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Variations in Vegetation and Nutrient Composition in Sal and Eucalyptus Stands: A Case Study of Bhagabatichak Forest Area, West Bengal, India

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Abstract

The study was conducted on two type of stands one was coppice sal (*Shorea robusta Gaertn.* F.) stand (CSS) managed by Forest Protection Committee (FPC) along with the State Forest Department and other was coppice eucalyptus (*Eucalyptus tereticornis Sm.*) stand (CES) solely managed by the State Forest Department. These two stands are in Bhagabatichak forest area under Midnapore East Forest Division, West Bengal, India. In this study Importance Value Index (IVI), biomass, species diversity index (H/), concentration of dominance(Cd), species richness index (d), beta diversity (βd), index of similarity (IS), nutrient composition and soil pH of the two stands were measured. The study reveals that the highest numbers of species were available during monsoon period in both the stands; these were 71 and 43 respectively in CSS and CES. The result also shows that the highest IVI was occupied by sal in CSS and eucalyptus in CES in all the seasons. Other major species were *Clerodendrum viscosum* Vent, *Lantana camara* L., *Combretum roxburghii Spreng*. Highest diversity index (H/) was in CSS during monsoon (1.983) and minimum in CES during pre-monsoon (1.274). So, the species richness index (d) was higher in CSS during monsoon (28.259) and lower in CES during pre-monsoon (12.112). Cd shows the opposite trend, it was higher in CES during pre-monsoon (0.125) and lower in CSS during monsoon (0.042). β diversity reflects the rate of species change, which was highest in CSS during post-monsoon (1.300). The similarity index (IS) between the two stands was 64.91%. The total annual above ground biomass (agb) were 87008.043 kg ha^{-1} yr^{-1} in CSS and 86309.837 kg ha^{-1} y^{-1} in CES. Among them major contributors were sal (82357.946 kg ha^{-1} yr^{-1}) in CSS and eucalyptus (84246.358 kg ha^{-1} yr^{-1}) in CES. In both the stands higher amount of nutrients were available in *Combretum roxburghii*. In CSS

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available NPK were 1.272%, 0.527% and 1.867% respectively in *Combretum roxburghii.* In CES the values were 0.864%, 0.513% and 1.724% respectively for the same species. Soil pH of CSS were 5.53 in top soil and 5.79 in subsoil, in CES soil pH were 4.88 and 5.02 in top soil and subsoil respectively. It was observed that sal stand was better than eucalyptus stand with respect to ecology and biodiversity.

Introduction

Forest represents the largest and most natural plant community. Though, today some woody plant species like *Eucalyptus* sp., *Acacia* sp., *Dalbergia* sp. are planted by human being for their economical need. This type of stands has traditionally been seen as a source of timber.[1] The return from different non-timber forest products (NTFPs) has been undervalued. But in recent decades, interest has grown in uses of NTFPs as alternatives or supplements of forest products, which are important for economic purpose of the local forest dwellers.[2 3 4 5 6] Now-a-days in few forests areas, during afforestation, some fruit yielding species, medicinal plant species are being planted as a policy decision. Plantation of these tree species are done to enhance diversity and heterogeneity in the tree level. Today establishment of new forest has been increased remarkably.[7 8 9] Since 1990 in India, as well as in West Bengal a major portion of the natural coppice sal forest is protected by concerned Forest Protection Committee (FPC) through Joint Forest Management (JFM), which was previously in a degraded condition and maintained by the State Forest Department.[10] There are the great differences of natural forest from a plantation ecosystem regarding the vegetation dynamics, structure and function also.[11] The quality and quantity of undergrowth depends on the tree canopy and the edaphic and microclimatic conditions existing under the particular type of forest.[12] The nature of ground flora, its diversity and density vary with the type of forest community.[13] The proportion of species to genera were 13:1 in world, 7:1 in India and 1.5:1 in Amarkantak, Madhya Pradesh, India.[14] It indicates that every genus is of great botanical importance in any plant community. The species diversity, density and nature of vegetation vary with the type of forest.[15]

