Study of biodiversity of grassland ecosystem through various diversity indices

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Abstract:

Biodiversity, a multidimensional property of natural ecosystems, is difficult to quantify partly because of the multitude of indices proposed for this purpose. Diversity Indices aim to describe general properties of communities that allow us to compare different regions, taxa, and trophic levels. Therefore, diversity indices play a fundamental role in environmental monitoring and conservation, although there is no consensus about which indices are more appropriate and informative. We normally use common diversity indices of species richness (S), Shannon's diversity (H'), Simpson's diversity (D1), Simpson's dominance (D2), Simpson's evenness (E) for community analysis. So far, there is no comprehensive phytosociological study on grassland ecosystems of Allahabad area have been undertaken. Using the diversity indices, the objective of the present study was to quantify the grassland community in Allahabad area to generate baseline information on the distribution patterns and composition of the species of grasslands in the District. This will also support long term conservation strategies and species level monitoring of biodiversity in Allahabad. The present effort is to study the grassland diversity in Allahabad area to channelize the conservation strategy for biodiversity of Allahabad.

Key words: Biodiversity, Diversity indices, grasslands,

Introduction:

Grassland ecosystem is critical for survival of herbivores and plays an important role in conservation and management of wildlife. These habitats are widely studied for various issues, including biodiversity, biomass assessment, carrying capacity, etc. Conservation of grassland is necessary to maintain biodiversity and to provide nutritious forages and to arrest desertification. Grassland vegetation differs from forests in that the above ground vegetation is completely renewed each year. The length of growing season in tropical grasslands is determined by duration of rainy season. The increasing human and livestock populations have caused a serious stress on the grassland resources. Investigation of species composition and sociological interaction of species in communities are integral part of vegetation ecology (Mueller-Dombois and Ellenberg, 1974). It is necessary to conduct the phytosociological studies to understand the current status of vegetation, species richness, diversity, explain or

predict its pattern, relationships, classification and distribution of plant communities for proper planning and conservation.

Ecological diversity includes the variation in both terrestrial and aquatic ecosystems. A study of grassland ecosystem diversity deals with the variations in ecosystems within a geographical location and its overall impact on human existence and the environment. Ecological diversity is a type of biodiversity. It is the variation in the ecosystems found in a region or the variation in ecosystems over the whole planet. Ecological diversity can also take into account the variation in the complexity of a biological community, including the number of different niches, the number of trophic levels and other ecological processes. An example of ecological diversity on a global scale would be the variation in ecosystems, such as deserts, forests, grasslands, wetlands and oceans. Ecological diversity is the largest scale of biodiversity, and within each ecosystem, there is a great deal of both species and genetic diversity.

Diversity increases with a decrease in the ratio of antithermal maintenance to biomass. i.e. R/B ratio or ecological turnover. (Schrodinger ratio). According to Fischer and Simpson- older community have greater species abundance than new. And community in tropics are much evolved and diversified due to constant climate. Simpson gave index for calculation of diversity of a community and said that more complex and heterogeneous the physical environment the more complex and diverse would be the flora and fauna. The degree of dominance is expressed by the index of dominance & it was given by Simpson 1949. Diverse plant communities can be more resistant to disturbances (McNaughton 1985, Tilman and Downing 1994).

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ungrazed lands (Milchunas et al. 1988) Aldo Leopold (1924) was among the first to recognize that livestock grazing can result in reduced fire frequency. Cooper (1960) echoed Weaver's concerns, stating that "The overuse and mismanagement which followed introduction of livestock into the West produced profound changes, some of them permanent, in the plant cover.

