Diversity Index

Method

Students will use sampling techniques in nearby parks, backyards, and natural areas to measure the affects of invasives on biodiversity.

Getting Ready

1. Prepare containers of beads for the warm-up activity. There should be 100 beads in each container. Try to vary both the number of different colors of beads and the number of each color. For example, the container representing a very diverse habitat could have equal numbers of 12 different colors of beads while the container representing the least diverse habitat could have only two different colors of beads with most of them one of the colors.
2. Find a location for the outdoor investigation.
3. Be sure the study site does not have any poisonous plants (e.g., poison ivy) or invasives that can cause skin irritations on contact (e.g., wild parsnip, leafy spurge, giant hogweed, St. Johnswort, and yellow flag).

Introducing the Activity

Biological diversity is all around us. It's in the variety of habitats that surround us, the different kinds of plants and animals that we see, and the subtle differences among plants and animals of the same kind. There are three levels of biological diversity:

- If we look out the window and see woodlands, wetlands, and grasslands, we are looking at a scene that has high *ecosystem diversity*. On the other hand, if we can only see croplands or housing developments, the ecosystem diversity is low.
- Another level of diversity is *species diversity*. This diversity is displayed by the number of different plants and animals present. A forest with dozens of kinds of trees and hundreds of kinds of other plants is more diverse than a city park with turf and three kinds of trees.
- The third level of diversity is the hardest to see. It is *genetic diversity*. Within a single species of plant or animal, there is variation. Take a close look at two plants of the same species collected from different locations, and you may notice subtle differences in color, leaf shape, or height.

We are going to focus on species diversity among plants. It's not hard to see that a prairie is more diverse than a lawn or that a woodland is more diverse than a city park. However, sometimes the differences are more subtle than that! How do scientists know that some places are more diverse? How do they know that diversity is declining on a worldwide basis?

poison ivy

Objectives

- Realize that scientists use sampling techniques to measure biodiversity.
- Calculate the Diversity Index of plants along a transect line.
- Understand the importance of diversity indexes in measuring the success of invasive species control methods.

Grades

6 – 12

Group Size

Small groups of 2 – 4

Activity Time

Three 50-minute periods

Setting

Indoors and outdoors

Materials

- 100 beads in a container for each group
- Tent stakes
- 50' cord wound on bobbin
- Paper, pencils, and writing surfaces
- Optional: plant identification books (See list page 139.)
- Optional: calculators

Connections

See next page.

Academic Standards

Grades 6 – 8

- Environmental Education: B.8.3, B.8.21, C.8.2
- Math: A.8.1, B.8.7, E.8.4
- Science: C.8.2, C.8.3, C.8.4, C.8.6, F.8.8, F.8.9

Grades 9 – 12

- Environmental Education: B.12.6, B.12.7
- Science: C.12.5, F.12.7, F.12.8

Scout Connections

- Boy Scouts: Environmental Science

In order for scientists around the world to calculate, compare, and discuss diversity, they have created many tools. One method uses sampling techniques and the Diversity Index to assign numerical values to the biodiversity of a given habitat. The Diversity Index is a tool that scientists use to:

- Calculate the diversity of organisms in an ecosystem and establish baseline information about a site. Baseline information provides a point of reference so that changes to plant communities can be measured.
- Measure the health of an ecosystem or compare healthy and disturbed sites.
- Track changes in diversity at one location over time. Monitoring could help determine if the changes are due to succession, disturbance, or invasion of a non-native species.
- Show the changes to vegetation at a site during and after an invasive species control project or evaluate the effectiveness of various control methods.

Doing the Activity

Diversity Index Warm-Up (Indoors)

1. **Talk about sampling.** If you were a scientist assigned to measure the biodiversity of plants in a habitat, how would you do it? (Entertain all answers, but help students realize that rarely can scientists count every plant in an area. Instead, they take samples using various sampling techniques and then perform calculations on the samples.)

2. **Introduce random sampling and the Diversity Index.** Explain that the students are going to use random sampling and a Diversity Index to study the "populations" of various beads in a "habitat" or container. Explain that the students are going to randomly pick a sample of beads from the container.

