

LESSON 12: Why would planting more kinds of plants benefit the ecosystem and the farmers?

PREVIOUS LESSON We investigated two cases of diversified oil palm farming and realized that these are like a rainforest because there are more different kinds of plants. We explored two related cases through StoryMaps and noticed that those cases also have much more plant biodiversity. We wondered why growing plants with more biodiversity is a good thing for ecosystems and farmers.

THIS LESSON

INVESTIGATION

2 days



In this lesson, we revisit our design criteria for designing farms that benefit both animals in ecosystems and farmers. We brainstorm events that could affect farmers' ability to make a living. We investigate how ecosystems and farmers in diversified and monoculture farms fare in three disruption scenarios: disease, drought, and oil palm price drop. We use oil palm farm system models to make predictions about the effects of these disturbances on populations in the ecosystem and on farmers. We figure out that the diversified farm is resilient for farmers and ecosystems because it has more components and links. We think we can answer our unit driving question.

NEXT LESSON We will co-construct different explanations to the unit driving question and do a gallery walk to view other groups' explanations. We will engage in a Consensus Discussion to decide how changes to ecosystems impact other populations in the system. We will use a generalized model to make predictions about changes to ecosystems. We will demonstrate our learning on an assessment.

BUILDING TOWARD NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4,
MS-LS2-5



WHAT STUDENTS WILL DO

Use a model to predict how a sudden change (cause) to a physical or biological component of a monoculture system and a diversified system will affect populations in the system and farmers (effect).

WHAT STUDENTS WILL FIGURE OUT

- A change to the living or nonliving parts of an ecosystem can cause a population to decrease below the typical range because there are fewer resources available to them.
- If an ecosystem has many connections between populations, the ecosystem has a better chance of being OK when a change happens.
- Populations with the fewest connections to other populations, or with connections to a few very important resources, will probably be the most affected if a part of the ecosystem changes.
- Ecosystems with more plant biodiversity can provide more human resources, such as food and timber products.

Lesson 12 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	NAVIGATION Revisit the design problem and criteria to design an oil palm farm that will help farmers make a living and also help animal populations.	A	Driving Question Board, criteria list from <i>Palm Farm Designs</i> (Lesson 5)
2	10 min	CONSIDER DISRUPTIONS THAT CAN AFFECT FARMERS Brainstorm events that could affect farmers' crops or crop prices. Reason about the effect of a large rain event on corn crops, farmers, and other populations in the ecosystem.	B-C	chart paper, markers, Too Much Rain Can Hurt Farmers news clip video
3	10 min	MODEL SCENARIOS ON OIL PALM FARMS INDIVIDUALLY Introduce three oil palm farm scenarios: drought, disease, and oil palm price drop. Individually model what the effects would be on crops, farmers, populations, and ecosystems.	D-F	<i>Three Disruption Scenarios, Cause-and-Effect Diagrams</i> , colored pencils, agreed-upon modeling conventions (Lessons 9 and 10)
4	15 min	MODEL SCENARIOS ON OIL PALM FARMS IN SMALL GROUPS Share individual models and develop a small-group consensus model to explain what would happen if there was disease, drought, or a price drop on monoculture and diversified oil palm farms.	G	<i>Three Disruption Scenarios, Cause-and-Effect Diagrams</i> , chart paper, markers
5	5 min	PREPARE FOR GALLERY WALK Create a graphic organizer to take notes for the gallery walk during the next class session.	H	
<i>End of day 1</i>				
6	5 min	NAVIGATION Revisit the lesson question, review the three different events, and prepare for the gallery walk.	I	Disruption Models (made day 1)
7	10 min	GALLERY WALK Visit other groups' models to predict what would happen to farmers and populations within ecosystems in different disruption scenarios: disease, drought, or oil palm price drop.	J	sticky notes, markers, Disruption Models (made day 1)
8	5 min	REVISE GROUP DISRUPTION MODELS Revise group consensus models after the gallery walk.	K	Disruption Models (made day 1), markers
9	20 min	BUILDING UNDERSTANDINGS DISCUSSION ABOUT DISTURBANCES AND FARMS Discuss the effects of disturbances on farmers and populations in ecosystems on diversified and monoculture farms.	L-N	<i>Cause-and-Effect Diagrams</i> , Disruption Models (made day 1)
10	5 min	NAVIGATION Fill out an exit ticket, sharing initial ideas for how to generalize the diversified and monoculture oil palm farm models.	O	
<i>End of day 2</i>				