The ecological explanations for the occurrence of grasslands are linked to two primary structuring forces that operate in different directions: competition for canopy space and grazing pressure (Diaz et al. 1992, in Mucina et al. 2006). Besides herbivory rainfall, temperature, soil type, and fire are further major determinants of grassland structure and these are strongly interactive (Walker 1993, in Mucina et al. 2006). Wilsey et al. –the value of species richness as a measure of biodiversity, but they noted that other measures do have important additional information. Reitula et al. (2009) report that interpretations of changes in small-scale (50 x 50 cm plots) patterns of biodiversity in semi-natural grasslands depend on whether one is assessing species richness or species evenness. For example, grassland plant species richness was positively associated with present-day availability of grassland species in the surrounding landscape, whereas evenness was mainly related to the historical landscape. Controlling factors may not simply be switched on or off to reset diversity. Loss of richness may not always be reversible (Lunt et al. 2009).

Ingression of woody native species, into grasslands is reported widely across the world (Knoop and Walker 1985; Bush and Van Auken 1986, 1989; McPherson et al. 1988; Grover and Musick 1990; Archer 1994; Wilson 1998; Van Auken 2000; `Polley et al. 2002) Knoop and Walker (1985), followed by Bahre (1995), reported that reduced fire frequency in Arizona grasslands can be correlated with reduced grassland biomass and increased density of woody plants. Investigation of species composition and sociological interaction of species in communities are integral part of vegetation ecology (Mueller-Dombois and Ellenberg, 1974).

The impact of grazing on the productivity, mineral status has been explained by studying the biomass structure and minerals status of the grazed grassland of Allahabad area. In the present study an attempt has been made to evaluate the impact of grazing on biomass structure and function, and productivity of a Grazed grassland

Human activities have mainly affects the grassland all over the world and much of the area has been converted in to agricultural land. As a result of excessive human interference, it is difficult to locate virgin grassland in our country.

So far, there is no comprehensive phytosociological study on grassland ecosystems of Allahabad area have been undertaken. The objective of the present study was to generate baseline information on the distribution patterns and composition of the species of

grasslands of Allahabad District in order to support long term conservation strategies and species level monitoring. Also, the role of herbivores in controlling plant species richness is a critical issue in the conservation and management of grassland biodiversity. The study emphasized on the effects of grazing on the grassland diversity in the sampled area

Materials and Methods:

A. Area chosen for Study: Allahabad is located at 25.45°N 81.84°E in the southern part of the Uttar Pradesh at an elevation of 98 meters (322 ft) and stands at the confluence of two, the Ganges and Yamuna. The city of Allahabad is located at the end point of the Yamuna River and is a section of the Ganga-Yamuna Doab. The area under study are given in the table 1

B. Sampling schedule and Abiotic conditions

Table 1: Sampling schedule

S No	Area	Soil type	Dates of sampling	Time	Temperature
1	C.MP Degree College, Allahabad, U.P	Clay loam	18-January-2018,	11:00am - 4:00pm	20°C
			28-January-2018	11:00 am - 4:00 pm,	23 °C
2	K.P. Inter College, Allahabad, U.P	Clay loam	19-January-2018,	11:00 am - 4:00 pm	20 °C
			29-January-2018	11:00 am - 4:00 pm	24 °C
3	Yamuna river bank, Allahabad, U.P	Sandy loam	20-January-2018	11:00 am - 4:00 pm	21 °C
			30-January-2018,	11:00 am - 4:00 pm	25 °C
4	Cantonment Area, Bamrauli, Allahabad, U.P	Clay loam	21-January-2018	11:00 am - 4:00 pm	22 °C
			31-January-2018	11:00 am - 4:00 pm	28 °C

C. Sampling Method:

Quadrat Method: I have selected Quadrat method for sampling.

Sampling is a process used in statistical analysis in which a predetermined number of observations are taken from a larger population. The methodology used to sample from a larger population depends on the type of analysis being performed. A quadrat is a sample plot of a specific size used for the study of population or a community. Quadrats are used in many different scientific disciplines like vegetation assessment, including plant density, plant frequency and plant biomass.

I have followed following rules while sampling.

