2 GROUPS /4 people each:

Jumping Cornflakes – Simpson (BIO)Diversity Index

Estimating Ecosystems diversity

Problem: Which is the forest containing the highest plant biodiversity?

INTRODUCTION

Background:

Biological diversity can be quantified in many different ways. The two main factors taken into account when measuring diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. For example, species richness is the number of different species present. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present.

1. Richness

The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample.

Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives as much weight to those species which have very few individuals as to those which have many individuals. Thus, one daisy has as much influence on the richness of an area as 1000 buttercups.

2. Evenness

Evenness is a measure of the relative abundance of the different species making up the richness of an area.

To give an example, we might have sampled two different fields for wildflowers. The sample from the first field consists of 300 daisies, 335 dandelions and 365 buttercups. The sample from the second field comprises 20 daisies, 49 dandelions and 931 buttercups (see the table below). Both samples have the same richness (3 species) and the same total number of individuals (1000). However, the first sample has more evenness than the second. This is because the total number of individuals in the sample is quite evenly distributed between the three species. In the second sample, most of the individuals are buttercups, with only a few daisies and dandelions present. Sample 2 is therefore considered to be less diverse than sample 1.

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

A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance.

Goals:

In this investigation, you will **calculate biodiversity in two different ecosystems** to determine which of them is considered more diverse (so, more rich from an ecological point of view). You will then **estimate** such biodiversity using the Simpson Diversity Index. The accuracy of the Simpson Diversity Index will be inferred by counting the model populations.

Concepts:

As species richness and evenness increase, so diversity increases. Simpson's Diversity Index is a measure of diversity which takes into account both richness and evenness.

Simpson's Diversity Indices

The term 'Simpson's Diversity Index' can actually refer to any one of 3 closely related indices.

Simpson's Index (**D**) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating **D**. Either is acceptable, but be consistent.

$D = \Sigma (n / N)^2$	$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$

n = the total number of organisms of a particular species
N = the total number of organisms of all species

The value of **D** ranges between 0 and 1

With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give:

Simpson's Index of Diversity 1 - **D**

The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species.

Another way of overcoming the problem of the counter-intuitive nature of Simpson's Index is to take the reciprocal of the Index:

Simpson's Reciprocal Index 1 / **D**

The value of this index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. The higher the value, the greater is biodiversity. The maximum value is the number of species (or other category being used) in the sample. For example if there are five species in the sample, then the maximum value is 5.

The name 'Simpson's Diversity Index' is often very loosely applied and all three related indices described above (Simpson's Index, Simpson's Index of Diversity and Simpson's Reciprocal Index) have been quoted under this blanket term, depending on author. **It is therefore important to ascertain which index has actually been used in any comparative studies of diversity.**

To calculate Simpson's Index for a particular area, the area must first be sampled. The number of individuals of each species present in the samples must be noted.

For example, the diversity of the ground flora in a woodland, might be tested by sampling random quadrats. The number of plant species within each quadrat, as well as the number of individuals of each species is noted. There is no necessity to be able to identify all the species, provided they can be distinguished from each other.

How many samples?

ECOLOGICAL SAMPLING METHODS

As an example, let us work out the value of **D** for seven quadrat samples of ground vegetation in two different woodlands. Of course, sampling 5 quadrats per ecosystem would give you a reliable estimate of the diversity of the ground flora in the two woods. Several samples would have to be taken and the data pooled to give a better estimate of overall diversity.

	ECOSYSTEM 1 (pooled)		**ECOSYSTEM 2 (pooled)**	
Species	**Number (n)**	**n(n-1)**	**Number (n)**	**n(n-1)**
Woodrush	2	2	4	12
Holly (seedlings)	8	56	10	90
Bramble	1	0	12	132
Yorkshire Fog	1	0	8	56
Sedge	3	6	8	56
Total (**N**)	**15**	**64**	**42**	**346**

Putting the figures into the formula for Simpson's Index

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

ECOSYSTEM 1

$$D = \frac{64}{15(14)}$$

$$D = \frac{64}{210}$$

D = 0.3 (Simpson's Index)

Then:

Simpson's Index of Diversity 1 - D = 0.7

Simpson's Reciprocal Index 1 / D = 3.3

ECOSYSTEM 2

D= 346 / 42 (41) = 346 / 1,722= 0.2

D = 0.2 (Simpson's Index)

Then:

Simpson's Index of Diversity 1 – 0.2 = 0.8

Simpson's Reciprocal Index 1 / 0.2 = 5

ECOSYSTEM 2 (BIO) DIVERSITY > ECOSYSTEM 1 (BIO) DIVERSITY

ECOSYSTEM 2 IS MORE RESILIENT THAT ECOSYSTEM 1 (resilient ecosystems are better at recovery than fragile ecosystems)

These 3 different values all represent the same biodiversity. It is therefore important to ascertain which index has actually been used in any comparative studies of diversity. A value of Simpson's Index of 0.7, is not the same as a value of 0.7 for Simpson's Index of Diversity.

