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Floral Composition and Soil Properties of Pristine Forests in Comparison to Managed Forests in Gangajalghati Forest area of West Bengal, India

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ABSTRACT

In this paper vegetational composition and soil properties of three pristine forests in the Gangajalghanti forest area, West Bengal, India have been compared with a semi and a fully man managed forest. Abundance, Basal Cover and Importance Value Index (IVI) of all species have been estimated. Biodiversity was estimated using a newer method of Jack-knifing the Shannon index to minimize sampling error introduced during field studies. *Shorea robusta* (sal) is the most prevalent tree in all three pristine forests whereas it is represented by *Acacia auriculoformis* (Akashmani) in two man-managed forests. Other trees like, *Buchaninia lanzan*, *Lannea coromandelica*, *Terminalia tomentosa* , *Soymida febrifuga*, *Madhuca latifolia*, *Semecarpus anacardium* and *Bridelia retusa* are also well represented in the natural forests with some variation among the three. Two woody climbers, *Erycibe paniculata* and *Butea superba* are present in good numbers. Both the semi man managed forest (SMMF) and fully man managed forest (MMF) have an entirely different floral composition. Though, the SMMF shows the presence of *Buchanania lanazan*, *Semecarpus anacardium* and *Lannaea coromandelica* to some extent, MMF is in fact a monoculture of *Acacia auriculoformis* with shrubs and herbs under its canopy. The Shannon diversity index of pristine forest is much high in the range of 2.64 - 2.95 which in man managed forests ranges from 1.94 – 2.51. Soil properties viz, pH, electrical conductivity (EC), C/N ratio, water content (WC) and water holding capacity (WHC) are more favorable in the pristine forests compared to the two man managed forests.

KEY WORDS: Pristine, man managed, Jack-knife, diversity, soil

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INTRODUCTION

Forest diversity in tropical region of the world is known to harbor rich biodiversity (Whitmore, 1998, Berry 2010)[1,2]. Some of the deciduous tropical forests of West Bengal India are also known to possess high biodiversity (M.N. Sanyal, 1994)[3]. But these forests are in threat due to human settlements and Industrial development and there are incidence of biodiversity losses due to these anthropogenic activities (Morris, 2010)[4]. In reality, there is a coexistence of tribal life and forests in these areas in which livelihood of tribal people is largely dependent on forest and forest products. Not only for the tribals, forests are beneficial for the population at large both in terms of ecology and economy. Forests are important sites of soil formation (pedogenesis) as well. The litter that falls on the ground are composted and mineralized to form humus rich fertile soil. Therefore conservation of these forests in its wild form is same as saying conservation of underlying soil and conservation of the social infrastructure of the entire area.

Industrial development is inevitable in a developing country like India and it also requires land acquisition involving cut down of trees leading to deforestation. Plantation of trees in such degraded lands is a common practice throughout the world. However, species selection in such plantation programs is an important criteria in maintaining sustainability (West, 2006)[5]. But, the plantations done under the afforestation programs in India are largely quantitative rather than qualitative. It mostly leads to development of monoculture particularly of *Acacia auriculoformis* and/or *Eucalyptus tereticornis* particularly in this part of the country. These forests are said to be man-made forests and have minimum biodiversity that not only affects the stability of the forest but also the underlying soil quality at the end. Because, in forested areas land use history and soil properties, have been found to be related to each other. The top cover effects the litter quality which in turn effects the colonizing species diversity leading to alteration in soil properties too (Verheyen 2001)[6].

To avoid failures, minimize ecological damage and to optimize the appropriate use of soil, water and energy resources obtained from the forests, it is necessary to understand the ecological characteristics of the forests in question. In this regard an in depth knowledge of species composition and its relation to the underlying soil properties is necessary (Cuevas and Lugo, 1998)[7]. A similar kind of approach has been taken in the present article where we have characterized the existing pristine forest and compared it with the man made forest in adjoining

region. The diversity has been interpreted using Jackknife method over Shannon index. This method automatically takes into account the restrictions laid down by field sampling and can provide a better way to answer the questions of further statistical interest. The biodiversity of plants have been correlated with the physicochemical properties of the soil and that too in a comparative way with the man made forests.

The objective of the study is to understand the problem of monoculture that affects the soil quality as well as species diversity that thrives otherwise in a natural forest. This work will be a suggestive literature for the people engaged in forest management practices.

MATERIALS AND METHODS –

The study area –

This particular study has been carried out in Gangajalghati forest area located at 23.430163- 23. 449533N of Latitude to 87.11046 – 87.121842E of longitude in the Bankura district of West Bengal, India. Once its area used to be 59.92 sq. km (8), but now it is drastically reduced to 12 sq. km (satellite calculation). Seeing the minor difference in physiognomy, the entire forest has been divided into three subzones, namely Hanspahari forest (HF), Deuli forest (DF) and Latiaboni forest (LF) in the present study. This was done for the convenience of sampling and comparison. They all are open pristine Sal forests with an overall density of 13%, 15% and 20% respectively. Two more small forests, one semi man made (SMMF) and another fully man made forest (MMF) have been considered for comparison. The overall annual rainfall of this area is ~1300 mm with major part of precipitation occurring during July and August. Temperature during summer days reaches to 20^{o} - 48 ^{o}C and during winter it ranges from 5^{o} – 20 ^{o}C [8].

