LESSON 8: Could planting more fruit trees help the orangutan population increase?

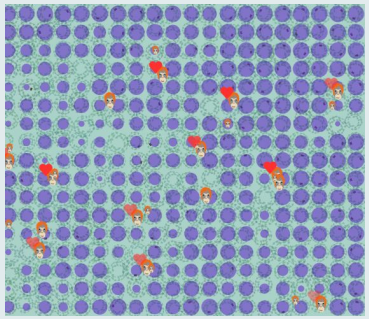
PREVIOUS LESSON

We gathered data from a whole-group computer simulation in which individual orangutans competed with each other for two different food sources (figs and termites). We tested the simulation in a variety of environmental conditions (independent variable). We constructed class histograms and examined how well individual orangutans and the orangutan population overall responded (dependent variables).

THIS LESSON

INVESTIGATION

2 days



We conduct investigations in a simulation, manipulating the amount of resources (IV) over longer periods of time to observe how populations increase or decrease (DV). We notice that population sizes increase when resources are plentiful and decrease when resources are limited. We also notice that all populations have natural fluctuations in size. We connect our findings to the differences in population density in the different ecosystems from Lesson 6. We think we have figured out how resource availability could support healthier orangutan populations.

NEXT LESSON

We will build a Gotta-Have-It Checklist and engage in consensus modeling to show what we have figured out so far about how changes to an ecosystem impact the population of organisms that live there. Afterwards, we will apply these understandings toward explaining a related phenomenon.

BUILDING TOWARD NGSS

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

WHAT STUDENTS WILL DO

Collect data from an investigation to draw conclusions about how stable populations of orangutans fluctuate over shorter periods of time based on resource availability.

Use mathematical representations to draw conclusions about how the size of orangutan populations changes over the long term, depending upon resource availability.

WHAT STUDENTS WILL FIGURE OUT

- If an organism cannot meet its needs, it may not grow and survive. Over a timespan of years, this could affect the total population number.
- If an organism cannot meet its needs, it may not reproduce. Over a timespan of years, this could affect the total population number.
- It's healthy and normal for populations to go up and down.
- If there is a lot of a resource available, populations go up. If the resource is limited, populations go down.

Lesson 8 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Set the purpose for the lesson by revisiting the design goal and having students consider ways they could increase orangutan populations.	A	
2	5 min	**ORIENT TO THE UPDATES IN THE SIMULATION** Orient students to the updates in the computer simulation by introducing the "reproduce?" and "starve?" features in the simulation.	B	Orangutan Forest Model Updates video
3	15 min	**CONDUCT INVESTIGATION 1** In small groups, run the simulation to examine what will happen to the orangutan population under "normal" environmental conditions. Engage in a discussion about fluctuation and stability.	C-E	*Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*, colored pencils, computer, Orangutan Forest Model Simulation 2, computer and projector
4	20 min	**CONDUCT INVESTIGATION 2** In small groups, plan and run an investigation to examine the question, "Could planting more fruit trees help the orangutan population increase?" Gather data from the simulation on a class data table and draw conclusions from the data.	F-G	*Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*, colored pencils, computer, Orangutan Forest Model Simulation 2
				End of day 1
5	25 min	**CONDUCT INVESTIGATION 3** In small groups, plan and run an investigation to examine the question, "What is the smallest percentage of fruit trees that could still support an orangutan population?" Gather data from the simulation on a class data table and draw conclusions from the data.	H-I	*Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*, colored pencils, computer, Orangutan Forest Model Simulation 2
6	10 min	**BUILDING UNDERSTANDING: CONNECTING OUR FINDINGS TO REAL ECOSYSTEMS** Look back to the four ecosystems we investigated in Lesson 6 and try to make sense of why each ecosystem supported a slightly different number or orangutans.	J-K	*Orangutan Populations in Protected Areas in Indonesia* (already in science notebooks), access to *Orangutans in Four Protected Areas in Indonesia* (from Lesson 6)
7	10 min	**NAVIGATION** Update Progress Trackers, summarize what we figured out, and navigate to the next lesson.	L	
				End of day 2

Lesson 8 • Materials List

	per student	per group	per class
Lesson materials	• science notebook • *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* • colored pencils • *Orangutan Populations in Protected Areas in Indonesia* (already in science notebooks) • access to *Orangutans in Four Protected Areas in Indonesia* (from Lesson 6)	• computer • Orangutan Forest Model Simulation 2	• Orangutan Forest Model Updates video • computer and projector • Orangutan Forest Model Simulation 2

Materials preparation (45 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.