Lesson 12 • Materials List

	per student	per group	per class
Lesson materials	<ul style="list-style-type: none">• <i>Three Disruption Scenarios</i>• <i>Cause-and-Effect Diagrams</i>• colored pencils• science notebook	<ul style="list-style-type: none">• chart paper• markers• sticky notes• Disruption Models (made day 1)	<ul style="list-style-type: none">• Driving Question Board• criteria list from <i>Palm Farm Designs</i> (Lesson 5)• chart paper• markers• Too Much Rain Can Hurt Farmers news clip video• agreed-upon modeling conventions (Lessons 9 and 10)• Disruption Models (made day 1)

Materials preparation (15 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Load the *Too Much Rain Can Hurt Farmers* news clip video from <https://www.teachersopensciencedfieldtest.org/palmoil> and make sure it plays.

If farming is central to students' communities, instead of using this video that depicts a rainy season in Minnesota, you can find a short recent news clip describing a memorable local weather event to use instead. This will help students relate the example to their lives. Try to avoid examples of drought, disease, and price drops, as students will explore those in the subsequent scenarios.

Lesson 12 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students explore why ecosystems with more plant biodiversity would be better for populations in ecosystems and farmers. For the first time in this unit, students explicitly consider disruptions to ecosystems and how they impact populations within the ecosystem. They consider both physical disruptions (e.g., extreme weather, like drought), biological disruptions (e.g., disease), and economic disruptions (e.g., price drops). They predict how these disruptions will lead to shifts in all of the populations within the ecosystem, as well as how they will impact farmers. While economic disruptions do not affect populations in ecosystems, they do affect farmers' livelihoods. These understandings are built from ideas learned in the 3-5 grade band about how changes to ecosystems test whether individual organisms can survive. New ideas in the middle grades include the idea that disruptions can cause changes in populations, not just individual organisms.

In addition, students develop ideas about how the numbers and different types of populations in an ecosystem affect the human resources people can get, such as food and timber products. In this lesson, students see that the monoculture farm ecosystems with less plant biodiversity are not only less stable in a disruption scenario, but they also provide fewer ecosystem services. The diversified farming system, in a disruption scenario, provides more ecosystem services because there are multiple plants that can be used for food or timber.

Where We Are NOT Going

Students consider disruptions to farm ecosystems and use their models to predict what would happen. However, their models are specific to the oil palm farm systems. In Lesson 13, students will generalize their models so that they could use them in other farming systems, as well as native plant ecosystems. In addition, students do not develop the LS2.C idea that “the completeness or integrity of an ecosystem's biodiversity is used as a measure of its health” in this lesson.

LEARNING PLAN for LESSON 12

1 · NAVIGATION

5 min

MATERIALS: Driving Question Board, criteria list from *Palm Farm Designs* (Lesson 5)

Revisit the design problem and criteria. Project **slide A**. Remind students of the larger mission: to try to figure out how to design a better oil palm farm that works for farmers and ecosystems. Reference the Driving Question Board revised question from Lesson 5: “How can we manage land in ways that work for people and other living things?”

Review the main criteria generated for the farm design. This should include criteria for farmers and criteria for animals and the forest. Example criteria from Lesson 5 are:

- farmers have the same amount of crop to sell or farmers still make money from their land,
- the amount of animals populations stays the same or goes up.

Situate the idea of growing diversified plants. Say, *We’ve been exploring the idea that growing many different kinds of plants, or diversified farming, could be one design solution to make the farm more like the forest. Today we’ll evaluate how this idea aligns with our two criteria around working for farmers and animal populations.*

With the whole class, have a few students share initial ideas generated from the end of Lesson 11 about why diversified farming might be better.

Suggested prompt	Sample student response
Why might growing more kinds of plants be better for populations in ecosystems? For farmers?	Farmers can sell more different kinds of crops. Animals have more food to eat and more plants for shelter. More different kinds of animals can live if there are different kinds of plants.