In this study the vegetation and nutrient composition of a sal dominated stand (natural forest) was compared with that of eucalyptus stand (plantation) in Paschim Midnapore district. The forest of Paschim Midnapore district is truly unique, which shows higher species diversity.[16, 17] As per Champion and Seth's classification of Forest Type of India, the study area comes under Major Group – II, i.e. "Dry Tropical Forest".[18]

Study Area

The study was done in Bhagabatichak forest area under Midnapore East Forest Division, West Bengal. This area has two type of stands, such as coppice sal stand (CSS) and coppice eucalyptus stand (CES), which are adjacent to each other. Sal stand was jointly managed by FPC and Forest Department, whereas eucalyptus stand was under management of Forest Department. In CES eucalyptus plantation was done by Forest Department. Bhagabatichak village is 8 km away from Midnapore town of Paschim-Midnapore District, where FPC has existed for the last 25 years. The area of the coppice sal (*Shorea robusta*) stand is 61 hectares and the area of the eucalyptus stand is 33 hectares. Bhagabatichak forest belongs to the latitude 22.4614^0N and longitude 87.2780^0E. The annual rainfall of this site is 1580 mm of which 80% is precipitated at the end of June to September. The mean minimum and maximum temperature ranges from 15.6^oC to 37.8^OC.

Material and Methods

The phyto-sociological observations in both stands were recorded every month during 2019 -20 using quadrat method.[15] The data were represented in pre-monsoon, monsoon and post-monsoon seasons. Pre-monsoon represents March to June, monsoon July to October and post-monsoon November to February.

Layout of sample plots

"Species area curve" method was used to determine the minimum size and minimum number of the quadrats.[19] To study the plant communities quadrats of (10 m X 10 m) for tree species, (5m X 5m) for shrubs and (1m X 1m) for herbs were selected randomly. Ten quadrats of each (tree, shrub and

herb) were studied in both the stands. Quadrat wise plant species were encountered, listed and then identified with the help of floristic study of regional vegetation by Prain.[20] The identifications were cross checked with the help of Bennet21. Different phytosociological parameters were measured as follows-

Table 1: Number of Plant Species in CSS and CES

	Coppice Sal Stand (CSS)			Coppice Eucalyptus Stand (CES)		
	Pre -monsoon	**Monsoon**	**Post -monsoon**	**Pre-monsoon**	**Monsoon**	**Post -monsoon**
Tree species	15	15	15	9	11	10
Shrubs & climbers	17	22	22	10	13	11
Herbs & grasses	16	34	30	12	19	15
TOTAL	48	71	67	31	43	36

Importance Value Index (IVI) – $IVI = R_D+R_A+R_F$[22]

Where, R_D= Relative Density, R_A= Relative Abundance and RF= Relative Frequency.

Diversity Index ($H^/$) = $-\sum\{(\frac{ni}{N})\ \mathrm{Log}\ (\frac{ni}{N})\}$[23],

where, ni = IVI of individual species and N= IVI of all the species.

Concentration of Dominance (Cd) - It was measured by Simpson's Index,[24] $Cd = \sum(ni/N)^2$, where, ni = IVI of individual species and N= IVI of all the species

Species Richness Index (d) - $d = S - 1 / \log N$[25] where, S= Total number of species, N= IVI of all the species.

Beta Diversity (βd) - $\beta d = Sc/S$[26], where, Sc = total number of species in all the sites and S = average species per site.

Index of Similarity (IS) or Quotient of Similarity (QS) - This was calculated by the formula of Sorensen,[27] which was described by Muller-Dombois and Ellenberg.[28] IS or QS = 2c/ a + b, Where, a = Total number of plant species in one stand, b = Total number of plant species in another stand, c = Total number of plant species in both the stand.