Review the *Orangutan Forest Model Updates* video introducing the modifications to the simulation on **slide B** and located at https://www.teachersopensciedfieldtest.org/palmoil . Spend some time familiarizing yourself with the simulation and the controls. Run each investigation outlined in the lesson on your own prior to running the investigations with the class.

Make sure you can open the *Orangutan Forest Model 2* simulation from https://tinyurl.com/forestmodel2 and that student devices can access this URL too. Alternatively, you can download the sim code file and run it directly from your computer and student devices. Instructions for different methods to access the Netlogo simulations are located at the field test website: https://www.teachersopensciedfieldtest.org/palmoil.

Obtain enough computers or devices for students to work in pairs on one computer. Make sure the devices are charged and that students can access the simulation from the devices.

Prepare space for two class data tables - one in *Investigation 2* and one in *Investigation 3*.

Retrieve enough copies of *Orangutans in Four Protected Areas in Indonesia* for each student to have access to one. These reference cards are based on the StoryMap students investigated in Lesson 6. Make sure students can access *Orangutan Populations in Protected Areas in Indonesia*, already attached in their science notebooks.

Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

In Lesson 7, students figured out that when certain food resources (figs) are plentiful, individual orangutans have higher energy levels because they can eat more figs than termites. When figs are scarce, orangutans can eat termites, but their energy levels decline. Students are left wondering how food availability affects population size. This lesson allows students to test their ideas about how food availability affects population sizes.

This lesson layers on population health and growth to previous ideas about organism health and growth. Specifically, this lesson targets the same DCIs that are part of LS2.A Interdependent Relationships in Ecosystems, with the addition of how resource availability impacts population. Students will figure out the following science ideas:

- If an organism cannot meet its needs, it may not grow and survive. Over a timespan of years, this could affect the total population number.
- If an organism cannot meet its needs, it may not reproduce. Over a timespan of years, this could affect the total population number.
- It's healthy and normal for populations to go up and down.
- If there is a lot of a resource available, populations go up. If the resource is limited, populations go down.

By the end of this lesson, students should be prepared for Lesson 9, a lesson that puts different pieces together and solidifies students' understanding about:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with non-living factors. (MS-LS2-1).
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1).
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1).

Lesson 10 will layer on additional environmental interactions and competition between populations to fully satisfy these DCIs, but students should have figured out most of the science ideas with respect to food resource availability, population competition, and population growth and decline.

This lesson builds on 5th grade DCIs, *Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs.* This lesson extends students' understanding by connecting resource availability to healthy population sizes and normal and unusual fluctuation in populations based on resources.

Where We Are NOT Going

This lesson focuses on normal and usual fluctuations in populations due to fluctuations in resource availability. This lesson introduces students to the idea that an extreme change in resource availability can greatly impact populations, but does not yet connect this to human-caused disruptions. This will happen in Lesson 10 as students build out ecosystem webs for the tropical rainforest and oil palm farms. Disruptions and ecosystem health will also be the focus of Lesson 12.

LEARNING PLAN for LESSON 8

1 · NAVIGATION

5 min

MATERIALS: None

Lead a navigation discussion. Use this discussion to help students consider ways to increase the size of orangutan populations and how they might use the simulation to test their ideas. Remind students that their overall design goal is to protect the orangutans in Borneo and Sumatra. In order to do so, we are likely going to have to do something to help the size of the orangutan population increase. Project **slide A** and have students consider ways they might increase the size of orangutan populations.

