TEACHER GUIDE
ELABORATE LESSON 19

Food and Agriculture Center for Science Education

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

What We Figure Out:

We figure out that grazing can change biodiversity impacts of the dairy system. We calculate biodiversity for three different locations to see grazing can positively impact biodiversity. We create models to show how grazing could result in more biodiversity in a location than growing feed in a monoculture crop field does.

3D Learning Objective:	**Time estimate:**	**Materials:**
Students use a computational model to calculate how biodiversity can change when a grazing system is designed to accomplish a new task: protecting biodiversity. Students develop and use a model to provide a mechanistic explanation of how a grazing system can accomplish a new task: protecting biodiversity.	100 minutes	Lesson 19 Student Guide Lesson 19 Student Handout Grazed Field Lesson 19 Computational Model Directions Lesson 19 Biodiversity Spreadsheet Lesson 19 Grazing Data Lesson 19 Grazing Study

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**	**CE-H3:** **Systems can be designed to cause a desired effect.** **SYS-H1: Systems can be designed to do**

MOD-H5: **Use a model to provide mechanistic accounts of phenomena.**	**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.	**specific tasks.**

Directions

Part 1: Our Motivation

Ask students to recall what they previously identified as the intended design of the dairy system. Students should say that the system was designed to produce many dairy products for consumers. Ask students to recall what they have figured out so far about the unintended effects of the way this system was designed.
In student responses, listen for the following ideas:

- From module one, students may share examples like air pollution, water pollution, and worker health effects.
- From the second module, students may share examples such as methane and carbon dioxide emissions that can lead to the greenhouse effect.
- From the current third module, students may share examples such as loss of biodiversity.

CCC SUPPORT
CE-H3: Systems can be designed to cause a desired effect.

Throughout the unit so far, students have figured out the effects of the design of the dairy system (to produce dairy products) and some unintended effects of the system (as listed above). In this lesson, students will investigate how a new design for feeding cattle in the dairy system may have intended effects that improve on the greenhouse gas emissions, pollution, and biodiversity impacts of the system in which

cattle are fed by monoculture crops. So overall in this unit, students engage in this CCC in several different ways – by looking at intended and unintended effects of the current system design, and by looking at intended effects of a new design to a part of the system.

Build off student responses to share that we will now investigate how the dairy system is trying to reduce these undesired effects. Point to the Biodiversity and Environment category of 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 is being done to stop these negative effects of the dairy system?

Students can record these questions in Lesson 19 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: Observing a New Phenomenon

Present students with the image of dairy cattle grazing in a biodiverse pasture. Ask students to reflect on how the new picture relates to what they have been learning about the dairy system's impact on plants and animals. The image they will observe is found in the Lesson 19 Student Guide Part 2: Observing a New Phenomenon. Ask students to compare this picture to what they observed in the investigative phenomena in Lesson 16.

Once students have individually answered the two questions in the Lesson 19 Student Guide, use a Think-Pair-Share Strategy to have students share what they noticed from the image.

1. Students are given time to think independently about their responses.
2. Students find an elbow partner.
3. Students take turns sharing their thoughts with their partner. Each student should be given time to respond.

As students share, use a Domino Share Routine to have them build off each other's contributions.

1. Each group nominates a spokesperson.
2. As a student from group 1 shares, all other students serve in a "listener" role, noting patterns or ideas that emerge as the group continues to share.
3. Spokespersons from each group continue to share ideas until all groups have shared.

4. The facilitator holds a whole class discussion and invites the remaining students to share what they heard that was similar across all the responses or a unique response they want to elevate.

In student responses, look for the following ideas:

- This image shows a thriving pasture with a wide variety of plants.
- This image seems to show a dairy system that has prioritized biodiversity.
- This image shows that a dairy system can be both productive and support thriving ecosystems.

STUDENT SUPPORT

If students need additional support in comparing the two systems, consider:

- Asking students what they see as differences between the investigative phenomena videos and this image. How do those differences relate to the impact on plants and animals?
- Showing the images of the two locations side by side and asking students to compare them.

Build off student contributions to confirm that this location shows a dairy system that seems to be more biodiverse than previous locations students have observed. Share with students that this location has cattle graze using a specific management strategy called **rotational grazing.** In this style of cattle management, the cattle are not fed monoculture crops. Instead, they are moved from one part of a pasture to another, usually every day. They can then be milked to provide milk for dairy products. Share that in this lesson, students will investigate the biodiversity impacts of this kind of cattle management system. Students will investigate the question, "How can grazing change the biodiversity impacts of the dairy system?"

