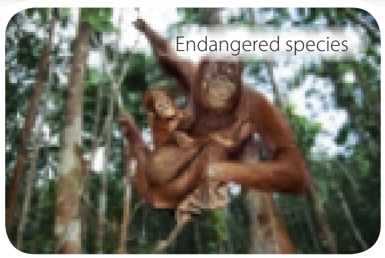
Ecosystem Dynamics:

How does changing an ecosystem affect what lives there?

Science Literacy

Teacher Guide



GRADE 7 Core Knowledge Science®

Core Knowledge®

This unit is a modified version of a unit that has earned the NGSS Design Badge. The sole instructional modification is the addition of Core Knowledge Science Literacy content. The modification has not been reviewed.

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Teacher Guide

Core Knowledge®

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Table of Contents

Teacher Resources

BEFORE YOU BEGIN

Before introducing the unit, please become fully acquainted with the program instructional model and classroom routines by reading the online resource **Teacher Handbook: Overview of the Core Knowledge Middle School Science Program**.

Online Resources	Use this link to download the **CKSci Online Resources Guide** for this unit, which includes specific links to: • the unit's comprehensive materials list • a full unit pacing snapshot • lesson guidance slides • all other recommended resources. **www.coreknowledge.org/cksci-online-resources**
Student Work Pages	All student handouts and exercise pages are included in the consumable Student Work Pages book so that there is no need to print copies of these resources.
Student Books	All student handouts and exercise pages are included in the consumable Student Work Pages book so that there is no need to print copies of these resources. Students also will use the Student Procedure Guide and the Science Literacy Student Reader throughout the unit.

UNIT OVERVIEW

How does changing an ecosystem affect what lives there?

This unit on ecosystem dynamics and biodiversity begins with students reading headlines that claim that the future of orangutans is in peril and that the purchasing of chocolate may be the cause. Students then examine the ingredients in popular chocolate candies and learn that one of these ingredients—palm oil—is grown on farms near the rainforest where orangutans live. This prompts students to develop initial models to explain how buying candy could impact orangutans.

Students spend the first lesson set better understanding the complexity of the problem, which cannot be solved with simple solutions. They will figure out that palm oil is derived from the oil palm trees that grow near the equator, and that these trees are both land-efficient and provide stable income for farmers, factors that make finding a solution to the palm oil problem more challenging. Students will establish the need for a better design for oil palm farms, which will support both orangutans and farmers. This design serves as a launching point as students investigate what orangutans need to survive. Students figure out that orangutans compete for resources and, when less forest space is available to them, those resources are more limited. Students then investigate how oil palm farming impacts other populations of animals and how rainforests and oil palm systems differ in terms of resources and their resilience to disruptions. The final set of lessons engage students in investigations of alternative approaches to growing food compared to large-scale monocrop farms. Students figure out that some of these alternative methods are less harmful for orangutans and other living things and provide farmers with the income and ecosystem services they rely upon, but are only realistic for some stakeholders. Students apply these ideas to design an oil palm farm that simultaneously supports orangutan populations and the income of farmers and community members.

As part of the process of investigating the palm oil problem, students will

- plan and carry out simulated computer model investigations to examine what orangutans need to support healthy populations,
- engage in mathematical reasoning and computational thinking to determine the area of forest required by orangutans and how resource availability impacts orangutan populations,
- model competition for available resources within and between populations, and model other interactions (e.g., predation, mutually-beneficial interactions, etc.) between populations,
- use models to predict and test how various disruptions would impact more or less biodiverse systems,
- construct arguments that more biodiverse plant communities support other living things, particularly when there is a disruption, and

- obtain information about alternative farming approaches and ecosystem services in comparison to monocrop farming and apply these ideas to the design of an oil palm farm system that supports both orangutans and farmers.

Focal Disciplinary Core Ideas (DCIs): LS2.A; LS2.C; LS2.D; ESS3.C; EST1.A

Focal Science and Engineering Practices (SEPs): Asking Questions and Defining Problems; Developing and Using Models; Planning and Carrying Out Investigations; Using Mathematics and Computational Thinking; Constructing Explanations and Designing Solutions; Engaging in Argument from Evidence

Focal Crosscutting Concepts (CCCs): Cause and Effect; Systems and System Models; Stability and Change

Building Toward NGSS Performance Expectations

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

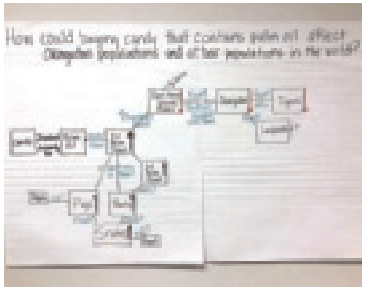
MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

UNIT STORYLINE

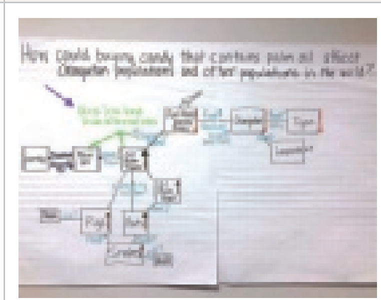
How students will engage with each of the phenomena

HANDS-ON/ LAB ACTIVITIES	VIDEOS OR IMAGES	DATA SETS	READINGS	COMPUTER INTERACTIVES

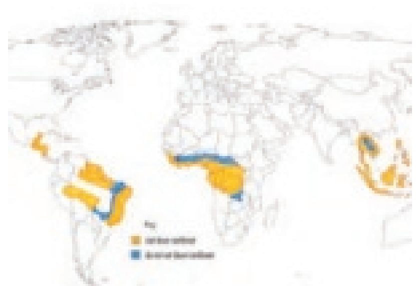
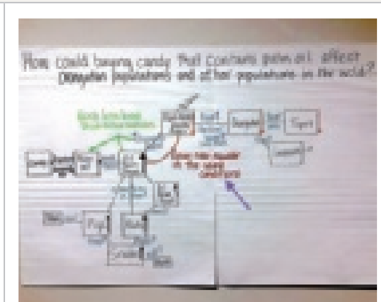
How does changing an ecosystem affect what lives there?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 **4 days** **How could buying candy affect orangutan populations in the wild?** **Anchoring Phenomenon**	 *Buying candy in the United States could lead to the death of orangutans in Indonesia.*	We read headlines that claim that our candy-buying habits could affect orangutan populations in the wild. We examine candy ingredients and realize that one ingredient, palm oil, is produced in the same location in which orangutans live. We read about tropical rainforests in Indonesia being cut down to grow oil palm. We wonder how oil palm trees lead to a decrease in the orangutan population. We develop a Driving Question Board (DQB) to guide future investigations. We figure out the following: • One of the main ingredients in many types of candy and cosmetic products is palm oil. Palm oil is one of the most commonly used oils. • Farmers/companies are cutting down rainforests to plant oil palm plants. • As oil palm numbers increase, orangutan and tiger populations decrease. • As oil palm numbers increase, rat, pig, and snake populations also increase.	

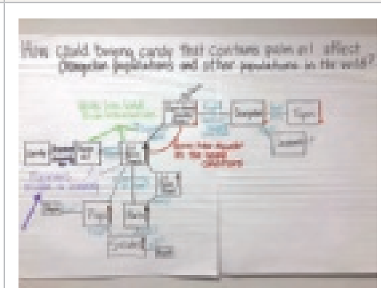
⇩ **Navigation to Next Lesson:** We figured out that when the number of oil palm trees goes up, the orangutan population goes down. We think this has something to do with orangutans not having enough food or habitat, or being killed when oil palm trees are planted. We wondered whether we could replace palm oil with something else in the products that we use.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 **1 day** **Can we replace palm oil with something else?** **Investigation**	 *Vegetable oils require land and produce different yields of oil.*	We explore other crops as a substitute for palm oil. We analyze data for soybean and canola oil and realize that palm oil requires much less land and produces way more oil than the other oils. We conclude that any oil would require clearing land for farming and that palm oil is very efficient, so it is probably not going away. This makes us wonder if there is somewhere else to grow oil palm, so we won't harm orangutans. We figure out: • Different kinds of oils that we consume in foods or products come from various ecosystems (via farms). • Native plants are removed to make space for farming. • Palm oil is more efficient than other oils because oil palms require less land to grow.	

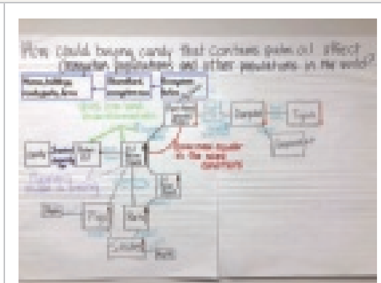
⇩ **Navigation to Next Lesson:** We figured out that oil palm trees are the most efficient oil plant to grow in terms of land use and that growing other oils takes up more land and also requires the clearing of native grasslands, which hurts grassland plants and animals. Since palm oil is likely not going away, we wonder if we can grow oil palm trees somewhere else so we're not cutting down tropical rainforests.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 3 **1 day** **Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?** **Investigation**	 *Oil palm grows best in equatorial regions because of the nonliving conditions suitable for plant growth, which is the same reason that tropical rainforests are found in these locations.*	We wonder if we can grow oil palm in other places. We obtain more information about the nonliving conditions that the oil palm plant needs to grow and examine maps that meet these conditions. We figure out that oil palm grows best in equatorial regions, which is also where tropical rainforests are located. We conclude that both kinds of plants share the same nonliving requirements and compete for the same space to grow. This makes us wonder how oil palm farmers and other farmers grow crops in places where they harm the ecosystem that was there first. We figure out: • Oil palm plants need a certain amount of sunlight, precipitation, and warm temperatures to grow. • Oil palm plants grow in the same locations as tropical rainforests (near the equator) because of these good growing conditions.	

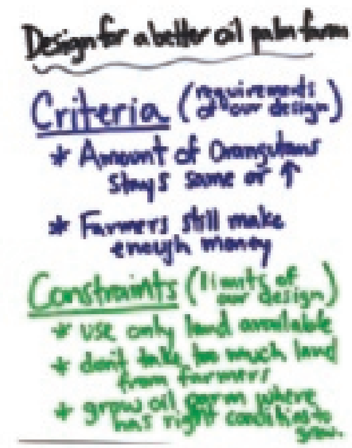
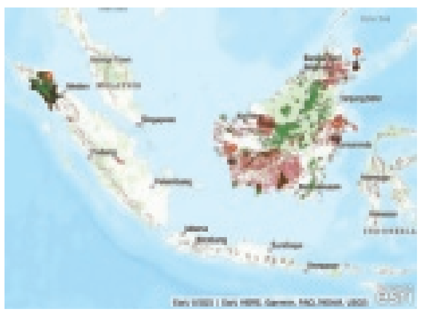
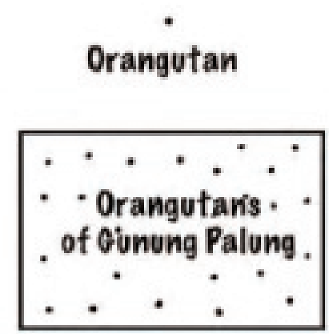
⇩ **Navigation to Next Lesson:** We figured out that palm oil grows best near the equator, where tropical rainforests are located. We wonder why people cut down tropical rainforests when they know this is bad.

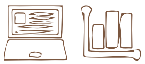
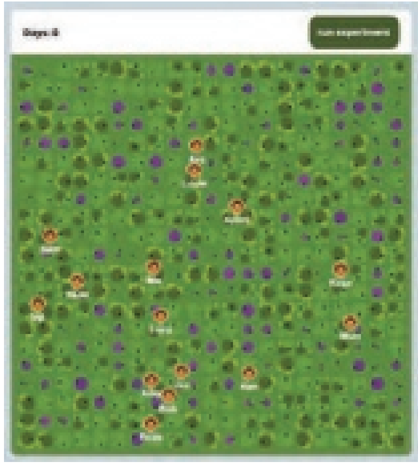
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 4 **1 day** **Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?** **Investigation**	 *Interviews with people who work to grow oil palms in developing countries reveal that this practice, though harmful to animals like orangutans, provides them with a way to make money to support themselves, their families, and their communities.*	We decide we need to learn more about the people who farm oil palms. We watch interviews with some of these farmers, and we learn that cutting down tropical rainforests to sell or grow resources is sometimes the only way for people in these areas to support themselves. We revisit our original problem with a new priority: We need to make sure that our solution allows all people to support themselves and their families. This makes us wonder if there are better ways for farmers to grow oil palms that could also save tropical rainforest animals. We figure out: • In many places in which oil palms are grown, people do not have a lot of opportunities to make money to support their families. • Cutting down tropical rainforests to sell or grow resources may be the only way for people in these areas to support themselves. • If we want a solution, we will have to make sure that these farmers can still support themselves and their families.	

⇩ **Navigation to Next Lesson:** We figured out that many farmers make a living off of farming and do not necessarily want to hurt animals. We wonder if people where we live have changed the land over time and how this might be impacting living things in our area.

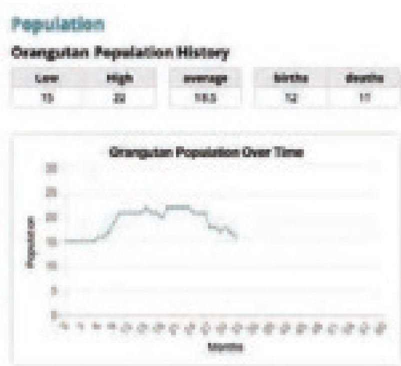
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 5 **2 days** **How have changes in our community affected what lives here?** **Investigation**	 *Some plants and animals seem to be doing OK, even with changes humans have made in our community, but others are missing altogether.*	We share our murals documenting changes in our own community since major human disturbance. We make outdoor observations of evidence of the plant and animal life around the school, along with observations about the changes humans have made to the land. We share what we notice and compare the changes in our own community to those in Indonesia. We modify our model, and then we add questions to the DQB about our local community. We figure out: • People in our community have changed natural habitats for their homes, buildings, roads, etc. • Some plants and animals are still around, despite the changes, but others have disappeared from the area.	

⇩ **Navigation to Next Lesson:** We figured out that changes in our own community also affect the living things. Given that human communities and agriculture are not going away and are still expanding, we wonder how humans can use the land in better ways that benefit both humans and other organisms.

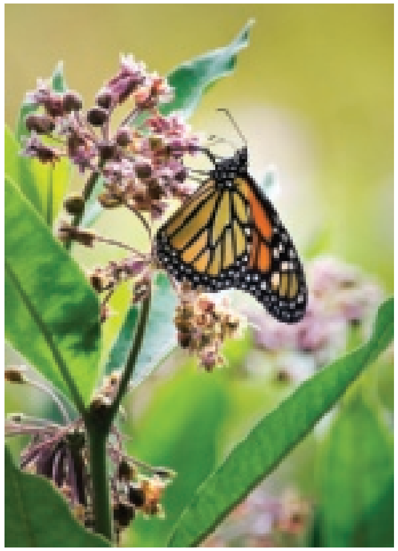
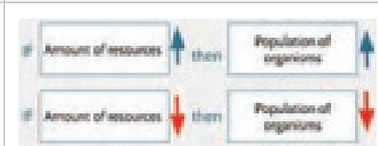
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 6 **1 day** **If palm oil is not going away, how can we design palm farms to support orangutans and farmers?** **Problematizing**	 *Palm farms that grow a single crop do not function well for tropical rainforest animals, leading to declines in these populations.*	We reflect on what we have figured out to define the problems associated with palm oil farms. We think about how we can design a better palm farm system that will support both the farmers and the orangutan and tiger populations. We use what we learn to coconstruct criteria and constraints to guide our design decisions. We revisit our Driving Question Board to add new questions that will help us design a system that is more stable and will help us refine our criteria and constraints. We figure out the following: • A better-designed palm farm needs to support living things in the tropical rainforest and farmers, too.	
Navigation to Next Lesson: We are motivated to design better systems, starting with a better palm farm. We want a palm farm in which orangutans can live, but we are not sure about what orangutans need to live and how many we can support in our new system.			
LESSON 7 **2 days** **How many orangutans typically live in the tropical rainforest?** **Investigation**	 *Orangutans at different times in 4 different protected areas show stable populations, with about 1-3 orangutans per 1 km^2.*	We examine a StoryMap that presents information about the number of orangutans in four protected areas with intact tropical rainforests. We notice that the number of orangutans in each area fluctuates some but is relatively steady. We notice that larger areas seem to have more orangutans. We calculate how many orangutans are in 1 km^2 for each park and realize that it is similar across parks, and only about 1-3 orangutans can live in 1 km^2. We figure out • populations of organisms are made up of many individuals living in the same area, and • individual organisms and populations of organisms are dependent on a certain amount of space.	
Navigation to Next Lesson: We figure out that only 1-3 orangutans can live in 1 km^2, which is a lot of space. We have some ideas about why and are wondering if it's because orangutans need a lot of space to find food. We consider what we would need in a simulation to test this food idea.			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 8 **2 days** **Why do orangutans need so much forest space?** **Investigation** 	 *Orangutans compete for food resources in three different environmental conditions.*	We gather data from a computer simulation in which individual orangutans compete with each other for food resources (fruit and termites). We run multiple trials of experiments to test three different environmental conditions with more or less rainforest fruit available (independent variable). After constructing class histograms using data from each trial, we examine how well individual orangutans and the orangutan population overall responded by analyzing averages and ranges of energy points for orangutans (dependent variables). We make claims about food resources and competition between individuals within the population. We figure out: • Orangutans in the same population compete with each other for food. • Orangutans like food sources that give them more energy, but can eat things with less energy to survive. • Competition between individual orangutans within a population increases when the availability of resources is limited. • If orangutans do not get enough energy from food resources, it may constrain their growth or limit their potential for survival.	

⇩ **Navigation to Next Lesson:** We figured out that orangutans eat mostly fruits because they get energy from these food sources. They compete with other orangutans for this food, and slight changes in the amount of fruit can have large impacts on orangutan competition and survival. We wonder if all we need is more fruit trees to have a healthy orangutan population.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 **2 days** **Would planting more rainforest fruit trees help the orangutan population increase?** **Investigation**	 *Orangutan population sizes increase when resources are plentiful and decrease when resources are limited.*	We conduct experiments in a simulation, manipulating the amount of food resources (independent variable) over time to observe how orangutan population sizes increase or decrease (dependent variable). We figure out: • It's normal for population sizes to increase and decrease (i.e., fluctuate). • If there are a lot of resources available, population sizes go up. If the resources are limited, population sizes go down. • When there aren't enough resources, orangutans have to compete for them, and some orangutans don't get what they need to survive. • When an orangutan gets enough resources, it survives and reproduces. • If an orangutan can't get what it needs, it may not reproduce. Over the years, this means the population goes down and not enough are born to keep the population stable. • Minor disruptions in resource availability may lead to small fluctuations in population sizes, while major disruptions in resource availability may cause populations to increase or decrease drastically in number. • Running multiple trials on an experiment can provide more data to get more certainty about the conclusions being drawn.	

