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Calculating Biodiversity

Introduction:
As you can imagine there is an enormous number of plants, animals, bacteria, and fungi on Earth. These living things occupy ecosystems. Ecosystems are areas where all the living things and the physical landscape (including weather) interact with and affect one another. For example, a change in the amount of salt in the water off the coast of Louisiana can affect whether or not oysters are able to grow and survive in a certain area. Understanding ecosystems is an important role of some scientists. Their research helps society make better decisions about the environment, conservation efforts, and laws that aid in protecting communities.

To better understand ecosystems a scientist may conduct studies that focus on the biodiversity of an ecosystem. **Biodiversity (or biological diversity)** is a term that describes the variety of living organisms found in an ecosystem. Usually when referring to biodiversity, scientists are talking about the variety of species in an ecosystem. However, biodiversity can also be used to refer to the variety of habitats and processes taking place in an ecosystem, or the genetic characteristics within just one species.

Biodiversity can be used as an indicator of ecosystem health. Ecosystems that have high biodiversity often are considered to be "healthier" than ecosystems that have low biodiversity. Since ecosystem health and function depend on the complex relationships and interactions of all living and non-living things in the system, the depletion or loss of any one species could have major effects. Communities that are more diverse are better able to recover from stressful events, like extreme weather changes, parasites and diseases, and natural disasters, because they are more likely to contain individuals that are more resilient to the impacts of those events.

Now let's examine how biodiversity is described. First, a scientist will need to collect information. In most cases this means doing field work which requires hours of sampling and identifying species. Once the information is collected from all the samples, a scientist can calculate species richness, species evenness, and a biodiversity index. Counting and identifying every single living thing in an ecosystem is impossible, impractical, and may be harmful to the community or the scientist. Sampling is usually done using something called a subsample, a common tool for this is called a quadrat. A quadrate allows scientists to collect enough information to meet their research goals and be representative of the entire ecosystem. Quadrats are a topic for another activity. Let's just focus on learning about species richness, species evenness, and biodiversity for this activity.

Make a Hypothesis

For this activity you will be determining the species richness, species evenness, and biodiversity of a representative community. We are going to call this community "Study Area 1". Before you begin, make some predictions based on your initial observations by looking at the diagram of "Study Area 1" and answering the questions below.

1. What are 3 things that you notice about the community of "Study Area 1"?

2. At first glance, do you think the community has a high biodiversity or a low biodiversity?

What is Species Richness?

Species Richness is simply the number of different species in an environment or a community. The abundance of each species or their distribution does not matter when calculating species richness.

Look at the diagram labeled "Study Area 1". If each shape is a different species, what is the Species Richness of this community? Write your answer in the space provided below.

"Study Area 1" has a Species Richness of ___________________

What is Species Evenness?

Species evenness refers to how similar the number of individuals within each species in the community are to each other. The total number of individuals of a species is called the **abundance** for that species. As an example, let's look at the data of two different communities.

Community A	
Species	**Abundance**
1	20
2	20
3	23
4	27
5	23

Community A is more "even" because the abundances are about the same for each of the 5 species. An example of this community might be the plants that occupy a swamp or fresh water marsh. Communities with evenness are generally more diverse.

Community B	
Species	**Abundance**
1	102
2	3
3	4
4	7
5	1

Community B has the same number of species (species richness) as Community A, but there is a big variation in the abundance among the species. This example could easily be something like a field of sugar cane or corn. Communities this uneven are generally less diverse.

Look once again at our "Study Area 1" diagram. This time you are going to count the abundances for each species. Follow the directions to complete the table. Remember that each shape is a different species.

Study Area 1	
Species	**Abundance**
Squares	
Circles	
Triangles	
Crescents	
Hearts	
TOTAL	

Step 1: Count the squares in "Study Area 1". Write that number in the table for the abundance for the squares.

Step 2: Do the same thing for the rest of the shapes.

Step 3: Add up all the abundances to get a total number of shapes found in "Study Area 1". Write the number in the table to the left.