Biomass – The above ground biomass were collected by destructive method. Destructive sampling of different species was done thrice (pre-monsoon, monsoon and post-monsoon). Species wise dry biomass estimated after drying the sample in Hot air oven at 80^0c for 24 hours.

Nutrient Composition - For assessing composition of flora, the plants from all the quadrats were harvested, identified and sorted out into dominant, co-dominant and other associated species by their occurrence/frequency in the forest. The vegetation was weighed, chopped, dried at 60°C, re-weighed, grind to fine power and analyzed for nitrogen, phosphorus, and potash.[29]

Soil pH - The pH meter is used to measure the soil pH, with the help of glass electrodes in 1: 1.25 of soil: water.

Result and Discussion

In a place the plant community nature is depend upon the plant species which grow and develop in this environment.[30] The variation of community composition between the two adjacent coppice stands and the effect of dominant tree species on other species were studied. The study reveals that more plant species were present in coppice sal stand (CSS) than coppice eucalyptus stand (CES). The numbers of tree and shrubs species were more or less the same in all three seasons in both the study sites (Table-1), but in case of herbs many species regenerate during monsoon period, which are not available in other seasons (Table-1). Maximum numbers of plant species were available in monsoon period, 71 in CSS, among them 15 tree species,

Table 2: Importance Value Index (IVI) and Annual Above Ground Biomass of all the species in CSS and CES

Sl. No	Scientific name	Coppice Sal Stand (CSS)				Coppice Eucalyptus Stand (CES)			
		IVI			Annual Above Ground Biomass (kg/ha/yr)	IVI			Annual Above Ground Biomass (kg/ha/yr)
		Pre - monsoon	Monsoon	Post - monsoon		Pre - monsoon	Monsoon	Post - monsoon	
	TREE species								
01	*Acacia auriculiformis* A. Cunn. . Ex.Benth. Ln. Hook	x	x	x	x	6.12	5.39	5.88	50.514
02	*Alstonia scholaris* R.Br.	8.47	8.33	8.41	42.647	9.15	7.91	8.48	28.172
03	*Antidesma acidum* Retz.	8.81	8.74	8.69	182.203	x	2.27	x	15.218
04	*Buchanania lanzan* Spr.	11.23	10.67	9.41	105.732	x	x	x	x
05	*Cassia fistula* Linn.	13.65	12.72	12.48	243.174	x	x	x	x
06	*Cleistanthus collinus* Benth.	3.17	2.46	2.52	28.46	9.16	7.56	6.72	79.850
07	Croton roxburghii Balak.	15.42	14.53	15.05	396.244	8.15	5.94	6.33	94.416
08	Diospyros exculpta Buch-Ham.	10.94	10.87	10.58	183.752	9.69	9.80	9.93	88.623
09	*Eucalyptus tereticornis* Sm.	x	x	x	x	97.58	88.62	93.24	84246.358
10	*Madhuca longifolia* (Koenig) MacBride.	13.72	12.23	12.19	226.283	x	6.16	7.57	89.107
11	*Phoenix sylvestris* Roxb.	7.81	7.79	7.74	37.965	10.48	8.62	9.06	32.432
12	*Pterocarpus marsupium* Roxb.	5.79	5.63	5.62	32.492	x	x	x	x
13	*Shorea robusta* Gaertn. F.	47.24	42.76	44.79	82357.946	x	x	x	x
14	*Sizygium cumini* (Linn.)Skeels.	5.26	4.49	4.45	24.124	7.54	5.25	5.69	55.176
15	*Tectona grandis* Linn. f.	12.44	11.91	11.84	145.377	x	x	x	x
16	*Terminalia bellerica* (Gaertn.) Roxb.	9.27	8.73	8.79	87.852	x	x	x	x
17	*Zizyphus mauritiana* Lamk.	7.83	7.61	7.64	78.344	6.73	5.84	5.13	32.318
	TOTAL ANNUAL BIOMASS (With Sal & Eucalyptus)				**84172.595**				**84812.184**