Characterization of the forests –

Random quadrat sampling method was employed for analyzing the vegetation characteristics like species richness, density, frequency, abundance, basal cover, IVI and diversity of these five forest types. A quadrat size of 10 x 30 m^2 was selected seeing the overall density of the forest and ten quadrats per pristine forests and six and four quadrats respectively for semi man made and man made forests were considered for this analyses. Necessity of counting 10 quadrats in SMMF and MMF seemed futile because these semi or fully man

managed forests are homogeneous all along. The data obtained through quadrat analyses was fed in to excel sheet and different aspects of vegetation were obtained using the formulae of Mishra (1968)[9] and Curtis and Mcintosh (1951)[10] as given below:

$$\text{Relative frequency} = \frac{Frequency\ of\ a\ species}{Frequency\ of\ all\ species} \times 100\%$$

$$\text{Density} = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ quadrats\ studied}$$

$$\text{Relative Density} = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ indiiduals\ of\ all\ species} \times 100\%$$

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

$$\text{Relative abundance} = \frac{\text{Basal cover of individual species}}{Total\ number\ of\ quaBasal\ cover\ of\ all\ species} \times 100\%$$

Imortance Value Index (IVI) = Relative density + Relative Dominance + Relative frequency

Equitability or evenness was calculated according to Pielou (1969)[11] using the formula;

Equitability (j) = $H'/ln\ S$ (where, H' is Shannon diversity with Jackknifing and S is the total number of species)

Soil sampling and storage –

Soil samples were collected in sterile plastic packets wearing sterile gloves so that minimum contamination takes place. This was done for bacterial and fungal isolation that has been going on parallel with this work. Soils were collected at 10-15 cm depth from four corners and center of each of the quadrats included in this study. Half of the soil used to be stored in refrigerator for regular use and rest were stored in – 20 ^{0}C deep freezer for enzymatic analyses.

Soil analyses –

Soil pH was determined with the help of a glass electrode pH meter. For this 10 g of dried soil was taken in an Erlen Meyer flask and suspended in 20 ml of 0.01M $CaCl_2$. The

suspension was then shaken vigorously on horizontal shaker for 1h and pH was measured after that (Akbor et al. 2006)[12]

Electrical conductivity was measured as per Instruction Mannual (Systronics). Calibration of the instruments was done using 0.01 M KCl.

Soil organic carbon was measured using the modified chromic acid digestion procedure of Black et al. (1965)[13,14]. One g of soil sample was extracted in 1N $K_2Cr_2O_7$ and 20 ml of H_2SO_4. The mixture was shaken for 1 h then centrifuged. Absorption of the green colored supernatant was measured at 660 nm in an UV-VIS spectrophotometer (Biomic).

Total nitrogen was determined following a modified Kjeldahl method developed by Gulick (1914)[15]. For this, 2g of sample soil was taken in Kjeldahl's flask/tubes and moistened with 5 ml of distilled water. It was then digested with 4 g of Na_2SO_4, a pinch of Selenium powder and 7 ml of conc. H_2SO_4. The flasks/tubes were put on a hot plate and gently swirled to digest the matter completely. This digested suspension was allowed to settle down and then decanted in a graduated tube to leave the solid material at the bottom. The volume was then made upto 10 ml by distilled water. From here, 1 ml is taken and mixed with 1 ml of pre-made mixture of 10% NaOH and $NaSiO_3$ (equal amount each). To this mixture added 5 ml of alkaline Nessler's reagent and the intensity of the color was measured at 420 nm in a UV-VIS spectrophotometer (Biomic).

Water content and water holding capacity were determined according to Choudhury and Gupta ((1976)[16] with a little modification. Water content (WC) is the amount of standing water that is present at the time of collection. It was measured after bringing the soil in the laboratory. It is the weight of undried soil minus the weight of oven dried soil. Water holding capacity (WHC) was measured at 50% saturation level by soaking the dried soil to 100% saturation first in a perforated aluminium foil. Excess water was drained out by blotting on dry tissue papers before taking the final weight. Difference in weight divided by two gives the WHC at 50% saturation.

Statistical Analyses -

Sampling distributions for the Shannon diversity index (1948)[17] have been calculated according to Zahl (1977)[18]. It follows the so-called jack-knife method of estimation of the

diversity index. This method helps to minimize the error introduced due to the existence of evenness in quadrat sampling. All these calculations were, however, made using R programming.

The Jackknife Method:

Here all quadrats that have been studied in a particular forest have been grouped together as a giant sample designated by *S*. Shannon index was calculated first on the basis of this grouped sample, S. Followed by repeated calculations of Shannon index using $S^{(-i)}$ samples. Here, $S^{(-i)}$ means grouped quadrat minus the i^{th} quadrat. That means if we have *n* number of qudrats then $S^{(-i)}$ constitutes $(n - 1)$ quadrats, and this is done for *n* number of times. The calculations regarding this are as follows:

$S \equiv$ A giant sample made by taking all quadrats together

$S^{(-i)} \equiv$ A sample is made by omitting i-th quadrat observations from S.

Suppose, we have *n* quadrats then we will have *(n+1)* samples.

Define,

g^0 = Shannon index for *S*.

$g^{(-i)}$ = Shannon index for $S^{(-i)}$,for all $i = 1(1)n$.

Pseudo values, $g_i = ng^0 - (n\text{-}1)\, g^{(-i)}$, for all $i = 1(1)n$.

Jackknife estimate of Shannon index, $\hat{g} = \sum_{i=1}^{n} \frac{g_i}{n}$

Here, the Shannon index is calculated using the formula, $H' = -\sum_{i=1}^{m} p_i \ln p_i$

m=total number of species in the community

p_i= proportion of i-th species in the community

A cluster analyses was made to generate a relationship tree on the basis of mutual distance among the forest types using single linkage method. The similarities were calculated using the formula given by Sorensen (1948)[19]

$$S = \frac{2C}{A+B} \times 100\%$$

Distance = 100 - S

(Where, A = number of species in sample A, B = number of species in sample B and C = number of species common between samples A and B)

Linear regression curve between the physicochemical data of soil and the Shannon index (after Jack-knifing) were generated using excel. The significance of variation of the physicochemical data were tested at 0.05 level using one way ANOVA in ms-excel.