Introduce the lesson question. Why would planting more kinds of plants benefit the ecosystem and the farmers?

2 · CONSIDER DISRUPTIONS THAT CAN AFFECT FARMERS

10 min

MATERIALS: chart paper, markers, Too Much Rain Can Hurt Farmers news clip video

Focus on things that could affect farmers’ ability to make a living. Say, *Let’s start by thinking about this first criteria. We want to design farms that will help farmers make a living from their crops. Farming is really risky. There are a lot of things that can happen that can prevent farmers from successfully growing or selling their crops.* Project **slide B**. Have students turn and talk to share initial ideas.

*** SUPPORTING STUDENTS IN DEVELOPING AND USING STABILITY AND CHANGE**

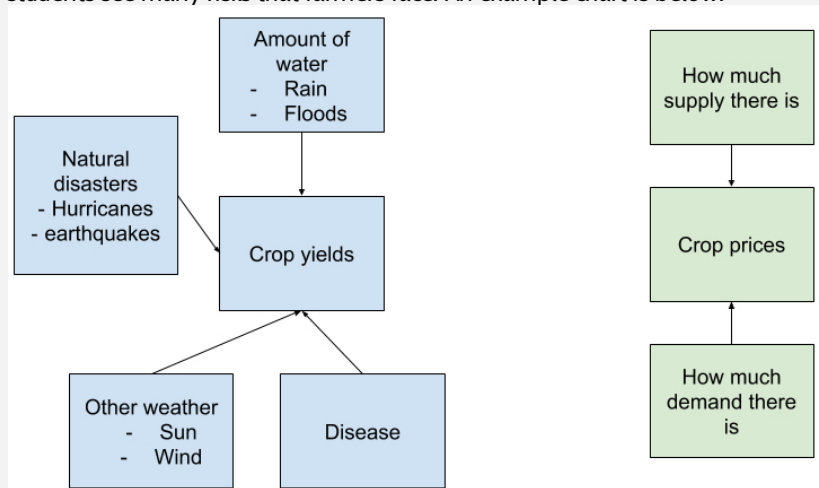
This is the first time that students are introduced to the idea that sudden events may alter the stability of farmers’ incomes and ecosystems. Emphasize that these events are unpredictable and out of farmers’ control.

Suggested prompts	Sample student responses	Follow-up questions
What could affect farmers' crop yields or how much of a crop farmers can produce?	Weather—rain, drought. Pests that eat the crops. Hurricanes. Money.	What would impact a plant population size that is difficult for farmers to control?
What could affect farmers' ability to make a living selling crops?	How much they grow.	Do prices for crops always stay the same? What affects the cost of crops?

* SUPPORTING STUDENTS IN DEVELOPING AND USING CAUSE AND EFFECT

The cause-and-effect diagram will help students think through the effects of different disturbances specifically on the crop (e.g., "Does it kill the whole plant or just affect the crop yield?") and then the effect that has on farmers' income and ecosystems. This will help students make predictions about what will happen in different disturbance scenarios.

Share ideas as a class. Have students share out their ideas as a class. As students share out, map their ideas on chart paper to help students see many risks that farmers face. An example chart is below.



Introduce the vocabulary “disruption.”* Now that students have generated some ideas about events that could impact farmers, give these events a name: disruptions. Add “disruption” to the classroom word wall.

Introduce a disruption example: a season of abundant rain. Say, *Let's think about one of these disruptions and how it might impact farmers and populations in ecosystems.*