Suggested prompt	Sample student response
Based on our investigations yesterday, what are some of your ideas about how we could increase the orangutan populations?	*Since orangutan energy levels increased when there were more fruit trees in the simulation, we could try increasing the number of fruit trees in the ecosystem to increase the size of orangutan populations.*
How could we test those ideas using our simulation?	*We would need to first add in births and death to our simulation so that we can see changes to orangutan population size.*

Summarize by saying, *It sounds like we are wondering, "Could planting more fruit trees help the orangutan population increase?" You mentioned that we would need to add in the opportunity for orangutans to reproduce and to die in order to see changes in population size. Our simulation can help us do that!*

2 · ORIENT TO THE UPDATES IN THE SIMULATION

5 min

MATERIALS: Orangutan Forest Model Updates video

Orient students to the updates in the computer simulation. Demonstrate the "reproduce?" and "starve?" features in the simulation. Project **slide B** and play the *Orangutan Forest Model Updates* video located at https://www.teachersopensciedfieldtest.org/palmoil . The video introduces students to the new reproduction and death features and the ways to monitor population size:

- If an orangutan reaches an energy level of 0, the orangutan will die. You will see a black X temporarily appear in the simulation anytime an orangutan dies.
- If an orangutan reaches an energy level of 200, the orangutan will reproduce. When an orangutan reproduces in the simulation, the orangutan splits in half and the energy is divided between the offspring. You will see a red heart temporarily appear in the simulation anytime an orangutan reproduces.
- You can monitor the size of the population by looking at the line graph created by the simulation. You can also observe the maximum and minimum population sizes, in addition to the average population size, for the entire run by looking at the yellow boxes.

Emphasize the idea that since orangutans can now reproduce and die, we will expect to see the size of the overall orangutan population increase and decrease.

Finally, frame the investigation to students by pointing out that they are no longer going to focus on just one individual orangutan in the simulation. Rather, the students themselves, will control the simulations and will focus on the orangutan population as a whole. It may help to reference the visual representation for individuals and populations that you developed in Lesson 6.

3 · CONDUCT INVESTIGATION 1

15 min

MATERIALS: science notebook, *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*, colored pencils, computer, Orangutan Forest Model Simulation 2, computer and projector

Orient students to the investigation. Share the investigation question, *"What will happen to the orangutan population if we add births and deaths to our simulation under 'normal' environmental conditions?"* To figure this out, students will transition away from focusing on one orangutan in an ecosystem, and instead they will focus on the entire population of orangutans.

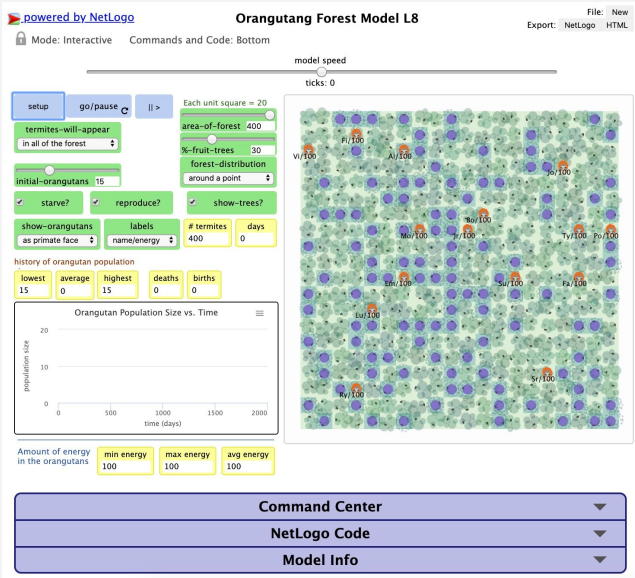
Handout *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* and use **slide C** to prompt students to paste each page of the handout into their science notebooks.

ADDITIONAL GUIDANCE	Decide whether you want students to paste all investigation pages into their notebooks now, or wait and paste the pages as you proceed through the investigations.

Arrange students in pairs with one shared computer or device. Explain that students will now control the ecosystem and will need to decide how to set the sliders for each investigation. Demonstrate how to open the simulation as students follow along on their own computers.

ADDITIONAL GUIDANCE	Having students share one computer between two students, as opposed to having each student work independently, will help to generate more dialogue between students as they plan, observe, gather data from, and analyze their investigations. Consider having students alternate who "drives" the computer for each trial or each investigation so that each student is actively participating in the process.

Set the context for the investigation. Project **slide D** and say, *We started this lesson by wondering whether adding more fruit trees might increase the size of the orangutan population. We realized that we needed to add births and deaths to our simulation, which we did. Now, we need to establish what happens to an orangutan population under "normal" conditions. The goal of* Investigation 1 *is to establish a baseline for how populations respond when we add in births or deaths. This can sometimes be referred to as a control trial.*



Preview the investigation. Prior to directing students to work in groups on *Investigation 1*, preview the investigation and some of the procedural details. First, direct students to *Investigation 1* on *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*. Explain that for this first investigation, we are just trying to get a sense of how the population changes when births and deaths are added. Students should use the default environmental settings, but make sure that the "starve?" and "reproduce?" settings are turned on (by checking the boxes). The default settings for *Investigation 1* are illustrated in the image.

