BIODIVERSITY INVENTORY

Students record the diversity of species in two study areas and use graphs and diversity indices to describe and analyze the data.

Time

Introduction: 10 minutes
Activity: 50–120 minutes
Discussion: 10–30 minutes

Materials

- ☐ Journals and pencils

optional

- ☐ Calculators, computers to assist with calculating diversity indices (may be done later in class)

Teaching Notes

Many scientists calculate species richness (the number of species in an area) and evenness (the relative numbers of individuals of those species). They analyze these values by creating graphs or using algebra and logarithms. These calculations are more appropriate for older students, and are included in the follow-up section.

This activity gives students an authentic experience of using math to describe the world and explore ideas.

Collecting biodiversity data and making species lists reveal patterns. Scientists use these approaches to gather information about ecosystems, assess how the distribution of organisms in an area has changed, and think about possible impacts of different disturbances or changes in environmental conditions. Students can use this activity to think about similar concepts, get a sense of the range of different species in an area, consider factors that influence organisms, and use their data to make predictions about what might happen should conditions change in the future. In this activity, students look for species, count individuals, then create pictures of the patterns. In the process, they develop an intrinsic understanding of the data and of what math can do, and learn a reproducible approach for gathering data.

NATURAL PHENOMENA

Find two natural areas with a diversity of trees, shrubs, and herbs. Make the two study areas the same size, and spend the same amount of time collecting in each. It's helpful if students have had some time to explore the area previously, so that they're familiar with the species there to some extent. Local parks are ideal locations. Vacant lots or unmowed edges of a ball field will also work. Limit the area of study based on the range of species there. The size of the area will depend on the density of plants and the ease with which you can find them. If the area is not very diverse, make the study area larger so that you can work with a bigger range of species. If there are a lot of species, make the area smaller so that students aren't overwhelmed.

Unless it is logistically impossible, plan to take two surveys in different, distinct areas. (The two observation periods could also take place on two different days.) A comparison will offer a wealth of information and provide a starting point for discussing possible causes of the variations. Find plant communities or habitats with contrasting environmental conditions or where one area has received a different "treatment" than another. For example:

- Plant communities in wet vs. dry areas
- Disturbed areas vs. restoration projects and natural areas
- Burned areas and unburned areas
- Areas that were burned in different years
- North- versus south-facing slopes

PROCEDURE SUMMARY

1. Make a biodiversity inventory of the species in the area.
2. Record some simple drawings and text for each species so that you remember it (but you don't need to know the name of it).
3. Compare notes with classmates if you think you are done. They might have found species you missed.

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DEMONSTRATION 1

When the whiteboard icon appears in the procedure description: Use writing and drawing to describe different plant species, modeling making a simple diagram of leaves with a few written notes.

PROCEDURE STEP-BY-STEP

1. **Tell students that they will explore the area looking for different kinds of trees and shrubs, cataloguing each one in their journals.**
   a. "We are going to take twenty minutes to record every kind of tree and shrub in this zone."
   b. "You will use your journal to help you remember what you see."
2. **Tell students that they will use drawing and writing to briefly capture key details (leaf shape, fruits or flowers, form of growth) of each plant, but that they do not need to make a detailed, pretty picture of each one.**
   a. "The goal is not to make an exact drawing showing everything about each species you find but to capture enough information so that you or someone looking at your journal could identify the plant later."
   b. "Record important details such as leaf shape, any fruits or flowers, and the form of the plant growth. A fast way to capture information is to trace the leaf, then draw in the veins."
3. **Set up the boundaries of the survey area. As noted earlier, the size of the area will vary depending on the plant diversity, access, and hazards.**
4. **Tell students to begin by working alone, to focus on a few important details of each plant before moving on, and to compare notes with classmates once they think they have found all the species in the area.**
   a. "Start by working alone. You will have lots of time to find different species. Remember not to get lost in making a pretty picture of the plant. Make a quick sketch of the leaves along with some written notes, then move on."
   b. "When you think you have found all the species, compare your notes with a few of your classmates and see whether they can direct you to a species you may have missed."
5. **Send students out to do their survey and circulate to offer support as needed.**
6. **Repeat steps 2–5 to measure the biodiversity in a second area (either right then or at a later time).**

DISCUSSION

Lead a discussion using the general discussion questions and questions from one of the Crosscutting Concept categories. Intersperse pair talk with group discussion.

General Discussion

Call the group back together to discuss their notes, using the questions here.

a. "How many species did you find in each place?"
b. "What differences were the most striking to you when you saw the study areas?"
c. "What are some possible explanations for the differences in species and numbers of species in these two areas?"
d. "How might you expect the biodiversity of these two areas to change over time?"

Ask students how making a biodiversity inventory helped them learn about the area, and point out how students can catalogue the plants they find in other settings.

e. "Looking at the biodiversity of an area can be an interesting way to study any place you go and to begin to understand it better."
f. "How did making a biodiversity inventory of this place help you learn about it?"

Patterns

a. "What differences did you notice between the two study areas?"
b. "What kinds of differences do not show up when we use this way of collecting our data?"
c. "What unseen forces may be behind some of the patterns we observed?"