Based on the results, is the community in "Study Area 1" even? _____________

Describing Biodiversity

Now that you understand what species richness and species evenness are, let's learn how to describe the biodiversity of a community. Earlier it was explained that counting and identifying every individual in a geographical area was impossible, impractical, and maybe harmful. Instead of trying to do the impossible, scientists will use something called a biodiversity index. A biodiversity index is a scale of the diversity in a study area. The index gives scientists a uniform way to talk about and compare the biodiversity of different areas.

There is more than one biodiversity index. This activity focuses only on the Simpson's Diversity Index. The Simpson's index uses the number of species present (the species richness), and the relative abundance of each species (the species evenness). Using this index, it is usually observed that as the species richness and evenness increase so does the estimated biodiversity.

The equation for the Simpson's index is below. It can look a bit intimidating at first, but it really is pretty easy once you break it down.

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

- **D** is the Diversity as estimated by the Simpson's Index.
- **n** is the total abundance of organisms of a particular species
- **N** is the total number of organisms of all species.
- **Σ** means "the sum of".

How to calculate the value of $\sum$ ***n(n - 1).***

Step 1: Copy your abundances for each species from the previous table into Column A. The values for abundance become the values of **n**. The example shows this value highlighted in blue.

Step 2: Subtract 1 from the abundance (Column A) you found for Squares. Write the result in Column B. Continue to do this until you have done for each of species. The example shows this value highlighted in yellow.

Step 3: Multiply the number in Column B by the number in Column A. Continue to do this until you have done it for each species. The result in the example is shown highlighted in green.

Step 4: Now all we need to do is add up all the values in Column C.

	A	**B**	**C**
Species	**n= Abundance**	**n - 1**	**n(n-1)**
EXAMPLE	4	4 - 1 = 3	4 X 3 = 12
Squares			
Circles			
Triangles			
Crescents			
Hearts			
TOTAL			

- What is the value you found for $\sum$ **n(n - 1)?** ___________________

*How to calculate the value of **N(N - 1)**.*

Step 1: **N** is the total number of individuals counted for all the species put together. You should already have the total number calculated in the table above in Column A.

Step 2: Subtract 1 from the value you calculated for **N.** Write the result in Column E. Step

3: Then multiply that number by **N.** Write the result in Column F.

	D	**E**	**F**
Species	**N= Total number of individuals**	**N - 1**	**N(N-1)**
EXAMPLE	22	22 - 1 = 21	22 X 21 = 462

- What is the value you found for **N(N - 1)**? _______________

How to calculate the Simpson's Diversity Index for "Study Area 1".

Step 1: Write in your value for **∑ n(n - 1)** in the equation on the top**.**

Step 2: Write your value for **N(N - 1)** in the equation on the bottom.

Step 3: Now that you have all the values you need, solve the equation. Remember your order of operations.

