Mesofauna biodiversity investigation

Focus questions	Can human impact affect soil biodiversity? How can Simpson's Index of Diversity help to determine the species richness of disturbed soils?
Vocabulary	Biodiversity, mesofauna, macrofauna, Simpson's Index of Diversity, species richness, species evenness, relative abundance
Learning target	Students will be able to understand and explain the importance of biodiversity in a soil ecosystem and calculate the Simpson's Index of Diversity to determine how human impact can alter the biodiversity in a soil ecosystem.

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance expectation HS-LS2-2	**Classroom connection:** Students explore the impacts of farming practices (conventionally-tilled soil versus no-till soil) on mesofauna biodiversity by calculating Simpson's Index of Diversity for various soil samples.

Science and engineering practices

Using Mathematics and Computational Thinking	**Classroom connection:** Students use mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) to determine the biodiversity index of organisms in a given area.

Disciplinary core ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience	**Classroom connection:** Students will investigate the human impact of disturbed soil versus non-disturbed soil on meso/macrofauna biodiversity.

Cross-cutting concepts

Scale, Proportion, and Quantity	**Classroom connection:** Students will measure and compare the volume of soil in each sample to the biodiversity index of each sample to determine the ecological impact on the soil ecosystems.

This activity focuses on Using Mathematics and Computational Thinking to determine the human impact on soil ecosystems.

Background

Mesofauna are defined as very small invertebrate animals that live in or on soil on benthic sediment, referred to as 'leaf litter' in this experiment. Leaf litter cover plays a protective role in resisting soil erosion due to rainfall. This protection is removed as litter decomposes. The protective effect is influenced by the presence or absence of soil **meso-** and **macrofauna**. Fauna in the leaf litter help to decompose the organic matter, releasing nutrients for flora use and aid in soil aggregation and porosity.

Biodiversity is important because the more diverse the different roles (producers, consumers, and decomposers) found within the ecosystem, the more the ecosystem can maintain stability. The greater the biodiversity in an ecosystem, the more healthy and stable the ecosystem is. The healthier an ecosystem is, the longer the ecosystem can exist in nature.

Agricultural tillage practices vary greatly across the world in preparation for growing crops. Students will research soil ecosystems that are both disturbed by human impact (conventionally tilled) and undisturbed by human impact (no tillage) in this investigation. Human impact is greatest when conventional tillage is employed. Tillage breaks up soil structure, destroys residue on the soil's surface and aids in soil compaction. No-till practices promote a higher water retention, reduce soil erosion, increase soil biological activity and increase soil organic matter. (usda.gov)

Students will use **Simpson's Index of Diversity** to determine the level of biodiversity present in soil ecosystems. Simpson's Index of Diversity is a measure of diversity that incorporates information about **species richness,** as well as the relative abundance **(species evenness)** of each species in the community. Species richness is the number of species per sample, whereas **relative abundance** compares the number of organisms of a species with the total number of organisms found in the sample. As species richness and evenness increase, then ecosystem diversity will increase. 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

Prior knowledge

In order to successfully complete this activity, students should know or have completed lessons relating to species classification, biodiversity, and ecological succession. Students should be able to complete algebraic equations as well as have a background of working with dissecting microscopes.

Teacher preparation

- Determine where students can collect soil samples or ask students to bring in samples from home. Each sample should fill one quart-sized bag.
- Collect 2-liter bottles prior to the investigation. There should be one 2-liter bottle per soil sample.
- Alternatively, students can use cardstock paper cones for the Berlese Funnel apparatus.
- Provide students with dichotomous keys or ID books for identification of mesofauna.

Suggested timing

- Day 1: Soil collection demonstration (have students collect samples for homework)
- Use soil samples from local farms with various tillage techniques.
- This investigation could also be done comparing different types of forests (coniferous vs. deciduous)
- Day 2: Set up Berlese funnels (youtu.be/KnoKvpqeMmA)
- Day 3: Data collection

Materials

Per student group:

- 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

Differentiation

Other ways to connect with students with various needs:

- **Local community:** If you live in an area with limited resources for soil collection, reach out to farmers near you and see if they would allow you to analyze their soil in crop production. Contact your local county natural resource specialist to locate soils within your county for school use.
- **Students with special needs (language/reading/auditory/visual):**
  - Soil Life in Action: Bioturbation with and without soil fauna: **thekidshouldseethis.com/post/bioturbation-with-and-without-soil-fauna**
  - How to Make a Berlese Funnel (Molly Dieterich Mabin): **youtu.be/KnoKvpqeMmA**
  - Calculating Simpson's Index: **youtu.be/8dYSvo8EqFE**
- **Extra support:** See above videos.
- **Extensions:** Students might compare soils from different areas to see how the diversity rates vary. This experiment could be done for a variety of locations, comparing fields for different crops, types of forests, wetlands, etc.

Student handout

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?

The purpose of this experiment was to calculate Simpson's index of diversity for various soil ecosystems. Students should describe the procedures that were used to calculate the Simpson's Index of Diversity of their samples and relate these back to the investigation's purpose outlining any possbile relationships to the sample locations and diversity found there.

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

Answers will vary.

Student handout

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.)

Answers will vary but should tie in the calculated values to either supoort or refute their hyposthesis.

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.

Answers will vary.

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.

Answers will vary.

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!

Answers will vary but must relate to the answers for question 5 above.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Uses mathematical and/or computational representations of species diversity to support explanations.	Simpson's Index of Diversity is calculated, but not correctly used.	Simpson's Index of Diversity is calculated and correctly used throughout the investigation.	Simpson's Index of Diversity is calculated and used to determine which farming practices are most advantageous to ecosystem health.
Uses the concept of orders of magnitude to understand how a sample relates to a larger ecosystem.	Sample size is measured by volume and mass.	Sample size is discussed as a scaled proportion of the calculated ecosystem biodiversity.	Sample size area is scaled to the total area of the soil ecosystem. Sample size is identified as a representative of an ecosystem and grouped with classroom data samples to determine the biodiversity of the larger system.
Determine and explain the sample ecosystem resilience due to human impact.	Understand what ecosystem resilience is.	Understand what ecosystem resilience is and identify sample resilience based on data.	Explain ecosystem resilience as it relates to classroom data samples and human impact on soil ecosystems.

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.			