1. Random sampling was done eliminating personal choice in the selection of a sample. So that every part of the sample area should have an equal chance of being sampled every time you go to take a sample.
2. The area that is chosen for study must not be so big that it cannot be sampled adequately, or so small that the habitat is difficult for sampling.
3. For herbaceous vegetation a meter square quadrat was used.
4. After setting up quadrats, the number of individuals within the boundaries of each one was counted and recorded in a sampling register.
5. Multiple quadrat samples are performed throughout the habitat at several random locations, which ensures that the numbers recorded are representative for the habitat overall.
6. In the end, the data can be used to estimate the population size and population density within the entire habitat.
7. In each sampling 10 quadrats were studied.

D. Parameters used for calculations:

Following parameters were calculated from the data recorded

1. **Frequency** =

$$\boldsymbol{Frequency}(\%) = \frac{\boldsymbol{number\ of\ sampling\ units\ in\ which\ a\ species\ has\ occurred} \quad \boldsymbol{x\ 100}}{\boldsymbol{total\ number\ of\ sampling\ units\ studied}}$$

After calculating the frequency, the Frequency class is allotted as per Raunkiaer's frequency class

Frequency %	Frequency Class
0-20%	A
21-40%	B
41-60%	C
61-80%	D
81-100%	E

>

Such that A > B > C = D < E

Frequency class was allotted as per Raunkiaer's system to find whether a vegetation is homogenous or heterogenous. If classes B C and D in the frequency diagram are comparatively higher than their respective values in normal frequency diagram then the vegetation is heterogenous. Higher the value of class E (as compared to its normal frequency diagram) greater will be the homogeneity in the system Frequency can be defined as the degree of uniformity of the occurrence of individual of species within a plant community

2. **Density:** Frequency doesn't gives a clear picture of distribution of any species unless it is correlated with other characters like density Density gives an idea of competition in the species Density represents the numerical strength of a species in the community, it is represented in terms of Number of Individuals per unit area. Density is an ecological parameter which signifies the numerical strength of field, it signifies about how dense the population is in particular community

$$\boldsymbol{Density = \frac{total\ no\ of\ individuals\ of\ the\ species\ in\ all\ the\ sampling\ units}{Total\ no\ of\ sampling\ units\ studied}}$$

3. **Abundance** Number of individuals of any species per sampling unit of occurrence: Abundance is although related with density but it may not be expressed generally in quantitative terms. It represents the species richness and their dominance in the community.

$$\boldsymbol{Abundance = \frac{Total\ no\ of\ individuals\ of\ the\ species\ in\ all\ the\ sampling\ units}{total\ no\ of\ sampling\ units\ studied}}$$

4. **Degree of dominance: Simpson's index:** The degree of dominance is expressed by the index of dominance & it was given by Simpson 1949

$$\textbf{Simpson's index D} = \sum \left(\frac{ni}{N}\right)^2$$

Where n_i = importance value of a species in terms of number of its individuals, or biomass or productivity of each species over a unit area.

N= total corresponding importance of value of all the component species in same area & period

5. $\overline{H}$ **= SHANNON'S INDEX (INDEX OF GENERAL DIVERSITY)**

$\bar{H} = -\sum \left(\frac{ni}{N}\right) log\ \frac{ni}{N}$

Or $\sum Pi\ log\ Pi$

Where N= total number of important values

ni=importance of each species

Pi= importance proportion of each species=$\frac{ni}{N}$

6. **EVENNESS INDEX (E)=** Evenness index or equitability index: it is the proportion of individuals among different species in a community

$$e = \frac{\bar{H}}{log\ S}$$

Where $\overline{H}$ = Shannon's Index

S= No of species

7. **SIMPSON'S INDEX OF DIVERSITY (1-D)**

Simpson's index of diversity =1-D

Here also the value ranges between 0 & 1

But greater the value of 1-D greater is the sample diversity

The sampling was done in 4 different grassland areas and the readings of number of species occurring in each quadrat was recorded and presented in tables.

