# Calculating Biodiversity
***Secondary***

## Key Inquiry Questions

1. What is biodiversity?
2. What are species richness, species abundance, habitat diversity, and genetic diversity?
3. How can we calculate biodiversity?

## Learning Outcomes

1. Students will be able to define and explain the value of biodiversity, species richness, species abundance, habitat diversity, and genetic diversity by the end of the lesson.
2. Students will be able to calculate biodiversity by the end of the lesson.

## Sustainability Curriculum Goals

**Systems Thinking:**

1. Our planet - the biosphere - is a complex system that supplies resources and creates conditions that sustain life on Earth.
2. All forms of life, including humans, are connected to each other through man-made and natural ecosystems on which their well-being depends on.

**Sustainable Futures:**

1. Actions associated with a sustainable future reflect values of care, respect, responsibility, empathy, and compassion for all living and nonliving things.
2. Sustainable futures involve actions that work to preserve, protect, and/or restore the natural environment.

**Activities/Goals:**

1. Students should be able to explain what sustainability is, the importance of ecosystem services and biodiversity.

## Overview:

Before the lesson students will watch a video to refresh their memories on what biodiversity is and why it is important to protect it. The video will set the stage for the rest of the lesson, where the students will learn how to calculate biodiversity. After completing an example as a class, students will work on calculating biodiversity on their own. Lastly, students will reflect on what they have learned by creating a poster and a one-page essay on how they view the future of our world, specifically in regards to biological and human systems.

## Materials

**SolarSPELL Resource:**

1. "What future is there for global biodiversity?" (Environment > Teaching Resources > Environment and Sustainability > What Future is there for global biodiversity? )
2. "Species Diversity Worksheet" (Included below)

**Other:**

1. Science journals
2. Pencils
3. Calculators (if available)
4. Colored pencils, markers, or crayons (if available)

## Suggested Procedure

*Before the Lesson:*

- Have students watch the video titled "What future is there for global biodiversity?"
- After the completion of the video, ask students to respond to the following questions as a group:
    - 1. Define biodiversity?
        - Answer: biodiversity is the variety of life on Earth.
    - 2. Which of the following is NOT a part of biodiversity: plants, animals, microorganisms, rocks.
        - Answer: rocks
    - 3. What major event led to the acceleration of biodiversity loss?
        - Answer: the Industrial Revolution
            - The Industrial Revolution started in Europe and the United States and was the transition of new manufacturing processes that rely on technology and machines rather than people power.
    - 4. What continent is the size of the amount of natural land converted for urban and agricultural uses?
        - Answer: Europe
    - 5. Name 2 causes of biodiversity loss.
        - Answer: crops and livestock, ocean exploitation, constructing roads, killing forests for timber and paper.
    - 6. Name 2 effects of biodiversity loss and habitat destruction.
        - Answer: acceleration of climate change, increased floods, and droughts, crops are more vulnerable to pests and diseases
    - 7. What are 2 ways people all over the world are protecting biodiversity?
        - Answer: increasing national parks and protected areas, better management of protected areas, better production processes, decreased meat and dairy consumption, reduction in food waste

- After giving students time to discuss as a group, call on a few students to share their answers with the class.

*During the Lesson:*

- Explain to students that biodiversity is actually made up of three main components:
    - S**pecies diversity**; **ecosystem (or habitat) diversity**; and **genetic diversity**. Thus, biodiversity can be used to measure how healthy biological systems are.
- Explain to students that species diversity is the variety of different organisms that make up a community.
    - Continue explaining that in relation to species diversity, there is a concept called "species richness". This concept is the number of different species present in a specific area. The more different types of species in a single area, the richer the area is.
    - Ask students to raise their hand to which of the following statements they agree with:
        - One Mahogany tree contributes as much to species richness as 100 Fig trees.
        - However, 100 Fig trees contribute more to species richness than one Mahogany tree.
            - Answer: Because species richness does not measure the number of individuals of each species present, only the existence of different types of species, one Mahogany tree has as much influence on the richness of a community as 100 Fig trees.
- Ask students to raise their hand if this seems like a good way to measure diversity.
    - Call on a few students to share their answers.
- Explain to students that a good measure of diversity should also take the abundance of species into account. Let's give an example:
- Imagine 2 different forests exist.
    - Draw the following diagram on the board in front of the classroom, or on sheets of paper for students to share in groups before the class.