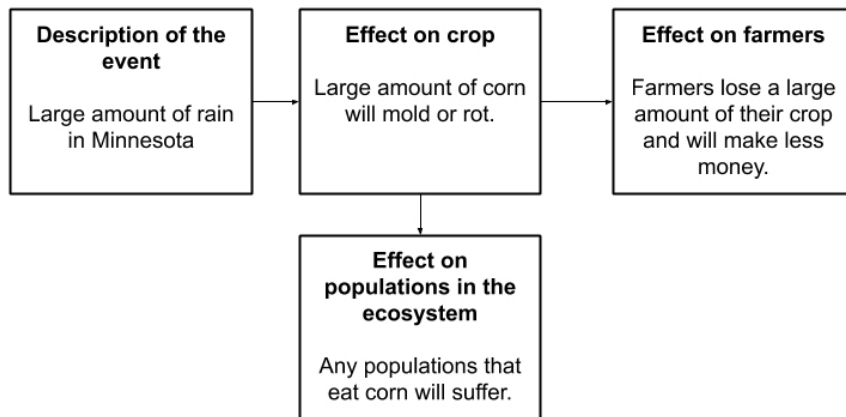
Show a short news clip of a rainy season in Minnesota in 2016. Project the, *Too Much Rain Can Hurt Farmers* news clip video from <https://www.teachersopensciencedfieldtest.org/palmoil> to introduce the idea of a very rainy season for corn and soybean farmers in Minnesota.

ALTERNATE ACTIVITY

If farming is central to students' communities, find a short recent news clip describing a memorable weather event to use instead of this rainy season example in Minnesota. This will help students relate the example to their lives. Try to avoid an example of drought, disease, and price drops, as students will explore those in the subsequent scenarios.

Map out a cause-and-effect diagram for this rain disruption as a class.* Project slide C. As a class, talk through this example and take suggestions from students to fill out the cause-and-effect diagram. Emphasize the cause (in this case, the rain event) and the effects on the crops, farmers, and other populations in the ecosystems. In this case, students may not have a lot of ideas about the populations in ecosystems because they are not familiar with this system. The purpose of this is to model the process of filling out the cause-and-effect diagram so that students can do it on their own with three oil palm scenarios.

Example cause-and-effect diagram:



3 · MODEL SCENARIOS ON OIL PALM FARMS INDIVIDUALLY

10 min

MATERIALS: *Three Disruption Scenarios*, *Cause-and-Effect Diagrams*, colored pencils, agreed-upon modeling conventions (Lessons 9 and 10)

Remind students of the lesson question. Remind students that we're trying to figure out why planting more kinds of plants would benefit farmers and the environment.

Introduce three different scenarios that could happen on oil palm farms. Project slide D. Introduce students to three scenarios: drought, disease, and palm oil price drop. Say, *These hypothetical scenarios are common and have happened on oil palm farms in the past. Let's consider, if this event took place on our monoculture farm or our diversified farm, what the effects would be on the crops, farmers, and other populations in the ecosystem.*

Prepare to model one scenario. Divide students into groups of 3-4. Have each group select the scenario they would like to investigate. Make sure that the class is roughly divided so that all three scenarios are investigated. Pass out 1 copy of *Three Disruption Scenarios* and *Cause-and-Effect Diagrams* to each student.

Explain the individual scenario modeling task. Project slide E. Explain that, first, students will review the scenario on their own and use *Cause-and-Effect Diagrams* to think through what would happen on the monoculture and diversified farms. Emphasize that students will need to reason about the effects on farmers themselves as they did with the previous example.

* SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

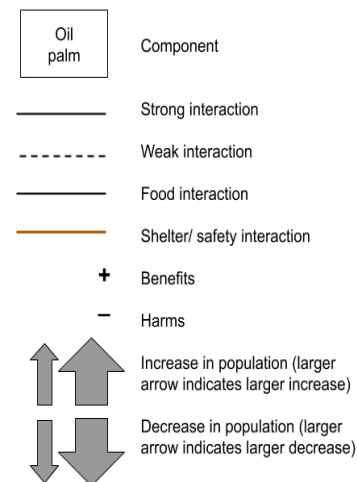
Students will individually use their diversified and monoculture oil palm farm models and modify them to predict what will happen to populations in ecosystems in different disturbance scenarios. The full models are included in *Three Disruption Scenarios*, and the boxes without links between them are included in *Cause-and-Effect Diagrams*.

Agree on modeling conventions for the effect on populations in ecosystems. Project slide F. Explain that students can use their systems model to think through what would happen to the rest of the populations if there was a change to the oil palm crop. This should be a review from Lessons 1, 9, and 10. Consider the hypothetical scenario in which there is a year of a lot of rain, and many of the oil palm kernels rot. Ask students:

- How will we represent when a population increases or decreases?
 - Talk through the example and agree on how you would show that the oil palm population would decrease (e.g., a large downward arrow next to oil palm).
- How will we represent when an interaction becomes weaker?
 - Talk through the example and agree on how you would show that the interaction between the oil palm and rats would be weaker than before (e.g., a dotted line instead of a solid line).