RESULT AND DISCUSSION –

A summarized result of the vegetational analyses of the five forests under this study has been depicted in the table – 1 which says that the three pristine forests, the Hanspahari forest (HF), the Deuli forest (DF) and the Latiaboni forest (LF) have most species diversity with Sal (*Shorea robusta*) being the most predominant tree. Others like *Buchaninia lanzan*, *Lannea coromandelica*, *Terminalia tomentosa*, *Soymida febrifuga*, *Madhuca latifolia*, *Semecarpus anacardium* and *Bridelia retusa* etc. together constitute the second most predominant spp. in these three natural forests. A large number of climber species with two lianes namely *Erycibe paniculata* and *Butea superb*a are also present in good number. As far as the abundance of *Shorea robusta* (sal) is concerned, it is most predominant in Latiaboni forest with a score of 24.1, whereas in the Hanspahari and Deuli forests the abundance is little less with the scores 19.90 and 17.0 respectively. The interesting thing to note is their complete absence in the semi and fully man-made forests, i.e. SMMF and MMF respectively. Instead, *Acacia auriculoformis* is the most abundant species in these two artificial forest types. In fact it is the only tree species in Man made forests (MMF) and rests are either climbers, undershrubs or herbs that have grown up under the shelter of *Acacia auriculoformis* monoculture. It is also worth mention that this monoculture is a common practice in this area and most of them are planted with either *Acacia auriculoformis* or *Eucalyptus tereticornis* (D kumar, 1984)[20]. The structure and composition of the two man made forests are thus completely different from their natural counterparts (Table – 1).

Table – 1 (Abundance, A; Basal Cover, BC and Importance Value Index, IVI values of different plant species in five different forest types) -

	HF			DF			LF			SMMF			MMF		
Name of the species	**A**	**BC**	**IVI**	**A**	**BC**	**IVI**	**A**	**BC**	**IVI**	**A**	**BC**	**IVI**	**A**	**BC**	**IVI**
Abrus precatorius Linn.	2	0.14	0.48	-	-	-	1	0.29	0.34	-	-	-	-	-	-
Abutilon theophrasti Medik.	1	0.01	0.41	1	0.02	0.88	2	0	0.37	1	0.01	1.72	-	-	-
Acacia auriculoformis A. Cunn.	-	-	-	-	-	-	1	9.75	0.8	1.83	131.4	62.27	-	-	-
Acacia nilotica (L.) Willd. Ex. Del..	2.86	2.53	3.8	4.13	1.39	5.52	1	0.25	1.95	2.67	10.4	11.42	-	-	-
Acacia rugata (Lam.). Ham.	-	-	-	-	-	-	1.75	0.13	1.44	-	-	-	-	-	-
Adiantum sp.	13	0.01	2.47	16	0.01	3.17	10	0.01	2.31	-	-	-	-	-	-
Ageratum conyzoides Linn.	-	-	-	3.67	0.03	1.93	9	0.02	1.44	12.2	0.04	17.37	16.3	0.02	21
Albizia lebbeck (L.) Willd.	1	6.24	0.82	1	6.24	0.89	-	-	-	1	10.4	5.31	-	-	-
Amorphophalus sylvaticus (Roxb.) Kunth.	-	-	-	-	-	-	3.5	0.5	0.92	-	-	-	-	-	-
Ampelocissus latifolia (Roxb.) Planch.	1.67	0.01	2.72	1.67	0.01	1.47	1.4	0.02	1.71	2	0.02	5.12	-	-	-
Andrographis peniculata (Burm.f.) Wall.	2	0	0.48	-	-	-	2	0	0.37	3.5	0.01	2.63	-	-	-
Annona reticulata Linn. Sp. DC	-	-	-	-	-	-	1	0.8	0.36	-	-	-	-	-	-
Aristida setacea Retz.	8.33	0.02	2.74	10.5	0.02	2.33	8	0.03	2.01	14	0.09	6.49	-	-	-
Asparagus adscendens	3.75	0.01	2.38	1.67	0	1.47	2.5	0.02	3.97	-	-	-	-	-	-
Asparagus racemosus Willd.	2.25	0.01	1.97	3	0	1.18	3.6	0.01	2.26	-	-	-	-	-	-
Atylosia scarabaeoides (L.) Benth.	15.6	0.2	14.13	13.1	0.17	13.7	10.3	0.1	6.26	2.67	0.03	6.99	1	0	4.47
Azadirachta indica A. Juss.	1	0.51	0.44	-	-	-	1	1.56	0.4	-	-	-	-	-	-
Barleria cristata Linn.	2	0.01	0.48	1.5	0.02	1.91	2.5	0	0.79	1	3.98	4.28	2.33	0.01	7.36
Biophytum sensitivum Linn.	-	-	-	-	-	-	-	-	-	2	0.01	1.06	2	0.01	3.88
Boerrhavia diffusa Linn.	-	-	-	-	-	-	-	-	-	-	-	-	4	0.01	7.99
Bridelia retusa Spreng.	1.2	9.36	2.72	1.33	6.24	1.84	1.67	38.7	5.1	1	2.6	1.98	-	-	-
Buchanania lanzan	2.	35.	6.6	3.	80	11	5.	27	6.	2	3.8	2.6	-	-	-

