Student Handout

Biodiversity Counts!

Our planet is filled with life. Do you know how to count it?

Words to Explore

Biodiversity
Richness
Evenness
Community
Species
Keystone species

Did You Know?

Tennessee is the most biodiverse inland state in the United States!

Did You Know?

Each year, about 15,000 NEW species are discovered!

Biodiversity, or biological diversity, is the variety of life on our planet. It includes everything from a tiny microbe to a giant blue whale, and everything in between!

In many parts of the world, human actions result in a loss of biodiversity—species can die off because of habitat degradation, loss of a food source, new diseases or introduction of an exotic species.

Why should we protect biodiversity?

We as humans are part of the planet's food webs. We are dependent on life around us!

- Many drugs and helpful products have come from nature, if we lose species we would lose these products
- Keystone species perform special functions. For example, a plant might depend on a certain species of insect for pollination.
- More biodiverse communities are more stable, so when disasters or an invading species comes along, it can resist the change.

How do we measure biodiversity?

<u>Diversity</u> is a measure of the different kinds of organisms in a region or other defined area. It includes the number of species and the distribution of individuals among the species.

<u>Richness</u> is the number the number of species in a region or specified area

<u>Evenness</u> is how equally the species are distributed. Maximum evenness is when all types of species have the same number of individuals.

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Activity 1: Calculating Diversity

Your leader will give you a community of different species. Take a look at your community, compare it to the other communities in the class and make a prediction.

Predict:

Which community do you think is the <u>most</u> biodiverse? _____

Which community do you think is the <u>least</u> biodiverse? _____

Investigate: Find out how diverse your community is.

1. Determine the RICHNESS of your community. Richness is the number of species present. List the names of the species in the first column and write the richness in the bottom row.
2. Count the number of each species and enter your numbers into the table.
3. Determine the EVENNESS. How evenly are the species distributed? Remember that the highest evenness is when all species have close to the same number. Score each community as high, medium or low evenness.

	Community				
Species	**1**	**2**	**3**	**4**	**5**
RICHNESS (number)					
EVENNESS (high medium or low)					
DIVERSITY (high, medium, or low)					
DIVERSITY (calculated)					

1. Which community was the most biodiverse? _____

2. Which community was the least biodiverse? _____

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Activity 2: DISASTER STRIKES!!!

Biodiversity is very important in helping a community withstand change. This change could be habitat descruction, disease, or invasion by another species. That's because different species perform different "jobs", and the more species, means you're more likely to have a species there to perform that job!

Your leader will present you with a disastrous scenario where some biodiversity is LOST.

Predict: What do you think will happen...

...to the most biodiverse community? _____

...to the least biodiverse community? _____

Investigate: After the disaster, look at your new communities and recalculate richness and diversity. Compare it to the numbers from Activity 1. Compare your data with the rest of the class.

	Community				
	1	**2**	**3**	**4**	**5**
RICHNESS					
EVENNESS					
DIVERSITY					

1. What happened to the biodiversity in the more diverse communities?

_____

2. What will be the effect of the disaster on the more diverse communities?

_____

3. What happened to the biodiversity in the least diverse communities?

_____

4. What will be the effect of the disaster on the least diverse communities?

_____

5. What else might have happened as a result of this loss of biodiversity?

_____

6. What are some ways humans cause losses in biodiversity?

_____ _____

_____ _____

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Activity 3: Small Samples

There are often so many species in an area that a scientist can't sample them all! They must rely on small samples and try to estimate richness. Could you estimate the diversity from a small sample?

Predict:

If you were to only sample 5 individuals, would you see the same richness as for the whole community?

_____

Investigate:

Step 1. Put your community back into the bag. Now, randomly draw 5 individuals. What is the richness of your subsample? Record your data below.
Step 2. Return your community to the bag. Mix them well, then randomly draw 10 individuals. Record you data below.
Step 3. Compare your community with the others in the class.

	Community				
	1	**2**	**3**	**4**	**5**
Actual RICHNESS (from Activity 1)					
RICHNESS (for 5 individuals)					
RICHNESS (for 10 individuals)					

1. Was 5 individuals a big enough sample to accurately measure richness?

_____

2. Was 10 individuals a big enough sample to accurately measure richness?

_____

3. Was small sample more accurate for more diverse or less diverse communities?

_____

4. How do you know if you have a big enough sample to estimate biodiversity?

_____

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Biodiversity Counts!