	TOTAL ANNUAL BIOMASS (Except Sal & Eucalyptus)				**1814.649**				**565.826**
	SHRUBS and CLIMBERS								
01	*Abrus precatorius* Linn.	2.19	1.27	1.25	2.349	x	x	x	x
02	*Abutilon indicum*(L) Sweet.	x	2.45	2.87	6.805	x	x	x	x
03	*Allophyllus cobbe* (L) Raeusch.	x	x	x		x	2.91	x	8.361
04	*Butea superba.* Roxb.	4.52	3.21	3.43	14.692	6.94	6.37	6.88	12.332
05	*Clerodendrum viscosum* Vent.	6.22	4.70	4.82	78.624	12.72	11.43	12.44	356.938
06	*Coccinia indica* Naud.	x	2.61	2.65	12.435	x	x	x	x
07	*Combretum roxburghii* Spreng.	15.78	14.16	14.46	1832.613	13.99	13.17	13.89	427.236
08	*Dioscoria alata* L.	x	3.16	3.63	12.864	x	x	x	x
09	*D. bulbifera* L.	x	2.84	3.10	11.962	x	x	x	x
10	*Flacourtia indica* (Burn. f.) Merr.	2.43	2.29	1.98	14.787	9.81	8.72	9.86	28.378
11	*Flamingia chappar* Ham.	2.81	1.78	1.76	3.125	x	x	x	x
12	*Gardenia gummifera* Linn. f.	2.66	2.33	2.59	4.266	x	x	x	x
13	*Grewia asiatica* L.	2.32	1.42	1.67	2.350	7.46	6.94	7.70	10.329
14	*Hemidesmus indicus* R. Br.	3.58	2.14	1.78	12.763	x	x	x	x
15	*Holarrhena antidysenterica* Wall.	9.80	8.77	9.22	343.542	11.87	10.76	11.35	151.944
16	*Ichnocarpus frutescence* R. Br	3.36	2.03	2.12	3.674	x	x	x	x
17	*Kirganelia reticulata* (Poir.) Baill.	x	x	x	x	x	3.83	x	4.167
18	*Lantana camara* L.	11.48	10.24	10.81	385.765	14.94	14.23	14.46	433.036
19	*Mucuna pruriens* (L) Dc.	2.26	1.17	1.02	2.763	x	x	x	x
20	*Smilax ovalifolia* Roxb.	2.35	1.22	1.45	2.284	x	x	x	x
21	*Tephrosia purpuria* (L) Pers.	1.82	1.78	1.73	3.174	x	4.82	4.54	2.164
22	*Tragia hispida* Willd.	x	x	x	x	4.59	3.57	4.15	
23	*Triumfetta rhomboidea* Jacq.	x	1.66	1.68	2.846	x	x	x	x
24	*Vitex negundo* Linn.	2.16	1.32	1.46	3.172	6.93	6.33	6.58	15.297
25	*Zizyphus oenoplia* Mill.	2.94	2.81	3.24	41.294	4.85	4.61	4.97	34.182
	TOTAL BIOMASS of SHRUBS & CLIMBERS	**-**	**-**	**-**	**2798.149**	**-**	**-**	**-**	**1484.364**
	HERBS and GRASSES								