(Roxb.)	88	89	5	88			22		11		2	9			
Butea superba Roxb.	1.4	4.03	2.44	2.14	8.63	4.3	1	0.2	0.33	-	-	-	-	-	-
Carissa spinarum Linn. Mant.	15.2	0.77	13.89	13	0.66	13.6	19.5	1.24	9.99	2	0.1	6.29	-	-	-
Casearia elliptica Willd.	8.6	0.34	4.67	5.2	0.41	7.63	11.1	0.88	8.28	1.5	0.08	5.19	-	-	-
Cassia sophera L.	-	-	-	-	-	-	-	-	-	9.17	0.47	14.28	2.75	0.06	10.5
Cayratia trifolia (L.) Domin	4.5	0.01	1.3	1.33	0.01	1.39	2.33	0.01	1.17	2.33	0.02	3.31	-	-	-
Chromalena odorata (L.) King & Robin.	13	0.1	2.47	4.25	0.07	2.75	1.67	0.02	1.07	5.8	0.19	9.42	24.8	0.11	30
Cissampelos pareira (Linn.)	1.57	0.01	3.12	2.33	0.01	1.62	2.5	0.01	0.79	1.5	0.01	5.16	1.75	0.01	8.66
Cleistanthus collinus (Roxb.) Bth.	1.9	0.34	4.71	2	0.25	3.63	-	-	-	2	1.27	3.67	-	-	-
Clerodendrum viscosum Vent.	5	0.01	0.68	5	0.16	2.99	1.17	0.05	1.98	4.5	0.1	3.03	4.25	0.3	13.5
Costus spaceosus (Koen. Ex. Retz.) Smith	-	-	-	4	0.23	3.36	2.33	0.35	1.18	-	-	-	-	-	-
Crotalaria prostrata Rottl.	2.33	0.01	1.5	1.5	0	0.95	1.5	0	0.69	2.33	0.01	3.31	-	-	-
Cryptolepis buchanani Roem. & Sch.	2.33	0.04	1.5	2	0.03	1.55	3.5	0.14	3.58	2	0.01	1.06	-	-	-
Curculigo orchioides Gaertn.	-	-	-	-	-	-	6.83	0.33	3.69	-	-	-	-	-	-
Cuscuta reflexa Roxb.	3.5	0.01	1.16	3	0.01	1.78	5.6	0.04	2.75	-	-	-	-	-	-
Desmostachya bipinata (L.) Stapf.	5	0.04	4.09	9	0.02	2.1	5.4	0.14	2.71	2.17	0.03	6.44	-	-	-
Dioscorea alata Linn.	1.75	0.02	3.67	3.25	0.02	2.45	1.5	0.01	0.69	1	0.01	2.58	-	-	-
Dioscorea bulbifera (L.)	1	0.01	1.63	1	0	0.88	2.22	0.06	3.45	1	0	1.72	-	-	-
Dioscorea esculenta (Lour.) Burkill	1.71	0.02	3.19	1	0	0.88	2	0.02	1.12	-	-	-	-	-	-
Dioscorea hispida Dennst.	1	0	1.22	-	-	-	1	0	0.32	1	0	0.87	-	-	-
Dioscorea polystachya Turcz.	1.5	0	0.88	2	0	0.52	6	0.03	1.14	-	-	-	-	-	-
Dioscorea villosa (L.)	7.1	0.36	8.29	8.7	0.44	10.3	33	0.34	3.84	1.67	0.04	2.96	-	-	-
Diospyros exculpta Buch.-Ham.	1.5	4.59	2.95	1.75	3.57	2.24	4.5	9.17	2.43	-	-	-	-	-	-
Diospyros montana Roxb.	2	1.02	0.54	-	-	-	1	2.55	1.74	-	-	-	-	-	-
Elephantopus scaber (L.)	1	0	0.4	1	0	0.	1	0	0.	1	0	0.8	-	-	-

