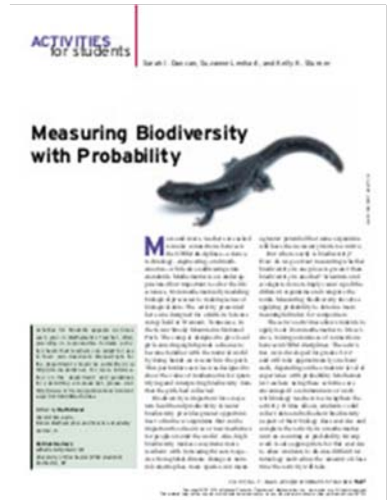
Measuring Biodiversity with Probability

TN Math Standards:


ACTIVITIES for students

Measuring Biodiversity with Probability

6th Grade
Statistics and Probability:
Develop understanding as one that anticipates variability in the data set related to the questions and accounts for it in the answers.
Summarize and describe distributions:
5a.) Reporting number of observations.
Expressions and Equations:
Reason about and solve one-variable equations and inequalities:
6.) Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or depending on the purpose at hand, any number in a specified set.

The Number System:
Compute fluently with multi-digit numbers and find common factors and multiples:
3.) Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.

7th Grade
Statistics and Probability:
Investigate change processes and develop, use, and evaluate probability models:
7.) Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observe frequencies.
Use random sampling to draw inferences about a population:
1.) Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population.
Expressions and Equations:
Solve real-life and mathematical problems using numerical and algebraic expressions and equations:
4.) Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

8th Grade
Expressions and Equations:
Work with radicals and integer exponents:
3.) Use numbers expressed in the form of a single digit ties an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other.
4.) Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Interpret scientific notation that had been given by technology.

Developed by Sarah Duncan, Kelly Sturner, and Suzanne Lenhart

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Biodiversity is ____

Biodiversity takes into account species richness and evenness:

Species richness is ____

Species evenness is _______________________________________

What is your HYPOTHESIS? Do you think there will be higher biodiversity in the woods or higher diversity in the pasture? Why?

____

____

Species	Plot 1 Woods	Plot 2 field
Centipedes	50	10
Millipedes	36	50
Butterflies	35	0
Lady bugs	55	39




Which plot is more species rich? ____________

Which plot is more species even? ____________

Simpson's Index:

$$D = 1 - \left(\frac{n_1(n_1-1) + n_2(n_2-1) + \cdots + n_S(n_S-1)}{(N)(N-1)}\right)$$

DEFINE:

D=

n_i=

N=

S=

Calculate Simpsons Diversity Index for Plot 1 Woods:

Calculate Simpsons Diversity Index for Plot 2 Field:

Which plot is more diverse?

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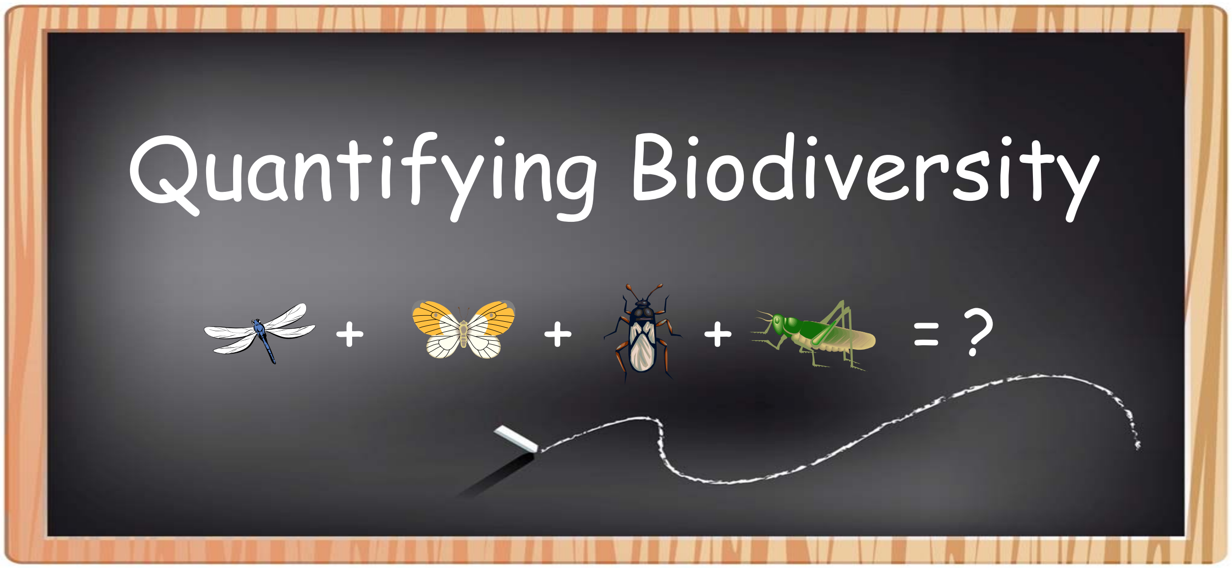
Biology Toolkit