Table 1: Species found in CMP college campus Date: 18-January-2018; Time: 11:00 am - 4:00 pm; Temperature: 20 °C

s.no	Name of species	Total number of individual species (n)	Total no. Of quadrat in which species occur	Mean ± SEM	Abundance	Density	Frequency %
1.	***Cynodon dactylon***	610	8	61± 12.39	76.25	61	80%
2.	***Garangea maderaspatana***	208	2	20.8±14.0	104	20.8	20%
3.	***Heliotropium indicum***	22	2	2.2±1.71	11	2.2	20%
4.	***Alternathera sessilie***	41	3	4.1±3.25	13.67	4.1	30%
5.	***Rumex dentatus***	53	1	5.3± 5.3	53	5.3	10%
6.	***Sida cordifolia***	12	1	1.2± 1.2	12	1.2	10%
7.	***Parthenium hysterophorus***	45	5	4.5±3.23	9	4.5	50%
8.	***Brassica compestris***	1	1	0.1±0.1	1	0.1	10%
9.	***Centella asiatica***	3	1	0.3±0.3	3	0.3	10%
10.	***Polygonum plebeium***	21	1	2.1±2.1	21	2.1	10%
11.	***Eclipta prostrata***	15	1	1.5±1.5	15	1.5	10%
12.	***Ranunculus sceleratus***	67	1	6.7±6.7	67	6.7	10%
13.	***Malvestrum sp.***	5	1	0.5±0.5	5	0.5	10%
14.	***sp. 10***	1	1	0.1±0.1	1	0.1	10%
15.	***Majus pumilis***	2	1	0.2±0.2	2	0.2	10%
16.	***Medicago polymorpha***	63	1	6.3±6.3	63	6.3	10%
17.	***sp. 12***	43	1	4.3±4.3	43	4.3	10%
18.	***Launaea procumbens***	15	1	1.5±1.5	15	1.5	10%
Total no of individuals of all the species (N)							

Raunkiaer's frequency class: A class=……15……%; B class……1……; C class……1……; D class……1……; E class……0……

Now finding the % of these species falling into different frequency class –

$$\text{Frequency} = \frac{\text{No of species falling in frequency class}}{\text{total no of species record}} \times 100$$

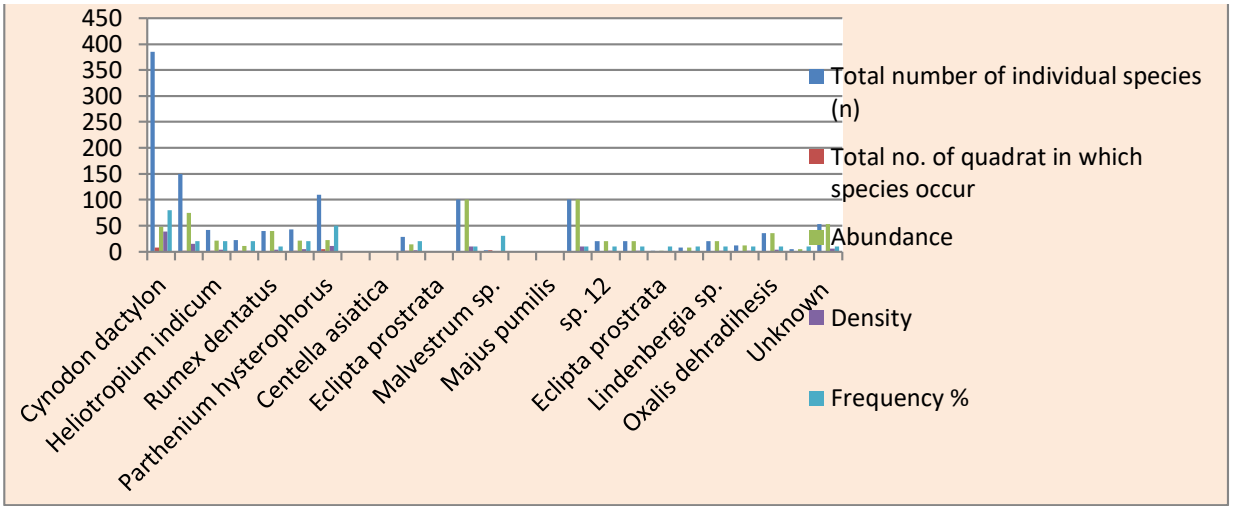
Frequency of class A= $\frac{15}{18} \times 100 = 83.33$