Preview the following investigation pattern: (1) plan, (2) predict, (3) gather data, and (4) analyze results (making sense). Show students that on *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* under *Investigation 1*, the first step is to plan their investigation by identifying the area of forest, percent of fig trees,

and number of termites. Once the investigation is planned, students should make predictions using the prompts on the handout. Next, students should run two trials of their investigation and record data from both trials. Finally, students should work with their partner to analyze their results using the prompts in the making sense section.

Lead a short discussion to help students understand why it is important that they run two trials for each investigation. For every investigation in this lesson, students are prompted to run multiple trials. It is important that they understand that each trial may yield slightly different results. In their analysis, they will have to generalize their findings.

Suggested prompt	Sample student response
You probably noticed that in the handout you are prompted to run two trials of your investigation. Why do you think it is important to run two trials?	*The results of each trial might be slightly different, so it is probably important to look at a few possible results.* *When we do other experiments we do multiple trials to make sure our results are accurate and not just from some error.*

Have students work in pairs to run the first investigation and analyze the results. Students can access the Orangutan Forest Model 2 simulation from https://tinyurl.com/forestmodel2 . They should aim to complete *Investigation 1* (pages 1 and 2) on *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*. As students work, circulate amongst groups to push their thinking.

When students are making predictions, consider the following prompts:

Suggested prompt	Sample student response
I notice that your graph shows the population size staying about the same. Can you say more about why you think that the population size will stay the same?	*Since we aren't changing the number of fruit trees, and since the energy levels of the orangutans stayed about the same in our investigation from Lesson 7, with 30% fruit trees, I think the population will stay about the same.*
I notice that your graph shows the population increasing. Can you say more about why you think the population size would increase?	*The orangutans have plentiful food, so I think they will have enough energy to reproduce. I don't think that the baby orangutans will eat enough food to make a difference, so the population size will continue to grow.*

When students are running the simulations, consider the following prompts:

Suggested prompt	Sample student response
Wow - it looks like the population size is going up and down! That is different from your prediction - why do you think that happened?	*Maybe as more orangutan babies are being born, the orangutan population eats more fruit, making fruit less plentiful. That means that the orangutans would compete more for fruit, so they might be more likely to die. Then, when the orangutans start to die, the fruit becomes more plentiful for the living orangutans so that they can reproduce more.*
What seems to be happening to the population size of the orangutans? Is it increasing, decreasing, or staying the same?	*It seems to be staying about the same. There are some slight increases and decreases, but we are noticing that it is hovering around a certain average size.*

Suggested prompt	Sample student response
Why do you think the orangutan population size is staying about the same?	*It must have something to do with the amount of fruit available for the orangutans to eat. Maybe that particular number of fruit trees can support that number of orangutans, sort of like what we saw in Lesson 6!*

After running the investigation, students should work on the "Making sense" section of the handout in pairs. Students should use one color of pen or pencil to indicate the ideas that they came up with, and use a second color of pen or pencil to add onto their thinking once they discuss with their partner and the class.

Make sense of data from *Investigation 1*. After students have had the opportunity to work in pairs on the "Making sense" section of the handout, lead a class discussion to make sense of findings from the investigation. Project **slide E** during the discussion. Prompt students to use a different colored pen or pencil to add ideas from the class discussion to the "Making sense" portion of their *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* handouts.

