

LESSON #2: DIFFERENT MEASURES OF BIODIVERSITY

OVERVIEW:

The goal of this lesson is to introduce students to different methods of calculating biodiversity and to consider how different biodiversity indices are sensitive to species richness and species evenness. This lesson builds off of the previous lesson where students brainstormed different ways of determining biodiversity. The first activity engages students in developing a way to evaluate which cell-phone plan is best. The goal of the first activity of this lesson is to help students to understand that there are multiple ways to measure something. The second activity introduces four measures of biodiversity (species richness, species evenness, Simpson’s Index and Shannon-Weaver Index) through a reading and discussion. The third activity has the students use these different measures to evaluate the bird biodiversity of the three urban sites introduced in Lesson 1. There is also a fourth optional activity that can be completed either in class or as homework that provides students with additional practice calculating biodiversity using tree data.

SUB-QUESTION:

How do we measure biodiversity?

WAYS OF KNOWING URBAN ECOLOGY:



Students will...

Understand

- Recognize the importance of using more than one method of measurement when evaluating biodiversity. (*ecosystem state and structure*)
- Recognize that species richness is the number of species present in a specific area. (*ecosystem state and structure*)
- Understand that species evenness is the similarity of the numbers of individuals of each species in a specific area. (*ecosystem state and structure*)
- Recognize that Simpson’s index and the Shannon-Weaver index are measures of biodiversity. (*ecosystem state and structure*)

Talk

- Justify the use of different biodiversity measures.

Do

- Calculate biodiversity indices of different sites using different methods.

Act

No specific goals connected with acting on urban ecology in this lesson.

SAFETY GUIDELINES:

None.

PREPARATION:

Time:

2-3 class periods

Day 1: Activity 2.1
Activity 2.2

Day 2: Activity 2.3

Day 3: Optional Activity 2.4

Materials:**Activity 2.1**

For each student

Copies of student sheet 2.1

Activity 2.2

Powerpoint and computer to project

For each student

Copies of reading, “Measuring Biodiversity”

Activity 2.3

For each student or group

Computer with Excel Biodiversity spreadsheet “M6_L2_biodiversity_measures.xls” (OR if multiple computers are not available then one computer with projector and PowerPoint Lesson 2.3)

Student instructions and sheets

Optional Activity 2.4

For each student or group

Computer with Excel Biodiversity spreadsheet “M6_L2_biodiversity_measures.xls”

Student instructions and handouts

INSTRUCTIONAL SEQUENCE:**Activity 2.1: Multiple Measures – Cell Phones**

1. Remind students that in the previous lesson they had been exploring biodiversity in order to answer the driving question for this module: How do we develop cities that sustain biodiversity? Before returning to talk about biodiversity, the students are first going to take a look at an everyday example to think about how people come up with ways to rate or evaluate things.

Teaching Alternative

- The Multiple Measures Cell Phone Activity can also be used as a “Do Now” or warm up activity at the beginning of the class either individually or in groups.

2. Either pass out the student sheet for Lesson 2.1 with the cell phone data or project the data table for the whole class. Have students work in groups to determine which cell phone plan they would purchase.
3. As you walk around the room, pay attention to what students observe about the three plans and what components of the plan they value most highly. You may need to probe the students’ thinking or help them get started if you see some groups struggling. Some potential questions to ask are:
 - What would you most value in a cell-phone – call quality, features, number of features, coverage area? Which is more important: the overall average score or the number of features?

4. Once the students have come to a conclusion, have groups share their analysis as to which cell-phone is best. You may want to take a tally of how many groups chose each plan and their reasons for their choice using a table format similar to the one below:

	Company A	Company B	Company C
Number of Student Groups that Chose this Plan	2	1	3
Reasons why they plan is best	Highest Average score. Highest call quality and reliability.	Lowest cost. Has more features. Has good downloadable games.	Medium cost. No feature has a real low rating. Has more features.

5. Discuss with the class the results of their analysis. Students should note that each plan has strengths and weaknesses, and different student groups focused on different aspects of the plan.
- Some groups may have focused on one or two particular features (e.g. cost or call quality) while other groups focused more on an overall average score or number of features. There are different potential ways to rate a cell phone plan.
6. You may also want to ask the students if they think their parents would choose a different cell phone plan. You could use this example to talk about how just like different people might look for different characteristics in a cell phone plan scientists may be looking for different characteristics when they are assessing an ecosystem. This is why they can have different indices to measure the same thing. In the next activity, you will be talking about different indices that they use to measure biodiversity.

Teacher Background Knowledge

- There is not a “right” answer to this activity – there is usually more than one way to measure the same phenomenon. When the students present their work it is important to point how different groups valued different aspects of each cell-phone plan. This is important because the two indices that your students will explore in the next lesson place a different value on different components of biodiversity.

Activity 2.2: Measuring Biodiversity

1. Discuss some of the key ideas with students. Ask students why they think scientists have different measures of biodiversity. You may want to suggest that they think back to what they talked about with the cell phone activity and in Lesson 1.
 - Biodiversity is the variation of life at all levels of biological organization (e.g. genes, species ecosystems). The level a scientist focuses on can influence their measure. Even if two scientists are focused on the same level such as the species, they can still have different interests or value different aspects.
2. Ask students - What are the different ways that scientist measure biodiversity? How are the measures different from each other?
 - Species richness - the number of species present
 - Species evenness (relative abundance)– considers the distribution or number of individuals of each species.

