Measurement of Species Diversity

From Ann Throckmorton.

CONCEPTS

- species diversity is an important community characteristic
- species diversity includes two components: richness and evenness
- species diversity can be measured by indices such as the Shannon Index which can be used to compare the diversity of different communities

OBJECTIVES

As you complete this activity, you should:

- understand the relationship between richness, evenness, and species diversity;
- measure species diversity in natural and man-made communities;
- calculate indices of richness, evenness, and diversity for both habitats and use then to compare species diversity in the two communities; and
- gain experience in gathering, graphing, and analyzing ecological data.

MATERIALS

Dichotomous key for trees Tree ID book Measuring tape

INTRODUCTION

Importance of Species Diversity

Species diversity is an important community characteristic. The diversity of species in an area reflects the uniqueness of the habitat and the interactions that occur between the organisms that live there. The presence and abundance of species is influenced by many abiotic factors, including availability of light, nutrients, moisture, and food, physical conditions of the habitat, and history of disturbance. Biotic interactions such as predation, competition, and mutualism also affect species diversity. Thus, a comparison of species diversity between different areas may reveal important information about environmental conditions in each area. Also, because these change in time, important information about the present and past condition of a habitat may be gained by comparing species diversity within one community at different times.

Measuring Species Diversity

Species diversity is composed of two components. The first is the number of species in the community, a character that ecologists often refer to as species richness. It would seem that the best index of species richness would be *S*, the total number of species in a community. However, *S* depends on the sample size, which in turn depends on the amount of time spent

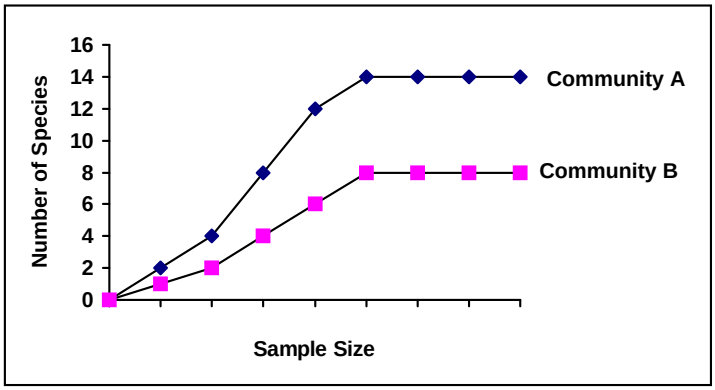
searching. Because of this, S is a poor comparative index. Instead, ecologists use the Menhinick Index which depends on *S and* the total number of individuals in the sample, *n*.

$$R = \frac{S}{\sqrt{n}}$$

where:

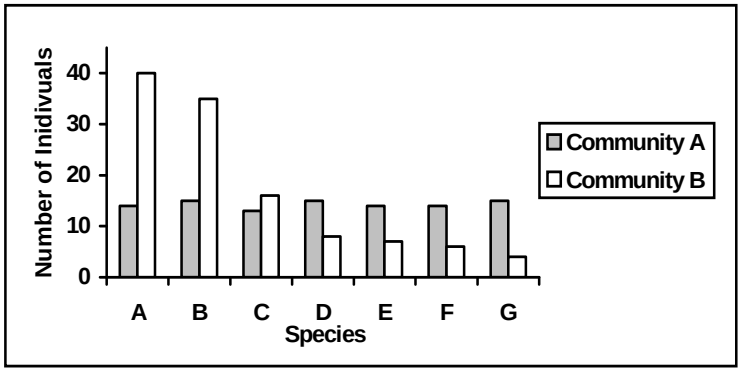
S = the total number of species, and
n = the number of individuals in the sample

Looking at the graph below, you can see how the number of species that you observe increases with the size of the size of the sample. Comparing the two communities, you'll see that community A has higher species richness than community B.



The second component of diversity is species evenness. Evenness refers to how the individuals in the community are distributed among the different species. The greatest evenness occurs when all of the species in a sample have the same number of individuals. Evenness decreases towards zero as the relative abundances of the species become more unequal.

In the graph below, the species in community A have approximately the same number of individuals. Thus, community A has a high evenness. In community B, species 1 and 2 are much more common than the other species. Thus, community B has a low evenness.



Notice that the two communities have equal richness.

The most common index of evenness used by ecologists is

$$E = \frac{H'}{\ln S}$$

where:

H' = the Shannon Index (see below), and
S = the total number of species in the community