Frequency of class B= $\frac{1}{18} \times 100 = 5.55$

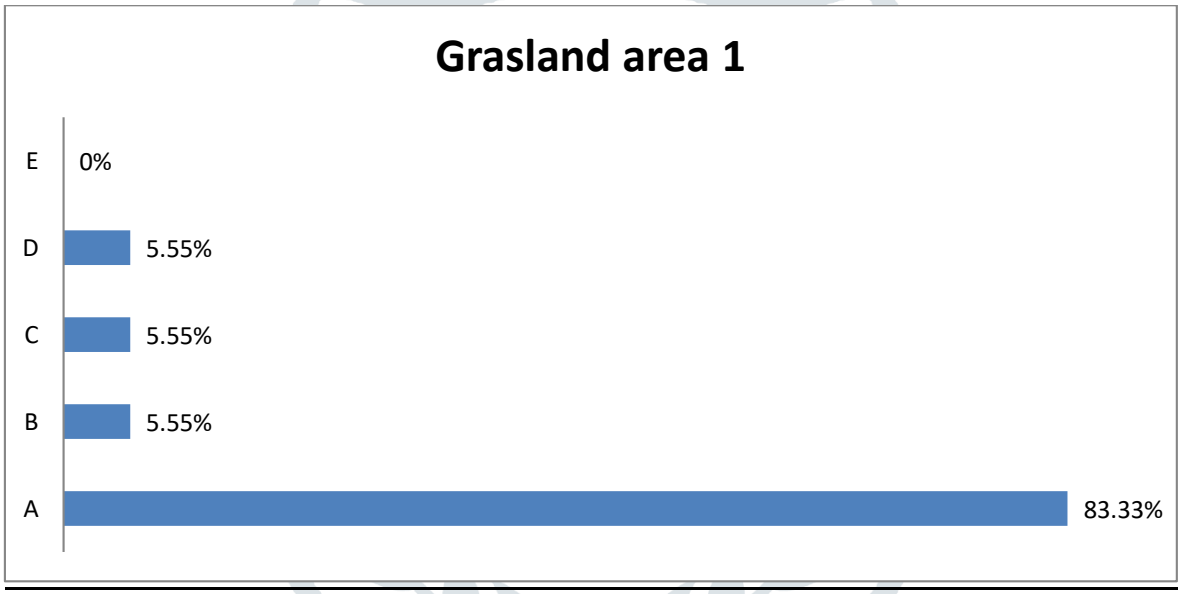
Frequency of class C= $1/18 \times 100 = 5.55$