01	*Aerva lanata* (L) Juss.	1.41	1.32	1.15	0.535	x	x	x	x
02	*Ageratum conyzoides* Linn.	2.29	1.97	2.20	0.793	x	x	x	x
03	*Alysicarpus vaginalis* (L) Dc.	x	2.17	2.18	0.678	x	1.49	x	0.870
04	*Andrographis paniculata* Nees.	x	1.40	x	6.352	x	x	x	x
05	Aristida adscensionis L.	4.26	3.82	3.96	2.793	5.37	4.45	4.28	1.327
06	*Atylosia conyzoides* Linn.	x	1.71	x	0.874	x	x	x	x
07	*Barleria cristata* Linn.	2.43	1.68	1.64	1.377	x	x	x	x
08	*Blumea lacera* Dc.	x	2.14	2.34	2.884	3.67	2.78	2.94	1.379
09	*Borreria articularis* (L.f.) F. N. Will.	x	1.65	1.49	0.634	x	x	x	x
10	*Chrysopogon aciculatus* Retz.	3.85	3.37	3.28	1.324	4.91	5.97	5.58	0.878
11	*Cynodon dactylon* Pers.	3.79	2.76	3.17	1.420	3.86	3.48	3.55	0.933
12	*Cyperus compresus* Linn.	x	1.13	1.16	1.128	x	1.73	2.18	0.634
13	*C. cyperoides* (L) Kuntze.	x	0.96	1.13	0.873	x	x	x	x
14	*C. rotundus* Linn.	x	1.47	1.56	0.947	x	1.28	1.42	0.537
15	*Desmodium triflorum* Dc.	x	1.35	1.41	0.677	1.91	1.44	2.17	0.448
16	*Eragrostis tenella* Roem & Schtt.	x	2.17	2.40	0.785	x	1.28	x	0.326
17	*Euphorbia hirta* Linn.	2.48	1.84	1.92	0.642	x	x	x	x
18	*Evolvulus nummularius* Linn.	x	1.56	1.42	0.438	1.94	1.76	1.87	0.295
19	*Fimbristyles dichotoma* (L.) Vahl.	x	x	x	x	x	2.17	x	0.237
20	*F. ovata* (Burm.f.) Kern.	x	0.87	x	0.244	x	1.18	x	0.138
21	*Hedyotis corymbosa* (L) Lamk.	x	1.53	1.10	0.445	1.61	1.08	1.28	0.296
22	*Heteropogon contortus* (L) Beavu.ex. Roem&Schtt.	2.73	2.16	2.14	0.783	3.49	3.73	3.86	0.323
23	*Lindernia ciliata* (Colsm.) Pennell.	x	0.76	x	0.186	x	x	x	x
24	*L. crustacea* (L) F. Muell.	x	0.87	0.95	0.214	x	x	x	x
25	*Mimosa pudica* Linn.	0.72	1.34	1.28	2.832	3.14	2.35	2.44	1.488
26	*Mollugo pentaphylla* L.	x	1.81	1.13	0.390	x	x	x	x
27	*Pergularia daemia* (Forssk.) Chiov.	2.80	1.45	1.48	1.427	4.37	3.68	4.72	0.836
28	*Perotis latifolia* Ait.	x	0.67	0.73	0.226	x	x	x	x
29	*Phyllanthus fraternus* Webstern.	x	0.92	1.16	0.367	x	x	x	x
30	*Rungia pectinata* (L) Nees.	2.57	1.17	1.14	0.626	x	1.39	1.84	0.438
31	*Sida cordata* (Burn. f.) Borssum.	2.88	2.08	2.04	0.973	x	x	x	x
32	*S. rhomboidea* Linn.	2.15	1.75	1.79	0.884	3.41	3.83	3.17	1.212
33	*Solanum nigram* Linn.	2.64	1.14	1.12	0.927	x	x	x	x

34	*Tridax procumbens* Linn.	1.75	1.35	1.37	0.876	3.62	3.88	3.85	0.694
35	*Vernonia cinerae* (L) Less.	1.52	0.83	1.24	0.745	x	x	x	x
TOTAL BIOMASS of HERBS & GRASSES		-	-	-	**37.299**	-	-	-	**13.289**
GRAND TOTAL		**300.00**	**300.00**	**300.00**	**87008.043**	**300.00**	**300.00**	**300.00**	**86309.837**