Part 3: Analyzing Data on Changes in Biodiversity

To start figuring out the lesson question, students will first determine if grazing does improve biodiversity compared to monoculture crop fields. Students will once again use a computational model to calculate Simpson's Biodiversity Index. Students will use the new data provided to determine the level of biodiversity present in a grazed field.

Allow students to open their spreadsheet from Lesson 16. Students can use the spreadsheet functions that they used in this spreadsheet and make a new copy of the tab to revise the spreadsheet to fit this context. Alternatively, a new copy of the spreadsheet template is provided in the lesson folder. Because this is the second time students are doing a similar task, you may not want to give them access to the directions used to build the spreadsheet so that they can show their proficiency with this process. If you do want to provide these instructions, another copy is present in the lesson folder.

Students are once again presented with three sample sites that were used to collect data on the types on number of organisms in the grazed field on the Lesson 19 Student Handout Grazed Field. This time, each student group or pair can design individual spreadsheet tabs for each sample site. Show students how to duplicate a tab in the spreadsheet, then allow them time to work to enter data and refine their spreadsheet functions as needed.

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.

Allow students time to follow the directions to build the spreadsheet equations. As students work, circulate the room to support students in building the computational model. Monitor student work as they implement the spreadsheet computations.

Once students have finished calculating biodiversity for the three different sample sites, ask them to take the average of the biodiversity measure for the three different sample sites. Then, ask students to return to the data from Lesson 16 and compare the biodiversity of the grazed location to that of the monoculture crop field and the undisturbed field. Students will capture their results and observations in their Lesson 19 Student Guide Part 3: Analyzing Data on Changes in Biodiversity. Invite a few students to share their responses and confirm that the grazed field has greater biodiversity than the monoculture crop field and less than the undisturbed location.

Ask students to reflect on what the purpose of grazing seems to be regarding biodiversity. Look for responses that indicate:

- The grazing system can increase biodiversity compared to monoculture crop land. This new system is improving on the biodiversity losses that happen when cattle are fed with monoculture crops.

FORMATIVE ASSESSMENT OPPORTUNITY
Students use a computational model to calculate how biodiversity can change when a grazing system is designed to accomplish a new task: protecting biodiversity.

Assessment Artifacts:

- Students' creation of a computational model using spreadsheet equations (Lesson 19 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 19 Student Guide Part 3 Analyzing Data on Changes to Biodiversity).

Look Fors:

- Students use the computational model to compare how biodiversity changes under a grazing management system. (MATH-H2) (LS4.D-H2)
- Students conclude that biodiversity can be protected by implementing a new dairy system design that intends to protect biodiversity (LS4.D-H2) (CE-H3) (SYS-H1).
- Students use the results of the computational model to provide evidence to support their claims. (MATH-H2)

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Student Spreadsheet: • Some spreadsheet equations are used. Reflection on Biodiversity Impacts and Patterns Identified: It looks like the grazing land has a pretty high biodiversity. I think the higher biodiversity must mean that people are trying to protect the biodiversity by grazing cattle.	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	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 remember that the undisturbed land had the highest diversity. The biodiversity calculation was 0.90 for

		function to calculate Simpson's Biodiversity index. Reflection on Biodiversity Impacts and Patterns Identified: The biodiversity in the grazing land is just about as plentiful as in the undisturbed land. The spreadsheet calculations allowed us to identify that the use of grazing can improve biodiversity.	undisturbed land. The higher the number, the more diverse the area. I am surprised to find that the land with cattle is almost as diverse as the undisturbed land, with a score of 0.88, which was way higher than the monoculture land which had a score of 0.79. The cattle on pasture are not quite the same level of biodiversity, but its biodiversity is higher than the monoculture crop land. Conclusion About Effects of Grazing System The grazing system can increase biodiversity compared to monocultured land. This new system has a new intended effect to improve biodiversity compared to when cattle are fed with monocultured crops.
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:

- Ask students to recall from module one what purpose the dairy system was designed for, and ask students to consider how this new system could be used in a new way.
- Ask students to return to their biodiversity computational model from Lesson 16 and review how they built spreadsheet functions in that lesson.
- Present the three average biodiversity values as produced by students' computational models for the three different locations side-by-side and ask students to interpret this data.

CCC SUPPORT
CE-H3: Systems can be designed to cause a desired effect.
SYS-H1: Systems can be designed to do specific tasks.