			1			44			64			7			
Erycibe paniculata (Roxb.)	2	18.41	1.69	2.33	64.4	6.26	1.25	24.9	2.56	-	-	-	-	-	-
Euphorbia hirta L.	-	-	-	-	-	-	-	-	-	-	-	-	6.33	0.01	9.54
Evolvulus nummularius(L.)	-	-	-	-	-	-	-	-	-	-	-	-	3	0	9.29
Ficus microcarpa (L. f.)	1	19.9	1.72	-	-	-	-	-	-	-	-	-	-	-	-
Flacourtia indica (Burm. f.) Merr	2	0.06	0.48	2	0.06	0.52	-	-	-	-	-	-	-	-	-
Gardenia latifolia Ait.	1	7.17	0.88	1	7.17	0.95	-	-	-	-	-	-	-	-	-
Gmelina arborea Roxb.	1	4.98	0.73	1	4.98	0.8	1	3.18	0.48	-	-	-	-	-	-
Helicteres isora (L.)	1	0.02	1.22	1	0.01	0.44	1.5	0.01	0.69	1	0.01	0.88	-	-	-
Hemidesmus indicus (L.) R. Br.	13.5	0.1	12.68	5.1	0.04	7.53	16.2	0.21	10.8	3.67	0.07	8.1	-	-	-
Holarrhena antidysentrica (Heyne ex. Roth.) A. DC.	3	0.07	1.64	5	0.24	4.49	5.9	0.68	5.69	-	-	-	-	-	-
Hymenophyllum sp	-	-	-	-	-	-	7.3	0.05	6.35	-	-	-	-	-	-
Ichnocarpus frutescens (L.) R. Br.	2.5	0.06	3.06	2.5	0.08	4.43	5	0.12	3.13	2	0.01	1.06	-	-	-
Ixora arborea Roxb. Ex Smith.	1.75	0.45	3.7	2.78	0.8	5.23	4.56	1.31	4.55	-	-	-	-	-	-
Ixora pavetta Andr.	1	0.03	0.41	-	-	-	1.67	0.36	1.08	-	-	-	-	-	-
Lannea coromandelica (Houtt.) Merr.	1.75	16.05	4.72	1.86	14.9	4.6	3.57	28.7	4.56	2.33	2.32	3.62	-	-	-
*Lantana camara*L.	-	-	-	-	-	-	-	-	-	-	-	-	1	0.04	7.08
Legerostroemia parviflora Roxb.	1.33	12.74	2.13	2	19.1	2.92	1.33	10.3	1.52	-	-	-	-	-	-
Lygodium sp	-	-	-	2.5	0	1.11	2.5	0	0.79	-	-	-	-	-	-
Madhuca latifolia (Roxb.) Macb.	3.29	73.25	8.77	2	38.2	5.84	3.3	105	9.52	-	-	-	-	-	-
*Mikania scandens, auct.*non.Willd	-	-	-	-	-	-	-	-	-	-	-	-	2	0.01	3.41
Morinda tomentosa Heyne ex Roth	1	1.15	0.48	-	-	-	1	4.08	0.84	-	-	-	-	-	-
Oxalis corniculata Linn.	-	-	-	-	-	-	-	-	-	-	-	-	32.5	0.02	18
Phoenix acaulis Linn.	3.8	1.21	6.07	4.44	1.27	6.41	3.33	8.6	4.36	1.5	0.32	4.52	-	-	-
Pterocarpus marsupium Roxb.	0.5	1.15	0.82	-	-	-	2.4	3.44	2.13	-	-	-	-	-	-
Schleichera oleosa (Lour.) Oken.	2.33	0.89	1.55	1.67	0.64	1.52	5	9.95	5.7	2	0.42	1.24	-	-	-

Semecarpus anacardium (L.f.)	2	3.18	1.16	3	2.39	0.76	2.57	14.3	3.5	1.67	1.06	3.39	-	-	-
Shorea robusta Gaertn. f.	19.9	1242	98.79	17.1	1067	93.5	24.1	1504	88.5	-	-	-	-	-	-
Sida acuta Burm. F.	-	-	-	-	-	-	-	-	-	-	-	-	2.33	0.01	7.12
Sida cordifolia (L.)	2.25	0.01	1.97	1.25	0.01	1.83	4.88	0.11	4.12	1	11.94	5.98	1.5	0.01	8.43
Solanum xanthocarpum	-	-	-	-	-	-	-	-	-	-	-	-	0.5	0	4.49
Soymida febrifuga A. Juss.	1.75	16.05	4.72	3.63	33.3	7.51	2.13	19.5	3.98	1	1.91	1.69	-	-	-
Streblus asper Lour.	1.67	0.01	1.36	2.6	0.02	2.81	1.5	0.04	2.08	-	-	-	1.5	0.02	9.15
Syzygium cumini (L.) Skeels	2	3.18	1.16	2.33	5.57	2.02	-	-	-	-	-	-	-	-	-
Tamilnadia uliginosa (retz.) Tirveng. & Sastre	5	2.55	0.85	-	-	-	-	-	-	-	-	-	-	-	-
Terminalia bellirica (Gaertn.)Roxb.	-	-	-	-	-	-	1.67	63.7	4.19	-	-	-	-	-	-
Terminalia chebula (Gaertn.)Retz.	-	-	-	-	-	-	1.88	107	8.2	1	21.23	9.96	-	-	-
Terminalia tometosa Cl.	2.88	26.37	6.02	1.88	17.2	5.28	2.56	26.4	4.89	2	5.31	4.35	-	-	-
Tribulus terrestris Linn.	-	-	-	-	-	-	-	-	-	-	-	-	4	0	2.9
Triumpfeta rhomboidea Jacq.	-	-	-	-	-	-	-	-	-	-	-	-	2.67	0.02	7.81
Urena sinuata (Linn.)	7.67	0.2	7.8	2	0.03	2.58	3.56	0.09	4.05	3.5	0.14	7.94	1.33	0.02	7.17
Vangueria spinosa Roxb.	3.57	0.07	4.09	10.3	0.24	9.19	18	0.83	10.5	2.83	0.14	7.22	-	-	-
Vernonia cineria (L.) Less.	3.17	0.02	3.34	3.2	0.02	3.04	1.33	0.01	1.02	3	0.03	6.8	-	-	-
Woodfordia fruticosa (L.) Curz.	2.33	0.89	1.55	2	0.51	1.07	2.33	2.68	3.63	-	-	-	-	-	-
Ziziphus mauritiana Lamk.	1.33	27.01	1.42	2	2.04	1.18	7	1.78	1.33	3	11.46	6.69	-	-	-
Ziziphus oenoplia (L.) Mill.	7.57	0.17	6.05	1.71	0.14	3.46	2.29	0.18	2.71	4	12.18	27.08	-	-	-

Leaf fall is also minimum in these two man-made forest types. Semi man made forest is, however, an admixture of plants like *Ziziphus oenoplia, Semecarpus annacardium, Bridelia retusa, Lannaea coromandelica, Terminakia tomentosa, Phoenix aculis, Cleistanthus collinus* etc. *Chromolaena odorata, Clerodenron viscosum, Urena lobata, Vangueria spinosa, Vernonia cineria* and species of *Sida* are most predominant herbs and undershrubs in the semi man made forest (SMMF). On the other hand *Chromolaena odorata* was most predominant undershrub in Man made forest (MMF) with species like *Mikania scandens, Triumpfeta rhomboidea, Solanum*

xanthocarpum, *Sida cordifolia*, *Tribulus terrestris*, *Oxalis corniculata* and *Biophytum sensitivum* are some of the representative of man made forest (MMF).

