Mesofauna biodiversity investigation

Focus questions	Can human impact affect the biodiversity of soils? How can Simpson's Index of Diversity help to determine the species richness of disturbed soils?
Vocabulary	Biodiversity, mesofauna, macrofauna, Simpson's Index of Biodiversity, species richness, species evenness, relative abundance

A healthy soil demonstrates high **biodiversity** with millions of **mesofauna** (microscopic invertebrates) and **macrofauna** (macro-invertebrates). Mesofauna are busy decomposing organic material and releasing key nutrients for plant use within the soil. Macrofauna play an important role in soil aggregation, porosity, and carbon accumulation within the soil. Healthy soils demonstrate high biodiversity. Human impact on soils due to construction, agricultural production, and lawn care can decrease soil biodiversity. Soil ecosystems can be altered as soil structure is changed and/or the loss of nutrients and/or erosion occurs.

Simpson's Index of Diversity is a tool used to measure the level of biodiversity present in each soil sample. It measures both the **species richness** (number of species per sample) and the **species evenness (relative abundance** of each individual species per sample) in a community. A community dominated by one or two species is considered to be less diverse than one in which several species have a similar abundance. The Simpson's Index of Diversity value (D) ranges between 0 and 1. In Simpson's Index of Diversity, 1 represents infinite diversity and 0, no diversity.

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Simpson's Index of Diversity
n = the total number of organisms of a particular species
N = the total number of organisms of all species

Example: Sample Calculation

Species	Number (n)	n(n–1)
A	2	2
B	8	56
C	1	0
D	1	0
E	3	6
Total	**N = 15**	**∑ n(n–1) = 64**

$$D = 1 - \frac{(64)}{(15\ (14))}$$

Simpson's Index of Diversity = 0.7

The Berlese funnel is commonly used to collect small organisms. A sample is taken and put in the funnel with a wire or mesh screen below the litter. A bright light is placed above the funnel and a container with alcohol is placed below the funnel. As the leaf litter dries, from the top down, the organisms in the leaf litter will migrate downward (trying to stay in the moist litter) and will eventually fall into the alcohol, which will preserve them for later observation. They can then be sorted, classified and the diversity index can be determined.

What soils will your group investigate? Agricultural soils have a wide range of tillage practices utilized, ranging from no-till (minimal soil structure disruption) to conventional tillage (high soil structure disruption). Soil structure refers to how the soil particles are grouped together into aggregates which determine how air and water are able to move through the soil. Human impact is greatest when conventional tillage is employed. Tillage breaks up soil structure by disrupting the way the soil particles aggregate together, destroys residue on the soil's surface and aids in soil compaction. Conventional tillage utilizes a blade to turn over the soil and exposes the soil to the atmosphere. No-till practices do not break up the soil structure but instead slice the soil to place a seed into it for planting and then closes the soil up to prevent moisture loss. Consequently, no-till practices promote a higher water retention, reduce soil erosion, increase biological activity and organic matter in the soil.

It is important to measure the volume of your soil sample in order to compare the Simpson's Index of Diversity of your sample to the entire ecosystem.

- 1 acre = 43,568 ft^2
- 1 inch of soil = .0833 ft

If your sample is 2 inches deep and measures 8 inches long by 10 inches wide, its volume (ft^3) equals:

.1667 ft deep × .6664 ft long × .833 ft wide = .0925 ft^3

Questions to research for this investigation with your group:

1. What are the agricultural benefits of conventional tillage practices versus no-till?
2. What are the environmental benefits of no-till versus conventional tillage?
3. From an economic standpoint, is it more advantageous to till or not till?
4. In the United States, is most commercial farmland tilled or not tilled?

Materials

- Soil samples (Human impacted ecosystem and natural ecosystem)
- 2, 1 gallon zip lock bags
- 2, 2-L bottles to create Berlese Funnel
- Scissors
- Duct tape
- Scale
- Ruler or tape measure
- Wire screen or mesh screen
- Isopropyl alcohol
- Dissecting microscope or magnifying glass
- Small jar with tight fitting lid
- Petri dish
- Heat lamp

Procedure

Day 1

1. Research different agricultural tillage practices such as conventional tillage and no-till practices.
2. Write a hypothesis to predict the Simpson's Diversity Index values of a disturbed soil ecosystem and an undisturbed soil ecosystem.
3. Get a plastic bag and go to your designated locations. Look for an area of soil that demonstrates human disturbance (agricultural production, lawn/flower bed, construction, etc.) and an area of soil in an undisturbed state.
4. Collect all the leaf litter and soil on the top layer of humus (to the extent that you can remove it with your fingers) and place into your plastic bag. Measure the area of the soil sample and depth of the soil sample and record. Determine how large the ecosystem is that your sample is taken from. If you are sourcing your sample from an agricultural field, ask the farmer and determine the acreage of the field.