| | **Number of individuals** | |
|---|---|---|
| **Tree species** | **Forest A** | **Forest B** |
| Mahogany | 30 | 1 |
| Fig | 33 | 5 |
| Palm | 37 | 94 |
| Total | 100 | 100 |

- Ask students to raise their hands if they think the species richness is the same in each field?
- Ask students to raise their hand if they think the total species abundance is the same in each field?
- Ask students to raise their hand if they think Forest A is more diverse than Forest B? Ask students to raise their hand if they think Field B is more diverse than Forest A?
- Explain to students that the species richness is the same because all three types of trees are present in both forests and the total abundance is the same because both forests have 100 species. However, Forest B has mostly just one species - Palm, meaning it is less diverse than Forest A because it has mostly just one type of species.

- Write the following equation - known as the Simpson's Index - on the board, or on sheets of paper prior to class to be handed out to students.

    - $D = \Sigma\, n(n-1) \div N(N-1)$

- D is the measure of species diversity, which takes both species richness and abundance into account, and is a measure between 0 and 1. The bigger the value, the lower the diversity, thus, 0 represents infinite diversity and 1 represents no diversity at all.

    - $\Sigma$ = the sum (add altogether)
    - n = the total number of organisms of each species
    - N = the total number of organisms of all species

- We are going to practice calculating the species diversity index for Forest A.
.
    - D (ForestA) = 30(30-1) + 33 (33 -1) + 37 (37 - 1) ÷ 100(100 − 1)
        - D = 870 + 1,056 + 1,332 ÷ 9,990
        - D = 0.329

- After calculating D, which is the measure of species diversity, ask students if 0.329 would indicate high, low, or moderate level of species diversity.
    - Answer: Forest A is closer to 0 than to 1, but is still quite large, thus, we would say that Forest A has *moderate* species diversity.

- Low species diversity suggests:
    - There are not many successful species in the habitat
        - Successful species refers to the ability of species to reproduce offspring that live long enough so they begin to reproduce.
    - The environment may have few ecological niches, which refers to the jobs or roles each organism has in an environment
    - Food webs are simple
    - Few species can adapt to that environment

    - A sudden change in that environment would likely have serious negative impacts

- High species diversity suggests:
    - There are many successful species in the habitat
    - A more stable ecosystem with lots of different niches
    - Complex food webs
    - A sudden change in the environment would likely be less damaging to the ecosystem as a whole

- Explain to the students that species biodiversity can indicate the biological health of habitat, but because some habitats are very stressful to live in, few organisms may be able to survive there. Thus, those that do, may be rare and are still important to biodiversity as a whole.
    - Additionally, a sudden decrease in biodiversity could mean there is a serious issue affecting the community, such as pollution.

- Explain to students that there are still two other types of diversity that make up biodiversity:
    - Ecosystem (habitat) diversity: Habitat diversity is the diversity of habitats or ecosystems in a specific area. Regions with a wide variety of habitats will have a much larger amount of diversity of species than one where there are few habitats present. For example, a farm, with some natural forest, a river, and a variety of different plants will have greater diversity than a farm without wet areas or natural trees.
    - Genetic diversity: Genetic diversity is the genetic variability of species. Recall that all species are made up of different DNA, which houses their genes. For example, human genetics are diverse by some people having brown eyes and other people having green eyes. We can thank genetics for making everyone look a little different from each other. A lack of genetic diversity is a huge problem because it indicates that the species may not have sufficient adaptability, making it less likely to survive an environmental hazard.

*After the Lesson:*

- Direct students to the worksheet titled "Calculating Species Diversity"
    - Go over Table 1 and Table 2 as a class, then have students complete Table 3and answer the questions on their own.
- After students complete the worksheet, go over it together as a class.