22 shrubs and climbers, 34 herbs and grasses. Whereas during monsoon period the total number of plant species in CES were only 43, among them 11 tree species, 13 shrubs and climbers, 19 herbs and grasses (Table-1). Similar observations were recorded in natural coppice sal forest and akashmoni (*Acacia auriculiformis* A. Cunn. Ex. Benth. Ln. Hook.) plantation stand of Paschim-Minapore district of West Bengal.[31] Several authors were noted that the variations of vegetation are depends upon several factors like species composition and structure,[32] management strategies,[33] soil moisture and nutrient dynamics,[34, 35] succession history[36] and fragmentation.[37] Occurrence of maximum number of plant species (71) in CSS shows its status as climatic climax, besides this, the stand is protected by FPC, so the disturbances were least. In CES the total number of species (43) was too much less than CSS during monsoon period, where the different disturbances like thinning, pruning, cutting, collection of fuel wood, grazing are too much high, so the number of species is too much less.

IVI of a plant community represents the ecological importance of a species in the community. In CSS highest IVI was occupied by sal in all the seasons (Table- 2), during monsoon this was followed by *Croton roxburghii* (14.53), then *Combretum roxburghii* (14.16). Similarly in CES highest IVI was occupied by eucalyptus in all the seasons (Table- 2), during monsoon *E. tereticornis* was followed by *Lantana camara* (14.23) and *Combretum roxburghii* (13.17) which are listed in Table-2. The result also shows that in between the sal and eucalyptus maximum IVI was occupied by eucalyptus in CES than the sal in CSS. It indicates the effectiveness of major species on other species was more by eucalyptus than sal. On the basis of the "Kath and Kukath" concept the FPC protects the forest specially the sal tree. But recent days different NTFPs are used and sold in the market, which support the economy of the forest people. So they protect the forest as a whole, which promote the conservation of forest. Similar findings were observed by some authors.[2, 6] The village people irregularly collect the different tree species (except sal) as fuel wood. These tree species remain in sapling condition throughout the year. Another dominant species like, *Combretum roxburghii, Holarrhena antidysenterica* and *L. camara* remain constant and showed better growth in CSS. Whereas in CES

the grazing and cutting of different plant species (except eucalyptus) were done continuously, no restrictions were there. Though in *CES Combretum roxburghii, C. viscosum, L. camara,* constantly present but not in better condition as in CSS.

Table: 3 Different phytosociological parameters of CSS and CES

	Coppice Sal Stand (CSS)			Coppice Eucalyptus Stand (CES)		
	Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
Total no. of species	48	71	67	31	43	36
Diversity Index(H/)	1.488	1.983	1.723	1.228	1.327	1.274
Dominance Index (Cd)	0.048	0.042	0.044	0.125	0.106	0.113
Species Richness Index (d)	18.974	28.259	26.645	12.112	16.956	14.129
β Diversity	1.215	1.245	1.300	0.784	0.754	0.699
Similarity Index (During monsoon)	64.91%					

Vegetation analysis and distribution patterns of this study are as follows, the diversity index ($H^{/}$) and concentration of dominance (Cd) were calculated on the basis of density and IVI. The information of species richness, distribution and the rate of change in species composition were available from diversity index. The ecosystem process is controlled by the strong function of the structure and diversity of vegetation. Diversity index is an important attribute of an organized community.[38] The diversity index (H/) was maximum in CSS during monsoon (1.983) and minimum in CES during pre-monsoon (1.228). It indicates that more species were observed in CSS (Table-2). In case of herbs the open canopy indicates the species richness and composition of an ecosystem.[39] The study reveals that higher species richness values (d) were observed in CSS during all the seasons, among them, the highest was in monsoon (28.259). The lower species richness value were observed in CES throughout the year, among them lowest in pre-monsoon (12.112). In Chendra teak forest of Dhaurpur range in Sarguja district, Chhattisgarh, India, the Shannon diversity index value and species richness value for shrubs of a natural forest was double than the plantation sites of teak.[11] The values of concentration of dominance (Cd) i.e. dominance index were maximum in CES and minimum in CSS in all the seasons, which are shown in Table- 3. Eucalyptus is a quick growing, large woody, gigantic tree species and the coppicing power is high, so the ecological success of the associated species was found to be very low in terms of their competing ability and therefore the ground vegetation was also found to be very thin. The adaptability and the coppicing ability of eucalyptus are better in lateritic region, a common soil type of the study region40. But sal is a slow growing species and it has no harmful effect on another plant species. The plant diversity was higher in CSS, this was also supported by several authors.[41, 42]