Objectives: ***Learners will:***
1) define the term biodiversity.
2) describe how biodiversity can be measured.

Skills: recording data, inference, answering own questions, analysis

Supplies:
- Biodiversity Counts! Datasheet
- pencils
- 'Habitat bags' *see datasheet key*
  - elbow macaroni
  - Spiral macaroni
  - Peanuts in shell
  - dried peas
  - rocks

Subjects: science, math

Time: 20 – 30 minutes

Location: indoors

Essential Questions:
How can biodiversity be measured?

At A Glance: This indoor activity helps students understand the concept of counting organisms in a plot study or line transect prior to doing the outdoor activity.

Getting Ready
Prepare one "habitat" bag for each scientist team ahead of time by placing "species" in a plastic ziploc baggie. "Species" are peanuts, pasta, rocks, etc. Each bag has a different combination of numbers of species. For example, one bag has many of one species, one bag has a few of five to six species, and the other bags have different combinations of species and numbers of individuals. The bag with just one species should have many individuals to keep this team busy while other teams are counting. Write a number on each bag.

Procedure
1. Introduce the term "biodiversity" to learners as referring to a variety of life. Bio means 'living' and 'diversity' is variety. So when we are talking about biodiversity we are looking at the variety of organisms (and their genes) in an ecosystem.
2. Divide learners into 4 to 6 scientist teams. Assign the team a number and give each team a "habitat" bag with "species" inside.
3. Explain to learners that the bag is like a habitat and is a home to the species within its borders. The items in the bag are "species". Make analogies to local or regional habitats and the species that live there to help learners to understand that their team's bag and its contents is a model of a real habitat.
4. Ask scientist teams to choose a recorder and give each team a Biodiversity Counts! worksheet, a species key and a pencil.
5. Ask teams to work together to count the different species and record the numbers on the worksheet. This can be done either by pouring the contents of the bag onto the Biodiversity Counts! Worksheet (with the circle on it) or by moving the items around to sort and count them without opening the bag. (Using the worksheet with the circle on it helps learners get ready for counting the species in a plot sample on their school site.)
6. Using the Biodiversity Counts! Key, team recorders will write down the names and numbers of species and tally them. The key is used to help learners know what to call the species and also gives them good practice in using reference materials. Tell learners that scientists often use keys called field guides to help them identify species that they have observed. In this key, peanuts are snakes. Learners should write "snake" in the species column of the worksheet and the number of them in the second column. Teams should tally the numbers of individuals and write the total in the gray box (the last row).
7. Ask teams to discuss what other species could use the "species" of their "habitat" bag to survive and write the names of these species in the third column. For example, if snakes are

present in a habitat, then hawks may also be present because they would have a food source. Teams should then tally the number of the different species they observed and record the total in the gray box. This allows learners to see that having a variety of species can lead to even greater variety and greater numbers.

8. After all teams have counted and recorded their species, ask a member from each team to tell the others what species they found in their habitat. Guide discussion about the needs of their species and whether or not they are met in this habitat. For instance, if a habitat has only peanuts (representing snakes), they will not live very long unless they adapt to eating their own kind.

9. Discussion can be expanded to include issues concerning the extinction of a certain species and the effect that has on other species populations or issues concerning the introduction of exotic species for biological control or by accident and the effects of this on native populations. Stress to learners that biodiverse habitats are healthier, more stable and balanced.

10. Conclude the activity by asking learners, “Which habitat is more biodiverse, a habitat with lots of one species of a few of several different species?” They will be able to see from the totals of their columns that a greater variety of “species” in their “habitat” is more biodiverse.

Biodiversity Counts!

In this activity, students will learn about biodiversity: how we measure it and why it matters!