Table – 2 gives the name of some plants that occurred in pristine forests but did not fall in the quadrats sampled. They in fact fell in the in between areas of the quadrats. Though these plants were not included in our diversity and other calculations but considering their pharmacological importance we find it important to mention here. Most of these plants that have been enlisted in table - 1 and 2 are in accordance with the web report of forest department and with the Flora of Bankura District by M. N. Sanyal (1994)[3]. This article is significant as it takes a quantitative approach to characterize the forest area and that too in the aspect of forest management.

Table – 2: Plants occurring in the inter-quadrat zones in pristine forests –

	Name	Family	Frequency
1.	*Olax scandens* Roxb.	Olacaceae	++
2.	*Ehretia laevis* Roxb.	Ehretiaceae	+
3.	*Tamilnadia uliginosa* (Retz.) Tirveg. & Sastre	Rubiaceae	+
4.	*Polyalthia suberosa* (Roxb.) Thw. Enum.	Anacardiaceae	+
5.	*Prosopis cineria* (L.) Druce	Fabaceae	+
6.	*Passiflora foetida* L.	Passifloraceae	++
7.	*Mimosa rubicaulis* Lamk.	Mimosaceae	+
8.	*Ficus benghalensis* L	Moraceae	+
9.	*Celastrus scandens* L.	Celastraceae	++
10.	*Mitragyna parviflora* (Roxb.) Korth.	Rubiaceae	+
11.	*Seseli diffusum* Roxb. Ex. Sm.	Apiaceae	+
12.	*Pentanema indicum* (L.) Ling	Asteraceae	+
13.	*Coldenia procumbens* L.	Boraginaceae	+
14.	*Cassytha filiformis* L.	Lauraceae	+
15.	*Indigofera prostrate* Willd.	Papillionaceae	+

+ few, ++ some

Species diversity which is an expression of the community structure has been measured here using Jack-knife method (Zahl, 1977)[18]. However, it has been finally expressed according to Shannon index[21]. It's a relatively newer approach and is particularly useful in the studies of forest biodiversity where drawing simple random sample is difficult. In the face of the restrictions imposed by field conditions on sampling, there is an usual statistical inference problem while estimating an index of diversity or functions; the question is, how to estimate it? Despite this, sampling distributions for the Shannon index (1948) have been used to calculate by

Good (1953)[22] and Basharin (1959)[23] assuming simple random sample. Pielou (1966)[11] had begun to account for the actual field conditions of sampling by means of a sequential estimate of the Shannon index. A similar sequential approach had also been taken by Monk and McGinnis (1966)[24] for the ratio of number of log number of individuals. The order (which is the number of species) thus affects the results. Heyer and Berven (1973)[25] have extended Pielou's (1966) method. Later Zahl (1977) took a further step in the direction taken by Pielou (1966) and Heyer and Berven (1973)[26] by applying the so-called jackknife method[18] to the estimation of the diversity index. This method automatically takes into consideration of the restrictions laid by field sampling and can provide a better way to answer the questions regarding further statistical interest. The method that has been employed is shown in the materials and method section of this article. Figure – 1 gives a comparative account of the species diversity after this jack-knifing. It also shows the difference of species richness and evenness among the different forest types. We can see that the Latiaboni forest being most diverse with a Shannon index of 2.92 where as the Man made Forest has the minimum Shannon diversity index of 1.9. Although the Shannon index of semi man made forest is nearer to the Hanspahari forest and Deuli forest, its species richness is much less than the former two. All these data give a better interpretation of the vegetation characteristics.

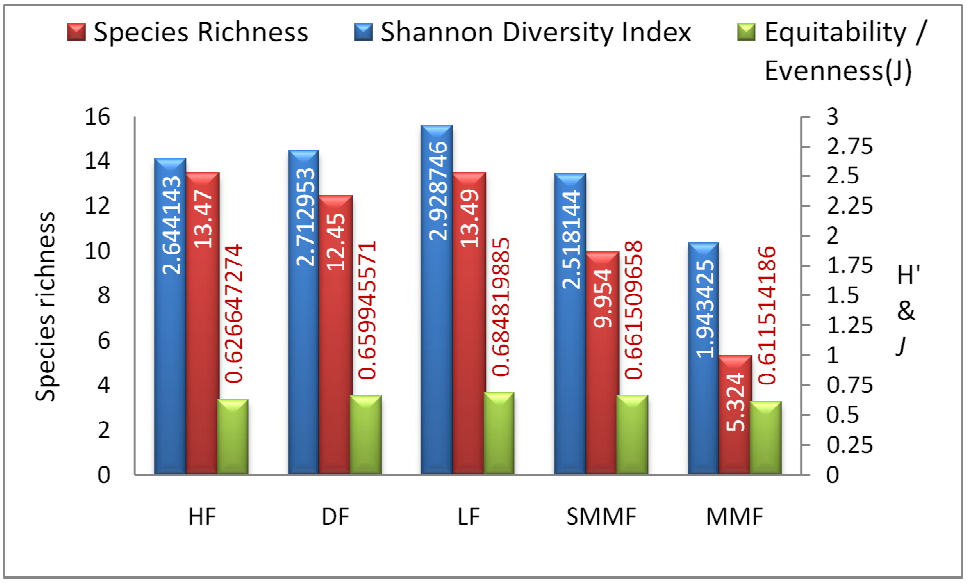

Figure – 1; Comparison of Shannon Diversity Index (H'), Species Richness and Evenness (*J*) among five different forests under study

Table – 3 shows the similarity matrix which gives the idea about forest to forest similarity. It is seen that the three pristine forests being a component of one main forest have close similarity values ranging from 84 – 90%. Deuli and Hanspahari forests are in fact 90% similar. On contrary to these both semi man made and manmade forests both are very much dissimilar to the three pristine forests. A relationship tree was created among these five forest types on the basis of mutual distance between each (Figure – 2).

