>	Char	6	3	0.6	3.225	30	0.37	2.00	3.596	0.067
6	<i>Ageratum conyzoides</i>	Dahanimari	7	3	0.7	3.763	30	0.37	2.33	4.133	0.078
7	<i>Elephantopus scaber</i>	Mayurachulia	10	1	1.0	5.376	10	0.12	10.00	5.499	1.000
8	<i>Dioscorea bulbifera</i>	Pita alu	2	1	0.2	1.075	10	0.12	2.00	1.198	0.200
9	<i>Isocarpos frutescens</i>	Dudhilata	6	3	0.6	3.225	30	0.37	2.00	3.596	0.067
10	<i>Andrographis paniculata</i>	Bhuinimba	2	1	0.2	1.075	10	0.12	2.00	1.198	0.200
11	<i>Indigofera cassioides</i>	Gileri	3	3	0.3	1.612	30	0.37	1.00	1.983	0.033
12	<i>Lygodium flexuosum</i>	Indrajai	4	4	0.4	2.150	40	0.49	1.00	2.644	0.025
13	<i>Imperata cylindrica</i>	Juna	8	4	0.8	4.301	40	0.49	2.00	4.794	0.050
14	<i>Ziziphus oenopila</i>	Kankoli	6	2	0.6	3.225	20	0.24	3.00	3.472	0.150
15	<i>Diospyros melanoxylon</i>	Kendu	4	3	0.4	2.150	30	0.37	1.33	2.520	0.044
16	<i>Mimosa himalayana</i>	Khirkhichi	1	1	0.1	0.537	10	0.12	1.00	0.661	0.100
17	<i>Hollarhena antydesenterica</i>	Kuluchi	1	1	0.1	0.537	10	0.12	1.00	0.661	0.100
18	<i>Haldinia cordifolia</i>	Kurma	1	1	0.1	0.537	10	0.12	1.00	0.661	0.100
19	<i>Scleichera oleosa</i>	Kusuma	8	2	0.8	4.301	20	0.25	4.00	4.547	0.200
20	<i>Ixora parviflora</i>	Luhajangi	2	2	0.2	1.075	20	0.25	1.00	1.322	0.050
21	<i>Dioscorea pentaphylla</i>	Bana alu	3	2	0.3	1.612	20	0.25	1.50	1.859	0.075
22	<i>Helicteres isora</i>	Modimudica	4	2	0.4	2.150	20	0.25	2.00	2.397	0.100
23	<i>Cleistanthus collinus</i>	Parasi	1	1	0.1	0.537	10	0.12	1.00	0.661	0.100
24	<i>Pterocarpus marsupium</i>	Piasal	2	1	0.2	1.075	10	0.12	2.00	1.198	0.200
25	<i>Catunaregam spinosa</i>	Potua	3	2	0.3	1.612	20	0.25	1.50	1.859	0.075
26	<i>Croton roxburghii</i>	Putuli	30	8	3.0	16.129	80	0.99	3.75	17.110	0.046
27	<i>Dillenia pentagyna</i>	Rai	7	5	0.7	3.763	50	0.62	1.40	4.380	0.028
28	<i>Smilax zeylanica</i>	Ramdantuni	3	2	0.3	1.612	20	0.25	1.50	1.859	0.075
29	<i>Shorea robusta</i>	Sal	28	7	2.8	15.053	70	0.86	4.00	15.910	0.057
30	<i>Asparagus racemosus</i>	Satabari	2	2	0.2	1.075	20	0.24	1.00	1.322	0.050
31	<i>Albizia lebbek</i>	Sirisha	5	3	0.5	2.688	30	0.37	1.67	3.058	0.050
32	<i>Curculigo orchoides</i>	Talmuli	5	1	0.5	2.688	10	0.12	5.00	2.811	0.500

Note: NOI- Number of individuals, NPSO- Number of plots in which species occurred, D- Density, RD- Relative density, F- Frequency, RF- Relative frequency, AB- Abundance, RVI- Relative value index.

Figure 4. Girth classes of tree species in Kuldiha Wildlife Sanctuary.