3. **Get ready for the warm-up activity.** Divide into teams of two. Give each team a habitat with 100 beads. Each color of bead should represent a different "plant" in the habitat. Assign a letter to each bead color by writing a code on the board or asking students to record it in their lab books.

4. **Conduct the sampling.** Instruct students to randomly choose nine beads from their containers, one at a time. Using the letter symbols, they should record each bead as they remove it. Their results should look something like this:

   PBGGWWGBB

5. **Count the number of runs in the sample.** Group letters that are the same by drawing alternating lines above and below the letters. The results from above would look like this:

   P̲B̲G̲G̲W̅W̅G̲B̅B̅

The number of runs is the number of groupings, or strings, of the same plant found consecutively in the sample. A run can consist of only one plant. This example has six runs.

6. **Count the number of individuals in the sample.** The example shows nine individual beads.

7. **Calculate the Diversity Index.** Use the following formula:

   Diversity Index = number of runs / number of plants = 6/9 = .67

8. **Discuss the results.** The Diversity Index is a measure of the biodiversity of a group of organisms in an area. The value of the Diversity Index will vary between 0 (no diversity) and 1 (high diversity). Values around 0.5 indicate that an area is relatively diverse. A healthy forest might have a Diversity Index of 0.7 or 0.8 while an agricultural field might have a Diversity Index of 0.02 or less.
   - How did the Diversity Index values vary from group to group? Note that the variety of beads is not the same from container to container. In other words, some habitats are more diverse than others.
   - Which habitat is the most diverse? (Assume that the container with the highest Diversity Index is the most diverse.)
   - Which habitat is the healthiest? Why are populations that are more diverse usually more stable? Why would a diverse population be more resistant to disease, predation, and invasion?
   - Which habitat seems to be dominated by one or two species of beads? What is the Diversity Index of that habitat? What kind of real-life habitat might this represent? (It might represent an area that has been planted for agriculture or an area that has been invaded by an invasive species.)
   - Assume two habitats have the same number of "species" of beads. One habitat is predominantly one species of bead with just a few beads of the other species. The other habitat has equal numbers of all the different species. Which will have the highest Diversity Index? (The habitat with equal numbers of each species will have the higher index. The number of different species [species richness] and the number of individuals of each species [species evenness] are both important measures of biodiversity.)
   - If you repeated the whole process with the same container of beads, do you think you would get the same results? (Probably not. This is why scientists often take several samples and average the results. If you have time, take three samples and average your results. You can also tally the entire container of beads and see how the Diversity Index of the whole compares with the Diversity Index of the sample.)

Plant Transect (Outdoors)

Students working in teams will randomly locate and establish a transect. They will count and identify the plants along the transect. Based on the amount, size, and diversity of vegetation, decide if students should count only those plants that actually touch the string or all plants that lie in the plane of the string. Give students a copy of *Conducting a Plant Transect* on page 104 as a reference during the field experience. Ideally, students should be familiar with the majority of plants they are likely to encounter. Review these plants with the students and assign letters to them prior to the field trip.

Diversity Index Calculations (Indoors or Outdoors)

1. **Determine the number of runs.** Ask students to group letters that are the same by drawing alternating lines above and below the letters. Count the number of changes or runs.
2. **Count the number of plants sampled.**
3. **Calculate the Diversity Index**. Use the following formula:

   Diversity Index = number of runs / total number of plants
4. **Find the average Diversity Index for the site.** Instruct students to collect data from all transects studied at one site and compute an average for the location.

Discussion Questions

1. You calculated the diversity of the plants in the area. Can this number tell you anything about the diversity of insects, birds, mammals, or other organisms? (It wouldn't be accurate to say that all of these indexes would be identical. However, a diversity of plants offers other organisms a variety of foods and places to hide. Thus, a high diversity of plants usually results in a high diversity of the organisms that depend on them for survival.)
2. What are some of the limitations of the Diversity Index?
   - The Diversity Index is a snapshot in time. If you did the sampling at a different time of year, you might get different results.
   - A "weedy" area might score a high Diversity Index. While the area might have a wide variety of plants, these plants don't provide the same quality of habitat as a diversity of native plants. There are some variations of the Diversity Index that adjust for weedy and invasive plants. See the Purple Loosestrife Project: Cooperator's Handbook under *Finding Out More!* on page 103.