⇩ **Navigation to Next Lesson:** We figured out that when there are more or fewer food resources available, it affects the orangutans' population size. We think we can plant more food resources in the oil palm farms to support a healthy population. We are wondering if our model can explain how other populations change over time.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 10 **2 days** **How do changes in the amount of resources affect populations?** **Putting Pieces Together**	 *The loss of short and tallgrass prairies to soybean oil production in the Midwest of the United States has caused declines in local monarch butterfly populations.*	We analyze other cases where populations changed due to a change in available resources. Across these cases, we see a pattern that connects the population of an organism to the availability of resources that organism needs. Afterward, we apply these understandings to an assessment in which we explain why the loss of short and tallgrass prairies has caused monarch butterfly populations to decrease. We figure out the following: • Organisms depend on specific resources to survive and reproduce. • An organism's population size depends on the amount of resources available. When resources decrease significantly, the population also decreases. When resources increase, the population increases. • It is normal for populations to fluctuate depending on resource availability from year to year. Drastic changes to resource availability can cause unusual and unstable changes to populations.	

⇩ **Navigation to Next Lesson:** We feel like we understand how the population of orangutans changes when more oil palms are planted in place of rainforest trees. We are curious if a change in resources also explains what we observed with other populations like tigers, rats, snakes, and pigs.

<table>
<tr><th>Lesson Question</th><th>Phenomena or Design Problem</th><th>What we do and figure out</th><th>How we represent it</th></tr>
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LESSON 11

2 days

How does planting oil palm affect other populations?

Investigation

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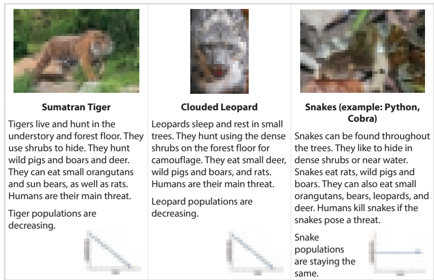
Predators of the Tropical Rainforest



Sumatran Tiger
Tigers live and hunt in the understory and forest floor. They use shrubs to hide. They hunt wild pigs and boars and deer. They can eat small orangutans and sun bears, as well as rats. Humans are their main threat.
Tiger populations are decreasing.

Clouded Leopard
Leopards sleep and rest in small trees. They hunt using the dense shrubs on the forest floor for camouflage. They eat small deer, wild pigs and boars, and rats. Humans are their main threat.
Leopard populations are decreasing.

Snakes (example: Python, Cobra)
Snakes can be found throughout the trees. They like to hide in dense shrubs or near water. Snakes eat rats, wild pigs and boars. They can also eat small orangutans, bears, leopards, and deer. Humans kill snakes if the snakes pose a threat.
Snake populations are staying the same.

Rat and snake populations are exploding in the oil palm system, but those populations are not exploding in the rainforest system.

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We are curious about other populations affected by the palm oil industry. We develop system models for the oil palm system and realize that when there are unlimited resources, both predators and prey do well. We develop system models for the tropical rainforest and realize there is more competition within this system to keep populations at a stable size. We decide that the rainforest system has more components and interactions than the oil palm system. We figure out:

- When there are many resources both snakes (predators) and rats (prey) do well.
- When there is competition between populations for the same resource, it keeps numbers from increasing too much.
- The tropical rainforest is a lot more complex than the palm farm, with a lot more plants and animals interacting with each other.
- Populations interact for more than just resources (like shelter and safety).
- If one population (like orangutans) were to go extinct, then it could cause changes to other populations because everything is connected.

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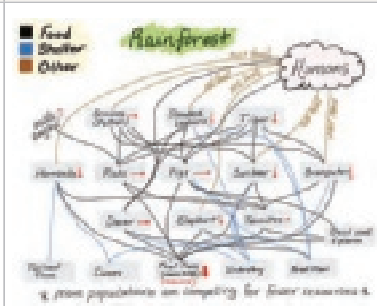

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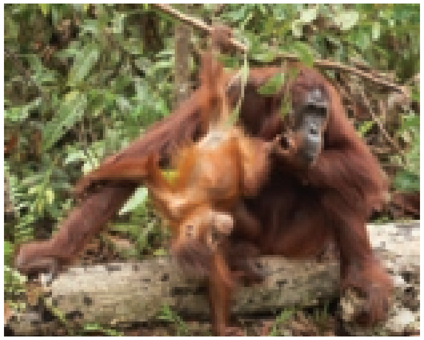
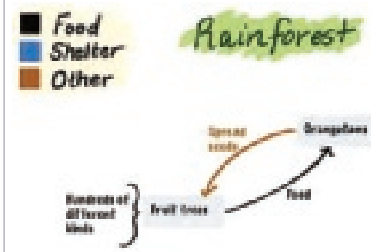
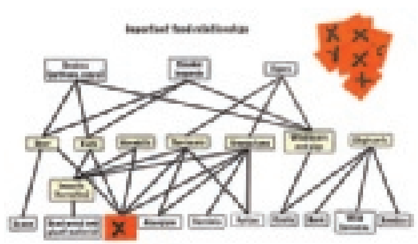
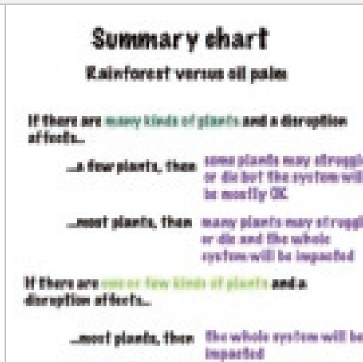
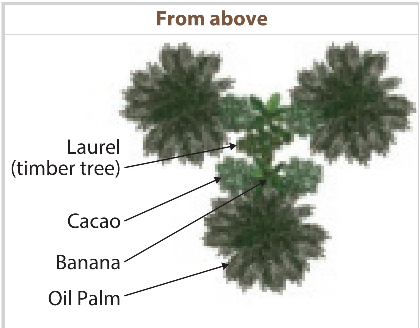
⇩ **Navigation to Next Lesson:** We figured out that the rainforest system has more components and interactions compared with the oil palm system. We think this is why the tropical rainforest supports so many living things. We are wondering how to make the oil palm farm have more components and interactions, like the tropical rainforest, so that it can support more animal populations.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 12 **1 day** **What would happen if orangutans go extinct?** **Investigation**	 *Many seeds from fruit trees are found in spit and fecal samples of orangutans. These seeds germinate better compared to control seeds.*	We are curious about what would happen if orangutans went extinct. We read an interview with Andrea Blackburn, who studies orangutans. We watch videos, examine images, and make noticings from data tables from her research. We support tentative claims with the data, and identify additional questions and data that would help clarify those claims. We figure out: • Orangutans disperse seeds throughout the tropical rainforest by spitting and defecating. • Both orangutans and fruit trees benefit from each other because orangutans get food from fruit trees and fruit trees get their seeds spread throughout the tropical rainforest. • If orangutans go extinct, some fruit tree populations may decrease, because seeds may not get spread and grow into trees, which could affect other populations.	

⇩ **Navigation to Next Lesson:** We figure out that fruit tree populations depend on orangutans to disperse seeds. If orangutans go extinct, there could be several effects throughout the tropical rainforest. We wonder if something were to happen to other populations, what kinds of changes we would see.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 13 **2 days** **How does an ecosystem change when the plants change?** **Putting Pieces Together**	 *Disruptions, like drought, fire, disease, or loss of a seed disperser, cause shifts in populations in an ecosystem.*	We use an updated system model to make predictions and test ideas about different kinds of disruptions to the rainforest and oil palm systems. We figure out that the rainforest system can withstand some disruptions due to its interconnectedness, but the oil palm system cannot. We apply ideas to a new case and complete a short individual assessment. We summarize what we know about monocrop oil palm farming to motivate us to design a better way to farm it. We figure out: • There are more populations and more connections in the rainforest system compared to the oil palm system. • Any change to the ecosystem, or disruption, will affect some populations. Some disruptions affect many populations. • If an ecosystem has many connections between populations, the ecosystem has a better chance of being OK when a change happens. • A disruption in a monocrop system will impact all the populations in the system.	

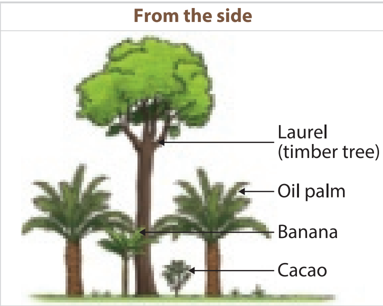
⇩ **Navigation to Next Lesson:** We figure out that biodiverse ecosystems can withstand some disruption, but oil palm farms cannot because everything relies on the oil palm. We wonder if there are better ways to farm for both people and other living things.

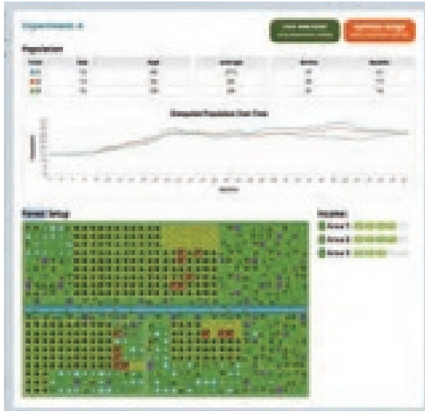
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 **1 day** **Are there ways people can grow food without harming the tropical rainforest?** **Investigation**	 *Farmers and other community members in Indonesia and Costa Rica observe positive impacts on plant and animal populations when growing food using different approaches from large-scale monocrop farms.*	We wonder how people cultivate food without harming living things. We read about one of the following approaches: (1) diversified farming, where farmers grow multiple crops together; (2) sustainable oil palm, where farmers don't clear forest and include wildlife habitat on the farm; and (3) Customary Forests, where people cultivate and harvest plants from intact forests. We figure out: • There are multiple ways communities grow food while also helping populations in ecosystems. • There are multiple ways communities grow food while also helping populations in ecosystems. • Diversified farming involves growing multiple crops together. • Sustainable oil palm farms do not clear forested areas and incorporate wildlife habitat on their farms. • Villages with Customary Forest permits cultivate and harvest food, medicine, and craft plants from within the forest that they can use and sell.	

⇩ **Navigation to Next Lesson:** We figured out that there are approaches people use to grow food that seem to not harm living things. We wonder if and how people benefit from each of these approaches.

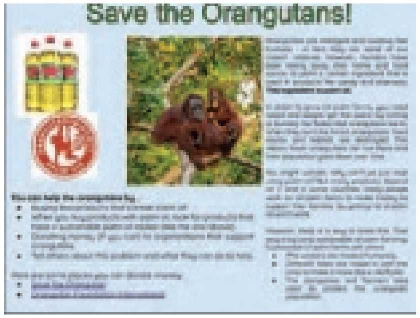
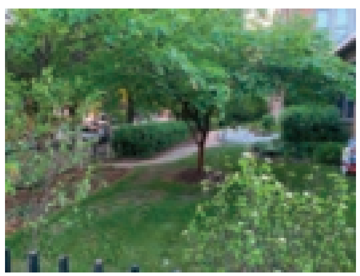
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 15 **1 day** **How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?** **Investigation**	 *Farmers gain ecosystem services (food, water, soil health, protection from crop disease, and the like) when they grow food differently from large-scale monocrop farming.*	We wonder how people can benefit from growing food in ways that help plants and animals. We view StoryMaps that include people's perspectives about (1) diversified farming where farmers grow different crops together; (2) sustainable oil palm and prairie strips where farmers do not expand their farms and include wildlife habitat on their farms; and (3) Customary Forests where people cultivate and harvest plants from existing tropical rainforest. We figure out these things: • Diversified farming like intercropping helps farmers have stable incomes if diseases, pests, or storms hurt one crop, but not the other(s). • Sustainable oil palm farms maintain healthy soils that help improve harvests, which means more income for farmers. • Customary Forests provide people with stable food, water, and materials and protection from landslides.	

⇩ **Navigation to Next Lesson:** We figured out that people can also benefit from approaches to grow food that differ from monocropping. We wonder which approach works best for people, plants, and animals in a natural ecosystem.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 16 **2 days** **What approach to growing food works for everyone and why?** **Putting Pieces Together**	 *People can use many approaches to growing food, and there are trade-offs to using them that have consequences for plants, animals, and humans in nearby ecosystems.*	We summarize what we know about monocropped farms. We jigsaw to synthesize information about different approaches to growing food. We rank how the approaches work for plants and animals and people. We discuss the trade-offs between each approach and clarify claims about which approach we think will work best. We brainstorm how to test our claims in a simulation. We figure out: • There are trade-offs in how we approach growing our food; some approaches work better for humans than for animals and plants in the natural ecosystem. • Some approaches to growing food work for some people and farmers, but not all people. • We can grow food in ways that minimize the effects of disruptions on natural and designed systems.	 Name: Date: Best Approaches to Growing Food for Animals, Plants, and People Approach to Growing Food / Animals and Plants / People Diversified farming and intercropping Sustainable oil palm and prairie strips Customary forests Monocropped farms
Navigation to Next Lesson: We figured out that there are some approaches to growing food that will work better for plants and animals, and other approaches work better for humans. We want to test our ideas in a simulation by designing a farm for both orangutans and people.			
LESSON 17 **3 days** **How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?** **Investigation**	 *Students redesign and optimize the way land is used to support orangutans and people.*	Working in groups of three, students use a computer simulation to redesign the way land is used in Indonesia to support orangutans and people at the same time. Students evaluate design solutions created by other groups and optimize their own design solutions. We figure out: • Some potential design solutions work well for the people and the orangutans but are not realistic due to land-use changes and time. • Using a variety of different ways to grow food can maintain or increase orangutan populations and people's income. • People can reasonably set aside a portion of their land to support orangutan populations without reducing their income. • Neighboring farms can coordinate their approaches to increase space for orangutans. • Rainforest corridors connecting intact areas of forest increase orangutan populations.	
Navigation to Next Lesson: We figured out that we can diversify oil palm farms and set aside areas of rainforest trees to improve orangutan populations and to support people. We optimized our design solutions, and we are ready to share them with our class to try to identify the best solution.			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 18 **3 days** **How do our designs work for orangutans and people in Indonesia?** **Putting Pieces Together**	 *The design solutions with mixed land use and some intact forests worked best for people and orangutans.*	We present our best designs to our peers and evaluate each other's designs based on the agreedupon criteria and constraints. We consider how well each design would work in the real world and trade-offs made in the design process. We argue for which designs work best for people, orangutans, and both, and make claims about why they work well. We figure out: • Design solutions that retained tropical rainforests and Customary Forests supported the largest orangutan populations. • Customary Forests provided income for people but were not realistic for large-scale farms. • Design solutions with more palm farms and crops provided income but did not increase orangutan populations. • Mixed land-use designs overall seemed best for people and orangutans. • Science learning is about asking questions and gathering evidence to answer those questions. • Science can help solve complex problems, but it's not the only thing to consider.	

⇩ **Navigation to Next Lesson:** We end the unit by returning to the DQB and celebrating our learning on graffiti boards, or we navigate to one of two extension opportunities.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 19 **5 days** **How can we inform others in our community about the palm oil problem and convince them to take action?** **Putting Pieces Together**	 *Public service announcements (PSAs) inform people and communities about issues like the palm oil problem and encourage them to take actions to help preserve natural systems.*	We have figured out that the problem will require large-scale solutions combined with individual action. We create public service announcements (PSAs) to inform stakeholders in our community about the palm oil problem and how they can act to address this problem. We present our PSAs to our peers, teachers, and/or stakeholders and receive feedback on our approach. We figure out: • People and communities can take small and large actions that aid the preservation of natural systems like the tropical rainforest. • Small actions, like changes in people's habits and behaviors, when combined with others' actions or extended over time, can have a large impact on the preservation of natural systems. • Some actions are more feasible for communities or individuals to implement, while others are more challenging.	
⇩ **Navigation to Next Lesson:** We figured out how to craft PSAs to communicate key messages about addressing the palm oil problem to stakeholder groups. We are now ready to look back at our DQB and celebrate what we have accomplished.			
LESSON 20 **5 days** **What should we do to take care of our local land, plants, and animals?** **Investigation**	 *A local population is declining (Pathway A) or we notice interesting patterns about the way our community is currently caring for the land (Pathway B).*	We are introduced to a local phenomenon, either a declining local population (Pathway A) or a way our community is currently caring for the land (Pathway B). We investigate this phenomenon through readings, videos, and/or learning with community members. We are introduced to one action we can take or multiple actions we could consider taking. We take action in our community in service of addressing a challenge with this local phenomenon, such as habitat restoration, monitoring biodiversity, or communicating with stakeholders about the issues. We figure out: • We apply many ideas that we figured out (during our examination of the palm oil problem and orangutans) to populations and lands in our local communities.	
LESSONS 1-20 **43 days total**			

TEACHER BACKGROUND KNOWLEDGE

Lab Safety Requirements for Science Investigations

It is important to adopt and follow appropriate safety practices within the context of hands-on investigations and demonstration, whether this is in a traditional science laboratory or in the field. In this way, teachers need to be aware of any school or district safety policies, legal safety standards, and better professional practices that are applicable to hands-on science activities being undertaken.

Science safety practices in laboratories or classrooms require engineering controls and personal protective equipment (e.g., wearing safety goggles, non-latex aprons and gloves, and making available an eyewash/shower station, fume hood, and fire extinguishers). Science investigations should always be directly supervised by qualified adults and safety procedures should be reviewed annually prior to initiating any hands-on activities or demonstrations. Prior to each investigation, students should also be reminded specifically of the safety procedures that need to be followed. Each of the lessons within the units includes any applicable teacher safety procedure guidelines for setting up and running an investigation, as well as a procedure for taking down, disposing of, and storing materials.

Prior to the first science investigation of the year, a safety acknowledgement form for students and parents or guardians should be provided and signed. You can access a model safety acknowledgement form for middle school activities (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

Disclaimer: The safety precautions of each activity are based in part on use of the specifically recommended materials and instructions, legal safety standards, and better professional safety practices. Be aware that the selection of alternative materials or procedures for these activities may jeopardize the level of safety and therefore is at the user's own risk.

Please follow these lab safety recommendations for any lesson with an investigation:

1. Wear safety goggles (specifically, indirectly vented chemical splash goggles), a non-latex apron, and non-latex gloves during the set up, investigation, and take-down segments of the activity.
2. Immediately wipe up any spilled water and/or granules on the floor, as these are slip and fall hazards.
3. Follow your *Teacher Guide* for instructions on the safe disposal of waste materials and/or storage of materials.
4. Secure loose clothing, remove loose jewelry, wear closed-toe shoes, and tie back long hair.
5. Wash your hands with soap and water immediately after completing this activity.
6. Never eat any food items used in a lab activity.
7. Never taste any substance or chemical in the lab.

Specific safety precautions are called out within each lesson using this icon and a callout box.

What is the anchoring phenomenon and why was it chosen?