The upper storey vegetation was covered by tall trees with epiphytic growth of lichens, bryophytes, ferns and orchids. In the present study, *Terminalia tomentosa* (Roxb. ex DC.) Wight & Arn. was the dominant tree species having maximum relative density (23.26) and relative frequency (89.11) followed by *Shorea robusta* Gaertn.f., *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill. & Perr and *Bridelia retusa* (L.) Spreng. in terms of

density/100 hector (Table 1). The importance value of *Terminalia tomentosa* (Roxb. ex DC.) Wight & Arn. was the highest (292.30) followed by *Shorea robusta* Gaertn.f. (270.40), *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill. & Perr (199.90), *Bridelia retusa* (L.) Spreng. (188.20) and *Schleichera oleosa* (Lour.) Oken (139.10). In the middle storey, some of the shrubs i.e. *Croton roxburghii* Balak, *Cleistanthus collinus* (Roxb.) Benth. ex Hook.f., *Polyalthia cerasoides* (Roxb.) Bedd., *Gardenia gummifera* L.f. and *Hollarhena pubescens* (Buch.-Ham) Wall. ex G.Don. were found to grow in dense in interior forests. In shrub layer the highest value of RVI (50.89) was recorded for *Shorea robusta* Gaertn.f. whereas lowest (RVI-1.36) was recorded for *Aegle marmelos* (L.) Corr., *Adina cordifolia* (Roxb.) Hook.f. ex Brandis and *Flacourtia species* (Table 2). A good number of lianas and woody climber were present in plots such as *Bauhinia vahlii* Wight & Arn., *Combretum albidum* G.Don., *Hemidesmus indicus* (L.) R. Br., *Smilax zeylanica* L. and *Vettilago species*. In the herb layer the most dominant species was *Croton roxburghii* Balak (RVI, 17.11) followed by *Shorea robusta* Gaertn.f. (15.91) and *Combretum decandrum* Roxb. (5.87) (Table 3). The family with the most species present in the study area is Euphorbiaceae, followed by Rubiaceae and Combretaceae. Twelve families are monospecific. For the analysis of individuals per GBH class, all tree species were taken into consideration. For individuals below 2 cm GBH were surveyed only in the 5 m × 5 m subplot. Ninety tree species were recorded having GBH between 51–100 whereas only two species like *Madhuca indica* Gmel. and *Dillenia pentagyna* Roxb. showed >200 GBH (Fig. 4). Medicinal plant species such as *Aegle marmelos* (L.) Corr., *Andrographis paniculata* (Burm.f.) Wall. ex Nees, *Asparagus recemosus* Willd., *Curculigo orchioides* Gaertn., *Emblia officinalis* Gaertn., *Madhuca indica* Gmel., *Nyctanthes arbor-tristis* L., *Syzygium cumini* (L.) Skeels, *Terminalia bellerica* (Gaertn.) Roxb. and *Terminalia chebula* Retz. were harvested in bulk for preparation of medicines by the local people (Fig. 5). Similar use has been reported in other studies of India (Kassam *et al.* 2011, Khan *et al.* 2011, Mehra *et al.* 2014, Bajpai *et al.* 2016) and also other parts of the world (Jones 2000, Maurer *et al.* 2006, Chowdhury & Koike 2010). The medicinal plant resources are depleting rapidly due to unsustainable harvesting, lack of awareness and unrestricted grazing by domestic animals from nearby villages. Unsustainable collection of above medicinal plants has placed them in threatened and vulnerable categories in Conservation Assessment and Management Plan (CAMP) of Odisha (Pattanaik *et al.* 2009). Sustainable utilization and conservation of biodiversity are essential for the continuation of ecosystem functioning (Srivastava & Vellend 2005). The indigenous people in the study area gave less attention to the long term ecosystem goods and services since they were focused on their marginal and short time benefits. They illicitly utilized plants for a number of uses including timber, fuel, medicines, food, grazing and fodder. Extensive use of natural vegetation in the sanctuary in the past has decreased the provisioning services (Stewart & Pullin 2008, Giam *et al.* 2010). This diminution is fairly remarkable in the categories of food, fodder, timber fuel and medicines. The consequence of the imbalance in supply of these services and the increasing human demands has been deterioration in the condition of the natural habitats and increasing rarity of plant biodiversity (Giam *et al.* 2010). These effects are becoming worse as the indigenous people neither possess enough services locally nor can they compete in the urban societies. Due to the depletion of important species, the traditional indigenous knowledge of the people is decreasing day by day. The impact of these problems on single species and ecosystems are likely to be complex. According to Bhandari *et al.* (1999), any species in a community plays a specific role and there is a definite quantitative relationship between abundant and rare species. Plant biodiversity can be restored and the risks of degradation may be combated, if measures like reforestation, greater awareness by the people and *ex-situ* conservation of rare species are initiated (Pereira *et al.* 2005, Muzaffar *et al.* 2011).