*Assessment (optional):*

- Ask students to imagine it is the year 2050. Have each student draw what they think their community will look like in the future and have them write a short 1-page story about the lifestyles people will be living. Will biodiversity be protected?

# Species Diversity Worksheet

Consider three different communities, each with 100 organisms, with 10 different species per community, labeled A to J.

**Table 1** *Species composition of three different communities.*

| Species | Community 1 | Community 2 | Community 3 |
|---|---|---|---|
| A | 11 | 4 | 0 |
| B | 10 | 3 | 0 |
| C | 9 | 3 | 37 |
| D | 9 | 5 | 0 |
| E | 9 | 1 | 33 |
| F | 11 | 4 | 0 |
| G | 11 | 65 | 0 |
| H | 9 | 3 | 0 |
| I | 11 | 2 | 30 |
| J | 10 | 9 | 0 |
| Total | 100 | 100 | 100 |

The formula for calculating Simpson's index is:

- $D = \Sigma\, n(n-1) \div N(N-1)$

n = the total number of organisms of each species
N = the total number of organisms of all species

Reminder: The higher the value of D, the lower the species diversity.

The lower the value of D, the greater the species diversity. Look to Table 2 for an example of calculating the D of Community 1.

**Table 2** *Data - Simpson's index for Community 1.*

| Community 1 | | | |
|---|---|---|---|
| **Species** | $\mathbf{n_i}$ | $\mathbf{n_i - 1}$ | $\mathbf{n_i(n_i - 1)}$ |
| A | 11 | 10 | 110 |
| B | 10 | 9 | 90 |
| C | 9 | 8 | 72 |
| D | 9 | 8 | 72 |
| E | 9 | 8 | 72 |
| F | 11 | 10 | 110 |
| G | 11 | 10 | 110 |
| H | 9 | 8 | 72 |
| I | 11 | 10 | 110 |
| J | 10 | 9 | 90 |
| Total | N = 100 | | $\Sigma_i(n_i - 1) = 908$ |

So for Community 1:

$$908 \div 100(100 - 1) = 0.09 \text{ (high diversity)}$$

Complete Table 3 by calculating the Simpson's index for both Communities 2 and 3. Show your work in your journals.

**Table 3** *Simpson's index for Communities 1, 2 and 3.*

| **Community** | **D** | **Level of diversity** |
|---|---|---|
| 1 | 0.09 | Very high |
| 2 | | |
| 3 | | |

**Answer the following questions:**

1. What is meant by *biodiversity?*

2. What is meant by the term *species richness?*

3. Looking at Table 1, why do you think species diversity is different between the three communities?

4. What might cause species diversity to be low?

5. Why is species diversity important?

6. What is one difference between species richness and species abundance?

# Species Diversity Worksheet - Answer Key

| Community | D | Level of diversity |
|---|---|---|
| 1 | 0.09 | Very high |
| 2 | 0.52 | Moderate (Lowest) |
| 3 | 0.33 | Moderate |

1. What is meant by *biodiversity?*
   - the variety and variability of all life on our planet.

2. What is meant by the term *species richness?*
   - Number of different species

3. Looking at Table 1, why do you think species diversity is different between the three communities?
   - Community 1 has higher species diversity because D is the lowest and it has the highest species richness with a relatively equal abundance of all species.
   - Community 2 has the same species richness as Community 1, but it has mostly one species so the diversity of that community is lower than that of Community 1.
   - Community 3 has lower diversity than Community 1 because it has a low species richness (3).
   - There might be more different niches in Community 1

4. What might cause species diversity to be low?
   - Communities 2 and 3 could be rebuilding after an environmental disaster
   - There could be a disturbance, such as humans clearing trees to build a house or a road, to animals or habitats in Communities 2 and 3
   - Community 1's habitat might be a pristine/untouched habitat
   - Community 1 could be protected under conservation

5. Why is species diversity important?
   - Each species has a role in the ecosystem, and if one species if removed then the balance of the ecosystem could collapse and cause further damage.

6. What is one difference between species richness and species abundance?
   - Species richness is the total number of different species in an area, but species abundance refers to the number of different species present in the area.