Table – 3; Similarity Matrix (Sorensen, 1948[19] and Odum, 1950)[30]

HF	100				
DF	89.92	100			
LF	87.14	84.21	100		
SMMF	72.56	73.58	71.79	100	
MMF	13.33	16.47	16.66	26.86	100
	HF	DF	LF	SMMF	MMF

The physicochemical analyses of the underlying forest floor was also done with respect to pH, electrical conductivity (EC), Total carbon and nitrogen and their ratio, water content and water holding capacity etc (Table – 4). Correlation between these physicochemical parameters with the Shannon diversity index of the five forests were done through linear regression in excel (Figure – 3). The significance level was tested by one way ANOVA analyses (Table-5). As far as pH, EC and water holding capacity (WHC) of each of the soil types collected from these five different forest types are concerned, they have a positive correlation with diversity index. On the contrary, water content has a negative correlation. Effect of total nitrogen on the diversity level is almost negligible, however, total carbon and its ratio with the nitrogen has a positive correlation to some extent. Now, water content may vary because the soils were collected during different seasons but the water holding capacity which measures the porosity of the soil as well was determined after drying the soil completely. So, it gives the actual idea about the porosity. We can see that more diverse the forest is more is its water holding capacity, greater EC and greater C/N ration.

Table – 4; Similarity Matrix

	HF	DF	LF	SMMF	MMF
pH	4.655	4.771	4.755455	4.603333	4.0675
EC (µS/cm)	44.2	39	35.6	23	18
Total C (mg/ml)	13.45	42.57	29.29909	11.175	12.8675
Total N (ppm)	30.411	15.82	41.732	35.24333	30.31
C/N	0.442274	2.690898	0.702077	0.317081	0.42453
WC (g)	0.6621	0.5623	0.562	0.856667	1.235
WHC (g)	1.3504	1.645	1.472	1.305417	1.223125

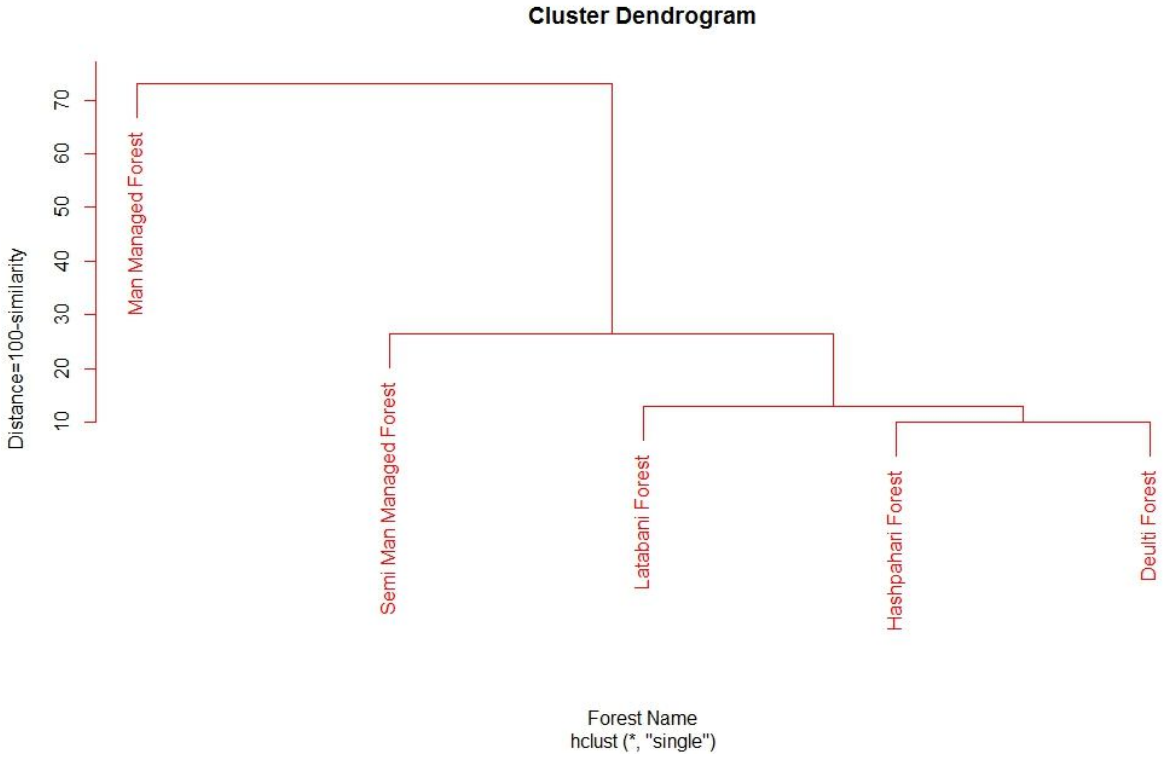

Figure – 4; Relationship tree on the basis of mutual distance

Mineralization and nutrient dynamics that includes the levels of C, N and P etc. in addition to the other element largely depends on the litter quality of the forest (Santa Regina)[27]. One of the measure of mineralization is C and C/N ratio. Its high concentration in the pristine forests is in accordance with Wifoon et al 2014[28]. The amount of organic carbon in forest floor is a result of balance between two process – annual C input that is added to the soil by litter fall and

annual C output released by microbial degradation. A shift to the right means high microbial activity Anne De Marco[29].