In the shrub layer Sal samplings were more in the plots. Consequently, these will be large trees after some years, if can be preserved in healthy condition. This is a natural state as trees are competing for space and light and not all of the seedlings and saplings reach the state of adult trees. Still one has to be aware of the fact that matured and adult trees are attractive for wood smugglers as well as villagers, searching for construction material. The relatively low percentage of those trees is pointing to this direction. Out of total 38 tree species recoded in the 10 plots, 36 number of matured good class tree shows 100% adult (>100 GBH). So, the protection is needed to preserve these highest GBH trees. Regeneration pattern of some species with good and healthy offspring are found in the forest floor. Examples include *Michelia champaca* L., *Shorea robusta* Gaertn.f., *Schleichera oleosa* (Lour.) Oken, *Smilax macrophylla* Roxb., *Aegle marmelos* (L.) Corr., *Bauhinia vahlii* Wight & Arn., *Combretum decandrum* Roxb. and *Hemidesmus indicus* (L.) R. Br. Few numbers of bamboos with dispersed distribution along with few grass species was observed in some sites of the forest. However, while the forest shows a good regeneration status, their further development is prevented by the various anthropogenic activities like lumbering, overgrazing, forest encroachments and fire. In the present study

under storey fires and grazing are major regulatory factors controlling species distribution. In all the plots dung were found, so livestock are destroying the new germinated seedlings as they prefer soft leaves of seedlings and saplings. Livestock grazing have gradually caused a reduction in vegetation cover. Continuations of overgrazing will not only endanger the sustainability of forest ecosystems, but also will increase the challenge of sustainable forest management (Pour 2012, Hailu 2017). Fire is one of the most important disturbance factors in natural ecosystems throughout the world (Moretti & Barbalat 2004, Pashaki *et al.* 2013). Frequent firing may remove vegetation species that rely on seed production for their persistence (Fox & Fox 1986). Changes in habitat structure as a consequence of frequent burning are likely to disadvantage many native species (Whelan 1995). Studies of Peterson *et al.* (2007) and Peterson & Reich (2008) indicated that repeated fires not only reduced biological diversity but also play a crucial role in eradication of species.

Figure 5. Some medicinal plant species of Kuldiha Wildlife Sanctuary: **A**, *Aegle marmelos* (L.) Corr.; **B**, *Asparagus racemosus* Willd.; **C**, *Madhuca indica* Gmel.; **D**, *Nyctanthes arbor-tristis* L.; **E**, *Syzygium cumini* (L.) Skeels; **F**, *Terminalia bellirica* (Gaertn.) Roxb.

CONCLUSIONS

Considering over all phytosociological status of Kuldiha Wildlife Sanctuary Odisha, India, it reveals that there is a big gap between the values of various parameters like IVI, density, frequency and abundance. There are many tree species having very low values of IVI and other parameters and these species deserve more attention. A special care should be taken for growth of immature tree species growing in these forest areas. Further, this forest exhibits good regeneration status, and offer opportunities to investigate forest dynamics and changes in species relative abundances in the future. Although the study site is protected, this forest is experiencing destruction because of the frequent visits of people from nearby villages for their daily requirements (fuel, medicine, fodder, bamboo and other non-timber forest produce) and over grazing by livestock. This has resulted in the fragmentation of the forest, thereby causing damage to biodiversity. Further, educating the local people and effective implementation of the rules would be helpful in decreasing the depletion of natural forest produce. The present study in the Kuldiha forest is preliminary, and subsequent re census will be helpful for the restoration and management of mountainous regions in the larger-scale conservation planning of the Kuldiha and adjacent ranges.

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