Students see that the design of the dairy system can be changed to achieve new effects and accomplish new tasks. By switching to a grazing system, the land where the grass the cattle graze on becomes more biodiverse than the land when it was a monoculture crop.

Part 4: Developing a Model of How Grazing Can Improve Biodiversity

Next, share with students that they will create initial models to show how grazing could result in more biodiversity in a location than growing feed in a monoculture crop field does. Students will create a new concept map model to show their current ideas that answer the lesson question, "How can grazing change the biodiversity impacts of the dairy system?" Students can use the same model conventions for a concept-map model that they have used previously. Students should place the phenomenon in question in the center of their model – cattle graze using grazing.

Ask students if they think it is important to include the impacts of biodiversity changes in these models. Build off student responses to indicate that if they think it is applicable, students can include impacts to the terms that were defined in the previous lessons (biodiversity, pollution, overexploitation, and overpopulation). As students create their model, they should record an explanation of it as well.

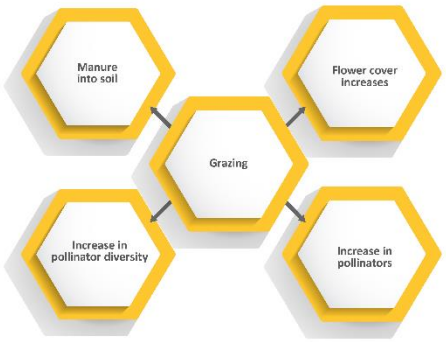
STUDENT SUPPORT

Suggest that students can review their models of how the construction of the dairy system decreases biodiversity. Ask students to consider how they can use this model in reverse – if this model is about how clearing land can lead to a loss of biodiversity, what might it mean about how grazing can increase biodiversity?

Allow students time to work on creating their models in their Lesson 19 Student Guide Part 4. While students are working on their models, circulate the room and ask pressing questions such as:

- If biodiversity increases occur in a grazing system, how do you think that occurs?
- What changes would you expect to see in a landscape if biodiversity increased? How do those changes happen?

Example Student Model



Part 5: Obtaining Information from Text

Share with students that they will gather evidence from a text to help add to their models of how a grazing system can increase the biodiversity of land. Students will read the study in the Lesson 19 Grazing Study.

Allow time for students to read the article and find and record evidence in their Lesson 19 Student Guide Part 5 that will help them answer the lesson question, “How can grazing change the biodiversity impacts of the dairy system?”

As students work, circulate the room and ask pressing questions such as:

- Why did you choose this part of the text as evidence?
- What is this part of the text saying about how biodiversity is supported by a grazing system?

After students have completed their reading and recording evidence, use a sharing routine such as a Mingle-Pair-Share for students to share the evidence they have found with their peers. Students can record additional evidence they hear from their peers during this time as well. Look for student responses that indicate a relationship between grazing and biodiversity, such as:

- Managed livestock grazing can have 4 general impacts on vegetation: (1) alter the composition of the plant community, (2) increase the productivity of selected species, (3) increase the nutritive quality of the forage, and (4) increase the diversity of the habitat by altering its [physical] structure.

- Grasslands with more vegetation heterogeneity support a greater number of plant and animal species because they contain additional structural complexity and/or diverse plant communities, which provide added spatial and temporal niches.
- Grazing, through influences on vegetation heterogeneity, can maintain a variety of successional or ecological states in grasslands. This increases both heterogeneity and biodiversity locally by limiting the proportion of climax communities in favor of increased and varied intermediate ecological states.
- The effects of grazing on plant communities and biodiversity thus reflect some basic ecological principles. These include: (1) plants are distributed in patches, and the status and distribution of patches depend upon the processes, such as grazing, that create them; (2) grazing can increase heterogeneity of plant communities by reducing dominance by a few species, which are replaced by numerous secondary species; and (3) habitat diversity (patchiness) and resultant ecotones or edges are important as wildlife habitat for many species, but not all.

