

Measuring Biological Diversity -- An Exercise in Community Ecology

Note: A calculator will be helpful for this lab exercise.

Objectives:

1. Learn two methods of quantifying biological diversity.
2. Reinforce material from Module 36.1
3. Examine plants adapted for different environments.

Introduction:

A **community** is a group of different species (including plants and animals) occupying a specific area. Communities are often described briefly by their dominant vegetation, as with the terms "grasslands," "deciduous forest," or "rain forest." However, communities can be more precisely described and quantified. One property of a community that is quantifiable is its structure. Community structure includes characteristics such as the number of species, and the relative abundance of each species.

The number of species is known as the **Species richness**; it is simply the number of different species of organisms in the sample. Just count the species in your sample to calculate it.

Measuring the relative abundance of species or the '**Species heterogeneity**' is a bit more complex. Species heterogeneity takes into account the relative numbers of individuals of the various species in a community.

'Hetero' is from a Greek word meaning 'different'; 'homo,' is from a Greek word meaning 'same.' A lawn with only one species of grass in it would be homogeneous. If it had a few dandelions in it, it would be less homogeneous since now it has two different species. A meadow with several species of wildflowers in it would be even less homogeneous and more heterogeneous than the weedy lawn.

For an example, compare the data from the two communities below. The numbers represent the number of individual organisms of each species. I.e., in community 1 there are 18 of species A, 1 of species B, and 1 of Species C.

	Community 1	Community 2
Species A	18	7
Species B	1	8
Species C	1	5

The **Species richness** is 3 in both Community 1 and 2; it is the same in both communities, but the communities are quite different. By measuring **species heterogeneity** biologists can place a numerical value on the diversity in communities and then use that value when describing or comparing communities.

We will measure species heterogeneity by calculating a number known as Simpson's index. **Simpson's index** is a scale ranging from 0 (no heterogeneity and no diversity) to a maximum close to 1 (high heterogeneity or lots of diversity).

This index is a measure of the probability that two organisms picked at random from the community will be different species. If there is only one species in the community, then the probability of picking two different organisms will be 0, and Simpson's index would be 0. If there are two species in the community, then the chance

of obtaining two species in a random pick of two individuals will be higher, i.e. some number above 0 but less than 1.

This is how to calculate Simpson's index: Let p_i stand for the proportion (a fraction of the number of species to total number of individuals in your sample). The probability of picking two individuals of this species at random is their joint probability, that is: $[(p_i)(p_i)]$, or $(p_i)^2$. If we add up the joint probabilities for each species, and subtract it from 1, we get Simpson's index. [The subscript 'i' means to calculate the proportion for each species.]

$$D = 1 - \sum_{i=1}^s (p_i)^2$$

where D = Simpson's index

p_i = the proportion of individuals of species 'i' in the community

s = number of species in the community

Σ means sum of all the $(p_i)^2$, one for each species in the community.

Example 1: Using the data from Communities 1 and 2 in the Introduction.

For Community 1:

For Species A, $(p_i)^2$	= $(18/20)^2$	= 0.81	18 of 20 individuals are Species A
For Species B, $(p_i)^2$	= $(1/20)^2$	= 0.025	1 of 20 individuals are Species B
For Species C, $(p_i)^2$	= $(1/20)^2$	= 0.025	1 of 20 individuals are Species C
	Σ	= 0.815	

Simpson's Index is $1 - 0.815$, or 0.185 for Community 1

For Community 2, more briefly:

$$\text{Simpson's Index} = 1 - [(7/20)^2 + (8/20)^2 + (5/20)^2]$$

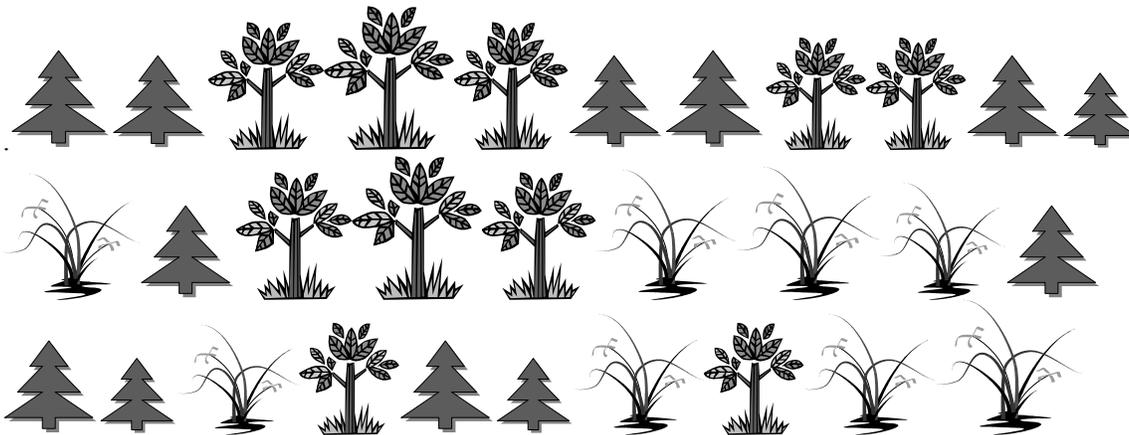
$$\text{Simpson's Index} = 1 - [0.1225 + 0.16 + 0.0625]$$

$$\text{Simpson's Index} = 1 - [0.345]$$

$$\text{Simpson's Index} = 0.655$$

Problems: Tables to organize the data needed to calculate Simpson's Index are found on the last page of this exercise.

1. Calculate Simpson's index for the community pictured below:



2. Compare the diversity of these two kinds of mixed nuts.

Species	Number in "Mixed Nuts"	Number in "Deluxe Mixed Nuts"
Brazil Nut	1	8
Cashew	8	15
Pecan	1	7
Almond	15	18
Hazel Nut	5	30
Peanut	85	0

Species Richness for Mixed Nuts =

Diversity Index for Mixed nuts =

Species Richness for Deluxe Mixed Nuts =

Diversity Index for Deluxe Mixed Nuts =

3. Calculate the Diversity index of one or more of the plant collections in the greenhouse. You probably do not know the names of all the species of plants in any of these collections, but you do not have to. In Problem 1 above, you didn't know species names of the plant facsimiles, yet you were able to calculate a diversity index based on your judgment of which facsimiles were the same species.

You will have to look at the plants in the greenhouse a little more closely to determine whether they are similar or different species. If two plants look very similar (for example, look at growth habit, leaf venation, leaf shape, leaf margin, leaf texture, flower morphology) you can assume they are the same species.

You may sample one or more of these collections:

- a. Entry room -- this room containing bromeliads, ferns, cycads, *Psilotum*, and a few epiphytic pitcher plants. The cycads look superficially like ferns, but their leaves are more leathery, and cycads are seed plants, though you probably will not see any seeds on those in the greenhouse.
- b. The Xerophyte collection, on the North end of the main room, contains plants from around the world that are all adapted to dry environments. Though superficially similar due to convergent evolution, there are at least four different plant families in this collection, and many different species.

Key to Xerophytic Families

1. Plants with spines ... 2
 1. Plants without spines ... 3
 2. Spines arise two at a time from a spotSpurge Family
 2. Spines arise several-many at a time from a spot, ...Cactus Family
 3. Leaves lanceolate or sword-shaped, often in a rosette, without petioles Lily Family
 3. Leaves broad, on stems and with petioles -- Sedum Family
- c. Orchid collection in the 'tropical room.' This room also contains a banana tree (currently in fruit), and a tree fern.
 - d. Coleus and Geranium table

Table 1: _____

Species	Number	$p_i = \text{Number} / \text{Total Number}$	p_i^2
Total Number:		$\Sigma p_i^2:$	

$$D = 1 - \Sigma p_i^2 = \underline{\hspace{2cm}}$$

Table 2: _____

Species	Number	$p_i = \text{Number} / \text{Total Number}$	p_i^2
Total Number:		$\Sigma p_i^2:$	

$$D = 1 - \Sigma p_i^2 = \underline{\hspace{2cm}}$$

Table 3: _____

Species	Number	$p_i = \text{Number} / \text{Total Number}$	p_i^2
Total Number:		$\Sigma p_i^2:$	

$D = 1 - \Sigma p_i^2 = \underline{\hspace{2cm}}$

Table 4: _____

Species	Number	$p_i = \text{Number} / \text{Total Number}$	p_i^2
Total Number:		$\Sigma p_i^2:$	

$D = 1 - \Sigma p_i^2 = \underline{\hspace{2cm}}$