The anchoring phenomenon, or problem, for the unit is the decline of orangutan populations in Indonesia that is linked to the use of palm oil in food and household products we use everyday. Students encounter this problem through videos, short readings, and headlines. Over the course of 3 class periods they develop an initial understanding that the ingredient palm oil is produced on oil palm plantations in Indonesia, where tropical rainforests are cleared to make space for the plantations. The palm oil problem is a global one, but also connects well to individual consumer choices. The root of this problem is not the palm oil itself, but rather the tension that occurs between large-scale industrial agriculture and the biodiversity that humans want to maintain and protect in ecosystems. This problem provides a rich context in which to investigate population dynamics, biodiversity, resilience, and human impacts in the context of natural and designed systems. The problem also represents a real-world system that farmers, scientists, community members, governments, and consumers are part of, and a context for thinking about how people can design better systems that work for humans and other living things.

The palm oil problem was chosen for this unit after reviewing interest survey results from middle school students, consulting with several external advisory panels, and piloting in middle school classrooms. It was chosen for the following reasons:

- The palm oil problem provides a rich context for students to engage with all the Disciplinary Core Ideas (DCIs) that are bundled with the Performance Expectations of the unit, and to do so in compelling ways.
- Agricultural practices and biodiversity are not always at odds with each other, but there is a real tension between the monocrop farming methods

today and maintaining biodiverse systems. This tension sets students up for authentic problem-solving and design tasks, keeping in mind different perspectives on the issue and different possible solutions.

- Protecting the rainforest and the orangutan is a natural inclination for young people. Beginning with a charismatic system and species opens the door for students to notice examples in their own communities in which humans have altered the land in ways that work for people and not other living things. The underlying mechanisms to explain the palm oil problem are broadly applicable to many contexts, including our own backyards and schoolyards.
- The palm oil problem sets the stage for designing and evaluating solutions from different perspectives, including farmers who want to maximize profits and protect important ecosystem services they rely upon, and the orangutans who need to meet their needs for growth and reproduction to maintain their population.

What are the NGSS Dimensions developed in this context?

This unit is guided by two big ideas to help us explain how ecosystems function: (1) When a component of an ecosystem (e.g., population or abiotic factor) changes, there are changes to the whole ecosystem because of the interactions between components and (2) when an ecosystem has more components and more interactions between components, the ecosystem is more resilient to disruption. In this unit, students will develop, refine, and apply models to explain how one population, orangutans, are threatened by an increasing number of oil palm farms in Indonesia. Across the unit, students encounter several analogous examples to orangutans and palm oil, such as the monarch butterfly and soybean farms. These examples include ones in which people manage land, particularly for agriculture, but also land changed for other uses. Students work toward a final model that explains why orangutans, who have important interactions in a rainforest system, are struggling to survive as humans change the land to a monoculture farm system. Students apply what they have learned to redesign land in Indonesia to support both people and orangutans.

The bundle of Performance Expectations in this unit is substantial. With 6 Performance Expectations across 20 lessons, and 38 class periods, students will engage with a wide range of DCIs, SEPs, and CCCs during this unit. Notable features of this unit include:

- An engineering focus on designing a system, which is new and different from previous units. The engineering component is situated in a complex problem that takes students several lessons to define.
- Students engage in planning and carrying out investigations using computer simulations that model real-world scenarios.
- You and your students have a choice about how to end the unit, with options to raise awareness about the problem or apply science ideas to a local problem in their community.

This unit builds toward these performance expectations:
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Focal DCIs	Focal Science and Engineering Practices	Focal Crosscutting Concepts
LS2.A: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with non-living factors. Students investigate how organisms (see Lessons 8) and populations of organisms (Lessons 7, 9-12) depend on interactions with other populations particularly as they search for food resources. Students focus on plant interactions with non-living factors in Lesson 3. **LS2.A: 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.** Students investigate competition between orangutans in a simulation in Lesson 8 and circle back to competition in Lesson 13. **LS2.A: Growth of organisms and population increases are limited by access to resources.** Students build these ideas through simulations and additional case studies across Lessons 8-11.	**Asking Questions and Defining Problems:** This unit is anchored by a complex socioscientific issue. Students' initial questions on the DQB lead them to investigate simple fixes to a complex problem. The first lesson set serves to complicate the problem for them, culminating in defining it more clearly later in Lesson 6. Students define a design problem that can be solved through the development of a *system*, but a designed system that is limited by both scientific and social factors. **Developing and Using Models:** Students develop new understandings about how to use a computer model to generate data to test ideas about population dynamics in the rainforest and farm designs. They evaluate the limitations of the computer model in comparison to the complex real-world systems the model is representing.	**Cause and Effect:** Cause and effect is a lens students apply throughout the unit, focusing on establishing cause and effect relationships in order to predict phenomena. Students use cause and effect in the context of natural systems and in their designs land-use systems. **System and System Models:** Students develop system models to allow them to understand the different components and interactions occurring within the system. They discuss limitations of their system models for representing the complexity of the real-world systems (e.g., simulations representing limited components and interactions).

Focal DCIs	Focal Science and Engineering Practices	Focal Crosscutting Concepts
LS2.A: Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and non-living, are shared. Students model different interactions in the rainforest and oil palm systems, including predation, competition, and mutualism between orangutans and fruit tree populations (see Lessons 11-13). **LS2.C: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.** Students model different disruption scenarios and predict how those disruptions would shift populations. Students hear from farmers about the strategies they employ to protect themselves from disruptions (see Lessons 13, 15, 16). **LS2.C: Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems.** The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. Students compare rainforest systems to oil palm systems in terms of the biodiversity found in each system (see Lesson 13). Students learn that farmers are interested in supporting biodiversity in Lesson 14. **LS4.D: Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.** Students figure out that people engage with different ways to grow food compared to monocrop in order to obtain different benefits, or services (see Lessons 15-16).	**Planning and Carrying Out Investigations:** Students engage in planning and carrying out investigations with independent and control variables in a computer simulation. They use the simulation in the unit as a way to collect data and produce data about design solutions and proposed systems under a range of conditions. **Mathematics and Computation Thinking:** Students calculate ratios of orangutans to land area to understand population density. They characterize and use graphical representations of populations over time to draw conclusions about resource availability and farm designs. The lesson 10 assessment on Monarch butterflies allows for assessment of this practice. **Constructing Explanations and Designing Solutions:** Students apply science ideas to construct explanations for how approaches to agriculture work to support orangutans and people. Students apply science ideas to design land-use systems, and optimize these systems to both support orangutans and be financially viable for people. Students consider the benefits and trade-offs of different designs for stakeholders. **Engaging in Argument from Evidence:** Students make and support claims throughout lesson sets 3 and 4. Students construct arguments in order to recommend strategies for land use. The arguments have no clear "right" answer for people in the system.	**Stability and Change:** Stability and change is a consistent lens students apply throughout the unit as they make sense of small changes in the system that have large impacts, as well as sudden and gradual changes over time. They look to stabilize orangutan populations and farmers income in their final designs. The unit also includes opportunities to apply: • Patterns • Scale, Proportion, & Quantity There are no specific opportunities to apply: • Energy and Matter • Structure and Function. Note: Structure and Function could be added as a lens for considering different approaches to growing food and how those approaches result in increased biodiversity, resilience to disruptions, and ecosystem services. This would need to be added to Lessons 14-18.

Focal DCIs	Focal Science and Engineering Practices	Focal Crosscutting Concepts
ESS3.C: Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Students focus on understanding the problem, which involves humans altering the biosphere in ways that negatively impact orangutans (Lessons 2-4) and alterations in their own communities (Lessons 5). Students also encounter ways humans farm for food that positively support biodiversity in Lesson 14. **ETS1.A: The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.** Students use criteria and constraints, based on the science and engineering ideas developed in the unit, with a particular attention to what land-use strategies work for different stakeholders and the limits of their application. Students make their first pass at criteria and constraints in Lesson 6 and revisit them to make them more precise in Lesson 17. Students evaluate design based on criteria and constraints in Lesson 18.	The following practices are used by students throughout the unit, but no new elements are being developed explicitly: • Analyzing and Interpreting Data • Obtaining, Evaluating, and Communicating Information Note: Lessons 19 and 20 provide substantial learning experiences for students to engage with Obtaining, Evaluating, and Communicating Information if the extension opportunities are selected.	

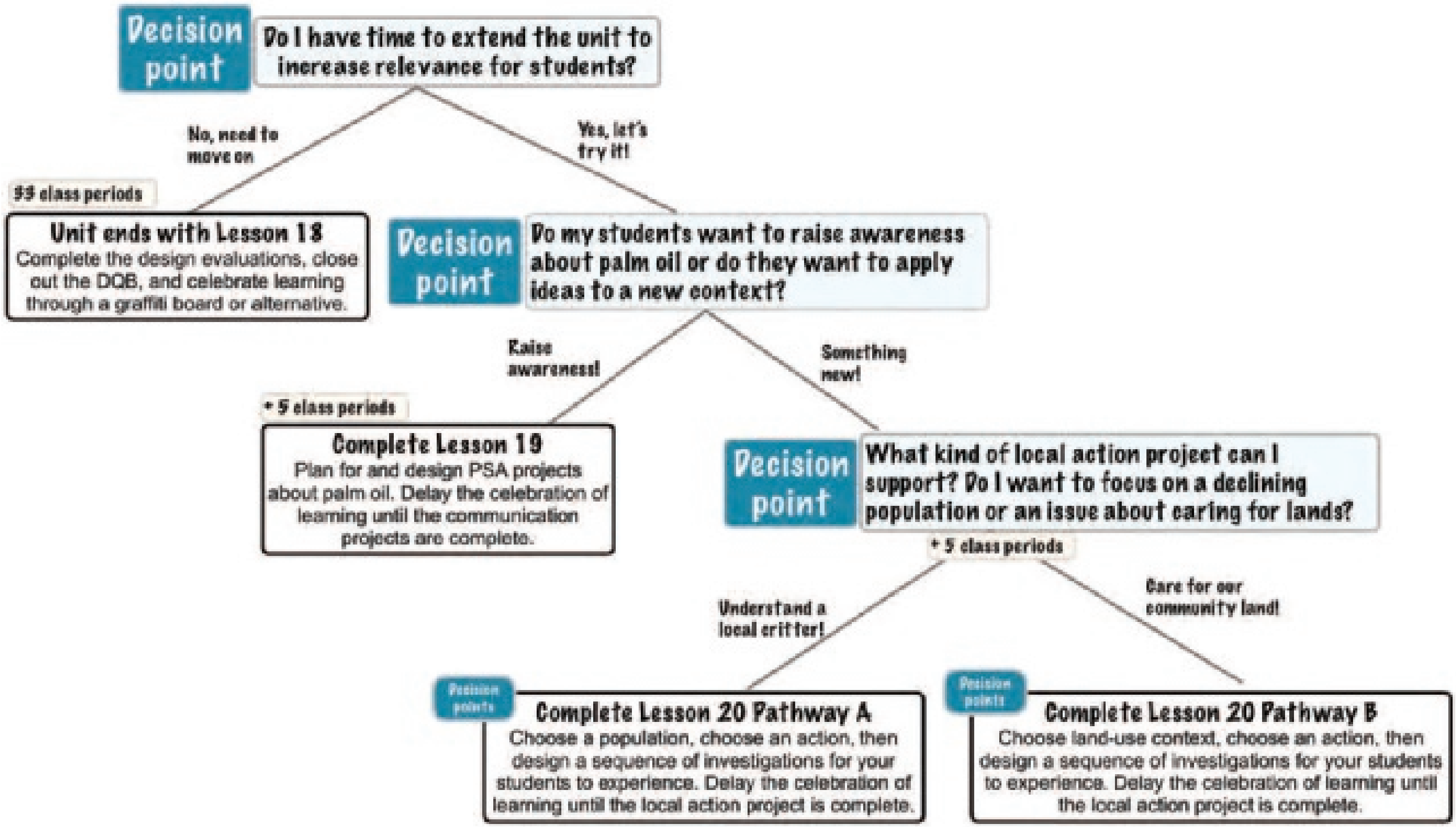
How is the unit structured?

The unit is organized into four lesson sets.

- Lesson set 1 consists of Lessons 1-5. The focus of this lesson set is to investigate a good portion of our initial questions that are rooted in "simple" fixes to the problem (e.g., Can we use something else? Can we grow it somewhere else?). We end this lesson set with a realization that the problem is more complicated than it initially appears.
- Lesson set 2 consists of Lessons 6-10. The focus of this lesson set is to define the problem and criteria and constraints for solutions, one of which is to maintain orangutan populations. This motivates a series of lessons to explore the connection between resource availability and population size.
- Lesson set 3 consists of Lessons 11-13. This short lesson set picks up with resource availability but in the context of systems, namely the rainforest system and oil palm system. Students consider how disruptions to key resources in these systems (i.e., fruit trees, oil palm) impact other populations in the system and develop ideas about biodiversity, disruptions, and monocrop agriculture.
- Lesson set 4 consists of Lessons 14-20. In this lesson set students investigate better ways to grow food that support both farmers and other living things. They apply these idea to design and evaluate palm oil farm designs. Lessons 19-20 are two pathways to extend the unit to communicate about the problem to one's community (Lessons 19) or to apply ideas to a local problem (Lesson 20).

Driving question: How does changing an ecosystem affect what lives there?

The core of this unit is Lessons 1-18, which requires 33 instructional class periods. There are two options to extend students' learning beyond Lesson 18. You will need to make decisions based on your students' interests and the instructional time you have available. The flow chart below shows the opportunities available to you and the decision points you have beginning in Lesson 18 onward.



Where does this unit fall within the Scope and Sequence?

This unit is designed to be taught after *Unit 7.4: Where does food come from, and where does it go next? (Maple Syrup Unit)* in the Scope and Sequence. As such, it can leverage ideas about food webs, producers, consumers, and interactions between these organisms in an ecosystem. Other prior engineering design focused units, such as *Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)*, *Unit 6.5: Where do natural hazards happen and how do we prepare for them? (Tsunami Unit)*, and *Unit 7.2: How can we use chemical reactions to design a solution to a problem? (Homemade Heater Unit)*, will allow students to leverage what they know about criteria, constraints, iterative design cycles, stakeholders, and optimizing designs.

This unit is designed to be taught prior to *Unit 7.6: How do changes in Earth's system impact our communities and what can we do about it? (Droughts and Floods Unit)*, which focuses on natural water resources, changing precipitation and climate, and human impacts. The two units together share Performance Expectation MS-ESS3-3 and its corresponding DCIs (ESS3.C Human Impacts on Earth Systems). There are no modifications to make to this unit but an awareness that the *Palm Oil Unit* and *Droughts and Floods Unit* are closely connected is important.

What additional ideas will my students have or know from earlier grades or units?

Population thinking. Students will be familiar with thinking about how individual organisms act in their ecosystem to meet their needs for food, water, and shelter. A new idea that students build in middle-school science is population thinking, moving beyond thinking about individual organisms or small groups of organisms to populations over a larger land area and over time. Students may still view organisms represented in a food web as an individual actor. This unit will help students start to view these organisms as representing populations and not individual organisms.

Interactions in an ecosystem. Students will bring prior ideas about food chains and food webs to this unit from the *Maple Syrup Unit* and previous elementary science learning. This prior knowledge could include consumers-producers and predator-prey relationships from 5th grade. Students will readily identify producers and consumers, particularly if they have completed the *Maple Syrup Unit*. From the 5th grade units, they should be able to identify predators as consumers that eat other animals. Students will be limited to thinking about individual organisms involved in these relationships (e.g., deer eats grass, wolf eats deer). The transition students make in this unit is toward interactions between populations and how changes in those populations impact other populations depending on their interactions. Interactions are important because they represent relationships that are not necessarily one way. Students may bring the idea that the connections between populations go in one direction, often from food source to food consumer. This uni-directional thinking makes sense when tracing matter or energy through an ecosystem but is not as helpful when thinking about relationships between populations. In this unit, students layer on additional kinds of interactions beyond feeding relationships (e.g., for shelter and protection), and consider mutually beneficial relationships between orangutans and the fruit tree population (e.g., seed propagation).

Changes to ecosystem components. It is expected that students' initial explanations to how populations respond to changes in their ecosystem involve animals finding new food sources or finding new homes by "migrating" to another place. This makes sense for human populations (among a few others) who have been able to live in a wide variety of environmental conditions and change food sources if one type of food becomes scarce. For this reason, students may not realize that many organisms are so interconnected with their system and adapted to the environmental conditions of the ecosystem in which they live that moving to new locations or changing food sources is not an option. This unit will deepen students' understanding of how changes to food sources affect the survival of organisms in the short term, therefore, population size over the long term.

Competition for resources. Students will bring an understanding that animals compete for resources, but they might not have thought about within population competition (e.g., between orangutans) or between population competition (e.g., orangutans and hornbills). This unit will expand students' understanding of competition for resources to systems in which resources are virtually unlimited and predator and prey populations can increase simultaneously. Students will also encounter disruptions to resources (e.g., fruit trees, crops) and predict impacts on other populations in the system and the system as a whole.

Engineering design. Students will know about criteria and constraints from elementary science and previous units (the *Cup Design Unit*, *Tsunami Unit*, and *Homemade Heater Unit*). This unit, particularly Lesson 6 assumes students will have a background understanding of criteria and constraints for design challenges.

Planning investigations. Students will know about independent and dependent variables from elementary science and previous units (e.g., (the

Cup Design Unit, *Storms Unit*, *Tsunami Unit*, and *Homemade Heater Unit*, among other units). Lesson 8 assumes students have this previous knowledge and we extend their understanding of these concepts as we apply them to testing investigations using a computer model.

How will I need to modify the unit if taught out of sequence?

This is the fifth unit in 7th grade in the Scope and Sequence. Given this placement, several modifications would need to be made if teaching this unit earlier or later in the middle-school curriculum. These include:

- If taught before the *Unit 7.1: How can we make something new that was not there before? (Bath Bombs Unit)* or at the start of the school year, supplemental teaching of classroom norms, setting up the Driving Question Board, and asking open-ended and testable questions would need to be added. (These supports are built into the *Bath Bombs Unit*)
- If taught before the *Maple Syrup Unit*, supplemental teaching of matter cycling between organisms and food webs would be required. In particular, students having experienced the *Maple Syrup Unit* will want to immediately investigate the ingredients in candy during the anchor lesson because students traced many ingredients back to plants in that unit. This may not be the case for students who have not experienced the *Maple Syrup Unit*, so the motivation to look at candy ingredients on day 1 of Lesson 1 may need additional support from you. The unit also relies on students having a recent learning experience around producers and consumers and the interconnection between the two in a food chain. This is particularly important for Lessons 11-13. Food webs are taught in 5th grade and students can work from this level of understanding, if needed. Lastly, Lesson 3 expects that students can readily identify the conditions that plants need to grow. The lesson has students briefly articulate these conditions so that students use most of the instructional time to identify growing conditions for oil palm plants. Additional time may need to be spent in this lesson if students have not learned about plant growth (MS-LS1-6).
- This unit is highly dependent on 6th-grade math concepts. If this unit is taught in 6th grade, it is suggested to work very closely with a 6th grade math teacher to understand when students will learn the mathematical concepts and process (listed below) so that this unit can reinforce those concepts in a real-world problem context but not come before students have developed these ideas in their math classes (or working in conjunction with math and science simultaneously).

How do I shorten or condense the unit if needed? How can I extend the unit if needed?