Example modeling conventions are shown to the right.

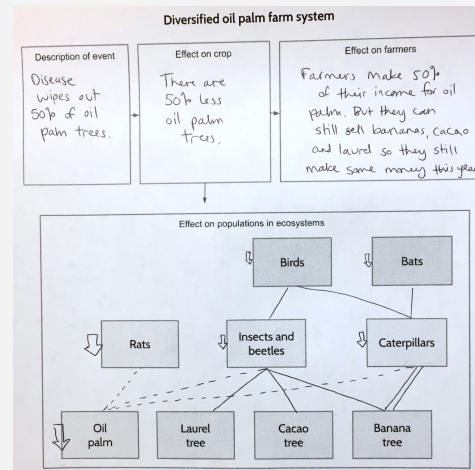
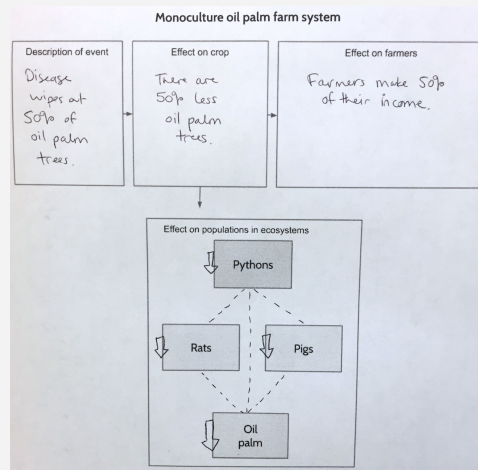
Give students time to work individually.* Project slide E again and give students time to work on the modeling task. Circulate around the room and help students think through which interactions would be stronger and which would be weaker. Have students tape *Cause-and-Effect Diagrams* into their science notebooks when they are done.



ADDITIONAL GUIDANCE

For students who work with the drought scenario, you can reference their experiences in Lesson 7 during which they saw that plants do not die in a drought year, but they will have lower production. This means that there won't be a "down" arrow showing a decrease in the oil palm population, but there could be a "down" arrow on rats, pigs, and caterpillars because there will be fewer oil palm kernels to eat.

Example student work for the disease scenario is below. The price drop scenario will have no modifications to the population models. The drought scenario should have similar population models to disease; however, the actual oil palm population will not decrease (because the trees do not die), as they just produce less fruit, which does ripple throughout the other populations.



ADDITIONAL GUIDANCE

To keep the models as simple as possible, the example work does not distinguish between black and brown lines (food and shelter) and also only uses dashed and solid lines. Students may want to show differences between very affected interactions (e.g., oil palm -- rats) and just slightly affected interactions (e.g., caterpillars -- birds). If that comes up, feel free to differentiate if it makes sense. The primary purpose is for students to use the models to reason with rather than to produce a perfect model.

4 · MODEL SCENARIOS ON OIL PALM FARMS IN SMALL GROUPS

15 min

MATERIALS: *Three Disruption Scenarios, Cause-and-Effect Diagrams*, chart paper, markers



Combine individual models into a shared group model.* Project slide G. Have students share their individual models with their small group. Using a piece of chart paper, have each group develop a group consensus model for what would happen if there was disease, drought, or price drop on the monoculture and diversified farms. Make sure to save the chart paper for the next class, as students will share their models during a gallery walk. These will be referred to as “Disruption Models” on day 2.

ASSESSMENT OPPORTUNITY

While students are modeling scenarios on oil palm farms individually and in their small groups, listen to student ideas for formative assessment. Listen for ideas about how a disturbance will affect populations in ecosystems and the resources that farmers can get from their farms to sell. Some ideas may include the following: (1) a limited availability of resources due to a disruption (e.g., less water or fewer oil palm plants) will cause declines in populations that rely on those resources; (2) a decline in oil palm plants or prices will cause farmers to get less money from those resources; and (3) differences in plant biodiversity (monoculture or diversified farms) affect how much impact a disturbance will have on the populations in the ecosystem and farmers’ livelihoods.