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d. "Look at the range and shapes of the leaves and plants you recorded in your journal pages. How are they similar to or different from one another? How do the leaf shapes and plants compare from one site to another?"

e. (*Note:* This question would require that students engage with a field guide or other resource.) "A species can only survive where its needs are met, and different types of plants have different needs. Knowing some things about the preferences of different plants can help us learn about the trends in environmental conditions in an area. Refer to this field guide [or other resource] to read about the plants you found in each area, and use this information to make some general statements about what you think the environmental conditions are like there."

Stability and Change

a. "Ecologists have found that ecosystems with more diversity tend to be more stable. Why might this be the case?"

b. "Which system do you think will change the most over the next five years? Why? What would cause the changes?"

Cause and Effect

a. "What were some of the differences between the two study areas?"

b. "What are some possible explanations for those differences?"

FOLLOW-UP ACTIVITY

Field Guide Identification

Students do not need to know the names of plants in order to have a general conversation about the biodiversity of an area, but identifying the plants that they have taken care to sketch can be rewarding and fun. Offer regional field guides and time for students to identify the plants they found.

EXTENSION

A Deeper Dive into Biodiversity: Richness and Evenness

Note: This extension is intended for seventh grade and higher.

Diverse ecosystems are more stable, productive, and better able to respond and adapt to environmental changes. Species richness and evenness are two ways of describing and quantifying biodiversity that offer an understanding of ecosystems. Measuring the number of species (the *richness*) in an area is a useful exercise, and is appropriate for younger students.

Richness leaves out an important part of the picture, however. Having an idea of the relative numbers of individuals within each species gives you a more nuanced understanding of diversity. Two areas might have the same total number of species, but one might have high numbers of all species, whereas the other is dominated by one or two species. This second pattern often occurs after a major disturbance or the introduction of an invasive species. The measure of the abundance of individuals within each species is called *evenness*.

Species richness and evenness are two diversity indices that scientists use to describe natural systems. Students can visualize this data with graphs or, at higher grades, algebra and logarithms.

DEMONSTRATION 2

When the whiteboard icon appears in the procedure description: Add tally marks next to the notes about each species to record the number of individuals in the study area.

PROCEDURE STEP-BY-STEP

1. **Define species richness as the number of species found in an area, referring back to the systematic observation students just did.**

   a. "Species richness refers to the number of species you find in an area. We made a species richness inventory just now when we recorded the plants, trees, and shrubs in this area."

   b. "In your journal, write 'species richness' at the bottom of the page with the number of species you found."

2. **Explain how to collect species evenness or abundance data: Walk through the study site making tally marks next to each species for every individual observed.**

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a. "Now we are going to collect abundance data about each of these species. You will walk through the study site and count how many individuals there are of each species."

b. "Use tally marks (or approximations if there are too many) to record the number of trees and shrubs of each species. Keep track of the number next to your sketches of the species." (Demonstrate on your whiteboard.)

3. **Ask students to share some ideas about how to be systematic in their counts to avoid marking the same plant twice or missing a part of the study area.**

a. "You are going to need to come up with a way of being systematic about how you count the plants so that you do not count the same one twice or miss a section of the study area. Turn and talk with a partner about how you might do this."

b. "What are ideas for how to make our data collection systematic so that you do not cover the same area twice or miss big areas?"

4. **Send students out to collect evenness data, circulating to provide support.**

a. "You will have fifteen minutes to collect this data. Are there any questions?"

5. **When the time is up, call the group back together and explain how to analyze diversity richness and evenness by creating graphs: Give each species a letter code (A for the highest number of plants, B for the next highest, etc.), listing those codes on the x-axis of the graph, making the y-axis as high as the most abundant species, then creating vertical bars to show numbers of individuals.**

a. "Give each species in your notes a letter code, starting with A for the species with the highest count, then B for the next highest, and so on."

b. "Now let's use your diversity data to make a bar graph. On the horizontal (x) axis, list all the species you found by their letter code."

c. "On the vertical (y) axis, make a scale that goes as high as the species that was the most abundant."

d. "Now draw bars to show the number of individual plants you observed for each species."

6. **Give students time to make their graphs, then call for the group's attention and discuss patterns in their data.**

a. "Look at your graphs. What statements can you make about the richness and evenness in each site?"

b. "Based on your data, which ecosystem is more likely to be resilient in the face of disturbances? Explain your thinking."

c. "How might the plants change in this ecosystem if there were some kind of disturbance or shift in environmental factors, such as a change in weather, the amount of water, and so on?"

d. "Ecologists have found that systems which have higher evenness tend to be more stable and resilient when there is a disturbance. What are some possible reasons for this?"

7. **Use the Crosscutting Concept Scale, Proportion, and Quantity to examine the relationship of size and abundance.**

a. "We did not directly take notes on this, but see whether you can pull any ideas from your notes or observations: Is there a relationship between the size of the species and its abundance? What are some possible explanations for this?"

b. "Were there any species that may be important parts of this ecosystem even though there were not very many individual members of them? What is your evidence?"