The following are example options to shorten or condense parts of the unit without eliminating important sensemaking for students:

- **Lesson 5:** If your students live in communities in which it is safe to make observations outdoors, you can shift some of the in-class observations to a home learning activity.
- **Lesson 19 and 20:** End the unit at Lesson 18. This will satisfy most students' understanding of the palm oil problem and close out the Driving Question Board. This decision will eliminate 5 class periods. Lessons 19 and 20 are intended to offer meaningful, community-based application of learning for students.

The following are example options to extend parts of the unit to deepen students' understanding of science ideas in the context of complex socioscientific issues:

- **Lesson 1:** An extension opportunity is offered to support your students in better understanding plantation systems over time compared to farms, with a particular look at labor practices and the enslavement of people.
- **Lesson 3:** An extension opportunity is offered to explore the financial costs of design and building greenhouses to grow oil palm. This extension allows you to engage your students in understanding limitations of designs, as well as using mathematics and computational thinking to solve problems.
- **Lesson 10:** The case studies provided in this moment allow you to step outside of orangutans to apply science ideas to a new context. Use this opportunity to extend science ideas to a local case.
- **Lesson 12**: An extension opportunity is suggested to support students in exploring local cases of seed dispersal.
- **Lesson 13**: An home learning assignment can be turned into a community photo-documentation activity for students to document examples of biodiverse plant communities and monocrop plant communities in their everyday lives.
- **Lessons 19 and 20**: These lessons offer two pathways to extend student learning through rich and substantial projects. Lesson 19 supports a communication project focused on communicating about palm oil to local community members. Lesson 20 offers an option to move away from palm oil into a local case where a population is struggling and/or land is being used in unproductive ways to support living things.

What mathematics is required to fully access the unit's learning experiences?

During Lesson Set 2, students will engage in population thinking, rate and ratio reasoning, and encounter many graphical representations of data (e.g., line graphs, histograms) that they will need to interpret. They will calculate ratios in Lesson 7, create histograms together in Lesson 8, and interpret single data points in a distribution during both Lessons 8 and 9. Students will also work with the concept of "trend" in Lessons 9 and 10. Prerequisite math concepts that may be helpful include:

- CCSS.Math.Content.6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
- CCSS.Math.Content.6.RP.A.2 Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship.
- CCSS.Math.Content.6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems.
    - *CCSS.Math.Content.6.RP.A.3.c Find a percent of a quantity as a rate per 100.*
    - *CCSS.Math.Content.6.RP.A.3.d Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.*
- CCSS.Math.Content.6.NS.B.2 Fluently divide multi-digit numbers using the standard algorithm.
- CCSS.Math.Content.6.NS.B.3 Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.
- CCSS.Math.Content.6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values.
- CCSS.Math.Content.6.SP.A.1 Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.
- CCSS.Math.Content.6.SP.A.2 Understand that a set of data collected to answer a statistical question has a distribution, which can be described by its center, spread, and overall shape.
- 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.

What additional strategies are available to support equitable science learning in this unit?

Units are designed to promote equitable access to high-quality science learning experiences for all students. Each unit includes strategies which are integrated throughout the routines and are intended to increase relevance and provide access to science learning for all students. units support these equity goals through several specific strategies such as: 1) integrating Universal Design for Learning (UDL) Principles during the unit design process to reduce potential barriers and provide more accessible ways in which students can engage in learning experiences; 2) developing and supporting classroom norms that provide a safe learning culture, 3) supporting classroom discourse to promote students in developing, sharing, and revising their ideas, and 4) specific strategies to supporting emerging multilingual students in science classrooms.

Many of these strategies are discussed in the teacher guides in sidebar callout boxes titled "Attending to Equity" and subheadings such as "Supporting Emerging Multilingual Learners" or "Supporting Universal Design for Learning." Other callout boxes with strategies are found as "Additional Guidance," "Alternate Activity," and "Key Ideas" and various discussion callouts. Finally, each unit includes the development of a Word Wall as part of students' routines to "earning" or "encountering" scientific language.

For more information about each of these different strategies with example artifacts, please see the Teacher Handbook.

GUIDANCE FOR DEVELOPING YOUR WORD WALL

This unit refers to two categories of academic language (i.e., vocabulary). Most often in this unit, students will have experiences with and discussions about science ideas before they know the specific vocabulary word that names that idea. After students have developed a deep understanding of a science idea through these experiences, and sometimes because they are looking for a more efficient way to express that idea, they have "earned" that word and can add the specific term to the class Word Wall. These "words we earn" should be recorded on the Word Wall using the students' own definition whenever possible. On the other hand, "words we encounter" are "given" to students in the course of a reading, video, or other activity, often with a definition clearly stated in the text. Sometimes, words we encounter are helpful just in that lesson and need not be recorded on the Word Wall. However, if a word we encounter will be frequently referred to throughout the unit, it should be added to the Word Wall. As such, the Word Wall becomes an ongoing collection of words we will continue to use, including all the words we earn in the unit and possibly a few key words we encounter.

It is best for students if you create cards for the Word Wall in the moment, using definitions and pictorial representations that the class develops together as they discuss their experiences in the lesson. When they co-create the posted meaning of the word, students "own" the word—it honors their use of language and connects their specific experiences to the vocabulary of science beyond their classroom. It is especially important for emergent multilingual students to have a reference for this important vocabulary, which includes an accessible definition and visual support. Sometimes creating Word Wall cards in the moment is a challenge. The teacher guide provides a suggested definition for each term to support you in helping your class develop a student-friendly definition that is also scientifically accurate. If you keep one Word Wall in your classroom for several sections of students, you might choose to record each class's definition separately, and then propose an "official" definition to post the next day that captures the collected meaning.

The words we earn and words we encounter in this unit are listed in this document and in each lesson to help prepare and to avoid introducing a word before students have earned it. They are not intended as a vocabulary list for students to study before a lesson, as that would undermine the authentic and lasting connection students can make with these words when they are allowed to experience them first as ideas they're trying to figure out.

Lesson	Words we earn	Words we encounter	Words from previous unit
L1	plantation		ecosystem
L2	palm oil, oil palm, land-use change		
L3			
L4			
L5		natural kinds	
L6			criteria, constraints
L7	population		
L8			independent variable, dependent variable
L9	trend, fluctuation, stable		
L10			
L11			
L12		seed dispersal, extinct, endangered	
L13	disruption, biodiversity, monocrop		
L14			
L15		diversified farming, sustainable, customary forests	
L16-20	*No additional words are developed here.*		

TEACHING SCIENCE LITERACY

How does the Core Knowledge Science Literacy routine integrate with the unit investigations?

The Core Knowledge Science Literacy Student Reader and the weekly Science Literacy routine layer varied reading opportunities into the science unit. In their lives after graduating from high school, most students will not become scientists. They will no longer routinely participate in guided investigations to figure out how phenomena work. They will, however, read text about science and scientific claims, day in and day out. The ability to learn and think about science through reading is a skill unto itself and is important in tandem with investigative learning. It is natural to primarily associate emerging literacy with reading and writing instruction at the elementary level, but middle school is an important time to hone literacy skills—specifically in science in the era of politicization of science topics, polarization among adults, and proliferation of misinformation on social media. Detection and construction of well-reasoned explanations are important not just in science, but throughout everyday life. Using claims and evidence in reasoning is the way that thoughtful people think about things, and writing is thinking in print. Students become voters as they emerge from high school, so it is important that they acquire skills for detection of faulty information and practice legitimate communication about scientific issues in the years leading up to that civic benchmark.

Throughout the course of the unit's investigative lessons, students write in their science notebooks in some fashion almost daily, and significant emphasis is placed on the speaking and listening communication threads of the CCSS. The instructional design of the investigations is deliberately light on having students access disciplinary core content through text. NGSS emphasis is on students investigating phenomena along the storyline, so students' interaction with text within lessons is minimal and in service to the unit's storyline. The Science Literacy routine is integrated to exercise students' ability to interact with text about science topics. The routine presents students with short reading selections in a variety of styles, all related to the unit in which students are engaged. Each reading selection is accompanied by a brief but thoughtful writing exercise.

The subject matter of the reading selections ties back to the unit, but the timing for the assigned readings is such that students do not read about specific facets of the subject before they have completed the lessons to investigate that content. In other words, the reading enhances and reinforces the knowledge that students have built in previous lessons; the reading does not reveal beforehand the key takeaways that students are intended to learn through lesson interactions.

When is it done within a unit?

The Core Knowledge Science Literacy Student Reader includes one reading collection per week for every week of the unit. A week's reading collection relates to the lessons completed in the previous week. The reading is assigned at the beginning of the week with the accompanying writing exercise due at the end of the week.

The reading and writing exercises are designed to be completed by students independently, with brief, supporting, teacher-facilitated discussions at the beginning, midpoint, and end of the week.

How do students typically represent their thinking as part of the routine?

Students generate a written product associated with each reading selection. The products are varied in form, and include graphic organizers, concept maps, cartoons, memes, infographics, storyboards, outlines, and paragraphs. The complexity of the products increases from week to week, with the final product for the unit being a single, thoughtfully reasoned, and well-constructed paragraph.

SCIENCE LITERACY: PREFACE

Put Yourself in This Scene

Literacy Objectives

✓ Initiate thinking about the need to evaluate information in text and images.

Literacy Exercises

- Read a brief selection to pique interest, launch discussion, and begin to frame expectations.

Instructional Resource

Student Reader

Preface

Science Literacy Student Reader, Preface
"Put Yourself in This Scene"

No Prerequisite Investigations

The reading of the Preface is appropriate during the first week of unit instruction. The reading does not preemptively tell students facts about the topic that they are intended to learn throughout the course of their investigations.

Standards and Dimensions

NGSS Performance Expectation

LS2-1: (Building toward) Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Disciplinary Core Idea LS2.A: Interdependent Relationships in Ecosystems

Science and Engineering Practice: Analyzing and Interpreting Data

Crosscutting Concepts: Cause and Effect; Energy and Matter

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. No Core Vocabulary terms are highlighted in the Preface.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

economic **ecosystem** **science literacy**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the Science Literacy Student Reader.
- Friday: Set aside time at the end of the week to facilitate a brief discussion about the reading.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know that for the Science Literacy routine, they will read independently and then complete short writing assignments. The reading selections relate to topics they will be exploring in their Ecosystem Dynamics unit science investigations.
- The reading and writing will typically be completed outside of class (unless you have available class time to allocate).
- The first week's reading is a short introductory segment in the book, and there is no accompanying writing exercise as the unit is getting started.
- The class will discuss the reading together at the end of the week.

SUPPORT—The Preface is written at approximately Lexile 1000–1100, which leans toward the high end of the expected text complexity band for middle school. You may wish to introduce a word identification and comprehension convention into your routine to support struggling readers. Hang an envelope near the door with the label, "When we talk about the next reading selection, I could use a little more help understanding the word(s). . . "Encourage students, as they are reading, to jot words, phrases, or sentences that they are unclear about onto small scraps of paper and tuck them into the envelope at any time preceding the discussion of the reading. Whenever you facilitate class discussion about a reading selection, check the envelope first, and layer in added examples and repeat definitions to help students build comprehension and fluency for terms or complex sentences about which they have revealed they are uncertain.

3. Facilitate discussion.

(Friday)

Facilitate a brief class discussion about the Science Literacy Student Reader Preface, entitled "Put Yourself in This Scene."

Pages 2–5 **Suggested prompts**	**Sample student responses**
How would you summarize the "scene" referred to in the title?	*People living in a coastal region are considering whether to conserve or develop a saltwater marsh.*
What is an area where you live that has recently been developed by humans?	*Answers will vary depending on localities, but common answers may be clearing farmland, building a bridge, building a shopping center, clearing trees for a house, widening a road, etc.*
What was the reason for that development?	*Common answers may be to provide housing, create places for shopping, or improve transportation.*
Why might an area of land be conserved?	*to save an animal habitat or maintain a recreation area*
What are some of the effects of developing a piece of land?	*Plants and animals are transplanted, move, or die. Water systems are disrupted. Sometimes ancient burial plots are uncovered.*
Describe an area you have been that has not been developed by humans.	*A forest had tall trees and a lot of wildlife; a desert was barren and untouched; the mountains were lush and quiet; the ocean and surrounding coastal areas were peaceful and sandy; the river/lake was surrounded by plants and trees and wild animals.*

KEY IDEA—Point out that all human habitats have been developed, even historic and established areas. Land has been cleared and prepared, and roads, bridges, and buildings have been built. The natural landscape has been changed. Both the investigations and the reading selections in the unit ahead will help students advance to a place where they have more knowledge to apply to the scenario, and they will circle back at the end of the unit to the topic of ecosystem dynamics and biodiversity.

Student Reader

Preface

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

EXTEND—Watch a video time lapse of a home construction project. Discuss how the land has been developed.

SUPPORT—Make a class list of the pros and cons of land development. Plan to reconsider this list at the end of the unit.

LESSON 1

How could buying candy affect orangutan populations in the wild?

Previous Lesson *There is no previous lesson.*

This Lesson

Anchoring Phenomenon

4 DAYS

We read headlines that claim that our candy-buying habits could affect orangutan populations in the wild. We examine candy ingredients and realize that one ingredient, palm oil, is produced in the same location in which orangutans live. We read about tropical rainforests in Indonesia being cut down to grow oil palm. We wonder how oil palm trees lead to a decrease in the orangutan population. We develop a Driving Question Board (DQB) to guide future investigations.

Next Lesson *We will read and examine data about soybean and canola oil as possible substitutes for palm oil. We will figure out that all three oils require clearing land for farming, which harms animals, and that palm oil is more efficient at producing oil per land area. This makes us wonder if there is somewhere else we can grow palm oil so we don't harm orangutans.*

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

1.A Develop an initial system model to describe a phenomenon in which changes to one living component of an ecosystem (cause) affect the other living parts of the ecosystem (effect).

1.B Ask questions that arise from initial observations of populations in an ecosystem to help seek additional information about the parts of the ecosystem and how they interact.

What Students Will Figure Out

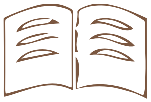
- One of the main ingredients in many types of candy and cosmetic products is palm oil. Palm oil is one of the most commonly used oils.
- Farmers/companies are cutting down rainforests to plant oil palm plants.
- As oil palm numbers increase, orangutan and tiger populations decrease.
- As oil palm numbers increase, rat, pig, and snake populations also increase.

Lesson 1 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	15 min	**INTRODUCE THE PHENOMENON: CANDY BUYING COULD BE KILLING ORANGUTANS** Read a headline about orangutans going extinct and watch a video showing orangutans in their natural habitat. Read a second surprising headline that says buying candy could be killing orangutans. Brainstorm how buying candy could affect orangutans in the wild.	A-D	*Orangutan*, chart paper, markers, Orangutans in the Wild video
2	15 min	**IDENTIFY WHAT CONNECTS CANDY TO ORANGUTANS** Examine candy ingredient lists and consider the sources of each ingredient and where each ingredient is grown. Revise our thinking about the connection between candy and orangutans.	E-H	*Global Production: Where Ingredients Are Grown*, Initial Ideas Diagram—Version 1 (made on day 1), Initial Ideas Diagram—Version 2 (made on day 1), chart paper, markers
3	10 min	**EXAMINE DATA ON PALM OIL TREES AND ORANGUTANS** Predict the relationship between oil palm trees and orangutans. Examine data related to orangutan populations and oil palm populations over time.	I-J	*Land Used to Grow Oil Palm in Indonesia*, *Orangutan Populations Over Time*
4	5 min	**ASSIGN HOME LEARNING: PALM OIL SCAVENGER HUNT** Consider other products that may include palm oil as an ingredient. Assign students the task of looking around their homes or communities (e.g., grocery store) for other products, in addition to candy, that include palm oil on the ingredient list.	K	one everyday product (dish soap, hand lotion, cleaner) that lists palm oil as an ingredient
				End of day 1
5	7 min	**FOLLOW UP ON PALM OIL SCAVENGER HUNT** Compile and organize a list of products that include palm oil.	L	sticky notes, markers, chart paper
6	10 min	**DECIDE WHAT TO CALL THE PLACES WHERE PALM OIL IS GROWN** Students consider the use of the term “plantation” and its negative social and historical meanings. They decide, as a class, to use an alternative word that does not have the same negative social and historical meanings as the word “plantation.”	M	*Extension Opportunity: Comparing Plantations and Farms* (extension opportunity)
7	13 min	**GATHER ADDITIONAL INFORMATION THROUGH A SHORT READING** Gather additional information through a short reading about oil palm plantations in Indonesia.	N	*Growing Oil Palm in Indonesia* or *Reading: Growing Oil Palm in Indonesia*
8	15 min	**IDENTIFY WHAT WE NEED TO INCLUDE IN OUR MODELS** Identify what we need to include in our models to explain this problem.	O	*Develop an Initial Model: Candy and Orangutans*, chart paper, markers
				End of day 2

Part	Duration	Summary	Slide	Materials
9	15 min	**DEVELOP AN INITIAL MODEL** Develop an initial model with a thought partner to answer the question, "How could buying candy with palm oil affect orangutan populations and other populations in the wild?"	P	*Develop an Initial Model: Candy and Orangutans*
10	25 min	**DEVELOP AN INITIAL CONSENSUS MODEL** Gather in a Scientists Circle to develop an initial consensus model.	Q	*Develop an Initial Model: Candy and Orangutans*, chart paper, markers, prepared chart paper for the consensus model
11	5 min	**NAVIGATION** As home learning, prompt students to think about other examples in which changing one component in an ecosystem caused other components to also change.	R	
				End of day 3
12	8 min	**SHARE RELATED PHENOMENA** Share responses to "Have you seen or heard of cases where changing one living thing in an ecosystem had an effect on other living things in the same area?"	S	chart paper, markers
13	5 min	**DEVELOP INITIAL QUESTIONS** Write down different questions students have about the orangutans and palm oil case and related experiences.	T	sticky notes, markers, *Asking Question Tool—Open/Closed Questions* (optional)
14	20 min	**BUILD THE DRIVING QUESTION BOARD** Develop a Driving Question Board to create a shared space for student questions.	U	sticky notes, markers, Driving Question Board
15	10 min	**BRAINSTORM IDEAS FOR DATA AND INFORMATION WE NEED** Use the categories of questions and have students identify the data and information that would help them answer each category of questions.	V	Driving Question Board, chart paper
16	2 min	**NAVIGATION** Conclude the lesson by working with students to decide on next steps.	W	
				End of day 4

Lesson 1 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide  Student Work Pages 	• *Orangutan* • *Global Production: Where Ingredients Are Grown* • *Land Used to Grow Oil Palm in Indonesia* • *Orangutan Populations Over Time* • science notebook • sticky notes • markers • *Growing Oil Palm in Indonesia* or *Reading: Growing Oil Palm in Indonesia* • *Develop an Initial Model: Candy and Orangutans*		• chart paper • markers • Orangutans in the Wild video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Initial Ideas Diagram—Version 1 (made on day 1) • Initial Ideas Diagram—Version 2 (made on day 1) • one everyday product (dish soap, hand lotion, cleaner) that lists palm oil as an ingredient • *Extension Opportunity: Comparing Plantations and Farms* (extension opportunity) • prepared chart paper for the consensus model • *Asking Question Tool—Open/Closed Questions* (optional) • Driving Question Board

Materials preparation (20 minutes)

Online Resources

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

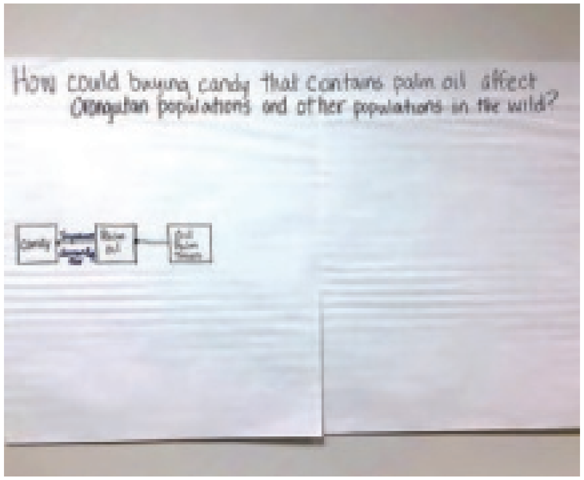
Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Test the *Orangutan in the Wild* video ahead of time. The video link is found on **slide A.** 7.5. Lesson 1 Orangutans in the Wild. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

Find at least one everyday product (dish soap, hand lotion, cleaner, peanut butter, packaged bread) that lists palm oil as an ingredient and place it in an easily accessible place in the classroom.