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GSMNP Tremont: Girls in Science Camp

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Goals:

1. Be able to define **biodiversity**
2. Be able to define **species richness** and **species evenness**
3. Be able to use the equation called **Simpson's Index of Biodiversity** to explain biodiversity in an area, and relate this index to probability

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Science Searches for Answers…

- How will climate change affect the ranges of species?
- Will climate change give invasive species advantages?
- Will endangered or geographically isolated species survive?
- Will species with narrow temperature or moisture tolerances survive?
- How will climate change affect phenological events that may lead to problems for species?
- **How will climate change affect species distributions and community compositions?**

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What does biodiversity mean to you

?

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What is **Biodiversity** to an Ecologist?

- Biodiversity is a **measure** of the different kinds of organisms in a region or other defined area.

- Biodiversity includes the **number of species** and the **distribution of individuals** among the species.

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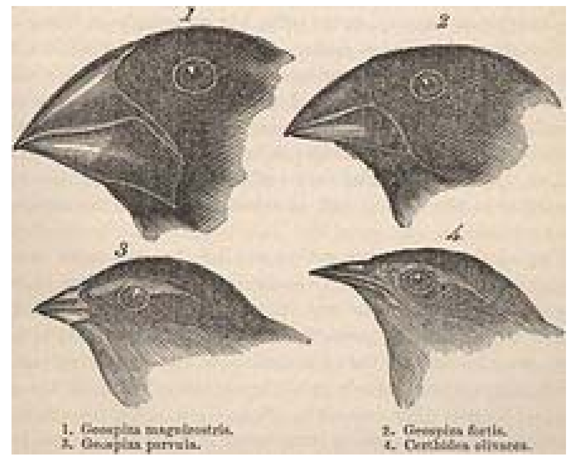
What is **Biodiversity** to an Ecologist?

- Biodiversity can also refer to species' range of ***adaptations***, which are traits that can be behavioral, physical, or physiological. These traits enhance an organism's fitness (ability to pass on its genes to another generation through reproduction)



Darwin's Finches

Biodiversity

Biodiversity takes into account:

- Species richness: the number of species in a region or specified area

Species	Number of Individuals
E. Redbud	3
Black Oak	4
Post Oak	5
White Pine	3
Honey Locust	1

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Biodiversity

<u>Biodiversity</u> takes into account:

- <u>Species richness</u>: the number of species in a region or specified area

- <u>Species evenness:</u> the degree of equitability in the distribution of individuals among a group of species. Maximum evenness is the same number of individuals among all species.

Species	Number of Individuals
E. Redbud	3
Black Oak	4
Post Oak	5
White Pine	3
Honey Locust	1

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Biodiversity

Biodiversity takes into account:

- Species richness: the number of species in a region or specified area

- Species evenness: the degree of equitability in the distribution of individuals among a group of species. Maximum evenness is the same number of individuals among all species.