Day 2

5. Create a Berlese funnel apparatus.
    a. Cut the top of the 2-L soda bottle off at about one third of the height. The top part will function as the funnel and will be inverted and inserted into the lower part of the bottle.
    b. Pour the isopropyl alcohol into the small jar to a depth of 1.5 cm. Place the jar in the bottom of the 2-L bottle.
    c. Invert the top part of the bottle and cut some wire mesh large enough to create a basket in the wide end of the funnel. To do this, you might need to fold up the corners of the mesh to make it fit inside the funnel part of the bottle.
    d. Tape the edges to the inside of the container. *If you are using a small mesh (such as a window screen) create a loose pit in the middle that is deep enough to hold your soil and allow the fauna room to burrow down. Cut numerous slits into the screen first so that larger animals can crawl through.*
6. Carefully set the funnel on top of the bottom portion of the 2-L bottle, making sure it fits tightly in the bottom and does not tip over. The tip of your funnel should be close to the jar with alcohol but should not touch the liquid.
7. Place the leaf litter/soil that you collected into the top of the funnel so that it rests on the mesh.
8. Put a light above your funnel apparatus to help dry out the sample.
9. Repeat this process with a second sample.

Day 3

10. Gently pour the contents of the alcohol jar into the petri dish for observation. Keep the alcohol jar tightly covered when not in use.
11. Set up a dissecting microscope and place the petri dish under the microscope to identify the species of invertebrates. *If you do not have a dissecting microscope, use a 10× magnifying lens.*
12. Use Invertebrate classification charts to help with your species identification and record them in your data table. If you cannot determine their identity, count the number and name them Species A, B, etc.
13. Collect data following the steps below.
    a. Determine the species abundance and species diversity of your sample locations. How do these samples compare to the entire ecosystem? If your sample is 1 ft^2 × 3 inches (.2499 ft) deep, then its volume equals .2499ft^3. If the ecosystem is one acre (43,560 ft2), then the ecosystem has a volume of 10,885 ft^3. What is the diversity index of the ecosystem?

Draft the data tables needed to display raw data collection that is measured for each trial. You may want to use another piece of paper for this and the following requirements below. Here is an example.

Species	**Number (n)**	**n(n–1)**	**Observations**
Total	**N =**	**∑ n(n–1) =**	

b. Determine the differences in the Simpson's Diversity Index values from one location to another. Show your work.
c. Create a data table to demonstrate the calculated D values from other student groups to determine the mean for each location.
d. Graph your data. You many want to use another piece of paper. Be sure to include a scaled interpretation of the volume of the ecosystem that the sample was taken from. *Remember, the x-axis is the horizontal axis and always is the independent variable. The y-axis is the vertical axis and is the dependent variable.*

Conclusion

Based on your findings from the lab, what conclusions can you draw? Write a conclusion to show your interpretation of the data and how it relates to the concepts studied in this lab.

1. What was your purpose? Did your procedure and findings relate to your original purpose? Does there seem to be a relationship between the sample locations and the biodiversity calculated? If so, what is that relationship?

2. What did you hypothesize? Did your experiment support your hypothesis?

3. Explain your results. Why do you think you got the results you did? (Use your researched resources if necessary, but remember to cite information used.)

4. Identify at least two things that happened during the lab that could have introduced error or affected the results. Not simply human error! Be sure that you explain *how/why* you feel these caused error in the experiment.

5. Were there any limitations to your experiment? In other words, were there matters that you feel may have affected the accuracy of your results, however were out of your control. If so, describe them.

6. What improvements could be made to the procedures for this lab to reduce the errors and or limitations identified? Make sure that the improvements are specific *and* feasible!

Rubric for self-assessment

Skill	Yes	No	Unsure
I understand the differences in agricultural tillage practices, such as conventional tillage vs. no-till, that can impact soil ecosystems.			
I understand what biodiversity is and can apply the concept to the ecological impact on soil tillage practices.			
I used mathematical thinking to provide evidence to answer the question: How do no-till and conventional till production practices impact soil biodiversity?			
I understand how to scale the Simpson's index of diversity of my sample to that of the entire ecosystem.			
I can determine the soil ecosystem resilience for each sample.			