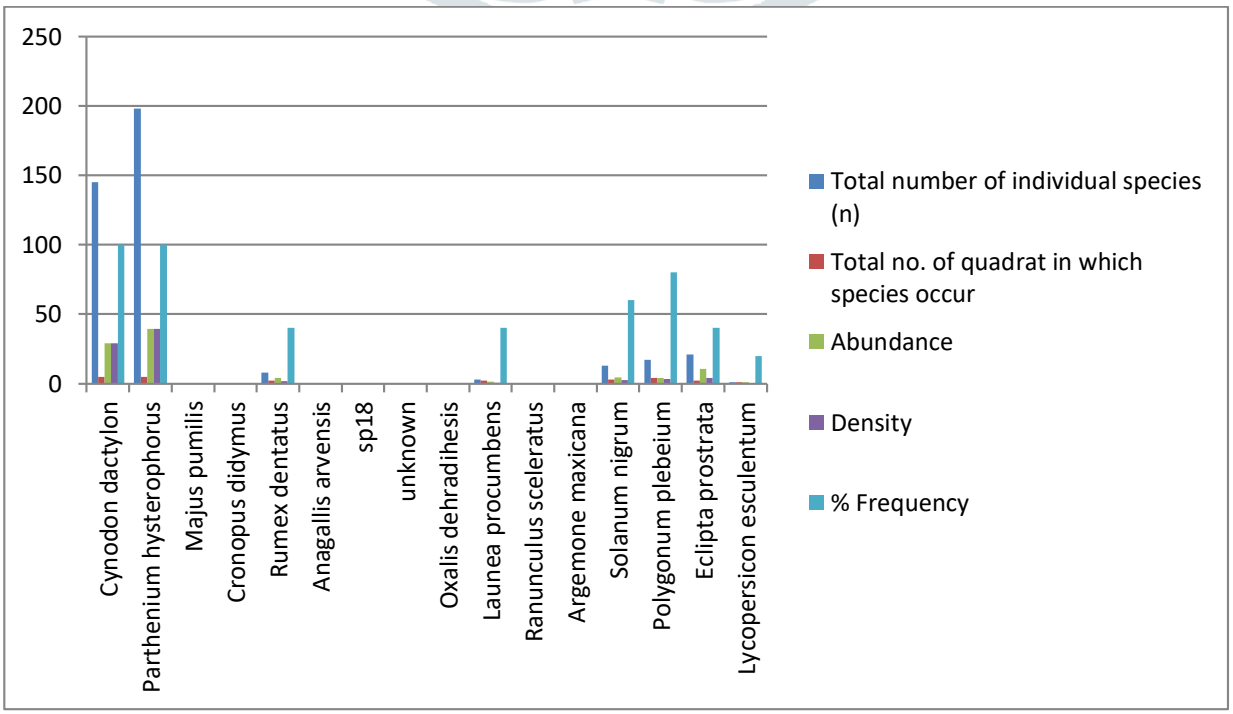
Frequency of class D = $1/18 \times 100 = 5.55$

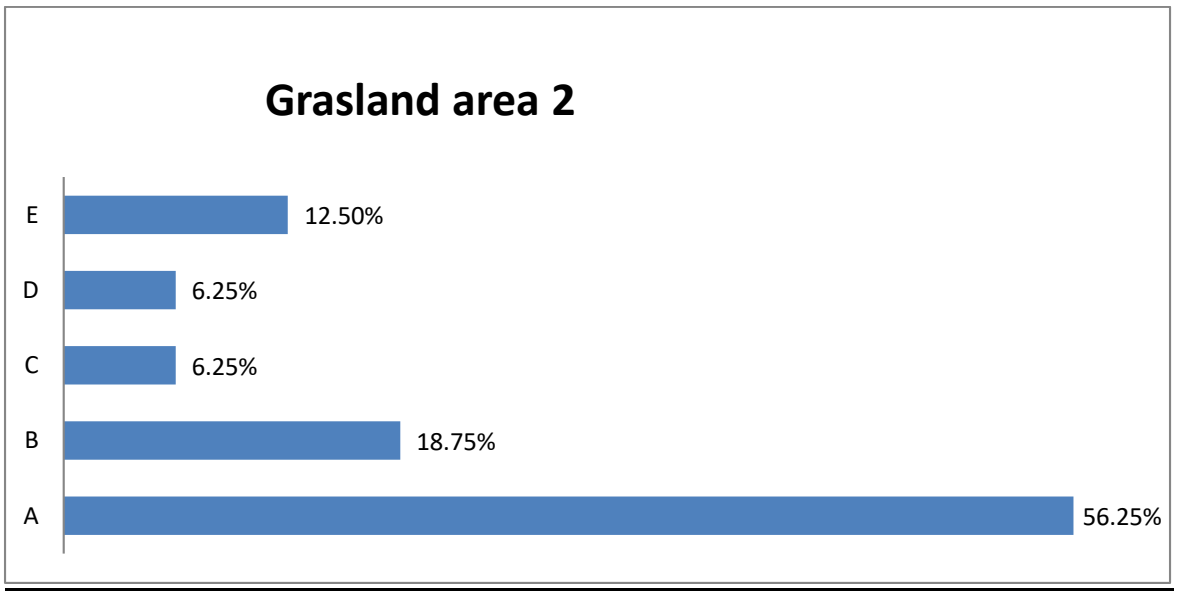
Frequency of class E= $0/18 \times 100 = 0$



Observed Raunkier's Frequency







Results and discussion

On the basis of above observation I it clear that there is a lot of species diversity and It was found that there is rich grassland diversity in grassland communities in Allahabad area. However the dominance of species in different grassland is variable in different areas surveyed.