Prepare all posters (e.g., *Related Phenomena*, *Ideas for Data and Information We Need*) ahead of time. Determine where to set up the DQB and posters so that students can gather around them. Make and post a discussion norms poster near your DQB space, if you haven't already. Download the *Communicating in Scientific Ways* file from the website and use it in your classroom as a poster, or add it to students' science notebooks as a handout.

Prepare chart paper for the consensus model on day 2 with the lesson question and the model stem already drawn onto the paper, as shown in the example to the right. Include three boxes with "candy," "palm oil," and "oil palm tree" written in each box. Draw an arrow from the oil palm tree box to the palm oil box and another arrow from the palm oil box to the candy box. The class will decide what the arrows mean (shown in blue marker on the example image). The class will label those together during the Consensus Discussion.



Determine whether to include the optional 1-day extension *Extension Opportunity: Comparing Plantations and Farms*. If you choose to do the extension, prepare the materials listed in *Extension Opportunity: Comparing Plantations and Farms*.

Use plastic sleeves or laminated readings and references to be reused across sections of your science classes, or print individual copies for each student to attach to their notebooks. References in this lesson will be revisited in later lessons.

Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

This lesson elicits students' initial ideas about how changes in one part of an ecosystem can affect living things in other parts of the same ecosystem. In this lesson, students are introduced to the anchoring phenomenon—orangutan populations in Borneo and Sumatra (islands in Indonesia) are decreasing. The decline in orangutan populations is connected with increased palm oil production. Palm oil is an oil used in many candy and beauty products. As the demand for palm oil increases, large scale farming operations in Indonesia are clearcutting tropical rainforests to make room for oil palm plantations. Orangutans need certain rainforest trees for food and shelter and can't survive on the oil palm plantations.

While palm oil has been harvested by humans for thousands of years in its native habitat in Africa, large-scale palm oil farming operations in Indonesia have primarily increased in the past 100 years where oil palm plants are not native. Throughout the unit it will be important to emphasize the following:

1. Palm oil has been harvested in west and central Africa for thousands of years. Be mindful that you may have students in your classroom who come from cultural backgrounds in which palm oil was sustainably harvested as part of their cultural tradition. You may also have students in your classroom for whom palm oil is the primary cooking oil in their homes. Instead of villainizing the palm oil itself, help your students focus on the way we are farming it today on large-scale plantations.
2. Palm oil is a far more efficient oil crop compared to the cooking oils that dominate the grocery shelves in the US (see Lesson 2).
3. The cultivation of palm oil in Indonesia has brought many Indonesians out of poverty (see Lesson 4).
4. There are different ways of farming crops that support both biodiversity and humans that we can apply to problems created by any large-scale plantation system (see Lessons 14 and 15).

Over the course of the unit, support your students in developing a deeper understanding of the tension that occurs when we farm using large-scale industrial monocrop plantations, like the oil palm ones in Indonesia, and the biodiversity we aim to protect in natural ecosystems.

The unit goal established in Lesson 1 is to figure out: "How does changing an ecosystem affect what lives there?" By the end of the unit, students will be able to answer this question by describing the living and nonliving components in the ecosystem and the interactions between those components.

Engagement with the phenomenon on days 1 and 2 sets students up for articulating a system model to explain the problem based on what they understand about it right now. As they model the system to explain the orangutan decline, they will pose multiple cause-effect relationships they believe are important for understanding the problem more fully. Students will then identify gaps or uncertainty in what they understand about the problem, setting them up to ask more targeted questions to investigate in the unit.

This lesson includes an optional extension designed to explore the characteristics of plantations and farms more fully, allowing students to connect to prior knowledge and experiences and more fully develop a historical and modern-day perspective of agricultural practices. It is designed intentionally to bring up similarities and differences across historical and modern-day plantations and farms. This will include the negative and controversial land and labor practices associated with these places. It is important to acknowledge these practices exist and to help students understand that when we choose to discuss these agricultural systems of plantations and farms, we are also acknowledging how the land is being used and who the workers are in these places, both past and present.

Regardless of the decision to pursue the optional extension, this lesson includes a discussion in which students consider the use of the term "plantation" and its negative social and historical meanings. Students decide, as a class, to use an alternative word that does not have the same negative social and historical meanings as the word "plantation." The materials will default to "farm," though the class should feel they can use the word they chose together.

Where We Are NOT Going

The term "population" is used throughout this lesson. In previous units, students focused mostly on individuals but have not yet been introduced to the idea of populations explicitly. Students may have some familiarity with populations from elementary science as they learned about "kinds of organisms." At this point in the unit, it is not important for students to have a complete understanding of the word "population." Students will build this understanding and co-construct a definition for "population" in Lesson 7.

In addition, it is not important for students to have a complete understanding of the different components in the ecosystem and the interactions among the components. Rather, students should focus on sharing their initial ideas about the components and interactions. Students will build this understanding throughout the unit, and will develop a more complete system model for the tropical rainforest and oil palm system in Lesson 11.

This unit directly builds off of *Unit 7.4: Where does food come from, and where does it go next? (Maple Syrup Unit).* This unit does not build an understanding of food webs, so students should come in with that previous knowledge. This unit will reinforce the concept of food webs in a new context, particularly in Lesson 11.

LEARNING PLAN FOR LESSON 1

1. Introduce the phenomenon: candy buying could be killing orangutans. 15 MIN

Materials: *Orangutan*, chart paper, markers, Orangutans in the Wild video

Launch the unit by meeting the orangutans. Tell students that you recently learned about a concerning situation involving orangutans.* Project **slide A** and read the headline from *The Independent:* "Orangutans Could Face Complete Extinction Within 10 Years, Animal Charity Warns." To introduce students to the orangutans, play the *Orangutans in the Wild* video from the slide 7.5. Lesson 1 Orangutans in the Wild. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) The video provides a brief background on where orangutans live, what they eat, and their natural predator.

Give students a few moments to review the information on the *Orangutan* reference card.

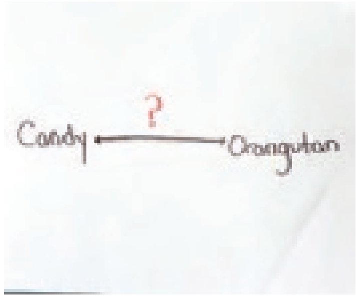
Students may notice that the orangutans only live in Borneo and Sumatra. To orient students to where the orangutans live, present **slide B**. Explain that Borneo and Sumatra are two of the islands that make up Indonesia. Show students where Borneo and Sumatra are on the Indonesian map. Then, show students where Indonesia is on the world map in the upper-right-hand corner of the image. Point out the United States and the Pacific Ocean on the world map. Finally, zoom back to Indonesia, and then to Borneo and Sumatra again.

Meet the cause for potential orangutan extinction. Tell students that, while you found it concerning that the orangutans could go extinct in the next 10 years, you were *really* concerned about the potential cause for orangutan extinction. Present **slide C** and read the headline from *The Huffington Post*, "Your Halloween Candy Could Be Killing Orangutans." Pose the question, *How could whether we buy candy have any impact on orangutan populations in the wild?* Give students a minute to think about the question. Then, give students 1-2 minutes to turn and talk with a partner. The purpose of this Turn and Talk is for students to voice their initial ideas about the phenomenon.

***Attending to Equity**
Research shows that middle-school students like exotic animals more than local animals (Schuttler, et al., 2019). Through books, television and movies, and visits to the zoo, they may have learned about exotic species more than local ones, thus having more prior experience to contribute. One overall goal in this lesson is to connect what is happening in non-local ecosystems to our personal consumer choices. A second overall goal for the unit is to connect students to their local ecosystems and local flora and fauna. The orangutan in Indonesia is just the initial entry into the unit.

Additional Guidance

If you are teaching this unit around a particular holiday event (Halloween, Valentine's Day, etc.), situate the candy topic around the holiday to increase relevance for students.



Lead an Initial Ideas Discussion to brainstorm the connection between buying candy and potential orangutan extinction.* Lead a whole-group brainstorming discussion about how our action of buying candy could affect the orangutans. Present **slide D** and remind them that the claim from *The Huffington Post* article is: *Our candy buying could affect orangutans in the wild.* We are wondering, *How could buying candy affect orangutan populations in the wild?*

Draw a quick sketch similar to the diagram on **slide D** onto a piece of chart paper.*
This will be referred to as "Initial Ideas Diagram—Version 1." Point to the arrow and have students brainstorm what could be happening to connect the two things.

***Strategies for This Initial Ideas Discussion**
The purpose of an Initial Ideas Discussion is to get students' *initial* ideas and experiences on the table and to provide a supportive opportunity for students to make sense of what may not be fully formed ideas. Realizing that there are gaps in our understanding can promote curiosity.

Key Ideas

Purpose of this discussion: To establish that there is a connection between consumer choices and animals in the wild, and to elicit students' prior knowledge about these connections.

Listen for:

- The candy could be made from trees or plants that the orangutans need to survive.
- We could be harming the orangutans' habitat when we are getting the ingredients to make the candy.

Suggested prompt	Sample student responses
What are some of our initial ideas about how these two things could be connected?	*The candy could be made from trees or plants that the orangutans need to survive.* *The orangutans eat the chocolate and it makes them sick (like when dogs eat chocolate).* *The candy wrapper becomes pollution that is harmful to the orangutans.* *Orangutans are somehow used to make chocolate (like as an ingredient in chocolate).* *An orangutan's hair or body is used to make plastic wrappers.*

***Supporting Students in Engaging in Developing and Using Models**

The sketch similar to the diagram on **slide D** (Initial Ideas Diagram—Version 1) serves as a scaffold to develop an ecosystem model. In this sketch, one component (candy) is connected with a second component (orangutan) by a line and a question mark. Throughout the first lesson set, this initial model will be progressively developed. The class will work together to include additional components and to agree upon ways to depict interactions between them.

2. Identify what connects candy to orangutans.

15 MIN

Materials: *Global Production: Where Ingredients Are Grown*, Initial Ideas Diagram—Version 1 (made on day 1), Initial Ideas Diagram—Version 2 (made on day 1), chart paper, markers

Additional Guidance

Universal Design for Learning: In the *Maple Syrup Unit*, students determined that all ingredients in food came from either plants or animals. Students also have experience examining food labels in their own lives. To support *engagement*, use this opportunity to activate prior knowledge and build connections between the current activity and what is familiar to students in their previous experiences.

Discuss how investigating candy ingredients could help us determine the connection between candy and the orangutans. Project **slide E** and say, *It seems like we need to know more about what is in candy since we've done some study of foods in our earlier units. I have a few more resources for us to look at, including candy ingredient lists and information about some of those ingredients. We already have some experience reading these labels, so there may be clues in the ingredients that could be helpful to us.* Lead a brief discussion about how investigating more about what's in candy might help us figure out the connection between candy and orangutans.

***Supporting Students in Engaging in Developing and Using Models**

The revised diagram (Initial Ideas—Version 2) is the second scaffold in model development in this lesson. This revised diagram incorporates two additional components (palm oil and oil palm trees) and includes an initial way to articulate the relationships between the components (e.g., "an ingredient in," "a substance from," and "overlap in where these are found"). Later in this lesson,

Suggested prompt	Sample student responses
How could investigating more about what's in candy help us figure out the connection between candy and orangutans?	*If we look at the ingredient lists, maybe we can see if there are any ingredients from where the orangutans live. This could help us figure out if we are using something to make candy that the orangutans need to survive.* *We could see if any of the ingredients are poisonous to the orangutans.*

Examine top candy ingredient lists. Project **slide F,** with the top candy ingredient lists from several different kinds of candy. Arrange students into pairs or groups of 3, sitting near each other for a brief discussion. Have students examine the ingredient lists for the different types of candy and discuss from where they think the ingredients came (e.g., plants or animals). You may wish to point out that the ingredients listed are the top ingredients in candy and don't include the ingredients that make up less than 1-2% of the candy.

Bring students back together as a whole group. Project **slide G** and discuss, as a class, the main plant and animal sources for candy. Make a list on the board or on chart paper. An example list is provided below.

Ingredient	Source
Sugar	sugarcane
Wheat flour	wheat
Nonfat milk, lactose, whey	milk/cows
Cocoa butter, cocoa	cocoa
Palm kernel oil, palm oil, partially hydrogenated palm kernel oil	oil palm
Ground roasted peanuts, peanuts	peanuts
Corn syrup	corn

Additional Guidance

As ingredients arise that have slightly different names, discuss how these are likely from the same source (e.g., palm kernel oil, palm oil, and partially hydrogenated palm kernel oil). Group ingredients from the same source (e.g., milk, lactose, and whey). Ingredients on the labels that students might not be familiar with include molasses (from sugarcane).

Examine the map showing where each candy ingredient is grown. Say, *We thought looking at what's in the candy might help us figure out this connection. Now that we know what the ingredients are, let's look at where these ingredients are grown, and see if there are any connections to orangutans.*

Project the map on **slide H**, which shows the top producing country of each ingredient. You can also hand out the *Global Production: Where Ingredients Are Grown* map so that students can look at the map on their own if you wish to. This reference sheet is printed in color in the *Student Edition* but can also be handed out to students to attach to their notebooks.

students will work to add even more components and interactions between components to their models. Then, in Lesson 7, students will further build upon this scaffold as they develop the modeling convention that boxes will stand for a group of organisms of plants and animals (i.e., populations) and lines between the boxes represent a connection. Use this opportunity to model for students how to include a new component of the system, connection and interaction between components (line), and a description of the connection (text written on or near the line between two boxes).

Ask, *What connections do you see between what is in our candy and the orangutans?* Have students discuss the question, first in pairs and then share their ideas as a class. You may wish to go back to **slide B** if students have forgotten where the orangutans live.

Suggested prompt	Sample student responses
What connections do you see between what is in our candy and the orangutans?	*It looks like oil palm is mostly grown in Indonesia, which is where the orangutans live.* *This makes us think that there is a relationship between the orangutans and the oil palm in our candy.*

Revise our initial diagram representing the connection between our candy and the orangutans. Return to Initial Ideas Diagram—Version 1 that you sketched on chart paper from **slide D** and revise ideas about the connection between orangutans and candy to include palm oil.

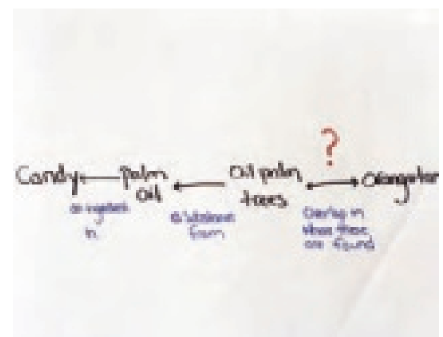
Suggested prompts	Sample student responses
Now that we know more, how can we revise our thinking on the diagram? What additional information helps us understand the connection between the candy and the orangutans?	*We know that there is an overlap in where orangutans live and where palm oil comes from.*
Where does palm oil come from?	*Palm oil is an ingredient that comes from oil palm trees.*

Additional Guidance

In the *Maple Syrup Unit*, students spent time figuring out which food items come from plants. Students should be able to draw upon this knowledge in order to reason that palm oil comes from the oil palm tree.

As a class, come to a consensus about how to represent the relationship between our candy and the orangutans, given the new information about candy ingredients and palm oil. Represent this revised model on a piece of chart paper. Include the candy bar on one side, the orangutan on the other, and add in detail about palm oil in candy and palm oil coming from palm trees. If students just say "palm oil," probe for where palm oil comes from, then add another box and press students for the connection. Write the connection above the arrow (e.g., palm oil is an ingredient that comes from oil palm trees).

An example is provided on the right. This revised diagram will be referred to as Initial Ideas Diagram—Version 2 in the teacher edition.



Initial Ideas Diagram—Version 2

3. Examine data on palm oil trees and orangutans.

10 MIN

Materials: *Land Used to Grow Oil Palm in Indonesia, Orangutan Populations Over Time*

Probe students for what they think the relationship is between oil palm trees and orangutans. Project **slide I** and have students discuss the following questions in pairs:

- How could oil palm trees affect orangutans?
- If there were fewer or more oil palm trees, what would happen to the orangutans? Why?
- What information would we need to support our predictions?

After discussing in pairs, have students share their ideas with the class. If students don't know much about the system, they may think that orangutans need oil palm trees to survive—so when they cut down oil palm trees, orangutans lose their habitat. In this case, students might predict that when oil palm decreases, the orangutan population decreases. Press students to provide ideas for evidence that they would need to support their predictions. In most cases, we would need evidence about the palm trees and orangutans over time. Tell students that you anticipated that they might ask for that data, so you were able to find information about the oil palm and orangutans over time.

Direct students to the *Land Used to Grow Oil Palm in Indonesia* and *Orangutan Populations Over Time* data reference sheets in their student edition. These data sheets contain information about palm oil and orangutans over time. Alternatively, these can be copied and passed out to individual students as a handout. Say, *It seems like we need to pay attention to the oil palm trees and orangutans over time. Let's take a look at some data about orangutan populations and oil palms.*

Divide students into groups of 3 to examine the orangutan and oil palm data. Project **slide J** and prompt students to discuss the following questions in their small groups:

- What has happened to the orangutans over time? The oil palm trees?
- What is the relationship between orangutan populations and oil palm trees?

Debrief the relationship between orangutans and oil palm trees as a whole class. Have groups share ideas from their discussions.

Suggested prompts	Sample student responses
What is the relationship between the orangutans and oil palm trees?	*As the number of oil palm trees went up, the orangutan population went down!*
What was surprising to you?	*It was surprising that the number of oil palm trees were going up. We thought that the orangutans needed something from the oil palm trees, so we expected that, since the orangutan population was going down, the number of oil palm trees must have also been going down. But, it looks like there is something else going on, since the number of oil palms are going up!*

***Attending to Equity**

Universal Design for Learning: Use the palm oil issue as a way to communicate *relevance* and set a purpose around a shared global concern. While palm oil and the ecosystem it affects could seem far away to many students, creating a personal connection to the anchoring phenomenon/problem through consumer choices and our shared desire to protect tropical rainforests can support student *engagement* with the science ideas in the unit, making the learning experience more meaningful to students.