β diversity reflects the rate of species change in the plant communities. It was more in CSS and less in CES, shown in Table-3. It shows highest stability in CSS in comparison to CES. Some authors has quoted that diversity generates community stability, dominance generates community productivity and increasing the number of species in a forest stand rather enhancing efficiency though more exploitation of site resources decreases efficiency perhaps through competition.[43,44] Greater diversity provides a number of pathways in the ecosystem's functioning which gives stability to the ecosystem.

The similarity index (IS) is 64.51%, because CSS and CES are situated side by side at the same locality. Though these two stands are situated side by side, but the vegetation was different, due to the effect of dominant species on other species, such as in CSS sal shares the competition with other species but in CES, eucalyptus suppresses the other species.[45] Due to the different effectiveness

of dominant species on other plant species the similarity of these two stands was not higher.

Comparative study of annual above ground biomass (agb) of the two stands shows that the total annual agb was slightly higher in CSS (87008.043 kg $ha^{-1}yr^{-1}$) than CES (86309.837 kg $ha^{-1}yr^{-1}$). The difference of agb was (87008.043 – 86309.837) 698.206 kg ha^{-1} yr^{-1}. But in tree species the individual agb was more in eucalyptus (84246.358 kg $ha^{-1}yr^{-1}$) than sal (82357.946 kg $ha^{-1}yr^{-1}$). This is due to the fact that eucalyptus is a fast growing species than sal. In CSS the total agb (except sal) was 4650.07 kg $ha^{-1}yr^{-1}$. Similar finding was recorded by Sahoo46. Sahoo enumerated the total agb (except sal) in Chandra natural coppice sal forest of Midnapur East Forest Division in West Bengal was 5932.01 kg $ha^{-1}yr^{-1}$ which was quite less in respect of the total annual agb. In CSS the total agb was 87008.043 kg $ha^{-1}yr^{-1}$, among this, tree species (except sal) contributed only 2.08% (1814.649 kg $ha^{-1}yr^{-1}$), shrubs and climbers 3.21% (2798.122kg $ha^{-1}yr^{-1}$), herbs and grasses 0.04% (37.299 kg $ha^{-1}yr^{-1}$). The rest amount 94.67% (82357.946 kg $ha^{-1}yr^{-1}$) was contributed by sal only, because sal is the most dominant tree species in this stand, besides this sal is protected by FPC. In CES the total agb was 86309.837 kg $ha^{-1}yr^{-1}$, among this, tree species (except eucalyptus) has only 0.65% (565.826 kg $ha^{-1}yr^{-1}$), shrubs and climbers 1.72% (1484.364 kg $ha^{-1}yr^{-1}$), herbs and grasses 0.02% (13.289 kg $ha^{-1}yr^{-1}$) and only eucalyptus contribute 97.61% (84246.358 kg $ha^{-1}yr^{-1}$). Eucalyptus was the dominant tree species in CES. The result shows that the individual agb was more in eucalyptus than sal. With respect to total annual agb, species diversity and stability, the CSS was performed better, more significant and more stable than CES. In CES eucalyptus suppress the growth of other species and allelo-chemicals secreted by eucalyptus which prevents the germination and growth of other species. Similar findings were observed by several authors.[47, 45]