Table – 5; One way ANOVA for some physicochemical data -

	ANOVA						
	Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
pH	Between Groups	1.573389	4	0.393347	1.190009	0.332311	2.641465
	Within Groups	11.56895	35	0.330541			
EC	Between Groups	3029.9	4	757.475	4.487411	0.004948	2.641465
	Within Groups	5908	35	168.8			
Total C	Between Groups	2012.826	4	503.2065	1.386772	0.258596	2.641465
	Within Groups	12700.16	35	362.8618			
Total N	Between Groups	1802.891	4	450.7228	1.93595	0.12621	2.641465
	Within Groups	8148.608	35	232.8174			
C/N	Between Groups	7684.801	4	1921.2	66.91957	6.62E-16	2.641465
	Within Groups	1004.818	35	28.7091			

CONCLUSION –

A number of inferences can be drawn from above study. One, the overall diversity of the pristine forests are greater than the semi and total man made forests with the man made forest with monoculture being minimum. Two, it has got impact on the under canopy soil properties that might have a long lasting effect. Three, this study is a reminder of the alarming situation when you claim to rehabilitate cut down forests with a monocultures of *Acacia* or *Eucalyptus*. Afforestation with mixed culture particularly with the plants of that area is recommended.

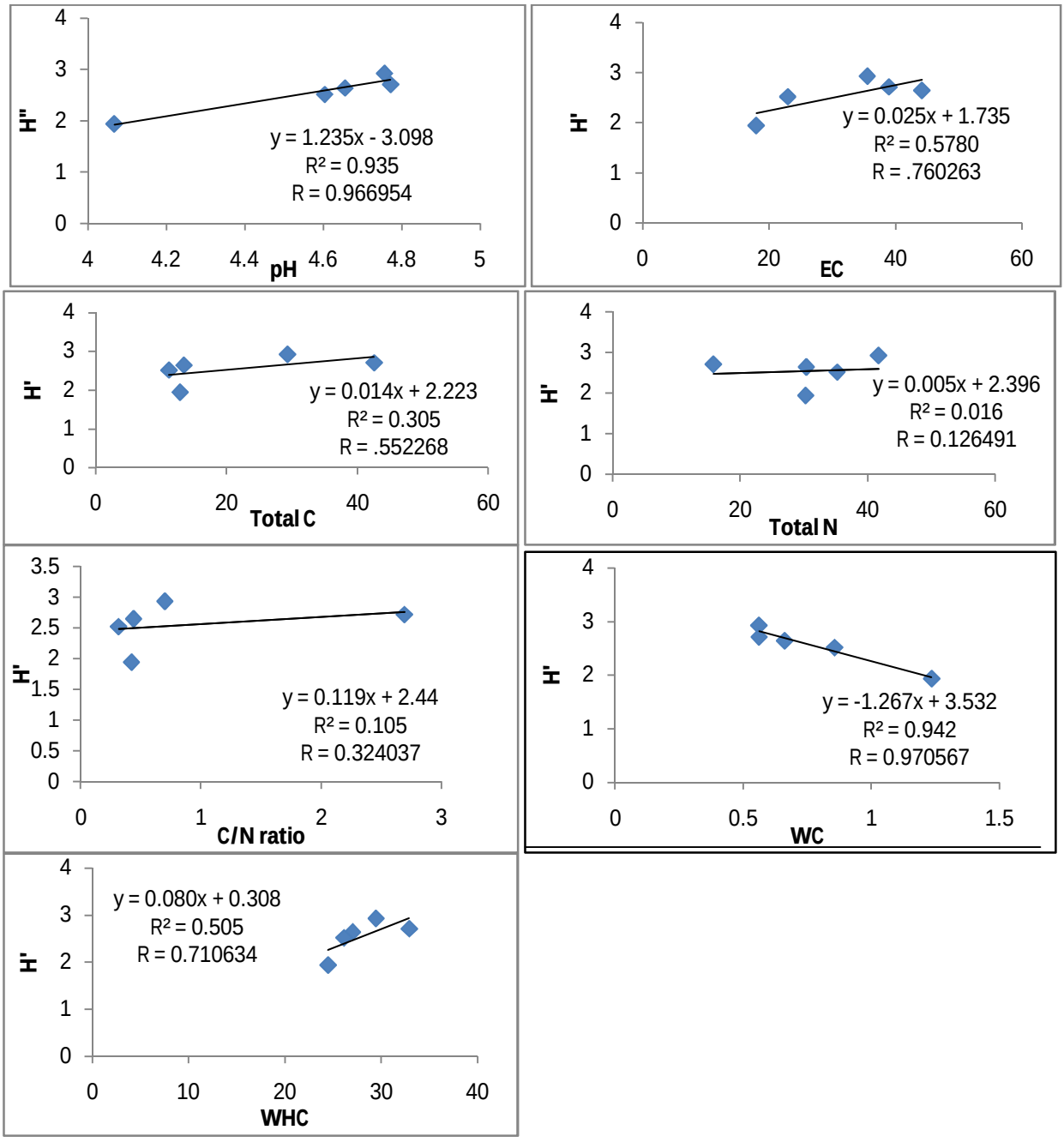

Figure – 3: Linear regression curves showing correlation between the Shannon diversity index (H') and different changing soil parameters viz, pH, EC, total C, total N, C/N ratio, water content (WC) and water holding capacity (WHC)

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