Revisit the Initial Ideas Diagram—Version 2 to summarize the discussion. Point to the Initial Ideas Diagram—Version 2, focusing on the relationship between the oil palm trees and orangutans. Say, *Our initial explanation doesn't seem to explain, yet, what is happening between the oil palm trees and orangutans. Now we need to figure out how an increase in the number of oil palm trees is related to a decrease in the orangutan population.**

Additional Guidance

As students examine new data, they should move away from the idea that orangutans are used in the making of candy, candy wrappers, or are dying because of candy wrappers and trash. Instead, they should be more focused on orangutans' connection to oil palm trees because of their needs for food or habitat.

Brainstorm additional information. Ask students, *What additional information do we need about what is happening in Indonesia?* Have students share their ideas with the class. As students share their ideas, jot down notes about the additional information that students are looking for.

Suggested prompt	Sample student responses
What additional information do we need about what is happening in Indonesia?	*We need to know more about what causes oil palms to go up.* *We need to know more about palm oil in general.* *We need to know what kinds of products palm oil is used in.* *We need to know more about what orangutans and oil palm trees need to live and grow.* *We need to know more about whether oil palm trees are helpful or harmful to the orangutans.*

Summarize by saying, *It seems like we have a lot more digging that we need to do to really understand the problem. Maybe we can start by learning a little bit more about palm oil, what it is used in, and how it is grown.*

4. Assign Home Learning: Palm Oil Scavenger Hunt.

5 MIN

Materials: science notebook, one everyday product (dish soap, hand lotion, cleaner) that lists palm oil as an ingredient

Consider other products that may include palm oil. Say, *We know that palm oil is an ingredient in many types of candy, but I wonder, how widespread is it? Could it be in other products as well?* Project **slide K** and have students turn and talk with a partner about the questions on the slide:

- What other products do you think might include palm oil?
- Where could you look in your home, at school, or in your neighborhood to find such products (so you can check the ingredient lists)?

***Attending to Equity**
Students do not need to take a picture of or bring in products that include palm oil. This activity is intentionally designed so that students do not feel embarrassed about using products that contain palm oil. You may wish to allow students to take photos of the

products to share with the class or load to a class website, or bring the empty product containers to school. Combined, the students could amass a wide variety of food and cosmetic/personal care products that contain palm oil. This strategy can help make the problem more relevant and connected to students.

Students will share a broad range of ideas. Accept all student responses at this point. If time permits, have students share their ideas with the class following the brief partner discussion.

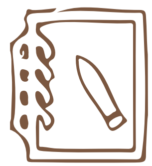
Assign the palm oil scavenger hunt. Say, *It sounds like we have some searching to do! Spend some time looking for these products in your home, school, or community. You don't need to move the product or bring it to class—just take a look at the ingredient list. Document what you find in your science notebooks.**

Instruct students to create a page in their notebooks titled: "Products that include palm oil." Instruct students to add to their lists whenever they notice a product that lists palm oil as an ingredient. Tell students that they will be sharing their lists on day 2 of this lesson.

Additional Guidance

Students will have a great deal of experience reading ingredient lists from the *Maple Syrup Unit*. If necessary, you may wish to project an example ingredient list of a non-food product to show students where to look to find palm oil listed as an ingredient.

Science Notebook



This is the first use of the science notebook for this new unit. You may need time to organize a new section in the notebook. It is recommended to have students do the following:

- Reserve a blank page at the start of the unit, to be titled on day 3 of this lesson when students are given the unit question.
- After the title page, reserve 2 pages (4 pages front-to-back) for the table of contents (unless all tables of contents are at the front of the notebook).
- Reserve 10 pages (20 pages front-to-back) for the Progress Tracker pages.
- Number the pages so that everyone begins the first investigation of the unit on the same page number.

Remind students that the notebooks are their tools for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking, as well as a place to show how their thinking changes as they learn more.

End of day 1

5. Follow up on Palm Oil Scavenger Hunt. 7 MIN

Materials: sticky notes, markers, chart paper

Compile and organize a list of products that include palm oil. Project **slide L** and say, *Yesterday, we were left wondering what palm oil is used in. Let's take a few minutes to reflect on our Palm Oil Scavenger Hunt.* Instruct students to turn to the page in their notebooks labeled "Products that Include Palm Oil." Instruct students to select 1-3 products from their lists and write the product name(s), using a bold marker, on a sticky note (one product per sticky note). While students create their sticky notes, post a piece of chart paper on the wall and label it, "Products That Include Palm Oil."

Instruct students to silently post their stickies to the chart paper, placing stickies with similar products close to one another. You may wish to have small groups of students post as they are ready to avoid crowding. As students post their stickies, clusters of categories may emerge (e.g., candy, food, toiletry products, cleaning products).

If time allows, ask, *What do you notice about our list? What do you wonder?* Accept all student responses.

Navigate to the next activity by saying, *It is really amazing how many products we use include palm oil. This seems like a really difficult and important problem to solve, since we seem to rely on palm oil in so many ways. Yesterday, we decided we wanted to learn a little more about palm oil. In addition to looking at the products that contain palm oil, we had some questions about the places where they grow oil palm. Let's spend a little bit of time thinking about where they grow oil palm—places that some call "oil palm plantations."*

6. Decide what to call the places where palm oil is grown.

10 MIN

Materials: *Extension Opportunity: Comparing Plantations and Farms* (extension opportunity)

Alternate Activity

Extension Opportunity: *Extension Opportunity: Comparing Plantations and Farms* provides guidance to extend this activity to explore the characteristics of plantations and farms more fully, allowing students to connect to prior knowledge and experiences, and more fully develop a historical and modern-day perspective of agricultural practices. It is designed to bring up similarities and differences across historical and modern-day plantations and farms. This will include the negative and controversial land and labor practices associated with these places. It is important to acknowledge these practices exist and to help students understand that when we choose to discuss these agricultural systems of plantations and farms, we are also acknowledging how the land is being used and who the workers are in these places, both past and present.

If you wish to do the optional 1-day Extension Opportunity, *Extension Opportunity: Comparing Plantations and Farms*, skip this activity and replace it with the extension. Substitute **slides M.1-M.5** into the main slide deck in place of **slide M**.

Have students do a Turn and Talk about the word "plantation." Display **slide M**, which shows different images of oil palm plantations. Give students 2–3 minutes to turn to a partner and share what they think of when they hear the word "plantation" and see the images.*

Elicit from the partners any ideas they would like to share with the class. This is an opportunity to share what they think about when they hear the term "plantation." Allow a few partners to share their ideas.

Say, *I was surprised to see that the word "plantation" is still used today to describe where oil palm is grown. To me, it seemed like a word we don't use anymore because it's a word that represents a tragic time in North American history. I wondered why they call these places "plantations" instead of "farms," which is what I tend to call places that grow crops.*

***Attending to Equity**

Universal Design for Learning: *Plantation* is used to describe where oil palms are farmed. This term is commonly used today for oil palm agriculture globally and is also widespread in other commodity crop industries, like banana and rubber. The word *plantation* has historically been used in tropical and subtropical regions of the world where commodity crops have been intensively grown and traded. Even though this word is used widely throughout the world, in the United States, many students may associate the word *plantation* with exploited or enslaved labor, particularly in the American South leading up to the Civil War, where the commodity crops of cotton, tobacco, and sugar were intensively grown by enslaved

Elicit initial comparisons between plantations and farms by asking, *What ideas do you have about how a plantation and farm might be similar or different from one another? Why might we use "plantation" for some places and "farm" for others?* Let students share some initial ideas. It's OK if students are uncertain about the similarities and differences.

Provide background on the terms "farm" and "plantation." Say, *From a biological perspective, the terms "plantation" and "farm" refer to land used in similar ways. They are both areas of land in which one or several crops, such as cotton, sugar, strawberries, corn, or oil palm, are grown. Historically, the term "plantation" referred to a larger area of land used to grow crops, and because the area was so large, they needed a lot of workers to care for and harvest the crops. To fulfill the need for so many workers, landowners enslaved people or hired exploited labor. Exploited labor means they hired people who were desperate for work and willing to work in poor conditions for little pay. The term "farm" has referred to land used to grow crops paying workers a wage, but some of the bad labor conditions still persist on farms, too.*

Decide what to call the places where they grow oil palm. Say, *To help us figure out what is happening to the rainforests and orangutans, we're going to need to study the oil palm plantations more. Sometimes, we may come across the word "plantation," and we know more about what these plantations mean now that we've done some more investigation. The people in Indonesia who work on oil palm plantations aren't necessarily slaves, but it is hard work and many do not get paid very much. Because of the negative history of plantations and slave labor in North America, and the negative emotions that the word may invoke, I'm wondering if we could call these places a different word that doesn't have all the negative historical and social meanings we learned about.*

Generate alternative words. Give students time to talk with a partner to brainstorm other words that could be used instead of *plantation*. Then elicit from students alternative words, which could include *farm*, *orchard*, *grove*, and more.

Decide as a class to use an alternative word that does not have the same negative social and historical meanings as the word "plantation." Use this word through the remainder of the unit.

Additional Guidance

Universal Design for Learning: The development team decided to use the term "farm" for the remainder of the unit. We did not want to put students in an uncomfortable position, should the frequent use of the word "plantation" upset them. Using a word like "plantation" regularly can also normalize a very problematic issue. Most unit documents will use "palm farm" or "oil palm farm." It is your choice what word to use going forward, and ideally your class will agree on a word they prefer. "Plantation" is the language of the trade, so you may choose to adopt that language and continue to use it throughout. We decided that using a familiar word that is comfortable to students and *minimizes threat* outweighed using the more accurate, but socially-laden, word. One tradeoff to our decision to call palm plantations "farms" is that by calling them "farms," we background unfair labor practices on some plantations today. Plantations today are large-scale industrial farms where commodity crops are intensively grown and many workers are minimally paid. This may not match your students' ideas about farms. They may imagine farms as family-operated, small scale, with mixed crops and livestock. Help your students develop an understanding that these palm plantations are generally large-scale farms with one crop, often run by a corporation. They will revisit these ideas in Lessons 13-16.

people. The word may surface negative feelings and associations from students; it might also surface distant student attitudes about plantations as "something in the past" that they might not understand or feel connected to.

This activity is an opportunity for students to acknowledge and have a conversation about the meaning of the word both in terms of its biological meaning and its historical and social use with the intent to *minimize threat* and *create a safe space* for a discussion of the term. It is also designed to help students choose another word to use in place of *plantation* that they may feel more comfortable using. These ideas are more fully developed in the extension, *Extension Opportunity: Comparing Plantations and Farms*.

7. Gather additional information through a short reading.

13 MIN

Materials: *Growing Oil Palm in Indonesia* or *Reading: Growing Oil Palm in Indonesia*

Introduce the reading. Project **slide N** and say, *I have a short reading about the oil palm trees and how they are grown and used for palm oil. There may be more information in the reading about the problem we discussed yesterday. Let's remind ourselves of the different ideas about how increased numbers of oil palm trees could be affecting orangutan populations.* Listen for student ideas.

Foreground the purpose of the reading.* Say, *The purpose of the reading is to help us understand why the number of oil palm trees going up might be related to orangutan populations going down. We are trying to gather any other information about what is happening in Indonesia.*

Give students time to individually read *Growing Oil Palm in Indonesia* and discuss the questions on slide M in small groups. Alternatively, pass out the *Reading: Growing Oil Palm in Indonesia* handout if you want students to mark the text and attach it to their science notebooks. After sharing their ideas in small groups, have a few students share their ideas from their discussions.

Suggested prompts	Sample student responses
Why is the number of oil palm trees increasing?	*The number of oil palm trees is increasing because farmers are cutting down rainforests to plant oil palm.* *Farmers are planting oil palm trees in these oil palm farms.*
What other information did you notice?	*Tiger populations are also decreasing.* *Snake and rat populations seem to be rising.*

***Attending to Equity**

Universal Design for Learning: The readability checks for this reading place it at a 7th grade level (i.e., Flesch-Kincaid: 7.5). Students who read below grade level could benefit from more *support to decode text, clarify vocabulary, and highlight big ideas* during the reading (*representation*). Consider using partner reading, small group reading with you, or whole-class reading. Spend more time previewing the purpose of the text and encouraging students to note words they do not understand. Include more frequent checks on comprehension as they read. Pause after each paragraph to summarize the main idea from the paragraph and to discuss any words or phrases that were difficult to understand.

8. Identify what we need to include in our models.

15 MIN

Materials: science notebook, *Develop an Initial Model: Candy and Orangutans*, chart paper, markers

Review the question we want the model to help us answer. Show **slide O**. The purpose of developing an initial model is to answer the question, *How could buying candy with palm oil affect orangutan populations and other populations in the wild?* Say, *OK, so they're cutting down rainforests and planting oil palm trees. How could that be causing orangutan numbers to change? And what about all of these other organisms that are also changing? We're going to try to explain as much as we know about this, but, first, let's decide what to include in our models.*

First, identify what we already know about what <u>causes</u> lead to the <u>effect</u> of increases and decreases in the number of living things that are living in an area.* Have students make a chart in their notebooks and generate lists of things that could cause a population to go up or down. Have them label their charts with "Causes" in the left-hand column and "Effect" in the top row. Students may work with a partner to generate their lists. You may wish to provide an example to help students get started. An example list is provided below:

***Supporting Students in Developing and Using Cause and Effect**

Frame the potential model components as "causes" and "effects." This will help students to think about cause-and-effect relationships and make clear that often, there is more than one cause for a particular effect.

	Effects	
	Increases	**Decreases**
Causes	A lot of food and water A lot of space and homes/habitat Making babies/reproducing Not a lot of predators No one is killing them	Can't find food Being hunted or killed Lose their homes Can't reproduce Too many predators Pollution killing them Climate change killing them

Additional Guidance

Students likely know the term "ecosystem" from their previous learning of Grade 5 LS2.A: Interdependent Relationships in Ecosystems. However, consider probing students' understanding of ecosystems throughout this discussion.

Next, lead a discussion to help students identify which *components* would be important to identify in the model. On chart paper, develop an initial list of the living and nonliving things in the ecosystem that we know about right now.

Suggested prompt	Sample student response
What components can we all agree are in the model?	*orangutans, oil palm, rainforest trees, tigers, rats, pigs, snakes, people, candy, the sun, rain, leopards*

Additional Guidance

During the field test, many students expressed an interest in understanding the role of humans in the ecosystem. Just as oil palm trees and orangutans are important parts of the model, so are humans. Make sure to point out that humans are impacting ecosystems and are also a part of the ecosystem.

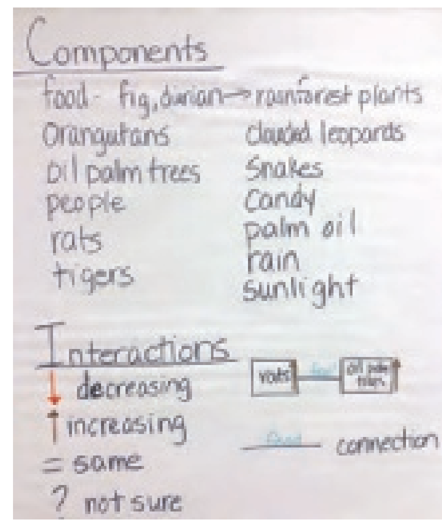
Agree on how we could represent what is happening to each component. Show students how to indicate whether a component is going up, going down, staying the same, or if they are uncertain.

Next, agree on how we could represent the interaction between two components. Select two components as an example—the palm kernel and the rats. Show that we can represent an interaction between the two components by drawing a line or an arrow and writing a quick explanation about the interaction, which could draw from what we know about what leads populations to increase or decrease.

Examples of the components and interactions are shown to the right.

Pass out handout *Develop an Initial Model: Candy and Orangutans*. Have students record the agreed-upon model components that were recorded on chart paper and symbols for model interactions in the appropriate boxes.*

***Attending to Equity**
Universal Design for Learning: Using a key can be beneficial to all students for clearly understanding *symbols* in the model, but these kinds of graphical representations of ideas can also embody *representations* of key concepts and processes, and support students in using multiple modalities for meaning-making, which is a powerful tool for equitable participation. Encourage students to develop their models using both linguistic resources and multiple modalities when *expressing* their ideas and reasoning.



Prime students for things to think about before they begin their models in the next class. Students will develop initial models on their own at the start of the next class. Use this opportunity to prime their thinking using a series of probing questions:

Suggested prompts	Sample student responses
What interactions could be playing out in your model?	*We know that there is a relationship between the oil palm and orangutans, but it probably isn't direct; we think there might need to be other living things or nonliving things involved.* *We think the tigers could be eating the orangutans.* *We know the rainforest trees are being cleared to plant oil palm trees.*
If a population is decreasing, what things from our brainstorm list do you think might be causing the decrease? How is the decrease related to another component of the system?	*Can't find food: Maybe another thing in the ecosystem is eating the food.* *Lose their homes. Maybe humans are cutting down their homes but cutting down rainforest trees.* *Too many predators; maybe the predators like oil palm.*
If a population is increasing, what things from our brainstorm list do you think might be causing the increase? How is the increase related to another component of the system?	*Lots of space and homes/habitat. Maybe the living thing likes living in places where they grow oil palm.* *Not a lot of predators. Maybe the predators can't live in the place where they grow oil palm.*

Additional Guidance

In previous units when we worked with models, we didn't actually have to draw the "thing" in the model (e.g., the orangutans). Remind students that it is OK to write the word "orangutan" and put it in a box, rather than drawing an actual orangutan. Students may use arrows to show a connection that isn't necessarily a food connection. That is OK for where they are in the modeling process right now. Students should recall from the *Maple Syrup Unit* that they can represent individual organisms in boxes. The move to use a box to represent populations of organisms may be uneven for students right now, but that is OK, as they will develop that idea in Lesson 7.

Say, *Let's keep thinking about these kinds of questions. In the next class, we're going to use these ideas to start on our models*.

Have students place their *Develop an Initial Model: Candy and Orangutans* handouts in their science notebooks for use in the next class period.

End of day 2

9. Develop an initial model.

15 MIN

Materials: science notebook, *Develop an Initial Model: Candy and Orangutans*

Work with a thought partner to develop an initial model.* Project **slide P** and refer students to *Develop an Initial Model: Candy and Orangutans***.** Assemble students into pairs to develop an initial model to answer the question, "How could buying candy with palm oil affect orangutan populations and other populations in the wild?" Students should develop their own models but can talk things through with their thought partners. Partners do not need to co-construct the same initial model, but they can if they want.

Keep the following visible to students:

- The question on **slide O**, "How could buying candy with palm oil affect orangutan populations and other populations in the wild?"
- The chart with a list of things that cause living things to increase or decrease
- The chart with agreed-upon components
- The chart with agreed-upon conventions for representing interactions

Before students begin modeling, prompt students to think about cause-and-effect relationships as they develop their initial models. As students develop their initial models, circulate to encourage students to use the agreed-upon conventions.