Table 4: Analytical composition of major plants of CSS and CES

		Analytical Composition of Above Ground Biomass					
		Coppice Sal Stand (CSS)			Coppice Eucalyptus Stand (CES)		
Sl. No.	**Scientific Name**	**Av. N (%)**	**Av. P (%)**	**Av. K (%)**	**Av. N (%)**	**Av. P (%)**	**Av. K (%)**
	Tree / Sapling						
01	*Madhuca longifolia*	0.761	0.394	1.324	0.685	0.317	1.278
02	*Croton roxburghii*	0.747	0.438	1.762	0.597	0.358	1.159
	Shrubs and climbers						
03	*Clerodendrumviscosum*	0.874	0.418	1.473	0.783	0.412	1.382
04	*Combretum roxburghii*	1.272	0.527	1.867	0.864	0.513	1.724
05	*Holarrhenaantidysenterica*	0.856	0.422	1.383	0.628	0.329	1.247
06	*Lantana camara*	0.879	0.515	1.642	0.835	0.487	1.686
	Herbs and grasses						
07	*Alysicarpusvaginalis*	0.873	0.313	1.217	0.768	0.280	0.936
08	*Aristida adscensionis*	0.792	0.349	0.946	0.728	0.311	0.876
09	*Chrysopogonaciculatus*	0.637	0.288	0.917	0.624	0.228	0.836

Nutrient Composition of Major Species

The major species having higher IVI and common to both the stands were selected for performing nutrient composition analysis, which are listed in Table-4. Their respective contribution towards production of biomass and nutrient uptake revealed that in both the stands higher nutrients (available NPK) were observed in *Combretum roxburghii*. In CSS available NPK were 1.272%, 0.527% and 1.867%. In CES the available NPK values were 0.864%, 0.513% and 1.724% in the same species. Next to *Combretum roxburghii* more nutrients were observed in *L. camara* (Table-4). In *L. camara* more nutrients (available NPK) were observed in CSS

than the CES. A similar trend was observed for other species (Table-4). Nutrient uptake efficiency was more in the species of CSS, though sal had optimum expression on these sites. Available NPK were less in the species of CES, these are due to the fact that this stand is open to biotic interference by the local people and considerable amount of understory vegetation is being removed by villagers leading to sparse understory.[11]

Table 5: Soil pH of CSS and CES

		1	2	3	4	5	Mean
Coppice Sal Stand (CSS)	Top Soil (0-15)cm	5.12	5.73	5.48	5.67	5.65	5.53
	Sub Soil (15-30)cm	5.54	5.92	5.82	5.81	5.88	5.79
Coppice Eucalyptus Stand (CES)	Top Soil (0-15)cm	5.06	4.87	4.68	5.12	4.70	4.88
	Sub Soil (15-30)cm	5.18	4.90	4.83	5.38	4.84	5.02

Mean pH value of soil in CSS was 5.53 in top soil (0 – 15cm.) and 5.79 in subsoil (15 – 30 cm.). The corresponding mean pH value of soil in CES was 4.88 in top soil and 5.02 in subsoil. In the lateritic region of West Bengal the soil pH under coppice sal forest ranges from 5.0 to 6.6 , which are acidic to nearly neutral in reaction.[48] Under neutral pH conditions, rapid transformation, low fixation and efficient extraction of available phosphorus in sal forest soil is more than eucalyptus forest soils.[49]

Conclusion

The results indicate that the availability and growth of the floral diversity in CSS is more than that of CES. There may be various factors to explain but most important one is the management of the stands. Most of the ecological factors like soil, water regime etc. being same, the dominant tree species of the stands are observed to be the drivers of community structure. Thus, it may be concluded that the sal stand is more stable as compared to the eucalyptus stand. These observations get credence from the fact that sal stand are more stable having better floral composition than the floral composition of eucalyptus stand, which can provide better welfare to human beings and more significant to human life.

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Conflict of interest

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