Project Area: Environmental Science

Skill Level: Intermediate—Advanced

Learner Outcomes:
-Define biodiversity
-Be able to count and calculate diversity metrics
-Understand why biodiversity is important

TN Science Curriculum Standard GLEs:

S1. Embedded Inquiry 0607.Inq.1-5, 0707.Inq.1-5, 0807.Inq.1-5

S5. Biodiversity & Change 0807.5.1, 0807.5.5

TNCore Math:
7.NS. 2-3
7.EE.1-4

Science Skills: Develop hypothesis, observe, collect data, interpret
Math Skills: Solve real world problems using numerical and algebraic equations; apply multiple operations on rational numbers (add, subtract, multiple, divide)
Life Skills: Observing, Reasoning

Tags: Biodiversity, communities

Time Needed:
Set up: 5 minutes
In class: 30 minutes

Materials:
-Small items that can be sorted by color, size, shape etc. (e.g. animal counters, lego blocks, beads, cards with pictures of animals etc.), approximately 20 per group of students
-Chalk board or large writing pad for recording observations

Set up

This activity can be done with either natural communities (e.g. insects collected from a pond or field, plant specimens collected from a field - see EXTENSIONS for more ideas), or can be done with an artificial community consisting of at least 4 different things (e.g. beads, animal figures, legos, cards with pictures of the animals - anything that can be sorted by a characteristic).

Students will work in small groups, 4 or 5 groups in a class. Before class, create 4-5 "communities" of approximately 20 individuals. Make some more diverse (equal representation of all types) and some that are less diverse (mostly one type of thing). Here's

Community	Pillbug	Monarch butterfly	Lady beetle	Honey bee	Stink bug
1 (more richness, more evenness)	4	4	3	5	4
2 (less richness, more evenness)	6	0	7	0	7
3 (more richness, less evenness)	15	1	2	1	1
4 (less richness and less evenness)	0	15	0	4	1

an example set up with insects:

Introducing the Activity

Ask your students: What do you think biodiversity means?

Possible answers : Diversity of life on earth, all the different species in a community, all the genetic differences in a population or community

Show your students pictures of various biomes. First show a tundra (arctic) biome and a rainforest. **ASK: Where do you think we find the most biodiversity?** (Answer: rainforest). **Ask your students why they think that is.** (Answers: warmer temperatures means greater plant productivity which can support a bigger food web, warmer temperatures mean nutrients are recycled quickly, lots of different niches and habitats, etc. If you think of a food pyramid, the rainforest has a broader base.)

Now show pictures of two temperate biomes: a grassland and a temperate deciduous forest. **ASK: Which has a greater biodiversity?** This should be difficult to answer, because it is hard to tell from simply looking at them.

Explain that because we cannot always tell what the diversity of an area is, we need ways to quantify and describe biodiversity. In this lesson, they will learn how to do just that.

Have your students work in 4-5 small groups for this activity. Give each group an artificial community (see set up) or have them collect a natural community (see extensions). They should be sitting so that they can see all the other groups' communities. As you work through this activity, record the answers for all groups on a large chart.

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Part 1. Calculating biodiversity

Predict: Ask your students to look at the different communities. **Have them make two predictions:**

1. **Which community has the highest diversity?**
2. **Which community has the lowest diversity?**

Investigate: Explain that one way we can quantify diversity is by counting **richness**: This is the number of types of species in your community. Have them count the number of species and record the observations. (In the example dataset, richness = 5, because there are 5 different species present).

Now explain that diversity takes into account both richness and **evenness**: This is relative abundance of each species (or how they are distributed). The highest evenness is when every species has equal representation in the community. Have them rate each community as **high**, **medium** or **low** evenness.

Have them look at the richness and evenness scores, and determine the **diversity** of each community.

For younger students: Have them score each community as low, medium or high.

For older students: Have them calculate diversity using **Simpsons diversity index**[1].

$$D = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)}$$

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

Species	Number of individuals
Pillbug	1
Monarch butterfly	9
Lady beetle	2
Honey bee	4
Stink bug	5

Example dataset and calculation:

First, calculate the numerator (top):
= (1 (1-1) + 9(9-1) + 2(2-1) + 4(4-1) + 5(5-1))
= 1(0)+9(8)+2(1)+4(3)+5(4)
= 0 + 72 + 2 + 12 + 20 **= 106**

Then, calculate the denominator (bottom):
N = 1 + 9 + 2 + 4 + 5 = 21
N(N-1) = 21(20) = **420**

Then, put it all together:
D = 1 - (106 / 420)
D = 1 - (0.25) **= 0.75**

This means that if you randomly pick two species you have a 75% chance of those two individuals being different species. We can say the diversity is HIGH (the closer to 1, the higher the diversity.) **Have your students record the diversity on their datasheets.**

Revisit the hypothesis: Were their original predictions correct? Who had the most diverse and who had the least diverse community?