Suggested prompt	Sample student response
What claims can you make about the question, "What will happen to the orangutan population if we add births and deaths to our simulation, under 'normal' environmental conditions?"	*When we add in birth and deaths to the simulation, the size of the orangutan population stays about the same.* *There are some fluctuations in the size of the population because when resources are plentiful, orangutans can reproduce more, but when resources are limited, orangutans tend to die more.* *Resources become plentiful or limited based on competition between individual orangutans. When there are more orangutans, the orangutans are all competing for the same amount of food, so each individual gets less of it. When there are fewer orangutans, the orangutans can compete less and each individual is able to access more food.*
Why did the population size fluctuate?	*As more orangutan babies are being born, there are more orangutans in the population eating more fruit. This makes the fruit less plentiful. That means that the orangutans will compete more for fruit, so they might be more likely to die. Then, when the orangutans start to die, the fruit becomes more plentiful for the living orangutans so that they can reproduce more.*
Why was it important that we conduct two trials?	*It was important to conduct two trials because our results were slightly different for each trial. It was important for us to see that even though the results might vary, we still observed the same general trends.*

Summarize results from *Investigation 1*. Say, *It seems like most of us noticed that when the population size is going up, more orangutans are being born. When the population size is going down, more orangutans are dying. Many of you mentioned that this was based on the availability of the fruit. Now that we have a pretty solid baseline, let's investigate our question about planting more trees!*

ADDITIONAL GUIDANCE	Students may notice that in NetLogo, they are able to tinker with the code for the simulation by clicking on the "NetLogo Code" bar in purple. Use your judgement to appropriately encourage this tinkering. Students may be able to generate some really interesting scientific investigations by tinkering with the code.

4 · CONDUCT INVESTIGATION 2

20 min

MATERIALS: science notebook, *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*, colored pencils, computer, Orangutan Forest Model Simulation 2

Define independent and dependent variables. Frame *Investigation 2* by reminding students about independent and dependent variables in investigations. Say, *Our investigation question is, "Could planting more fruit trees help the orangutan population increase?" Remember that independent variables are variables that we manipulate in an investigation, while the dependent variables are variables that respond as a result of that manipulation. In our investigation, what will be our independent variable and what will be the dependent variable?*

Suggested prompt	Sample student response
What is the independent variable in our simulation?	*The thing that we are going to change is the amount or percentage of fruit trees in the forest.*
What is the dependent variable in our simulation?	*The thing that is responding is the average population size of the orangutans.*

Preview *Investigation 2*. Prior to directing students to work in groups on *Investigation 2*, preview the investigation and some of the procedural details. Utilize **slide F** to guide the discussion. Direct students to *Investigation 2* on *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*. Explain that for this investigation, we are trying to see if increasing the number or percentage of fruit trees in the forest might help the orangutan population size increase. Students should use the default environmental settings **except** for the percentage of fruit trees. Students will need to decide in their groups how they would like to change the percentage of fruit trees. Remind students of the following investigation pattern: (1) plan, (2) predict, (3) gather data, and (4) analyze results (making sense). Orient students to where on their handouts they can find this pattern.

Have students work in pairs to run the second investigation and analyze the results. Students should aim to complete *Investigation 2* (pages 3 and 4) of their handout. As students work, circulate amongst groups to push their thinking. Consider the following prompts:

Suggested prompt	Sample student response
How did your orangutan population respond to the changes you made in your independent variable?	*We have way more orangutans! It seemed like adding fruit trees really made a difference!* *It didn't really seem to make a noticable difference for us.*
What could explain whether or not you saw a noticeable difference?	*We only went up a little on the amount of fruit trees, so maybe that doesn't affect orangutans very much.* *We added a lot of fruit trees and it seemed to cause a big difference.*

✱ SUPPORTING STUDENTS IN ENGAGING IN PLANNING AND CARRYING OUT INVESTIGATIONS

It is important that students *only* change the percentage of fruit trees (independent variables) while holding all of the other variables (e.g. area of the forest, initial number of orangutans, etc.,) constant. You may wish to point out that each of the other variables become control variables that must be held constant in our investigation when we are manipulating one of them as an independent variable. If we change any of the control variables in addition to percentage of fruit trees, it will be impossible to tell whether our findings are a result of the changes in the independent variable or changes in the control variables.

Suggested prompt	Sample student response
Why do you think you are seeing/not seeing the changes?	*We think that it is because there is more food available to the orangutans. When there is more food available, more orangutans can survive.* *We think that there isn't enough of a difference in the amount of food available to orangutans, so the ecosystem can support about the same size population.*

Generate a class data table. As students complete their trials, have them add their data to a class data table. Create a data table on the board that looks like the chart below.