Dominant for grass in CMP college the dominant species is *Garangea maderaspatana* (208 individuals), While in KP college the dominant species is *Oxalis dehradihesis* 195. Also some of the species were absent in the same area after After 10 days this indicates loss due to grazing by herbivorus animals. It was observed that in second survey there was addition of some new species in the same area. This shows that the grassland ecosystems are dynamic and in process of constant change in species diversity and dominance.

It was also found that the abundance of two different species in a community was same for e.g. In second survey of field in C.M.P Degree College The *Madicago polymorpha* and *Ranunculus sceleratus* show same no individual species i.e. *100*

A comparison of total density and abundance of grasslands it was found that maximum abundance is found in second survey of C.M.P Degree College = 629.625 while minimum abundance is found in second survey of Field Near bank of Yamuna river = 68.376. Maximum density of grasses was is found in first survey of Cantonment area = 137.5 while minimum density is found in first survey OF Field Near bank of Yamuna river = 40.5 it was seen that abundance was greater than density for every grassland

A comparison of Frequency Class of different grassland with Raunkier's Frequency diagram. It was fiound that the value of E class is. 30.76% in *first survey of field in* KP college Ground the is higher than the Raunkier's Frequency class E value i.e. 16% . The higher value class

E denote that the community is homogenous. While the grassland turned out to be heterogenous in second survey with the value of E class is (12.50%) is lower than the Raunkier' s Frequency class E value i.e. 16% .

All other grassland community under study were heterogeneous, but in *in first and second survey of Field Near bank of Yamuna river* the value of class E is near about equal to the Raunkier' s Frequency class E value (16%) i.e. 15.38%

Where as in first and second survey of CMP College grassland the value of class E is 0 whereas the value of class A 83.33 % and 88 % respectively i.e. higher than the Raunkier' s Frequency class A value i.e. 53 %. the higher value of class A denote that the community is heterogeneous

The *first and second survey of field in Cantonment area* the value of class E and A are lower than the Raunkier' s Frequency class value E and A but the value of class C and B is highe. Higher values of class C and B community indicate that the community is heterogeneous .

Simpson's index (D):

Value of Simpson's index (D) is higher in first survey Of field *in Cantonment area i.e* - 0.378 while Value of Simpson's index D is lower in second survey of CMP College grassland i.e - 0.149, this indicates that the community in second survey of CMP College grassland has more divers whereas the community of *first survey OF Field in Cantonment area is less divers because the* Value of Simpson's index(D) is range between the 0 &1. 0 represent infinite diversity and 1 reperesent no diversity and Bigger the Value of Simpson's index(D) lesser is diversity.

The order of diversity as per values of D is cantoment 1 (0.378) < kp2 (0.371) < cantoment 2 (0.324) < cmp1 (0.288) < kp1 (0.233) < yamuna bank 2(0.177) < yamuna bank 1 (0.174) < cmp2 (0.149)

Simpson's index of Diversity = (1-D)

A comparison of all community in reference with Simpson's index of Diversity = (1-D), shows that cmp2 = 0.850 < yamuna bank 1 = 0.825 < yamuna bank 2= 0.822 < kp1 = 0.766 < cmp1= 0.711 < cantoment 2 = 0.675 < kp2 = 0.628 < < cantoment 1 = 0.621

it show that the comunty of in second survey of CMP College grassland more diverse whereas the community of *first survey of Field in Cantonment area is less divers because the* Here also the value ranges between 0 & 1. But greater the value of 1-D greater is the sample diversity

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