TEACHER GUIDE
EXPLORE 1 LESSON 16

Food and Agriculture Center for Science Education

Module Question: What impact does the dairy production system have on biodiversity?

What We Figure Out:

We realize that there are impacts on biodiversity from the construction of dairy food systems. When land is cleared to create modern dairy farms, the biodiversity of the land decreases compared to the biodiversity of the uncleared land. We find that biodiversity can be measured by Simpson's Biodiversity Index and see how undisturbed land and monoculture crop fields compare.

3D Learning Objective:	Time estimate:	Materials:
Students create a computational model to examine patterns using mathematical representations that reveal how habitat destruction impacts biodiversity.	100 minutes	Lesson 16 Student Guide Lesson 16 Student Handout Monoculture Crop vs Undisturbed Land Lesson 16 Student Handout Computational Model Directions Lesson 16 Plant and Animal Counts in Different Fields Spreadsheet Lesson 16 and 19 Plant and Animal Counts in Different Fields Teacher Key

Targeted Elements

SEP:	DCI:	CCC:
MATH-H1: **Create** and/or revise **a computational model** or simulation **of a** phenomenon, **designed device, process, or system.**	**LS4.D-H2:** **Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through**	**PAT-H4:** **Mathematical representations are needed to identify some patterns.**

	overpopulation, overexploitation, **habitat destruction,** pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.	

Directions

Part 1: Our Motivation

USE OF PHENOMENA

Between Lessons 16 and 19, students will focus on the Module Phenomenon. In Lesson 20, they will return to evaluating the media claims from the Anchor Phenomenon using the knowledge they gain from this module.

Display a few student models from Lesson 15. Ask students to identify any gaps in their models that need to figure out to develop a full mechanistic understanding of how the construction of the dairy system impacts biodiversity. Ask students to share what some of those gaps were. In student responses, look for the following ideas:

- I know that the construction of the dairy system might destroy habitats, and I think that could influence biodiversity, but I'm not sure how.
- I am not sure how changes to biodiversity might impact humans.

Build off student responses to share that we will now gather evidence on how clearing land and constructing dairy buildings can impact biodiversity. Finally, point out the Biodiversity and Environment category of questions on the Driving Question Board. Share a few selected questions that align with what students will investigate in the upcoming lesson.

Example student questions or ideas could include:

- What plants and animals are affected by the dairy industry?
- How is biodiversity measured?
- How does the construction of the dairy system impact the local biodiversity?
- How does the construction of the dairy system change the number or variety of species present in the lands used?

Students can record these questions in Lesson 16 Student Guide Part 1: Our Motivation. This will help students understand how this lesson connects to what they were trying to figure out about the investigative phenomenon.

Part 2: Analyzing Data on Changes in Biodiversity

To be able to figure out how the dairy system impacts biodiversity, students must figure out how to measure biodiversity. Ask students to respond in their Lesson 16 Student Guide Part 2, and then share with the group how they think they could determine if biodiversity is changing in an area. Student responses might look like:

- If there are a lot of animals and plants present in a certain area, then there are less.
- There are different kinds of species in a certain area, and how that changes over time.

Confirm that a change in biodiversity can be determined by measuring the number and types of species in an area and how those numbers change over time. Share that students will be collecting these measurements using two simulated ecosystems: land that has been cleared and converted to a monoculture crop to feed cattle and undisturbed land. This will show how biodiversity has changed over time from undisturbed land to monoculture crops.

STUDENT SUPPORT

Some students might be unfamiliar with the term “monoculture crop.” Assist students in understanding the term by asking if anyone knows what the root “mono” means. Build on their understanding by asking students for examples of monoculture crops. Ask the students if any monoculture crops are grown near them or in their state.

Introduce students to the images of monoculture crop fields and undisturbed land and the simulated representations of the variety of plants and animals in a small sampling zone in each location. This can all be found in their Lesson 16 Monoculture Crop vs Undisturbed Land Handout. Ask students which of the locations they think has a higher biodiversity. Students may say:

- The monoculture cropland has higher biodiversity because it has more worms and bees.
- The undisturbed field has higher biodiversity because it has more different plants and animals.

- It's hard to compare them because there are multiple different sample sites.