Species	Number of Individuals
E. Redbud	5
Black Oak	5
Post Oak	5
White Pine	5
Honey Locust	5

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Okay, Ecologists … Get ready for data!

An ecologist goes out into the field and collects information from two separate plots of the same size but with one big difference: Plot 1 is in the woods and Plot 2 is in a pasture. The ecologist is interested in the types of insects that are found in the plots and whether there is a difference between the two plots.

What will we find out?

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Field Data

Species	Plot 1 Woods	Plot 2 Field
Centipedes	50	10
Millipedes	36	50
Butterflies	35	0
Lady bugs	55	39




Based on the data:

- Which plot has more species richness?
- Which plot has more species evenness?
- Which plot has more biodiversity?




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Answers:

- Plot 1, the woods, has more species richness. In plot 2, the pasture, there are no butterflies. Plot 1 has 4 species while Plot 2 only has 3 species present.
- Plot 1 also has more species evenness. There is close to the same number of individuals in each group.
- Therefore, plot 1 is more diverse than plot 2 because species richness is higher and the species are more evenly distributed

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What if your data looked like this?

Species	Plot 1 Woods	Plot 2 field
Centipedes	50	1
Millipedes	36	1
Butterflies	35	30
Lady bugs	55	39
Grasshoppers	0	40




What if your data were more complicated?

Species	Plot 1 Woods	Plot 2 field
Centipedes	50	1
Millipedes	36	1
Butterflies	35	30
Lady bugs	55	39
Grasshoppers	0	40

Maybe more evenness?

Maybe more richness?

Which one has more biodiversity now?




Edward Hugh Simpson's Idea

- Scientists needed a universally recognized method of comparison.
- In 1949, a British statistician came up with an idea he published in the journal *Nature*:

    In order to understand how diverse an area is we can do a math problem that shows us in terms of a **probability** how diverse the area is!

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Let’s Review Probability:

Probability is a way of expressing likelihood that an event will occur

For example: If I toss a coin how what is the probability of the coin landing on heads?

- Heads

- Tails

One side of the quarter is heads and the other side of the quarter is tails, so we can say you have a half or ½ or 0.5 or 50% chance of the quarter landing on the heads side. Another way you can say this is you are about 50% sure the quarter will land on the side with the head.

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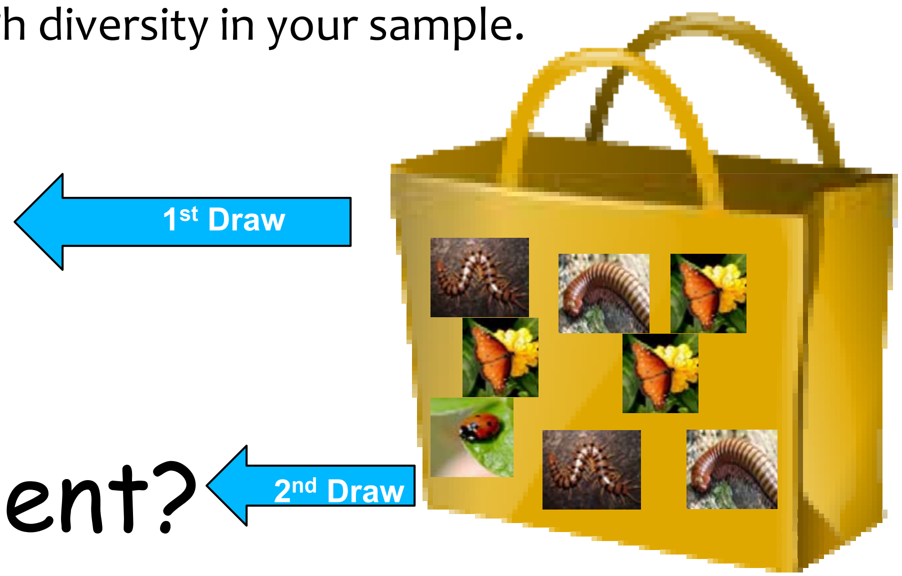
Simpson's Index of Biodiversity

Simpson's Index is a way to express how diverse a sample is based on a probability. The probability can be explained as follows:

If you close your eyes and pick out an individual organism from a sample and then you repeat by closing your eyes and picking out another individual from your sample, what is the probability that the organisms will be different species?