% Fruit Trees	Average Orangutan Population Size	Range of Orangutan Population Size
35%	18.6	15-23
45%	26.4	15-32
50%	29.0	15-37
60%	33.9	15-40
65%	36.9	15-48
75%	41.5	15-51

After running the investigation, students should work on the "Making sense" section of the handout in pairs. Students should use one color of pen or pencil to indicate the ideas that they came up with, and use a second color of pen or pencil to add onto their thinking once they discuss with their partner and class.

Make sense of data from *Investigation 2*. After students have had an opportunity to work on the "Making sense" section of the handout in pairs, lead a class discussion to make sense of findings from the investigation. Utilize **slide G** to guide the discussion. Prompt students to use a different color of pen or pencil to add ideas from the class discussion to the "Making sense" portion of their *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* handouts.

ADDITIONAL GUIDANCE

For every trial, the orangutan population will begin with 15 orangutans and therefore have a low range value of 15 and a high value that varies by percent of fruit trees. If your students notice this pattern and have questions about it, and you have the time for additional analysis, you may want to do more with the histograms. Below is a suggestion for how to approach refining the range of orangutan population size to reflect the range of the stable population.

Take a moment during whole-group discussion to demonstrate the range of the "stable population" after the sharp initial increase. For example, run the model at 75% of fruit trees until you get the histogram and low and high values. The low and high values will indicate a range of 15-50 orangutans. Hover over the histograms to highlight the lowest and highest values over time that confirm this. Then, identify the lowest point other than the initial 15 orangutans. Once the population stabilizes, this is the lowest value for a stable range. As you demonstrate and discuss this as a class, you may want to revise the class chart as shown in the image to the right to reflect the more accurate range for stable population.

% Fruit Trees	Average Orangutan Population Size	Range of Orangutan Population Size
35%	18.6	15-23
45%	26.4	15-32
50%	29.0	15-37
60%	33.9	15-40
65%	36.9	15-48
75%	41.5	36 ~~15~~-51

Suggested prompt	Sample student response
What trends do you notice in the class data table?	*We notice that as the percentage of fruit trees increases, the average size of the orangutan population increases. This must mean that our idea of adding more fruit trees could help the orangutans could work!*
What claims can you make about the question, "Could planting more fruit trees help the orangutan population increase?"	*Planting more fruit trees could help the orangutan population!*
Why can you make this claim? What is your evidence?	*We know this based on our own investigation and the classes investigations, which show that as percentage of fruit trees increases, so does the average population size of the orangutans.*
What questions do you have now?	*If saving the orangutans is just a matter of planting more fruit trees, why can't we just do it now?!* *I remember that we still need to have palm oil and we probably can't just add a ton of fruit trees, so I wonder - what is the lowest number of fruit trees that we could add that could still sustain a healthy orangutan population?*

Summarize the findings from *Investigation 2* and the applications to the design solutions. Say, *Wow - we had some major realizations! If we plant more fruit trees, we can increase orangutan populations. But, as we know from previous lessons, we can't just plant a ton of fruit trees. There still needs to be space for oil palms to grow. So we have a bit of a conundrum. We want to have more fruit trees, but we can't just plant as many as we would like. So it sounds like we are going to need to know, more precisely, how many fruit trees would we need to still support a stable orangutan population. Let's investigate that next.*

End of day 1

5 · CONDUCT INVESTIGATION 3

25 min

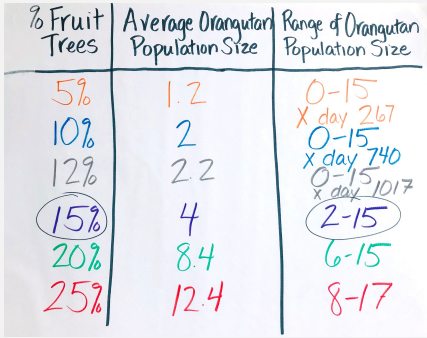
MATERIALS: science notebook, *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*, colored pencils, computer, Orangutan Forest Model Simulation 2

Preview the investigation. Prior to directing students to work in groups on *Investigation 3*, preview the investigation and some of the procedural details. Use **slide H** to guide the discussion. Direct students to *Investigation 3* on *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size*. Explain that for this investigation, we are trying to determine the smallest percentage of fruit trees that would still support an orangutan population. Students should use the default environmental settings **except** for the percentage of fruit trees. Students will need to decide in their groups how they would like to change the percentage of fruit trees. Groups should determine three different values of fruit trees that they would like to test. Remind students of the following investigation pattern: (1) plan, (2) predict, (3) gather data, and (4) analyze results. Orient students to where on their handouts they can find this pattern.