* ATTENDING TO EQUITY

Consider revisiting the classroom norms before students start their work together to develop a consensus model. Encourage students to listen carefully to each others’ ideas, make sure everyone in the group shares their ideas, probe for clarification, and be open to changing their minds.

Update individual models. Once the group comes up with a consensus representation, give students time to update their individual models on *Cause-and-Effect Diagrams* in their science notebooks.

5 · PREPARE FOR GALLERY WALK

5 min

MATERIALS: science notebook

Prepare for gallery walk. Say, *Next class, we’ll have a chance to look at the scenarios that other groups investigated. Let’s get ready for that now. Since we’re interested in why diversified farming would be better for farmers and populations in ecosystems, we’ll organize our observations to be able to easily compare.*

Project slide H. Show the example graphic organizer and give students time to draw the organizer into their science notebooks.

End of day 1

6 · NAVIGATION

5 min

MATERIALS: science notebook, Disruption Models (made day 1)

Remind students of the lesson question. Project **slide I**. Remind students that we're trying to figure out *why* planting more kinds of plants would benefit farmers and the environment. Remind students that we looked at three disruption events—drought, price drop, and disease—and used our models to predict what would happen in the monoculture oil palm farm and the diversified oil palm farm.

Give students time to prepare for the gallery walk. Have students get into their small groups and make any last revisions to their group model. Have students get out their notebooks with the graphic organizer to take notes.

7 · GALLERY WALK

10 min

MATERIALS: science notebook, sticky notes, markers, Disruption Models (made day 1)

Set the stage for the gallery walk. Project **slide J**. Remind students of the purpose: to evaluate why having more different kinds of plants would be beneficial for farmers and ecosystems. Review the graphic organizer with which students can take notes. Students should record what happens to populations in ecosystems and farmers when there are disturbances on the monoculture and diversified farms.

	Monoculture	Diversified farm
Populations in ecosystems		
Farmers		

Introduce clarifying questions. Tell students that, if something is not clear on another group's model, they can record a clarifying question on a sticky note and post it on that group's model.

Have groups rotate together to the other models. Have students go with their home group to visit the other group models. Encourage students to talk with each other about what they are noticing and make comparisons to the disruption they investigated. Encourage students to record observations about the effect of these disturbances on populations in ecosystems and farmers in the monoculture and diversified farms in the graphic organizer in their science notebooks.

8 · REVISE GROUP DISRUPTION MODELS

5 min

MATERIALS: Disruption Models (made day 1), markers

Give groups five minutes to revise their models.* Display **slide K**. Encourage students to make changes to their group's models, based on what they observed during the gallery walk from other groups who examined the same disruption.

* SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

The opportunity to revise their models multiple times throughout this lesson reinforces the idea that models are not products but are tools to think with that can help students explain what will happen in different scenarios.

9 · BUILDING UNDERSTANDINGS DISCUSSION ABOUT DISTURBANCES AND FARMS

20 min

MATERIALS: science notebook, *Cause-and-Effect Diagrams*, Disruption Models (made day 1)

Bring the class together in a Scientists Circle for a Building Understandings Discussion. Project slide L. Have students bring their science notebooks together in a Scientists Circle. Have students share their observations from the gallery walk. Focus students on the impact of the disturbances on populations in ecosystems, as well as on the resources that farmers can get from the farm to sell.

KEY IDEAS

Purpose of the discussion: Help students recognize that farms with more biodiversity are better able to cope than farms with less biodiversity, in terms of both populations and farmers' income.

Listen for students' ideas:

- When there is a disturbance that affects the crops directly (disease, drought) in the monoculture farm, all of the populations in the system are affected because they all rely on oil palm. In the diversified oil palm farm, populations are less affected because most of the organisms rely on multiple plants.
- When there is a disturbance that affects crop prices, the ecosystem is not affected at either farm, but the farmers lose all of their income in the monoculture and can still sell some crops, like cacao/cocoa and bananas, in the diversified farm. The diversified farm can provide more resources, like food and timber, that farmers can sell to make a living.
- The diversified farm seems to be better for farmers and populations when there is a disturbance.
- The monoculture seems to be worse for farmers and populations when there is a disturbance. The monoculture is riskier.
- Resource availability limiting populations: In the drought case, when there was limited water, that limited the ability of the oil palm plants to fruit. In the case of disease, the reduced availability of oil palm plants limited the size of the rat population.