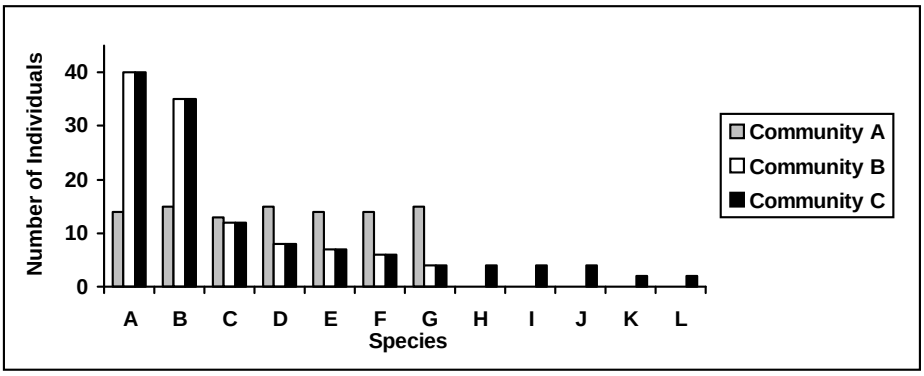
Indices of diversity incorporate both species richness and evenness into a single value. The index that you will be using is the Shannon Index (*H'*). Diversity is at its lowest and H' = 0 when there is only one species in the sample. Diversity increases as the richness and evenness of the community increase. It reaches a maximum when there is a large number of species in the community (i.e., there is high richness) and all species have the same number of individuals (i.e., there is high evenness).
This is the equation for the Shannon Index:

$$H' = \sum_{i=1}^{S}\left[\left(\frac{n_i}{n}\right)\ln\left(\frac{n_i}{n}\right)\right]$$

where:

S = the number of species in the sample,
n_i = the number of individuals belonging to the each species, and
n = the total number of individuals in the sample

The following graph shows how species diversity is related to richness and evenness. Community A and community B have the same richness, but community A is more even. Thus, of the two communities, community A has the greatest diversity. Community B and community C are equally even, but community C has more species, therefore, of the two communities, it has the greatest diversity. Compare community A and community C. Which do you think has the greatest diversity?



CHALLENGE

In this exercise, you will measure the richness, evenness, and diversity of tree species at the College Woods and compare it to that of trees on the Westminster College campus. You will work in groups of two or three to collect the College Woods data. You will count how many individuals of each species of tree there are in the Woods. Because it is important to have a large sample size, the data from the separate groups will be pooled for the final analysis. This means that everyone in the class must use *exactly* the same technique for gathering data and that you must have some way to prevent different groups from sampling the same trees over and over. It is also important that the trees be selected randomly to eliminate experimental bias.

The data for the Westminster College Campus are included on the last page of this exercise.

Before you gather the data, answer the following questions in your lab book:

- Which habitat do you think will have a higher richness?
- Which habitat do you think will have a higher evenness?
- Which habitat do you think will have a higher diversity?

Once you have the data from the two habitats, you will use a computer program to calculate richness, evenness, and diversity for each habitat. The program is loaded on all of the computers in the Biology computer lab. You will be given instructions on how to run the program.

After you have analyzed the data, you will make several graphs to compare richness, evenness, and diversity in the two communities. Then, you will answer the following questions in your lab book.

QUESTIONS

- Which habitat had the highest richness?
- Which habitat had the highest evenness?
- Which habitat had the highest diversity?
- Hypothesize about the various factors that caused the pattern in species richness, evenness, and diversity that you observed. Why were these values so much higher in one habitat than in the other?
- Imagine that you've been given the job of increasing the species diversity of trees on the campus. Describe exactly what you would do to accomplish this. You may cut down no more than 30 trees and any tree that is cut down has to be replaced. You may not plant more than 100 new trees.

TREES ON THE WESTMINSTER COLLEGE CAMPUS
MAY, 1992

Species	Number of individuals		Species	Number of individuals
Sugar maple	79		Red spruce	4
Black cherry	40		Balsam fir	4
Norway maple	31		Flowering crabapple	4
Eastern white pine	29		Holly	4
Silver maple	24		Ginkgo	4
Blue spruce	20		Tulip tree	3
Black locust	19		American elm	2
Green ash	14		Catalpa	2
Red maple	14		Honey locust	2
Flowering dogwood	12		Red oak	2
Pin oak	10		Buckeye	2
Norway spruce	10		Sycamore	2
Slippery elm	9		Tree-of-Heaven	1
White spruce	9		Mulberry	1
Shining willow	8		Eastern red cedar	1
Bitternut hickory	8		Bear oak	1
White oak	8		Gray birch	1
Eastern hemlock	6		Linden	1
Mountainash	6		American plum	1
Sweet gum	5		Boxelder	1
Arborvitae	5		White poplar	1
Scotch pine	4		Black ash	1

Random number table:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1	8	0	9	4	2	5	2	5	8	2	4	7	1	3	4	7	7	4	3	3	3	6	2	0	1	8	9	7	2	1	3	4
2	3	5	6	3	2	1	9	6	8	2	1	1	9	0	4	5	2	6	1	8	2	7	5	1	2	6	2	7	1	0	9	5
3	1	3	3	0	6	3	3	1	3	7	5	3	9	6	9	3	8	7	3	6	6	8	1	5	1	5	3	8	8	5	4	3
4	3	5	6	5	0	0	1	6	2	2	4	3	6	4	3	2	4	7	9	6	6	0	9	5	5	2	8	3	1	6	2	0
5	7	8	5	0	5	9	2	5	5	5	8	8	7	3	1	1	2	1	9	2	4	5	4	5	3	5	3	0	5	5	8	9
6	4	4	9	0	5	4	1	7	9	7	2	7	6	1	5	3	5	9	0	1	4	8	7	8	9	9	8	0	9	8	7	7
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