- The index depends on the skill of the person using it. Someone with more experience identifying or distinguishing between different kinds of plants might get different results.
- This transect method does not do a very good job of finding and including rare plants.
- There is the chance that the random selection of the sample area could have resulted in a slice of the habitat that was exceptionally diverse or exceptionally lacking in diversity.

3. We've focused on the human-caused losses of biodiversity (e.g., habitat destruction and introduction of invasive species). Are there any natural events that could alter the Diversity Index? (Storms, disease, cycles of predation, floods, and other natural disasters.)
4. How do invasive species change the Diversity Index? (As invasive species crowd out native plants, some of the most sensitive species are lost first. The Diversity Index goes down as the number of invasive plants increases. The index goes down because there are fewer kinds *and* numbers of native plants.)
5. What happens to the habitat as the plant diversity declines? (The variety of food and cover also declines. This means that fewer numbers and kinds of animals can find the things they need to survive. In other words, all aspects of diversity decline.)

Assessing the Learning

Use a rubric to evaluate students' work during this lesson. Evaluate students on how they worked in teams, how they approached and completed the task of counting plants along their transects, whether they could correctly identify different species (if required), whether they could record their data on meaningful charts, and whether they were able to calculate the diversity index.

Finding Out More!

This activity is adapted from the following activities:

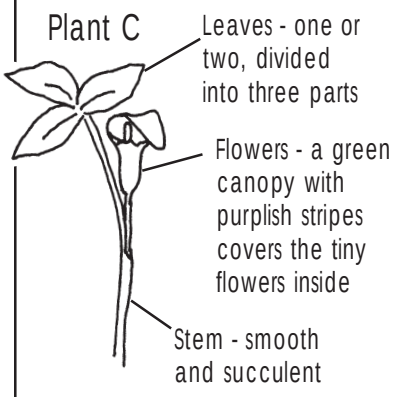
Biodiversity, Wetlands, and Biological Control. Illinois Natural History Survey. 1999. See the activity "The Spice of Life: Assessing Species Diversity."

The Purple Loosestrife Project: Cooperator's Handbook. Michigan State University. 1998. See the activity "Annual Wetland Plant Diversity Survey."

Windows on the Wild: Biodiversity Basics. World Wildlife Fund. 1999. See the activity "Insect Madness."

Conducting a Plant Transect

Sample Plant Sketch



Sample Letter Assignment Chart

A - white or pink flowers with grass-like leaves (spring beauty)
B - yellow lillies with spotted leaves (trout-lily)
C - large green flower with 3-part leaves (Jack-in-the-pulpit)

Sample Data Recording

A B B C A A

Follow these directions when you arrive at your sampling site.

1. Tie one end of your cord to one of the tent stakes.
2. Push the tent stake into the ground at your team's designated starting point.
3. Stretch the cord to its full length, being careful not to step on the plants that lie along the cord. You will be sampling these plants, so you don't want to disturb them!
4. Tie the other end of the cord to the other tent stake and push it into the ground.
5. Divide responsibilities among your team.
   - One person to identify plants along the transect.
   - One person to keep track of letters assigned to plants.
   - One person to record data.
   - One person to sketch plants the team cannot identify.
6. Starting at one end of the cord, walk the entire transect and record each plant along the transect. Record the plants in order as you walk the line, counting all trees, shrubs, and herbaceous (non-woody) plants. Depending on the habitat, your teacher might instruct you to count only the plants that actually touch the line or to count all the plants in the plane of the line (i.e., above and below).

   Follow the directions given by your teacher to assign a letter (i.e., A, B, C, etc.) to each different kind of plant. Your teacher might require you to identify each plant or to draw pictures of each plant. Either way, you will record each plant by letter similar to the way you recorded beads in the warm-up activity.
7. When you reach the end of the transect, pull up your tent stakes and rewind the cord on the bobbin.

Sample Transect Line