* ATTENDING TO EQUITY

Have students share how they have used the word "resilient" before. They may have used it personally ("I am a resilient person who bounces back after hardship."). Distinguish how the word is used in everyday language, and what it means when we use it in science class.

Suggested prompts	Sample student responses	Follow-up questions
<i>How did the drought, disease, or price drop affect farmers in the monoculture farm?</i>	<i>In the monoculture, when oil palm is stressed or the price drops, there's no other plant to rely on for income.</i>	
<i>How did the drought, disease, or price drop affect farmers in the diversified farm?</i>	<i>When the oil palm is stressed from drought, disease, or the price drops, there are still other plants that farmers can sell to make money (cacao/cocoa and bananas).</i>	<i>How does the number of different types of plants affect the resources people can get from the land?</i>
<i>How did the drought, disease, or price drop affect populations in ecosystems in the monoculture farm?</i>	<i>When the oil palm is stressed, it produces less fruit.</i> <i>In the monoculture farm, there's no other plant for animals to eat or use for shelter, so more of the populations struggle.</i>	<i>Why would the amount of water affect the oil palm plants ability to fruit?</i> <i>Why would the amount of oil palm plants affect the rat and pig populations?</i>
<i>How did the drought, disease, or price drop affect populations in ecosystems in the diversified farm?</i>	<i>This has less of an impact on all the populations in the diversified farm because they can eat or use other plants for shelter.</i>	

Compare the systems models. Project slide M. Have students turn and talk about the differences between the two systems. Then have students share their ideas with the class. The purpose of this discussion is to highlight differences in both biodiversity (the number of boxes), as well as the number of connections between populations (the lines between boxes), and push students to summarize why biodiversity and links matter if there is a disturbance.

Suggested prompts	Sample student responses	Follow-up questions
How are these two systems different?	<i>They have different organisms in them.</i> <i>The diversified system has more different populations (or more biodiversity).</i> <i>The diversified system has more connections between populations.</i>	
Why does the number of populations in a system and how many connections there are matter? For populations in ecosystems? For farmers?	<i>If something happens, the system with more populations and links will do better because other populations can step in.</i> <i>Farmers have more options for what they can sell if one population suffers in the system with more populations and links.</i>	<i>Which farm will be better for ecosystems if there is a disturbance and why?</i> <i>Which farm will be better for people if there is a disturbance and why?</i>
What kind of farm would you rather run and why?	<i>Listen for ideas about how the diversified farm is more “flexible” or you have “more options.”</i>	

Introduce the idea of resilience. Revoice the ideas that students have been sharing about how the diversified oil palm farm is more “flexible” or that animals and farmers have “more options.” Introduce the idea that a system is more resilient or able to bounce back after a disruption if it has more biodiversity (more boxes) and more interactions between populations (the lines connecting the boxes).* Add “resilience” to the classroom word wall.

Answer the lesson question. Project slide N. Have students share their answers to the lesson question in pairs: “Why would planting more kinds of plants benefit the ecosystem and the farmers?”

10 · NAVIGATION

5 min

MATERIALS: None

Motivate the need to answer the driving question. Say, *We’ve figured out that diversified farming has some benefits to both farmers and to the native ecosystem. It’s interesting that in both farming cases—monoculture and diversified—people are making changes to the ecosystem, and that changes what lives there. That sounds a lot like our unit driving question.*

Fill out an exit ticket. Have students record ideas for changes to ecosystems that affect what lives in the system.

Additional Lesson 12 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

CCSS.ELA-Literacy.SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

During day 1, students develop their own individual models and then come to a group discussion prepared, having developed their ideas about the material under study. They collaboratively discuss and develop a group consensus model, which requires students to share their ideas, reflect on others' ideas, and modify their own views when warranted to come to a consensus.