Have students work in pairs to run the third investigation and analyze the results. Students should aim to complete *Investigation 3* (pages 5 and 6) on their handout. As students work, circulate amongst groups to push their thinking. Consider the following prompts:

Suggested prompt	Sample student response
How did your orangutan population respond to the changes you made in your independent variable?	*Our entire orangutan population died.* *Our orangutan population stayed alive, but it was a very small population.* *Our orangutan population stayed alive and it was a pretty big population.*
What is happening with the population during the decline-can you show me on the graph? *What does that mean?*	*It goes down, but not in a straight line.* *They don't all die at once-there is some normal up and down.*
Why do you think you are seeing/not seeing the changes?	*We think that our orangutan population died because there wasn't enough fruit to support the living orangutans.* *We think that even though our orangutan population is small, it stayed alive because we had just enough fruit to support the population.* *We think that our orangutan population is big because we have a little more fruit than what we need to keep the population alive.*

Generate a class data table. As students complete their trials, have them add their data to a class data table. Create a data table on the board that looks like the chart depicted.



% Fruit Trees	Average Orangutan Population Size	Range of Orangutan Population Size
5%	1.2	0-15 X day 267
10%	2	0-15 X day 740
12%	2.2	0-15 X day 1017
15%	4	2-15
20%	8.4	6-15
25%	12.4	8-17

After running the investigation, students should work on the "Making sense" section of the handout in pairs. Students should use one color of pen or pencil to indicate the ideas that they came up with, and use a second color of pen or pencil to add onto their thinking once they discuss with their partner and class.

Make sense of data from *Investigation 3*. After students have had an opportunity to work on the "Making sense" section of the handout in pairs, lead a class discussion to make sense of findings from the investigation. Use **slide I** to help guide the discussion. Prompt students to use a different color of pen or pencil to add ideas from the class discussion to the "Making sense" portion of their *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* handouts.

Suggested prompt	Sample student response
What trends do you notice in the class data table?	*We notice that as the percentage of fruit trees decreases, the average size of the orangutan population decreases. There seems to be a certain point where all of the orangutans die, so the number of fruit trees needed to support the orangutan population must need to be somewhere slightly above that point.*

Suggested prompt	Sample student response
What claims can you make about the question, "What is the smallest percentage of fruit trees that could still support an orangutan population?"	*The smallest percentage of fruit trees that could still support an orangutan population is around 15%. That means that for our orangutans to survive, there needs to be at least that many trees.*
Why can you make that claim? What is your evidence?	*When we went below 15% all the orangutans died. When we stayed at 15% or higher the population leveled off. It was a low number but it a few stayed alive and the histogram seemed steady or stable.*
How might our findings help us design a solution to the palm oil problem?	*In a real ecosystem, is it possible to establish that amount of fruit trees to keep the orangutans alive?* *How could we plant the fruit trees in the real ecosystem so that the orangutans can access them?*

Summarize the findings from the investigation and the applications to the design solutions. Say, *This is exciting! We figured out that increasing the number of fruit trees could help the orangutans and we figured out that there needs to be a certain amount of fruit trees in order for the orangutans to stay alive. Now we have some work to do thinking about how this might relate back to a real ecosystem. Before we think about the palm oil farm, let's map what we just did to the real ecosystems we looked at in Lesson 6.*

6 · BUILDING UNDERSTANDING: CONNECTING OUR FINDINGS TO REAL ECOSYSTEMS

10 min

MATERIALS: science notebook, *Orangutan Populations in Protected Areas in Indonesia* (already in science notebooks), access to *Orangutans in Four Protected Areas in Indonesia* (from Lesson 6)

Look back at the four ecosystems from Lesson 6 to explain variations in orangutan populations. Project **slide J.** Prompt students to locate *Orangutan Populations in Protected Areas in Indonesia* in their science notebooks. Point out that we noticed that each ecosystem supports between 1-3 orangutans per square kilometer but that there were differences in each ecosystem. For instance, Gunung Palung National Park had a population density of about 3, while Kutai National Park had a population density of about 1. You may wish to project **slide K** as a resource. Ask, *What conclusions can we now draw about each of these ecosystems and why they supported different numbers of orangutans?*

Assign each pair of students one ecosystem to look at more closely. In pairs, the students should discuss why they think their assigned ecosystem had the population density that it did. Prompt students to use evidence from this lesson in their responses.