Assessment Opportunity

***Building towards*: 1.A** Develop an initial system model to describe a phenomenon in which changes to one living component of an ecosystem (cause) affect the other living parts of the ecosystem (effect).

What to look/listen for:

- Inclusion of the living components of the system models (such as the oil palm trees, orangutans, rats, snakes, tigers, and pigs) in the systems model
- Inclusion of at least some of the needs that these livings components have in the system model, such as needs for food, water, air, habitat, or shelter
- Initial ideas about what causes the population sizes of living things to increase in number (a lot of food or water, a lot of mates, not very many predators) and decrease in number (very little food or water, can't reproduce, many predators)
- Uncertainty about interactions between the living things within the system and the specific cause-and-effect relationships in the system model
- Uncertainty about which components of the system model are causing increases or decreases in the different population sizes

What to do: If your students struggle with identifying important components of the ecosystems, refer them back to the class-developed list of ecosystem components. Students may also wish to revisit *Growing Oil Palm in Indonesia* to

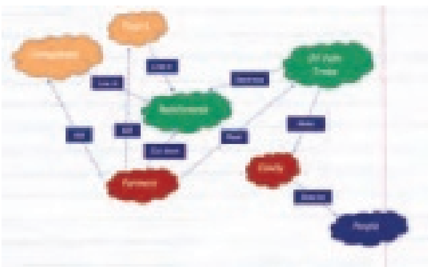
***Supporting Students in Three-Dimensional Learning**

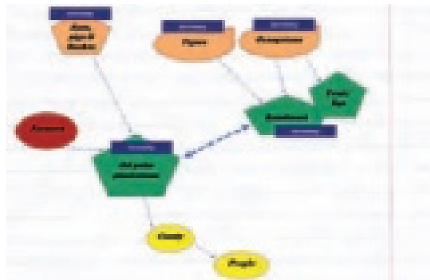
Students are working to develop an initial model that can help them explain why orangutan populations are decreasing while oil palm tree populations are increasing. When developing their initial models (Developing and Using Models), students think about the individual components of the ecosystem (oil palm trees, orangutans, tigers, rats, snakes, pigs) and the interactions among the components, so that they begin thinking about the ecosystem as a system of interacting parts (Systems and System Models). In their effort to use the model to explain the phenomena, students draw heavily on their knowledge of ecosystems developed in previous grade bands (DCI) and must consider the cause-and-effect (Cause and Effect) relationships driving the interactions among components.

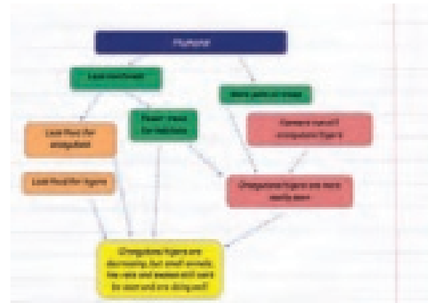
find more information about the components in the ecosystem. If students are not sharing their initial ideas about what causes the population sizes of living things to increase or decrease in number, or if students are not sharing their uncertainty about interactions in the system model, encourage them to draw a large question mark and then record their thinking. It may help to refer to these thoughts as “first draft thinking,” “initial ideas,” or “questions I have.” It can also help to provide students with the sentence starter “Maybe…” and then ask them to record their thinking.

This assessment guidance also applies for the Consensus Discussion that follows.

A range of student-created initial models are shown below:



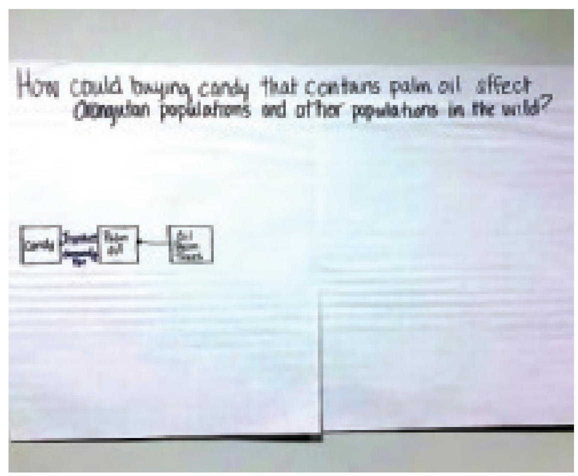




10. Develop an initial consensus model. 25 MIN

Materials: science notebook, *Develop an Initial Model: Candy and Orangutans*, chart paper, markers, prepared chart paper for the consensus model

Gather students in a Scientists Circle to develop an initial consensus model.* Have students bring their science notebooks with them to the circle. As a class, work together to build a new systems model, starting with the initial model from day 1. Project **slide Q** and say, *There may be a lot of similarities and differences in our ideas about how buying candy that contains palm oil could affect orangutan populations and other populations in the wild. Let’s come together and make a consensus model of what we agree on in our explanation and where we disagree or have questions.*



Say, *Since we developed our initial diagram, we gathered some more information about the different components in the ecosystem and how those components might be interacting. We need to figure out what parts of our explanation we agree upon and what parts we need to investigate to make a full and complete model for how buying candy can affect the orangutan population and other populations in the wild.*

Post the prepared chart for the consensus model on the board. The prepared chart paper for the consensus model should include the lesson question and the model stem already drawn onto the paper. Include three boxes with “candy,” “palm oil,” and “oil palm

***Attending to Equity**
Universal Design for Learning: You will form a Scientists Circle in many lessons. If this is your first time forming one, you will need longer than 15 minutes to coordinate it. If your class is familiar with the Scientists Circle, the movement in and out of the circle can happen fairly quickly. Setting up the norms and logistics for forming, equitably participating in, and breaking down that space is important to do if this is your first time forming such a space. Having students sit in a circle so they can see and face one another can help build a sense of shared mission and a community of learners working together (*engagement*). Returning to this Scientists Circle

tree" written in each box. Draw an arrow from the oil palm tree box to the palm oil box and another arrow from the palm oil box to the candy box. The class will decide what the arrows mean (shown in blue marker on the example image). The class will label those together during the Consensus Discussion. Start co-constructing additions or revisions to this model by adding additional components and interactions that the class identified in the last step.*

Key Ideas

Purpose of this discussion: Develop an initial class consensus model to capture the ideas we agree and disagree on or are more uncertain about. Help students realize that even though we agree upon some common ideas, we still have many questions.

Listen for these ideas:

Areas of agreement:

- As we need more palm oil, farmers in Indonesia need to grow more oil palm trees.
- The tigers are eating the orangutans.
- The orangutans either need something from the rainforest that they aren't getting in the places where they grow oil palm OR there is something in these places that is harming them.
- The interactions between the living and nonliving things in the ecosystem are complex and seem to impact each other.

Possible areas of disagreement or controversy:

- What is happening to the orangutans? Is there something in the places where they grow oil palm that is harming the orangutans? Do the orangutans need something in the rainforest?
- Why are rats, snakes, and pig populations also changing? Do rats, pigs, and snakes do better in places with oil palm? Do rats, pigs, and snakes eat orangutans as they are dying? Do orangutans also eat rats, pigs, and snakes?
- Why can't orangutans just live in palm trees?

Suggested prompts	Sample student responses	Follow-up questions
What are some new things that we can add to the model to include any new components?	*snakes, rats, pigs, tigers, rainforest trees*	*Is this something everyone added?* *How did different people show the interactions between these different components? Did we all show it the same way?*
What is happening to the components? Are their numbers going up, going down, or are you not sure?	*We know that orangutans and tigers are going down and that rats, snakes, and pigs are going up. We also think that oil palm trees are going up and rainforest trees are going down.*	*Do all of those changes happen immediately? Are some of those changes delayed?*

throughout the course of the unit to take stock of what the class has figured out and where students need to go next will be an important tool for helping the class take on greater agency in steering the direction of their learning. This circle will also help build a sense of pride in their work. You may want to inform students that professional scientists also collaborate with one another to brainstorm, discuss, and review their work.

***Supporting Students in Developing and Using Cause and Effect**

At the middle school grade-band, students build on their previous understanding of cause and effect to include the idea that there can be multiple causes leading to the same effect. In this discussion, students build on a prior scaffold in which they identified potential causes, and work to trace, in the model, how each cause might contribute to the same effect. Consider using the following prompts from STEM Teaching Tool #41 to further support students' causal reasoning:

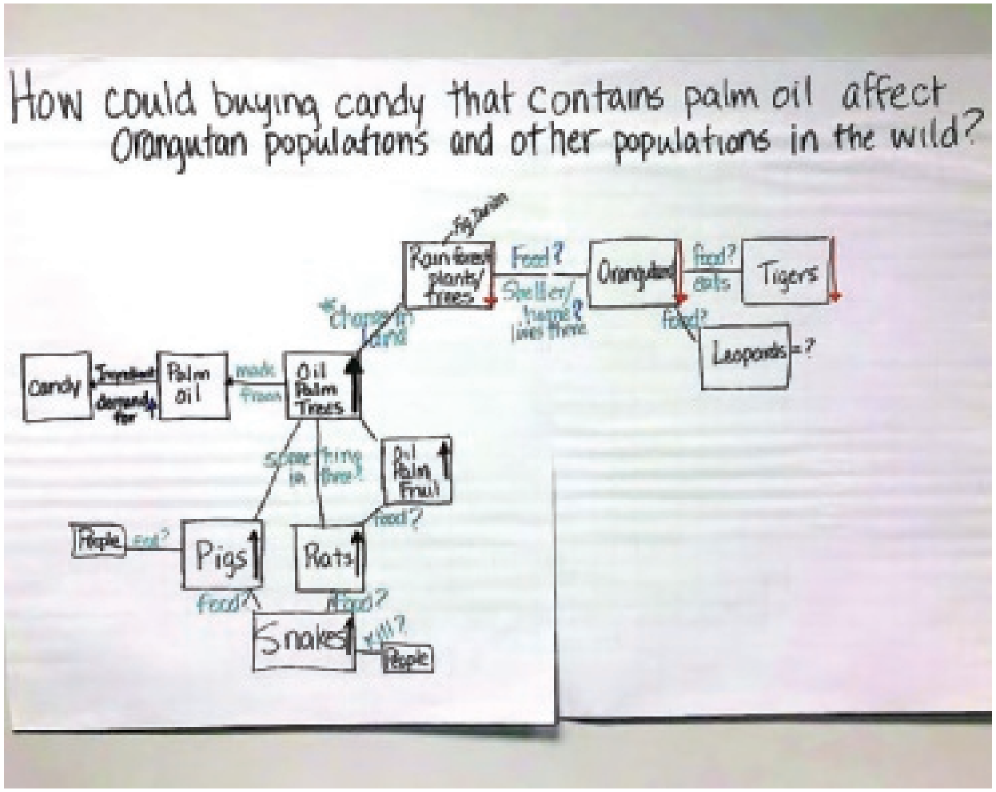
- How do ____ and ____affect ____?
- What evidence do we have so far that ____ causes ____ to happen?
- What do you predict would happen to ____ component if ____ component changed?

Students will revisit these ideas in a later lesson, particularly Lesson 10.

Suggested prompts	Sample student responses	Follow-up questions
What are some differences in how you showed the interactions between the components?	*I showed the snakes, rats, and pigs eating the dead stuff from the rainforest that was cut down.* *I showed the snakes, rats, and pigs eating food in the places where oil palm is growing.*	*So, are you saying that snakes, rats, and pigs might do better in the new environment? Can you say more about that?* *How is that different from what ________ is showing?* *Hmm, that's interesting. Did anyone else show the interactions between the different components differently?* *Are the connections between the components one-way, two-way, or are we not sure?*
What do we think is causing ___ and ___ to interact this way? What could we write in as the "mechanism" on top of the line showing the connection?	*For tigers and orangutans, we could show that tigers are eating the orangutans.* *For orangutans and rainforest trees, we could say that orangutans somehow need the rainforest trees, possibly for food, but we aren't exactly sure yet.*	*Which of these mechanisms are we sure about?* *Which of these mechanisms would we need more evidence about?*

Observe the cause-and-effect relationships included in the model.* Say, *When we initially developed our list of potential causes for populations increasing and decreasing, we noticed that there could be multiple causes contributing to the same effect.* Ask, *Where in our model do we see evidence of multiple causes contributing to the same effect?* Accept all student ideas, as long as students can identify more than one cause contributing to the same effect.

Say, *It seems like we have a lot of ideas about what is going on in Indonesia, but we have a lot of gaps in our mechanisms. We don't really know why orangutans can't just live in the oil palm trees. It sounds like we need to find some more information or data, or perhaps do more investigations to figure this out!* One example of an initial consensus model can be found below. It's important to follow your students' ideas during this discussion and not feel strongly tied to replicate this exact model.



Example Initial Consensus Model

11. Navigation

5 MIN

Materials: None

Navigate to the last part of the lesson by prompting students to consider related phenomena. Project **slide R** and assign students home learning. Prompt students to think about other examples where changing one component in an ecosystem affected the living things in the ecosystem. Students should record their ideas in their science notebooks and bring them to the next class.

Additional Guidance

This is the first time that the term "ecosystem" is used in a prompt for students in this unit. Students should be familiar with the term "ecosystem" from Grade 5 LS2.A: Interdependent Relationships in Ecosystems. If students have not used the term "ecosystem" before, take a moment to remind students that when we say "ecosystem," we are referring to groups of living things interacting with one another and their physical environment.

End of day 3

12. Share related phenomena.

8 MIN

Materials: science notebook, chart paper, markers

Have students locate their home learning on related phenomena. Project **slide S** and have students take out their home learning from the previous day. Remind students that they were asked to think about other examples where changing one component in an ecosystem caused other components to also change.*

Have students share their ideas with a partner. After a few moments, have students share their ideas with the whole class. Accept all student responses. Try to draw out a wide variety of related phenomena. Encourage students to consider how the related phenomena are similar to or different from the case of the orangutans and the oil palms. Keep a public record of the related phenomena. You may also want to prompt students to keep a record of the related phenomena in their science notebooks. Some examples of related phenomena can be found in *Example Student Ideas*.

The shift to related phenomena may feel disconnected from the palm oil problem, and that is OK. In Lessons 5 and 6, students will shift their focus to the problems presented in the palm oil case and how they relate to other similar problems.

Conclude the discussion by saying, *It seems like there are multiple cases that we can identify in which changing one living thing in an ecosystem can affect other living things in the same area. Sometimes the connections seem to be direct, and at other times, they don't seem direct. Sometimes, the cases involve people, and other times, they don't. All of these cases sound like they could be connected! Maybe if we can figure out what is going on with the orangutans and the oil palms, we can figure out how the living and nonliving things in these other cases are connected, too.*

Before we started thinking about these related experiences, we were trying to figure out "How could buying candy affect orangutan populations in the wild?" *Now, in light of this broader set of things we are wondering about, it seems like we need to modify our question a bit. Perhaps something like,* "How does changing an ecosystem affect what lives there?" Record this new question at the top of the DQB.

***Attending to Equity**
Universal Design for Learning: A key element of the Anchoring Phenomenon routine is letting students share their experiences with related phenomena. By doing this, students can connect their diverse experiences with the shared phenomenon that is the focus of the unit, supporting student *engagement* in the unit.

13. Develop initial questions.

5 MIN

Materials: sticky notes, markers, science notebook, *Asking Question Tool—Open/Closed Questions* (optional)

Prepare for the Driving Question Board. Display **slide T.** Remind students that we are going to try to capture all of our questions about what is going on with the orangutans and the oil palm, along with all of the related cases, so we can use our questions to guide our investigation into what is going on. To do this, we are going to build a DQB.*

Prompt students to take out and review the following resources (in their science notebooks):

- students' initial models
- the class model
- our list of related phenomena

After students have had a chance to review their resources, ask them to generate a list of questions about the case of the orangutans and oil palm, along with the other related cases. Students should record their questions on sticky notes—one question per sticky note. They should write their questions out big and bold—so everyone can see them clearly.

***Attending to Equity**
A DQB provides a public representation of the class's joint mission. Students can share their questions and wonderings with one another, and the visual representation offers another modality for students to access science in the classroom. It should be centrally located in the classroom so that it can be referenced and added to throughout the unit.

Give students several minutes to populate their sticky notes with questions. In order to generate a diverse array of questions, it helps to have students think carefully about the case of the orangutans and oil palm, along with other related phenomena.

If time permits, have students share questions with a partner, first. Ask students to share their questions with a partner to ensure that the questions are clear and productive for the phenomena. The partners should act as critical peers and ask clarifying questions if they don't understand something. Each student can edit their questions before sharing them with the whole class.*

Many of the questions students will have are very strong open-ended questions that can be utilized to help navigate into and out of future lessons in the unit.

- Is there another ingredient we can use besides palm oil?
- Why don't orangutans move away from the rainforest and get a new home?
- Why can't they use a different plot of land?
- Why are they taking down the rainforest trees?
- Why do palm oil farms attract pigs, snakes, and rats, but not other animals?
- Is there a way to make palm oil but not cut down trees?
- Why can't they use a different kind of oil?
- Why can't they move the trees to a different place, like a deserted island?

Other questions, such as "How many orangutans die every year?," are interesting but closed-ended. Work to help students broaden such questions into open-ended questions.* Consider some of the following prompts:

- "Hm, that's an interesting question—what made you wonder about how many orangutans die every year?"
- "What could that question help you figure out?"

If students are new to open versus closed questions, the *Asking Question Tool—Open/Closed Questions* is a scaffold that you can choose to support students in developing their questions.

14. Build the Driving Question Board. 20 MIN

Materials: sticky notes, markers, science notebook, Driving Question Board

Share questions to develop the Driving Question Board (DQB). Next, begin the process of developing a shared DQB. Background about the use of a DQB and guidance about the development of a DQB is provided in the Teacher Handbook.

Share **slide U** and say, *We have a lot of really good questions about the case of the orangutans and oil palm, along with some other related cases. It is important that we hear everybody's questions, and we might find that we have questions similar to some of our classmates' questions. In order to help us group similar questions, we are going to create a Driving Question Board, or DQB. We are going to use our DQB to guide our investigation into what is going on with the orangutans and the oil palm, and in our work of figuring out how changing one living thing in an area could affect other living things in the same area.*

Asking questions in everyday language allows students to share their thinking or experiences, even if they do not have the appropriate scientific vocabulary yet. This is helpful for emergent multilingual students, because by not requiring scientific words at the onset, you do not limit their participation in classroom discourse.

***Supporting Students in Developing and Using Cause and Effect**

Encourage students to use the crosscutting concepts of Cause and Effect or Systems and System Models to help develop questions. You may wish to provide Cause and Effect sentence starters such as:

- In the ecosystem, how did ____ cause ____?
- How do ____ and ____ work together to affect ____?
- How does ____ affect ____ and _____?
- What would be the effect if ____?
- What feedback loops are causing this system to _____?
- How can a small change to ___ have a big effect on ____?

***Supporting Students in Developing and Using Systems and System Models**

Systems and System Models sentence starters may include:

- What are the key parts of ____?