If the probability is high, for example 0.8, then you have an 80% chance of picking out different species, so you have high diversity in your sample.



Same or Different?

Simpson's Index of Biodiversity

$$D = 1 - \left(\frac{n_1(n_1 - 1) + n_2(n_2 - 1) + n_S(n_S - 1)}{(N)(N - 1)}\right)$$

Let's define the variables:
D= Simpsons Index of Diversity
n_i= number of individuals within the ith species
N= total number of individuals within the sample
S = total number of species

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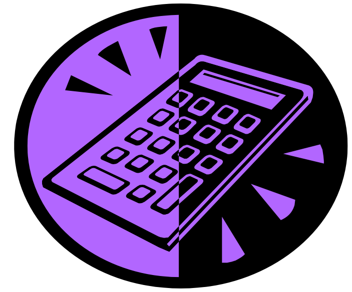
$$D = 1 - \left(\frac{n_1(n_1-1) + n_2(n_2-1) + n_S(n_S-1)}{(N)(N-1)}\right)$$



D= Simpsons Index of Diversity
n_i= number of individuals within the i^{th} species
N= total number of individuals within the sample
S = total number of species

Species	Plot 1 Woods	Plot 2 field
Centipedes	50	10
Millipedes	36	50
Butterflies	35	0
Lady bugs	55	39

Let's calculate D for plot 1:
First do the numerator (top part):

*Use each observation to get count n, then multiply it by (n-1) and add those products together.

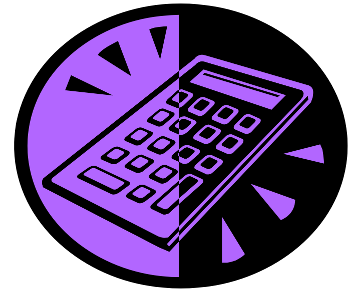
=(50(50-1)+36(36-1)+35(35-1)+55(55-1))

=50(49)+36(35)+35(34)+55(54)

=2450+1260+1190+2970

=7870

$$D = 1 - \left(\frac{n_1(n_1-1) + n_2(n_2-1) + n_S(n_S-1)}{(N)(N-1)}\right)$$



Next, let's calculate the denominator:
Remember N = total number of individuals counting all species in your plot.
In plot 1:

50+36+35+55=176=N

For the denominator we have to calculate:

N(N-1) = 176(175)=30,800

Species	Plot 1 Woods	Plot 2 field
Centipedes	50	10
Millipedes	36	50
Butterflies	35	0
Lady bugs	55	39

Next let's put it all together:

$$D = 1 - \frac{7870}{30800}$$

***D* = 1 - (0.256)**

***D* = 0.744**

So what does this mean? If you randomly pick two individuals in plot 1 you have a 74.4% chance of those two individuals being different species. We can say the diversity in the plot is high.

ON YOUR OWN:
Can you calculate Simpson's Index for Plot 2?

$$D = 1 - \left(\frac{n_1(n_1 - 1) + n_2(n_2 - 1) + n_S(n_S - 1)}{(N)(N - 1)}\right)$$

Remember:
Start with the numerator
Then calculate the denominator
Then divide the numerator by denominator
Then subtract your fraction from 1

Species	Plot 1 Woods	Plot 2 field
Centipedes	50	10
Millipedes	36	50
Butterflies	35	0
Lady bugs	55	39

Which plot is more diverse based on your calculations?
Does this support or refute your hypothesis?

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Looking for More?

- Check out our second biodiversity module on real salamander data!
- Look up on your own: Shannon's Index of Biodiversity
- Real datasets to compare available at www.handsontheland.org

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For The Biodiversity Module & More:

- Website: www.nimbios.org
- See what we're all about
- Sign up for our bimonthly email newsletter
- Check our blog

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