$$D = 1 - \left(\frac{\quad}{\quad} \right)$$

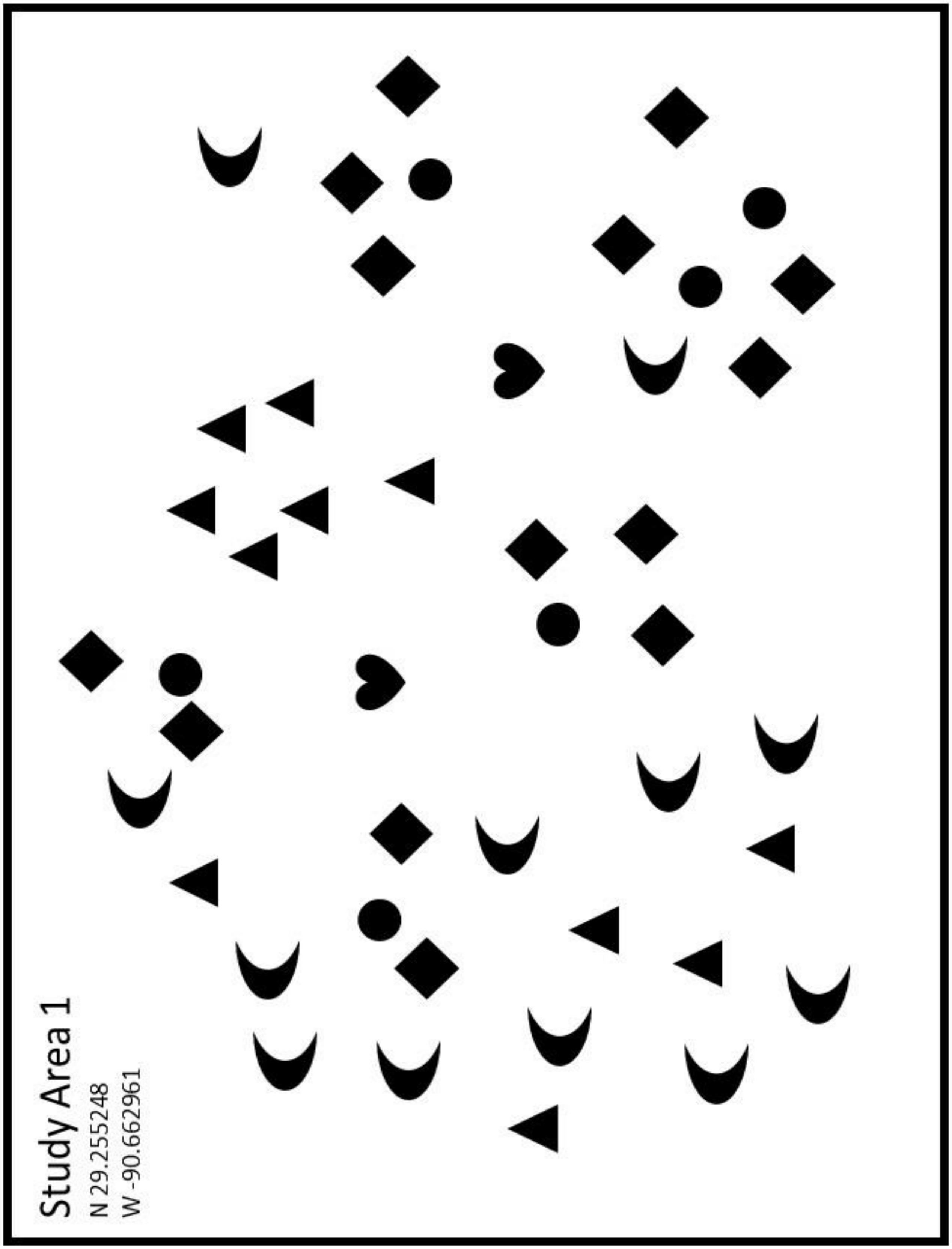
What is the Simpson's Diversity Index of "Study Area 1"? __________________

The closer to 1 the result of the equation is the higher the biodiversity index. In other words, the bigger the result, the more diverse a community or ecosystem is.

1. Is ‘‘Study Area 1’’ a diverse ecosystem?

2. Is the biodiversity of the community as diverse as you initially thought?

3. Now that you know something about the community of ‘‘Study Area 1’’, what further questions would you like to investigate by doing more research?


Study Area 1
N 29.255248
W -90.662961

Answer Key:

Species Richness

"Study Area 1" has a Species Richness of ____5______.

Species Evenness

Study Area 1	
Species	**Abundance**
Squares	14
Circles	6
Triangles	11
Crescents	12
Hearts	2
TOTAL	45

Based on the results, is the community in "Study Area 1" even? _it is only somewhat even since there are 2 species with low abundances. Most species have abundances that are pretty close.

Biodiversity

	A	**B**	**C**
Species	**n= Abundance**	**n - 1**	**n(n-1)**
EXAMPLE	4	4 - 1 = 3	4 X 3 = 12
Squares	14	13	182
Circles	6	5	30
Triangles	11	10	110
Crescents	12	11	132
Hearts	2	1	2
TOTAL	45		456

- What is the value you found for $\sum$ **n(n - 1)?** ____456__________

	D	E	F
Species	**N= Total number of individuals**	**N - 1**	**N(N-1)**
EXAMPLE	22	22 - 1 = 21	22 X 21 = 462
	45	44	1980

- What is the value you found for **N(N - 1)**? ______1980_____

$$\mathbf{D = 1 -} \left(\frac{456}{1980} \right)$$

456/1980 = 0.2303

1 – 0.2303 = 0.7697

What is the Simpson's Diversity Index of "Study Area 1"? _____0.7697_____