Build on student responses to explain that it is difficult to determine which location has higher biodiversity just by looking at the samples. Explain to students that scientists obtain a more quantitative and precise measure of biodiversity at a location by sampling the number and kinds of species present in a small area of land, such as a 10 m by 10 m square. Explain that the data students are looking at represents this process – scientists visited each location, set up three different sample sites at each location, and counted the kinds and number of species present in a 10 m x 10 m square at each and recorded their findings.

Share with students that, to figure out exactly which of the two locations has the most biodiversity, they will calculate a quantitative measurement of biodiversity called Simpson's Biodiversity Index for each of the sample sites at each location.

TEACHER SUPPORT

Simpson's Biodiversity Index is a calculation of the evenness and richness of a population. Biodiversity can be measured in either of these two ways individually or in a way that combines the two measurements mathematically, which is what Simpson's Biodiversity Index represents. If you have students showing increased engagement in this topic, you may ask them to research to find other methods of determining biodiversity.

Students will now create a computational model using the Lesson 16 Plant and Animal Counts in Different Fields spreadsheet to determine the differences in biodiversity as measured by Simpson's Index at each of the six samples of land at the two different locations. This will help them figure out how the biodiversity of the land changed when it was converted from undisturbed land to monoculture fields.

Instructions for students to set up the computational model are in the Lesson 16 Handout Computational Model Directions, and they will set up the model in the template in the Lesson 16 Biodiversity in Different Fields Sheet. Open both files, read through the introductory steps with students, and show students a few examples of how to enter the different functions in the formula bar. Importantly, don't give away the exact way to set up the formulas and functions to calculate Simpson's Biodiversity Index. We want students to figure out how to use the functions on their own.

Assign pairs or groups of students one sample site each. Create a class data table on the board so that students can record the Simpson's Biodiversity Index of each sample site on there after they have completed their calculation.

Allow students time to build the spreadsheet. As students work, circulate the room to support students in building the computational model. Some prompts to press and probe student thinking include:

- Why did you choose that function?
- What function did you enter? What does that represent in the mathematical formula?
- What is the purpose of this mathematical model? What are we trying to accomplish?

SEP SUPPORT

MATH-H1: Create and/or revise **a computational model** or simulation **of a** phenomenon, **designed device, process, or system.**

This activity is intended to help students use this SEP element. Students will be using this element once again in Lesson 19, so they will have an additional opportunity to develop their proficiency with this element.

CCSS SUPPORT

MP.4: Model with mathematics

MP.5: Use appropriate tools strategically.

Students are engaging in these standards as they work to develop their biodiversity computational model using appropriate spreadsheet functions. Knowledge of the mathematical formula they are trying to build into the computational model will help students choose which formulas to use to accomplish the goal of the task.

Once students have completed their spreadsheet, have them review the class data table. Students should take a moment to reflect on the biodiversity measures that the Simpson's Index reports for each of the six sample sites. To analyze the data more precisely, you can ask students to find two averages for the Biodiversity Indexes for the two different locations. Then, they will answer these questions in Lesson 16 Student Guide Part 2: Analyzing Data on Changes in Diversity. Students should analyze the results by answering these two questions:

- What patterns in biodiversity exist between the two locations?
- How did creating the spreadsheet model help you reveal patterns in biodiversity?

FORMATIVE ASSESSMENT OPPORTUNITY

Students create a computational model to examine patterns using mathematical representations that reveal how habitat destruction impacts biodiversity.

Assessment Artifacts:

- Students' creation of a computational model using spreadsheet equations (Lesson 16 Resource Biodiversity Spreadsheet).
- Students' analysis of patterns in biodiversity in the three locations and their reflection on how land use impacts biodiversity and how the model helped reveal these patterns (Lesson 16 Student Guide Part 2 Analyzing Data on Changes to Biodiversity).

Look Fors:

- Students use the computational model to compare biodiversity on locations with different land uses. (MATH-H2)
- Students conclude that human land use is having adverse impacts on biodiversity (LS4.D-H2).
- Patterns in biodiversity, as revealed by the results of the computational model, are used as evidence to show how the dairy system impacts biodiversity. (LS4.D-H2) (PAT-H4)

Assessment Rubric:

	Emerging	Developing	Proficient

Sample Student Response	Student Spreadsheet:
	• Some spreadsheet equations are used.
	