When students are ready, have them share their ideas with the class. Lead a discussion to help students connect their findings from the investigation in this lesson to the real ecosystems from Lesson 6.

Suggested prompt	Sample student response
Why could some ecosystems support more orangutans per square kilometer than others?	*The ecosystems with higher population densities must have more fruit trees than the ecosystems with lower population densities. This is like what we saw in our simulation. When we had higher percentages of fruit trees, the populations were larger.*

Differentiate between "normal" fluctuations in healthy populations and fluctuations that are not normal. Point out that the orangutan populations in each ecosystem seemed to be healthy even though each ecosystem supported a different number of orangutans per square kilometer. Say, *I wonder, why would each of these populations be considered healthy, while others might not be?"* In the following discussion, help students see that healthy populations fluctuate, but generally tend to fluctuate around the same average size. Populations that may not be considered healthy might also fluctuate, but the average size of the population is likely dropping. Have students described the histograms they saw in *Investigations 2* and *3* that reflect healthy fluctuation and an unstable pattern.

Suggested prompt	Sample student response
What kinds of patterns do we notice in healthy populations?	*In healthy populations, we see fluctuations (ups and downs) around generally the same average population size. We don't see the population size deviate much from this population size.*
What kinds of indicators do we have to tell us that a population might not be healthy?	*In some of our simulations, we saw the average population size start to decrease quite a bit. In some cases, the average population size fell to 0. If we see populations that are fluctuating, but the average population size seems to be decreasing, this might be an indication that the population is not healthy.*

7 · NAVIGATION

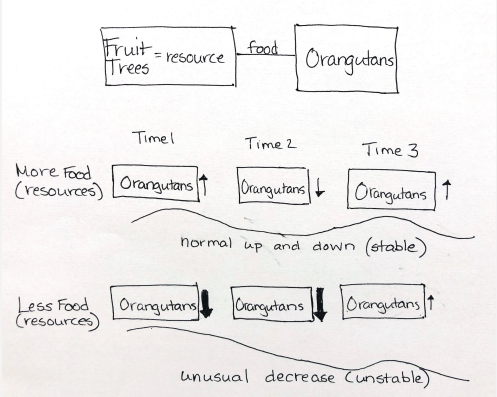
10 min

MATERIALS: science notebook

Give students 5-6 minutes to quietly update their Progress Trackers using words and drawings to show what they have figured out. Project **slide L** to guide student work. Ask students to draw a line underneath their responses when they are done.

After students update their Progress Trackers, have students share our some of their ideas about what we figured out in this lesson. Example student response:

- We figured out that when there are more resources (food) available orangutan populations increase because orangutans have enough energy to reproduce and more are reproducing than dying. At some point, the increase levels off. When there are less resources (food), populations decline because orangutans aren't reproducing as much and some are dying but eventually the population size levels off. So the amount of food available affects a population's size. We think we've figured out what can get us a healthy population of orangutans.



As students share their ideas about what we figured out, create a shared class representation of the ideas. An example is provided to the right.

Navigate to the next lesson by saying, *Cool! So it looks like we have a solution - we need to plant more fruit trees. We will likely need to think about how we will plant the trees and where they will be planted, but we want to test it! Before we do, let's revisit our Driving Question Board and build a revised model to put all of these different pieces together to make sure we aren't missing anything.*

Additional Lesson 8 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN MATH

CCSS.Math.Content.6.SP.B.5.c Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

When analyzing data from each investigation, students examine the mean population size for orangutans in addition to the maximum and minimum population sizes for the run. Students also examine a line graph showing the changes in population size over time. Students compare these findings to simulation runs in which there are either more or fewer fruit trees. As such, students examine the relationship between the percentage of fruit trees (independent variable) and the population size of the orangutan (dependent variable) as measured by mean, range, and changes in population size over time. When analyzing the mean, range, and changes in population size over time, students look for striking deviations between simulation runs (e.g., unusual declines or increases in orangutan populations) in order to draw conclusions about population sizes.