[1]Simpson, Edward H. (1949). Measurement of diversity. Nature, 163, 688

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Part 2: Disaster Strikes!

Introduce: ASK: Why do you think biodiversity is important?

Possible answers: Aesthetics (looks nice), recreation (e.g. bird watching, fishing, hunting), source of new products (e.g. pharmaceuticals), resists invading species or diseases, important for other organisms in the food web, other ecosystem services (e.g. clean water, air, soil, clean up pollutants).

Predict: When disaster strikes (like disease or natural disasters) which communities do you think will be more affected?

Investigate: Pick a species and explain that they have a very important function in the community. e.g. flowers depends on honey bees to pollinate. These flowering plants can't reproduce without the help of honey bees.

Tell your students there's been a terrible disaster (e.g. hurricane, disease, hunters) which has killed off almost all the honey bees. Go around the classroom and randomly remove 2 honey bees from each group. (If they only have one honey bee, remove that one).

ASK: Do you have any bees left in your community?

-Students with more diverse communities should still have some bees, the less diverse communities may have no bees.

ASK: What do you think will happen to the flowering plants in your area?

-Possible answers: If several bees are left, likely has little or no effect. If no bees are present, then the flowers won't get pollinated and that plant species might die off.

Get your students to recalculate the richness, evenness and diversity of their new communities, just as they did for part 1. If short on time, then just re-calculate richness. Record the data and share the with the class.

Revisit your hypothesis: Which communities were more affected by the disaster? (Answer: Least diverse)

Disscuss & Apply:

What happened to the diversity in the more diverse communities? Answer: richness/diversity stayed about the same.

What will be the effect of the disaster on the plants in these more diverse communities? Answer: still bees there to spread seeds, probably little effect on the plants

What happened to the diversity in the least diverse communities? Answer: richness/diversity was lower

What will be the effect of the disaster on the blueberry plants in the least diverse communities? Answer: bees are gone (or reduced), so flowers won't get pollinated and won't be able to reproduce.

What else might have happened as a result of this loss of biodiversity? Possible answers: no honey is made, so bears and other animals might lose a food source, birds that eat bees also lose a food source

What are some ways humans cause losses in biodiversity? Possible answers: habitat destruction due to civilization or climate change, spread diseases, spread invasive species, forest fires, pollution, over hunting, over fishing etc.

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Extension and Variations:

1. Use a natural community. Instead of using toys, get your students outside to sample their own community! Try to pick at least two sites, one which is impacted by human activity (e.g. urban area) and one that is more natural. From a creek, use a bucket to collect sediments and collect the larvae that live there. On land, use a hula hoop to designate an area in a field or forest, and collect different plants or insects that live there. Students can use a key to identify the organisms. For example, use the activities in the "life beneath your feet" module on soil biology to collect organisms and preserve them in isopropanol. Then carry out the diversity exercises here.

2. Small samples (Activity 3 in student handout). Since scientists usually can't count ALL the species in a given area, they must use small subsamples to estimate biodiversity. In this activity, students randomly pull 5 and then 10 individuals from their community, then recalculate richness and/or diversity as for part 1. They should find that for less biodiverse communities, a small sample is fairly accurate, but for more biodiverse communities, they need a larger sample to estimate richness or diversity.

> **Was small sample more accurate for more diverse or less diverse communities?** (Answer: less diverse)
>
> **How do you know if you have a big enough sample to estimate biodiversity?** (Possible answers: if you have the same richness in your small and large sample, then it's probably pretty accurate; keep sampling more and more until the richness doesn't change anymore.)

3. Biodiversity as a function of scale. Biodiversity can depend on the size of the area you are measuring. Typically, we expect higher richness if we take a larger area into account. If your students are working in small groups, tell them each group is a different patch of forest. Now ask them to predict if the biodiversity would be higher or lower for the entire forest (i.e. the whole class). Then, pool all the communities and have your students calculate richness and/or diversity.

Resources

Project Learning Tree: "Exploring Environmental Issues: Biodiversity" is available at www.plt.org

Duncan, S.I., Lenhart, S.L. and K.K. Sturner. 2014. Measuring biodiversity with probability. The Mathematics Teacher. *In press*

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