

Measuring Species diversity

Biological Diversity

- Biodiversity can be quantified in many different ways.
- Two main factors taken into account by ecologists are:
 1. Species richness
 2. Species evenness

Species Richness

- Is a measure of the number of different kinds of organisms present in a particular area.
- Species density or the number of species per m^2 is most commonly used to measure species richness.
- This is a simple count of the species in a community.
- Each species contributes one count to the total.

Flower Species Counts from Two Communities

	Numbers of individuals	
Flower Species	Community 1	Community 2
Daisy	300	20
Dandelion	335	49
Buttercup	365	931
Total	1000	1000

Species Richness for Two Flower Communities

Community	Species Richness
1	3
2	3

Species Evenness

- Evenness is a measure of the relative abundance of the different species making up the richness of an area.
- Evenness can be calculated as:

$$\text{Relative abundance} = \frac{\text{number of individuals of a species}}{\text{total number of individuals}}$$

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Species Evenness of Two Communities

	Numbers of individuals	
Flower Species	Community 1	Community 2
Daisy	0.30	0.02
Dandelion	0.34	0.05
Buttercup	0.36	0.93
Total	1	1

Biodiversity

- A community dominated by one or two species is considered to be less diverse than one in which several different species have similar abundance.
- As species richness and evenness increase, so does diversity.

Simpson's Index

- Simpson's Index is a calculation done by ecologists that is a measure of diversity which takes into account both richness and evenness of species.

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

n = the total number of organisms of a particular species

N = the total number of organisms of all species

Simpson's Index of Diversity

- The value of D ranges between 0 and 1.
- With this index, 0 represents infinite diversity and 1 represents no diversity.
 - The greater the value of D , the lower the diversity.
 - The less the value of D , the higher the diversity.

Using Simpson's index to measure biodiversity – a worked example

It may be easier to understand the use of Simpson's index with the following example. Consider three communities, each made up of a total of 100 organisms, drawn from combinations of ten species, A to J.

Community 1 has the highest diversity. It has the joint highest species richness (10) and each species has a similar relative abundance. Community 2 has the same species richness as community 1, but is dominated by one species (A) so that the diversity of this community is lower than in community 1. Community 3 has a lower diversity than community 1, due to its lower species richness.

Table 1 *Species composition of three different communities.*

Species	Community 1	Community 2	Community 3
A	10	72	35
B	9	6	34
C	11	3	31
D	10	3	0
E	8	1	0
F	12	3	0
G	10	4	0
H	11	3	0
I	10	2	0
J	9	3	0
Total	100	100	100

The formula for calculating Simpson's index is:

$$D = \frac{\sum n_i(n_i - 1)}{N(N - 1)}$$

Where N = the total number of all organisms

n_i = the numbers of individuals of each individual species

The lower the value of D, the greater is the species diversity. Take for example community 1 in the table 1 above. The values of $(n_i - 1)$ and $n_i(n_i - 1)$ in the computation of D are shown in table 2 opposite.

Table 2 Data for calculation of Simpson's index for community 1.

Community 1			
Species	n_i	$n_i - 1$	$n_i(n_i - 1)$
A	10	9	90
B	9	8	72
C	11	10	110
D	10	9	90
E	8	7	56
F	12	11	132
G	10	9	90
H	11	10	110
I	10	9	90
J	9	8	72
Total	$N = 100$		$\sum n_i(n_i - 1) = 912$

So for community 1:

$$D = \frac{912}{100 \times 99}$$
$$= 0.09 \text{ (high diversity)}$$

By the same method, the Simpson's index, D , for community 2 has been calculated and is shown in table 3 below.

Table 3 *Values for Simpson's index for communities 1, 2 and 3.*

Community	D	Level of diversity
1	0.09	Very high
2	0.52	Moderate
3		

Calculate the value of D for community 3 and insert these in the table. Show your working in the space below.

Simpson's Index Scale: Level of Diversity

1	no diversity
0.9	extremely low diversity
0.8	very low diversity
0.7	low diversity
0.6	moderate-low diversity
0.5	moderate diversity
0.4	moderate-high diversity
0.3	high diversity
0.2	very high diversity
0.1	extremely high diversity
0	infinite diversity

Shannon-Weiner Index

- Another commonly used index is the Shannon-Weiner Diversity Index (H).
- Mostly used in freshwater ecology

Shannon Index:

The index independently derived by Shannon and Wiener from the application of information theory is known as the Shannon index of diversity. It is sometimes incorrectly referred to as the Shannon – weaver index (Krebs, 1985).

The index assumes that:

- (a) All species are represented in the sample, and
- (b) Individuals are randomly sampled from an ‘indefinitely large’ population (Pielou, 1975).

It is calculated from the equation:

$$H' = - \sum p_i \ln p_i$$

Where p_i is the proportion of individuals found in the i th species. It is estimated as (n_i/N) . N is total number of individuals in S species. The value of **Shannon index usually varies between 1.5 and 3.5** and rarely exceeds 4.5. The value of H' is related to species richness but is also influenced by the underlying species abundance distribution.