- Simpson's index – a measure of biodiversity that takes into account both the number of species and the evenness or abundance of each species.
 - Shannon-Weaver index – Similar to the Simpson's Index, it is also a measure of biodiversity that takes into account both the number of species and the evenness or abundance of each species. It places a greater importance on distribution and evenness (i.e. If there is one new individual of a species added to an area, Shannon-Weaver is more likely to decrease than Simpsons).
3. If students seem confused by the difference between species evenness and richness, you may want to draw a picture like the following on the board or overhead and ask them questions about these different biodiversity measures.

Site 1
10 robins
12 song sparrows
14 Dark-eyed juncos
11 American Crows

Site 2
10 robins
2 song sparrows
14 Dark-eyed juncos
7 American Crows
1 Common Grackle

- What is the species richness of each site? Site 1 = 4. Site 2 = 5.
- Which site has a greater species evenness? The species evenness is higher for Site 1 than Site 2, because they are more evenly distributed at Site 1.

Activity 2.3: Calculating Biodiversity for the Three Urban Sites

1. Remind the students of the previous lesson where they were comparing the biodiversity of the three different urban sites. You may want to show the PowerPoint from Lesson 1 with the images of the three sites. Tell the students that they are now going to use the different measures for biodiversity that they just discussed to calculate the biodiversity at the three sites.
2. Have the students work in groups or individually to use the biodiversity excel sheet and the student activity sheet to calculate the different biodiversity indices for the two sites. If your students are new to using excel, you may want to project the excel sheet first and talk through the excel sheet before having them work on the computers.

Teaching Alternative

- Having the students actively manipulate the excel file can help them develop a stronger understanding of the indices. However, if computers are not available for the students, alternatively you can project the excel file and go through the scenarios as a class or you can use the Activity 2.2 PowerPoint which has the biodiversity indices for the three locations. You can use an overhead projector to show students the PowerPoint.
3. As your students are working on calculating the different measures, you may want to ask individuals or groups questions such as the following to help them to make sense of the numbers
 - Which site has the greatest species richness? Which site appears to have some dominant species (large numbers)? What characteristics of the data impact whether the Shannon-Weaver and Simpsons indices are high or low?
 4. In a full class discussion, have students share their responses to the reflection questions and discuss the differences in the two indices in terms of how they measure biodiversity

Teacher Background

- The Simpson's Index ranges from 0 to 1 where zero is no biodiversity and 1 is infinite biodiversity. The Simpson's index represents the probability that if you randomly selected two individuals, that the two individuals would belong to different species. If the Simpson Index = 1, that means you have a 100% chance of selecting two individuals from different species.
- The Shannon-Weaver Index ranges from 0 to a theoretically infinite level. The maximum value is calculated by the $\log(1/\# \text{ of species})$ so it is limited only by the number of species in the community. The Shannon-Weaver index places a greater weight on the species evenness. In other words, if one new individual of one new species is added to an area, the Shannon-Weaver is more likely to decrease while the Simpson's index is more likely to stay the same.
- Under most conditions, the Shannon-Weaver and Simpson will change in similar ways as the biodiversity of an area changes. In order to see a difference in the two indices, you typically need a large number of species (100+), which the students will not collect in their field studies. If you do want to observe the difference with the 10 species in excel sheet, set the excel sheet to the following conditions: Condition #1: 10 species all with 99 individuals: S-W = 2.3 and S = 0.90. Condition #2: 9 species with 99 individuals, 1 species at 25 individuals: S-W = 2.26 and S = 0.90. The Shannon-Weaver will decrease slightly while the Simpsons remains the same.
- More information on both indices including their mathematical formulas can be found in the teacher background information in the beginning of Module 6.

Optional Activity 2.4

If you feel that your students need more practice calculating biodiversity, you may want to complete Activity 2.4. This activity has two versions. Version 1 has students revisit their tree data from Module 2 and calculate the biodiversity of their trees. Version 2 provides the students with tree data from two areas in Boston to calculate biodiversity and can either be used in class or as a homework assignment.

Optional Activity 2.4: Version 1 - Revisiting the tree data from Module 2

1. Ask students if they remember earlier in the year during the Land Use Module going out to their field site and collecting information on what trees were in the field site and the health of those trees.
 - You may want to ask students probing questions: What species of trees did we find? How many trees did we find? What was the role of those trees in the environment in terms of global warming? What was the economic value of the trees?
2. Have students use their tree data from Module 2 along with the excel sheet and Activity Sheet 2.4 – Version 1 to calculate and analyze the biodiversity of their field site.
3. Discuss students' responses to the conclusion questions.

Teaching Alternative

- If it is difficult for you to access computers or if you want to provide your students with mathematical calculations, you can have students calculate the Simpsons index by hand. The formula and an example are provided in the Teacher Background Information at the beginning of Module 6. Please note that this could extend the time of the activities so plan accordingly.

Activity 2.3: Version 2 – Data Provided

1. Tell students that they will be analyzing urban street tree data collected in Boston in 2006 from two different sites. Have students use the excel sheet and Activity sheet 2.4 – Version 2 to calculate and analyze the biodiversity of the two sites.
 - Discuss students' responses to the conclusion questions.

Concluding the Lesson

1. Tell students that in the next lesson they are going to start investigating the biodiversity of their field site. Ask students the following reflection question:
 - In order to determine the biodiversity of our field site, what data do you think we need to collect from our site? What measure or measures of biodiversity should we calculate? Why?
 - You may want to introduce here that they will be studying the bird biodiversity of their field site. You can link this discussion to the first narrative, which discussed that birds are good indicators of the ecological health of a community, because they are so mobile and will leave if the conditions deteriorate. You may also want to discuss the importance of using more than one measure of biodiversity (species richness, species evenness, Simpson's Index and Shannon-Weaver Index) because they give you different perspectives on a site.