Going Further: Constructing Rank-Abundance Curves

1. **Rank-abundance curves enable students to visualize richness and evenness. The calculations are straightforward and only require division and an understanding of proportions. The graphs are useful if you plan to ask your students to compare two or more communities.**

a. "To begin, create a table. [You can refer to the one on this page to demonstrate what this table should look like, or reproduce this table on a whiteboard or poster.] In the first, left-most column, list all the species you found. You do not need to know the names of the species; you can use letters or your own descriptive names."

Species	Number in Sample	Number in Sample/Total	Rank
A	32	32/280 = 0.11	4
B	12	12/280 = 0.04	6
C	8	8/280 = 0.03	9
D	55	55/280 = 0.20	2
E	46	46/280 = 0.16	3
F	31	31/280 = 0.11	5
G	10	10/280 = 0.04	7
H	74	74/280 = 0.26	1
I	3	3/280 = 0.01	10
J	9	9/280 = 0.03	8
Total	280		

b. "In the second column, write the number of individuals you counted in the sample. Add up the numbers in this column to get the total number of individuals you counted. Write this total at the bottom of the column."

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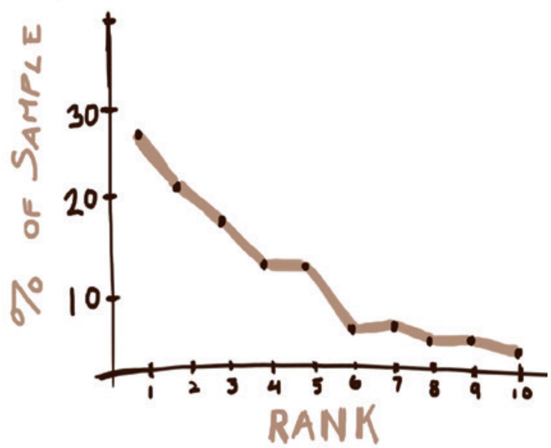
c. "In the third column, calculate the proportional abundance of species by dividing the number of individuals by the total number of individuals in all the species combined."

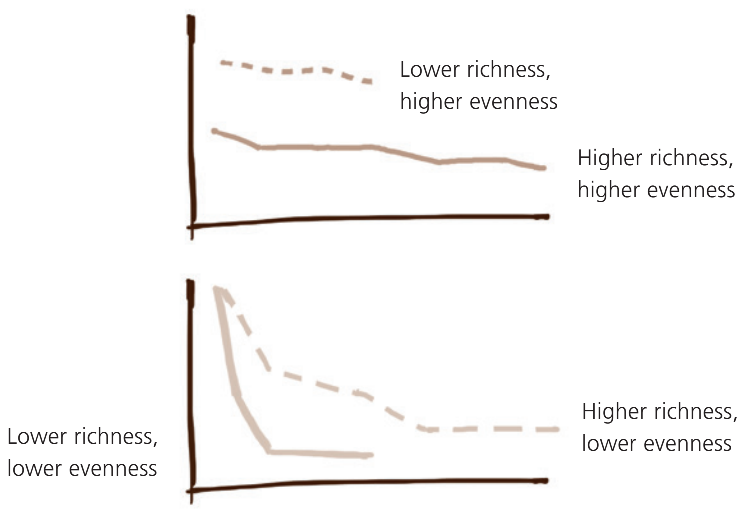
d. "Assign a rank to each species starting with 1 for the most abundant species. If two species have the same number of individuals, choose one to be a higher rank, the other to be the next highest."



e. "Repeat this process for the second community or system."

f. "Graph the results with the rank on the horizontal axis and the percent of the sample on the vertical axis. To convert proportional abundance (number in sample divided by total) to percent, move the decimal point two places to the right."

g. "Now graph the second community on the same chart and compare the shapes of the two lines. How do the lines describe richness and evenness? What differences do you see between the two communities?"



If graphed lines are roughly horizontal, the community they represent has high evenness, whereas lines that start high and then dip sharply indicate low evenness, as you might see in a highly disturbed area or a habitat being overrun by an invasive species. Short lines indicate low richness (fewer species). Longer lines show higher richness.

Going Further: Advanced Math—Calculating Diversity Indices Using Algebra and Logarithms

Species richness, the Shannon Diversity Index, and evenness are useful ways of quantifying biodiversity.

- Species richness, denoted by R, is simply the number of species found.
- The Shannon Diversity Index, denoted by H, takes into account the number of individuals found in each species. To calculate this index requires the use of algebra and logarithms.
- Evenness, denoted by $E_{H,}$ converts the value of the Shannon Diversity Index to a number between 0 and 1, where 1 is total evenness, with the same number of individuals found in each species.

If you are not familiar with these indices, there are many good free online tutorials, videos, and step-by-step walkthroughs of how to calculate them. You may choose to calculate these by hand or to help your students format spreadsheets to calculate the indices for their data sets. Learning how to format spreadsheets is a skill equally as valuable as solving problems by hand.

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