Part 6: Revise a Model and Use It to Explain the Phenomenon

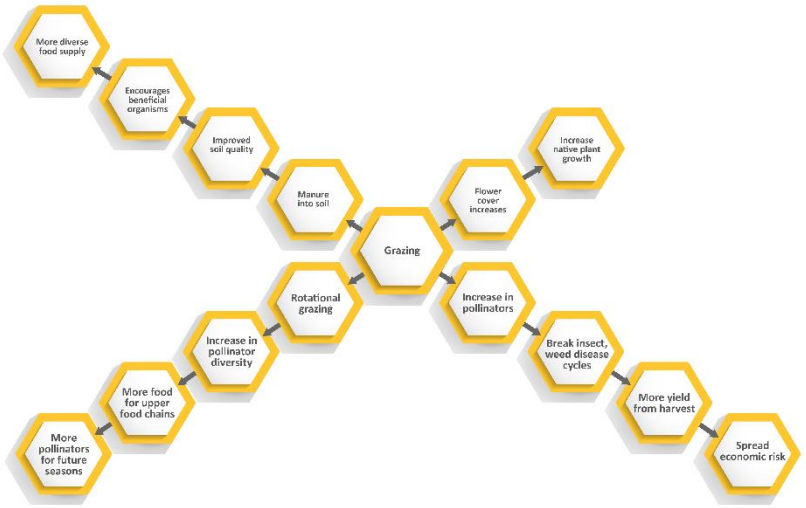
Share with students that they will now use the new information they gathered from the texts to edit their initial model from Part 4. Allow students time to use the evidence they gathered to update their models. They have space to do this under Part 6 of their Lesson 19 Student Guide. As students work, circulate the room to press students with questions such as:

- What evidence did you find to add that to your model?
- Can you say more about that relationship in your model?
- How is your model showing a new task that the dairy system is engaging in?
- What new task is the system accomplishing according to your model?

Once students complete their individual models, they will share them using the Sharing Routine below.

1. Each student will share their individual model with a partner. Students should be mindful to share how biodiversity connects to the impacts they have found.
2. After the first partner shares, the other partner will ask questions to clarify any points that seem unclear.
3. The second partner will repeat the sharing protocol.

Example Student Model



FORMATIVE ASSESSMENT OPPORTUNITY

Students develop and use a model to provide a mechanistic explanation of how a grazing system can accomplish a new task: protecting biodiversity.

Assessment Artifacts:

- Students' models of how the dairy system impacts plants and animals and why it matters (Lesson 19 Student Guide Part 6 Revise a Model and Use It to Explain the Phenomenon)
- Students explanation of their models (Lesson 19 Student Guide Part 6 Revise a Model and Use It to Explain the Phenomenon).

Look Fors:

- Students update and revise their model to show how the use of a cattle grazing practice impacts biodiversity. (MOD-H5) (LS4.D-H2)
- Students describe examples of how cattle grazing, through its impact on biodiversity, impacts people. (MOD-H5) (LS4.D-H2)
- Students describe examples of how cattle grazing system can have a desired effect on improving biodiversity. (CE-H3)

Assessment Rubric:

	Emerging	Developing	Proficient
Sample Student Response	Model shows: • A link between grazing practices and biodiversity. Example explanation: When cattle graze on grass, there are more plants and animals in the area. This means there is more biodiversity, which is good for people because it can provide more food.	Model shows: • A link between grazing practices and improvements in biodiversity. Example explanation: Grazing improves biodiversity in a variety of ways. Grazing breaks disease cycles in animals, making them produce a healthier product. It increases plant and therefore pollinator diversity, meaning more plants will bloom and reproduce. It can also add manure to the soil, which provides the soil nutrients to grow more different plants. Therefore, an increase in biodiversity impact humans in a beneficial way.	Model shows: • A link between grazing practices and improvements to biodiversity. • A link between impacts on biodiversity and their effects on humans, such as a more diverse and plentiful food supply. Example explanation: Grazing improves biodiversity in a variety of ways. Grazing breaks disease cycles in animals, making them produce a healthier product. It increases plant and therefore pollinator diversity, meaning more plants will bloom and reproduce. It can also add manure to the soil, which provides the soil nutrients to grow more different plants. An increase in biodiversity impacts everything in a beneficial way. If biodiversity increases, we can expand food sources, find balance in ecosystems, increase healthy nutritious food available to consumers, and create increased security in the global food supply. Each of these impacts benefit people, animals, and plants.
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:

- Ask students to explain the relationships they are showing with a sentence frame such as, “A grazing system leads to _____, which then can lead to _____.”
- Ask students to return to the text from Part 5 of the lesson and focus their attention on evidence they may have missed.
- Ask students to review their models from Lesson 18 and consider how that model can be used to inform the way this model is built.

STUDENT SUPPORT

To support students in making connections to their local community or personal experiences, ask students to think about the positive impacts of biodiversity. Ask students how they, their family, or their community benefit from increased biodiversity in your community, state, or world.