Simpson's Index gives more weight to the more abundant species in a sample. The addition of rare species to a sample causes only small changes in the value of **D**.

Materials:

- Colored cornflakes.
- White shopping bag.
- 5x5 (25) quadrats (25 floor tiles of 40x40 cm each placed in the classroom).

Procedure:

- We are going to calculate the Simpson Diversity Index for two different ecosystems showing different (bio) diversities. Both ecosystems will be represented by two 5x5 quadrats placed in two different corners of the classroom. Two white shopping bags will contain different numbers of individuals of different populations (each color represents a population or individuals belonging to the same species). There will be two groups working on the Simpson Diversity Index, and each group will start from a single white shopping bag and a single ecosystem (5x5 quadrats) to perform the experiment that is explained below.
- All members of each group should collect the results obtained.
- After these experiments, each member of each group will share the results with 1 member from each other experiments (three more people, four in total, see the other Simpson diversity index experiment group) for explanation and discussion of results.
- After discussion, you will proceed to the individual writing of the practice report.

Experiment #:

1. The cornflakes into the white shopping bag represent the biotic fraction of one ecosystem. Shake the bag and pour it as skillfully as possible over the 5x5 quadrant created by the floor tiles. If any colored cornflake is outside this 5x5 quadrant push it towards the nearest square and leave it there.
2. The colored cornflakes represent the different populations (one color = same species) in your habitat. **NOTE: Do not count the exact number**

of cornflakes for each species until the end of the experiment.

3. Without thinking too much, choose five quadrats and proceed to count individuals of each species in those 5 quadrants. Photos can be taken. Record the results for each color in the table below.
4. Choose another selection of 5 quadrats (any of the previous chosen quadrats may be included but you cannot move organisms included in them). Repeat counting and write it down in the table.
5. Repeat again step 4 (you will obtain 3 different trials).
6. Remember, it is important that no organism is removed from its original placement.
7. Using the Lincoln Index, calculate D, 1-D and 1/D for Trials 1-3 for this Experiment #.
1. DO NOT THROW AWAY YOUR CORNFLAKES/ORGANISMS YET!

DATA TABLE

	Trial #1			
	ECOSYSTEM 1 (pooled)		**ECOSYSTEM 2 (pooled)**	
Species	**Number (n)**	**n(n-1)**	**Number (n)**	**n(n-1)**
White				
Pink				
Grey				
Brown				
Orange				
Green				
Blue				
Total (**N**)				
	Trial #2			
	ECOSYSTEM 1 (pooled)		**ECOSYSTEM 2 (pooled)**	
Species	**Number (n)**	**n(n-1)**	**Number (n)**	**n(n-1)**
White				
Pink				
Grey				
Brown				
Orange				
Green				
Blue				
Total (**N**)				
	Trial #3			

	ECOSYSTEM 1 (pooled)		ECOSYSTEM 2 (pooled)	
Species	**Number (n)**	**n(n-1)**	**Number (n)**	**n(n-1)**
White				
Pink				
Grey				
Brown				
Orange				
Green				
Blue				
Total (**N**)				

Analysis Questions:

1. Record the obtained for the Simpson's Reciprocal Index for each trial here:

   Trial #1:

   Trial #2:

   Trial #3:

   a. Are there differences between the three trials performed within each ecosystem? Are they relevant?

   b. Discuss at least 3 factors that might affect the accuracy of your estimates.

2. Count the total number of cornflakes in your ecosystem. Count the number of individuals for each species.

Species	**ECOSYSTEM 1 Number (N)**	**ECOSYSTEM 2 Number (N)**
White		
Pink		
Grey		
Brown		
Orange		

Green		
Blue		
TOTAL		

Note and compare your results to those obtained from the other ecosystem.

3. What is your prediction regarding both ecosystems? Which should be the ecosystem showing the highest diversity, so, the highest Simpson's reciprocal Index? Why?

4. Calculate D, 1-D and 1/D values for your ecosystem. Note those obtained from the other ecosystem. Calculate averages. Include calculations for D

	ECOSYSTEM 1 (pooled)			**ECOSYSTEM 2 (pooled)**		
Species	**D**	**1-D**	**1/D**	**D**	**1-D**	**1/D**
Trial#1						
Trial#2						
Trial#3						
MEAN						

5. Why is 1 – D rather than D used as a measure of diversity?

6. 1 Why is 1/ D rather than D used as a measure of diversity?

7. Which of the two ecosystems shows greater variation between trials? Can it be related to the relative number of each species it contains and its dispersion? How?

8. Discuss about the resilience of both ecosystems. Which of the two ecosystems will be more fragile? Which of the two ecosystems will show a more complexity from the point of view of trophic webs?

9. Low values for 1/D in Arctic Tundra may represent ancient and stable sites as growth is so low there and diversity is low. May you explain how make the difference with another low 1/D value from another fragile ecosystem? What other observable factors would you support in establishing this difference related to ecological stability?

10. Name two biomes where 1/D values are high. Explain briefly why.