	Reflection on Biodiversity Impacts and Patterns Identified:
	I think the undisturbed lands have more biodiversity. This is because I can count and see how these lands have more plants and animals.
		Student Spreadsheet:
		• Accurately reflects calculations for Simpson's Biodiversity Index.
		• Cells of spreadsheet use mostly spreadsheet calculations, such as those that follow:
		  ○ Uses cell references and subtraction to calculate n-1 and n(n-1).
		  ○ Uses Sum function to determine the total of organisms of a single species.
		  ○ Uses Sum function to determine the total number of organisms.
		  ○ Uses division function to calculate Simpson's Biodiversity index.
		
		Reflection on Biodiversity Impacts and Patterns Identified:
			Student Spreadsheet:
			• Accurately reflects calculations for Simpson's Biodiversity Index.
			• Cells of spreadsheet use only interdependent spreadsheet calculations, such as those that follow:
			  ○ Uses cell references and subtraction to calculate n-1 and n(n-1).
			  ○ Uses Sum function to determine the total of organisms of a single species.
			  ○ Uses Sum function to determine the total number of organisms.
			  ○ Uses division function to calculate Simpson's Biodiversity index.
			
			Reflection on Biodiversity Impacts and Patterns Identified:
			I realized from the calculations that the undisturbed land had the most biodiversity. I think that the more diversity in the amount of habitats, then variety of plants and animals in that area will be higher too. The average biodiversity in the undisturbed lands

		I realized from the calculations that the undisturbed land had the most biodiversity. The average biodiversity in the undisturbed lands was 0.901, and the average biodiversity from the monoculture farmland was 0.802. The spreadsheet calculations allowed us to identify which of the locations had the greatest and least biodiversity.	was 0.901, and the average biodiversity from the monoculture farmland was 0.802. Human activities like planting monocultured crops decreases biodiversity. The average biodiversity in the undisturbed lands was 0.901, and the average biodiversity from the monoculture farmland was 0.802. I think this is because there are less habitats for plants and animals in the monocultured farmland. It wasn't clear just by looking at the number of plants and animals which of the locations had the greatest biodiversity. The spreadsheet calculations allowed us to identify which of the three locations had the greatest and least biodiversity.
How to Achieve This Level	Student completes 0 out of 3 Look Fors	Student completes 1-2 out of 3 Look Fors	Student completes 3 out of 3 Look Fors

To Provide Additional Support for Students:

If students struggle to create their computational models, consider:

- Providing students with one or two of the first functions and formulas to build the model.
- Having students share what success they are having with individual steps in building the model so that other students can learn from them.
- Focusing students' attention on the types of functions and formulas that they might be overlooking or not using.

If students struggle to find patterns between the two sample plots of land, consider:

- Asking students to return to the meaning of the Simpson's Biodiversity Index and look up what a high value and a low value indicate.

Have students share what they found in the last two questions on the Student Guide using a Mingle-Pair-Share routine.

1. Have students move about the room to find a new partner to share their thinking with.
2. Student pairs share the results of what they found.
3. Students thank their partner and mingle in the room to find a new partner and share once again.
4. Repeat these steps for three sharing rounds.

Invite a few students to share their results. In student responses, look for:

- An indication that they found the biodiversity in the undisturbed land to be higher than the biodiversity in the monoculture crop field.
- A comparison of how useful using the computational model to reveal patterns was compared to analyzing the data without the computational model.

CCC SUPPORT

PAT-H4: Mathematical representations are needed to identify some patterns.

Students are using the results of the mathematical model to find patterns that they might not have been able to find previously without using the mathematical computation. Students see a consistent pattern of results across sample sites: that the undisturbed land had greater biodiversity than that of the monoculture crop field.

Build off what students share to confirm that the average biodiversity in the samples of undisturbed land was higher than the average biodiversity in the samples of the monoculture crop field and that the computational model was able to reveal patterns in biodiversity that students were previously uncertain about.

Ask students why the results they found are significant and why they were trying to figure this out. Build off student responses to confirm that these are the biodiversity changes that could be happening when land for growing feed for dairy cows is converted to monoculture crops and when land for the construction of dairy buildings is cleared. Share that this is one example of how one part of the dairy system impacts biodiversity, and in the next lesson, students will continue to investigate how other parts of the dairy system impact biodiversity.