Instruct students to share their questions, one by one, with the whole group.* Explain to students how you will create the DQB:

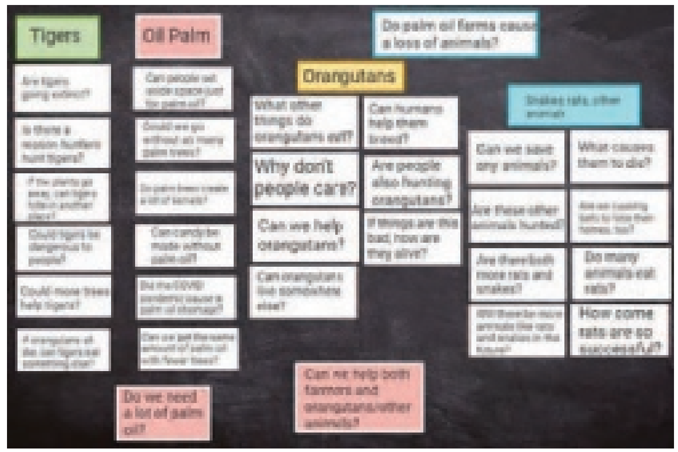
- The first student reads his or her question aloud to the class, and then posts it on the DQB.
- Students who are listening should raise their hands if they have a question that relates to the question that was just read aloud.
- The first student selects the next student whose hand is raised.
- The second student reads his or her question, says why or how it relates, and posts it near the question it most relates to on the DQB.
- The student selects the next student.
- Continue until everyone has at least one question on the DQB.

If the question is a new question and doesn't fit with any questions that are already on the board, students should create a new cluster.

Cluster the questions. After all students have shared their questions, you will end up with a DQB that has several different clusters of questions. As a class, decide on "umbrella" questions or topics for the clusters of questions.

Examples of the kinds of questions students might come up with can be found in *Example Student Ideas*.

Here are two examples of DQBs that were developed in field test classrooms.



Additional Guidance

If students are struggling to categorize questions on the DQB, consider starting with categories related to the components of the ecosystem (oil palm trees, orangutans, tigers, other animals, tropical rainforest trees). Next, consider the relationships among the components and try to generate categories or groupings that reside between two components. For instance, a grouping will likely emerge about the interaction between orangutans and oil palm trees. You may also wish to consider a grouping of related phenomena or similar cases in different ecosystems.

- How do the parts ____, _____, and ____ work together?
- What would happen in this system if you ____?

***Attending to Equity**

First and foremost during the formation of the DQB is reinforcing a classroom community, wherein all ideas are valued and everyone has a question up on the board. Use your judgment on how to press students to form "how" and "why" questions. If a student struggles with sharing, encourage them to go public with questions, rather than focusing specifically on forming a "how" or "why" question.

***Supporting Students in Three-Dimensional Learning**

When developing questions for the DQB, students are prompted to review their initial model, paying specific attention to the components and the interactions between the components (Systems and System Models) to develop questions (Asking Questions and Defining Problems) about the orangutan and oil palm tree populations in an ecosystem. Developing questions should require students to think about the ecosystem model and important science ideas in the context of the practice of asking questions.

Assessment Opportunity

Building towards: **1.B** Ask questions that arise from initial observations of populations in an ecosystem to help seek additional information about the parts of the ecosystem and how they interact.

What to look/listen for:

- Make note of any closed-ended questions and use navigation time throughout the unit to turn closed-ended questions into open-ended ones that necessitate a need to examine additional evidence. As you move into the discussion of ideas for future investigations and data we need, have students focus on categorizing their questions and then identifying the kinds of data and additional information that would help answer a category of questions.

What to do: Make note of the parts of the ecosystem that have many questions and the parts that have few or no questions. If a part of the system has few or no questions, prompt students to generate more questions in this space so that each part of the system has a set of questions to guide investigations. When students share their questions, make a note of how your students are doing in terms of asking "how" or "why" open-ended questions. Use *Asking Question Tool—Open/Closed Questions* as a scaffold to support students in turning closed-ended questions into open-ended questions. This scaffold does not need to be used as students build the initial DQB. Consider using it throughout the unit when students investigate a set of questions that may include many closed-ended examples.

15. Brainstorm ideas for data and information we need. 10 MIN

Materials: science notebook, Driving Question Board, chart paper

Brainstorm ideas for data and information we need. Now that the class has created a DQB, tell students that it is time to really dig into the hard work of figuring out what is going on! Stay in the Scientists Circle to brainstorm ideas for the data and information we need. Present **slide V** and ask students, *What kinds of information or data do we need to figure out the answers to our questions?*

Prompt students to use the categories of questions from the DQB to identify the data and information that would help them answer the category of questions. Have students turn and talk about their ideas before sharing with the whole group. Assign each small group a category of questions.

Have small groups share out their ideas with the whole group. Make sure that all groups get to share at least a few ideas. Make a class record of the ideas for future investigations and data we need. You may also want to prompt students to keep a record of proposed investigations in their science notebooks.

An example is provided below, and more can be found in *Example Student Ideas*:

Category of questions	Data and information that could be helpful
Where can oil palm trees grow?	Climate for oil palm trees Ideal temperature for oil palm trees Ideal amount of water for oil palm trees

16. Navigation

2 MIN

Materials: None

Discuss what questions to investigate next. Conclude the lesson by working with students to determine your next steps. Say, *We figured out a lot the past few days! We figured out that when the number of oil palm trees goes up, the orangutan population goes down. We think this has something to do with orangutans not having enough food or habitat, or being killed when oil palm trees are planted. It seems like growing oil palm is causing orangutan populations to decrease.*

Direct students' attention to the DQB and display **slide W**. Say, *We asked a lot of really good questions on our DQB! Which of these questions or clusters of questions do you think we should investigate first to help us understand the problem?* Allow students to propose which questions they would like to pursue first. Students will likely feel motivated to think more about palm oil as an ingredient and oil palm farms. In most cases, there will be a cluster of questions related to replacing oil palm with something else. As students share their thoughts about which questions to discuss first, you may wish to read several of the questions from the DQB. Work to develop agreement to pursue the questions about using oil palm as an ingredient first. Summarize by saying, *It seems like we have a lot of questions about why people use palm oil in foods and products in the first place, and if there is something else we could use instead, so we could help orangutans. That sounds like it could be a promising solution. Let's start our investigations there.*

ADDITIONAL LESSON 1 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

On day 2, students gather additional information from a reading about palm oil production and use it to determine that it is a crop grown to produce an oil that is an ingredient in many food and cosmetic products.

CCSS.ELA-Literacy.SL.6.1.c: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

When the class is building the DQB, if a student forgets to explain why or how their question is linked to someone else's question, press that student to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off of one another's ideas; it also helps scaffold student thinking.

If students can't figure out which question to connect with theirs, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question.

Today's activities rely on students communicating and articulating their thinking. One tool that may support classroom discussion is the *Communicating in Scientific Ways* sentence starters. This 1-page document can be blown up and printed as a class poster, printed on 8.5-by-11 paper, and posted near students' desks; it can also be scaled down and taped into students' science notebooks. To support discussion, reference the sentence starters on the poster and encourage students to use those sentence starters to help them communicate. The sentence starters can be especially useful for helping students engage in scientific discussion, particularly students who may feel reluctant to contribute.

LESSON 2

Can we replace palm oil with something else?

Previous Lesson

We examined headlines claiming that our candy-buying habits could affect orangutan populations in the wild. We examined candy ingredients and realized that one ingredient, palm oil, is produced in the same location in which orangutans live. We read about rainforests in Indonesia being cut down to make room for growing oil palm. We wondered how increasing oil palm trees can lead to a decrease in orangutans.

This Lesson

Investigation

1 DAY

IUCN

We wonder if there is a substitute for palm oil. We obtain information about soybean and canola oil, the two other most commonly consumed vegetable oils. We figure out that all three oils come from farming plants, which requires clearing either prairies or tropical rainforests. We analyze data and realize that palm oil requires much less land and produces way more oil compared with other oils. We conclude that any oil would require clearing land for farming and that palm oil is very efficient, producing a lot of oil using only a small amount of land, so it is probably not going away. This makes us wonder if there is somewhere else to grow palm oil so we won't harm orangutans.

Next Lesson

We will identify places around the world that have suitable nonliving conditions for growing oil palm plants. We will compare those locations to that of tropical rainforests. We will figure out that both kinds of plants share the same nonliving factor requirements and compete for the same space. This will make us wonder more about how farmers harm the ecosystems in these areas that were there first.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

2.A Define a pattern of design problems for systems that provide food resources that humans need (cause) but transform the land and the biosphere once occupied by native plants and animals (effect).

What Students Will Figure Out

- Different kinds of oils that we consume in foods and products come from farmed crops.
- Native plants are removed to make space for crops.
- In comparison to other oils, palm oil requires less land to grow.

Lesson 2 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**NAVIGATION** Discuss prior knowledge about ingredients from plants and make sense of palm oil as a product and oil palm as a plant by watching a video. Focus on the lesson question and revisit ideas for how to investigate possible palm oil substitutes.	A-C	chart paper, markers, computer, projector, Palm Oil—From Tree to Table video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), Driving Question Board (DQB), word wall
2	20 min	**EXAMINE SOYBEAN AND CANOLA OILS AS POSSIBLE SUBSTITUTES** Read and examine data about soybean oil and canola oil. Compare these oils to palm oil.	D-H	*Soybean Farms in the Midwest*, *Canola Farms in Canada*, *Growing Oil Palm in Indonesia*
3	10 min	**BUILDING UNDERSTANDINGS DISCUSSION** Discuss how all three crops require clearing land for farming, which means reducing native forest or grassland ecosystems. Discuss how oil palms are more efficient at producing oil per area of land than all other oil sources.	I-J	class whiteboard or chart paper, markers, initial consensus model (developed in Lesson 1)
4	5 min	**ADD TO OUR PROGRESS TRACKER** Record what we have figured out about possible palm oil substitutes in our individual Progress Tracker.	K	
5	2 min	**NAVIGATION** Revisit the DQB and navigate the class toward the Lesson 3 question: "Can we grow oil palm trees somewhere else so we're not cutting down tropical rainforests?"	L	
				End of day 1
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 2, students are ready to read Student Reader Collection 1 and then respond to the writing exercise.		Student Reader Collection 1: *Using Earth*

Lesson 2 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Soybean Farms in the Midwest* • *Canola Farms in Canada* • *Growing Oil Palm in Indonesia*		• chart paper • markers • computer • projector • Palm Oil—From Tree to Table video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Driving Question Board (DQB) • word wall • class whiteboard or chart paper • initial consensus model (developed in Lesson 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.

Prior to day 1, locate and watch the 7.5 Lesson 2 From Tree to Table video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Prepare to add three new terms to your class word wall: "palm oil," "oil palm," and "land-use change."

Use plastic sleeves or laminate readings for reuse across sections of science class and to protect the materials for later use in the unit. Alternatively, print a copy for each student to attach to their science notebooks as a reference.

If students have a print copy of their assigned reading, provide highlighters or colored pencils to help them annotate the text.

Online Resources

Lesson 2 • Where We Are Going and NOT Going

Where We Are Going

This lesson has three important purposes: (1) Within this unit storyline, this lesson serves to answer some of students' initial questions from Lesson 1 ("Is there a substitute for palm oil?"), while also further complicating the problem for them. Through this lesson, students realize that all oils come from plants, and farming these plants requires the clearing of native tropical rainforests or grasslands for space. Thus, using another oil would just harm a different ecosystem and the animals that live there. (2) This lesson also serves to complicate the problem, with students realizing that palm oil is the most efficient oil to grow because it requires the least amount of land, so the problem of clearing tropical rainforests for palm oil is likely not going away. Using a substitute oil is not a quick-and-easy solution. Students start to realize that solutions may be limited. (3) A new element for middle school is the integration of patterns to help identify cause-and-effect relationships. Students will be using the element of patterns as a lens for making sense across the three cases of vegetable oil that they will investigate in the lesson.

Where We Are NOT Going

Management of land use is a key idea that will be built throughout this unit, and Lesson 2 serves as an initial introduction to this idea. In Lesson 5, students will broaden their understanding of this problem beyond just farming plants for oil to land use in our communities (e.g., clearing land for livestock and/or clearing land for neighborhoods and communities). Anticipate this concept broadening to a discussion of land-use change in your local community or communities, but avoid touching on local problems until Lesson 5.

1. Navigation

8 MIN

Materials: chart paper, markers, computer, projector, Palm Oil—From Tree to Table video, Driving Question Board (DQB), word wall

Review a list of ingredients derived from plants. Display **slide A.** Review what students know about ingredients that come from plants. This is similar to the list created in Lesson 1, but focuses specifically on plant origins. Pose the question, *What ingredients are in our foods that come from plants, and which plants do they come from?* Using the classroom whiteboard or chart paper, record a list of ingredients and the plants they come from. Listen to students' responses and record examples such as the following:

Ingredients in food	Plant
maple syrup	maple tree
sugar	sugarcane
chocolate	cacao
flour	wheat
corn syrup	corn
cornmeal	corn
peanuts	peanuts

Distinguish between palm oil as an ingredient and the oil palm trees. Display **slide B**, which depicts both palm oil and oil palm trees, as shown in the class model from Lesson 1. Ask students what they notice about the two terms.* Listen for students to point out that *palm oil* and *oil palm* look similar but are mirror images. Ask students:

- What are some ways for us to remember that *palm oil* is the product or ingredient while *oil palm* is the plant?

Work together to discuss strategies and tips for helping students remember and differentiate the two words they investigate in this unit.

Additional Guidance

Add "palm oil" and "oil palm" to your word wall and include a photograph or picture to help students remember the difference between the two words.

Discuss ideas on how palm oil is extracted. Say, *So, we know that palm oil comes from the oil palm trees. But how do they get the palm oil?* Ask 2–3 students to predict how we extract palm oil from oil palm trees, based on what students learned in the *Maple Syrup Unit*.

***Attending to Equity**
Universal Design for Learning: We use *palm oil* in reference to the product or ingredient and *oil palm* in reference to the trees. People in the industry tend to distinguish between the two, while the popular press and media mostly use only the term *palm oil*. The distinction between the two terms may be difficult for your students and particularly challenging for your emergent multilingual learners. Use this conversation as an intentional moment to build students' understanding of these two terms and to *clarify vocabulary (representation)*, which students encountered in Lesson 1 and will continue to encounter frequently in this unit.

***Supporting Students in Engaging in Asking Questions and Defining Problems**
Referencing the DQB reminds students that the purpose of the unit is to answer questions students have posed that the class is investigating together. Many students will likely have wondered if there is a substitute for palm oil. Reminding them that this question came from the class can help motivate them and maintain student interest.

Watch a video on how to extract palm oil. Watch the *Palm Oil—From Tree to Table* video, which shows how palm kernels are heated and oil is extracted. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Spend about 2–3 minutes sharing students' observations about the video and discuss how this process is similar to or different from those you learned about in the previous *Maple Syrup Unit* unit. Use your discussion of the video as an opportunity to practice using words such as *oil palm trees*, *palm oil kernel*, and *palm oil*.

Focus on one particular DQB question, which was previously posed by many students: "Is there a substitute for palm oil?" Reference the DQB and remind students that many of them wondered if we could use some other kind of oil.* Project **slide C** and have a few students remind the class about the information the class thought would be helpful for answering this question.

Suggested prompts	Sample student responses
What information did we say would be helpful for answering this question?	*information about other oils or substances that can do the same thing that palm oil does in food or beauty products*
What other kinds of vegetable oils have you seen before?	*vegetable oil, olive oil, canola oil, peanut oil, and sesame oil*

2. Examine soybean and canola oils as possible substitutes.

20 MIN

Materials: science notebook, *Soybean Farms in the Midwest*, *Canola Farms in Canada*, *Growing Oil Palm in Indonesia*

Introduce other types of vegetable oil. Say, *There are a lot of different kinds of oils, and they can help products or foods achieve the right consistency, like palm oil does. Let's take a look at the vegetable oils that are consumed worldwide.* Project **slide D** and lead a brief class discussion about what students notice about these oils and their prior experiences.

Suggested prompts	Sample student response
What do you notice about vegetable oils that are consumed worldwide?	*Palm oil and soybean oil are used the most.* *Not that many different kinds of oils are commonly used.*
Is anything surprising to you?	*There isn't any oil called "vegetable oil."* *Olive oil is not on the list.*
Do you have any experience using any of these oils?	*Accept all answers.*

Observe common vegetable oil ingredients. Project **slide E** and have students look at the main ingredients in different vegetable oils.* Point out that the main ingredients in these two vegetable oils are soybean oil and canola oil.

***Attending to Equity**
Universal Design for Learning: Students may not realize that "vegetable oil" is often made from soybean, canola, sunflower, or a mixture of several different kinds of oil. They also may not realize that these oils are found in many of the foods they eat. Prompt students to look at the ingredients list on vegetable oils and other processed foods that they have at home and report back to share if they contain soybean, canola, palm, sunflower, or any other oil. This is an important way of supporting student *engagement* by

Focus on soybean and canola oils as possible substitutes. Say, *Palm oil is the most commonly consumed vegetable oil. Let's investigate soybean and canola oils, the next most commonly consumed oils, to see if they could be possible substitutes.*

Introduce a pre-reading strategy. Tell students that you have some short readings about these two kinds of oil. Ask students to define the purpose of this reading. Listen for students to suggest the following:

- *To learn more about soybean and canola oils, and compare them to palm oil*
- *To find out if there is a substitute for palm oil that is a better choice*

Divide students into groups of four and then into pairs within each group. Have each pair decide if they want to read either *Soybean Farms in the Midwest* or *Canola Farms in Canada*. You should have two copies of these cases. The first copy is printed in color in the Reference section of the *Student Edition*. A second copy is included as a handout (*Reference: Soybean Farms in the Midwest* and *Reference: Canola Farms in Canada*) for printing, writing on, and attaching to students' science notebooks. You can use either option for this activity.

Make a box and T-chart organizer for comparison. Present **slide F** and model how to make a box and T-chart (see example below). Give students time to make that chart in their science notebooks. Explain that notes about what the different kinds of oils have in common can go in the "similar" category and notes about how palm oil and soybean/ canola oil are different can go in each of the bottom boxes.

Additional Guidance

For the T-chart of differences, encourage students to compare the same property or characteristic by placing those ideas across from each other on the chart. For example, students should consider where each type of oil is grown. Palm oil is grown where there are tropical rainforests, *but* canola and soybean oil are grown where there are prairies. Place these differences alongside each other in the left and right columns of the T-chart.

Read about soybean and canola oils. Give students time to work in pairs to read about either *Soybean Farms in the Midwest* or *Canola Farms in Canada*. Then have students compare what they have read about canola or soybean oil to what they read in Lesson 1, *Growing Oil Palm in Indonesia*.

Share information about canola and soybean oils. Project **slide G** and give students time to work in groups of four to share about the specific oils they studied, compare all three oils, and discuss whether canola or soybean oil are possible substitutes for palm oil.*

Example box and T-chart:

Similar
• *All three oils are used in foods, as well as products.* • *Growing all of these oils means clearing land to grow crops.* • *Farming causes some populations of organisms who live in these areas to decline (such as orangutans and bison).*

optimizing relevance to their lives; it is directly connected to foods that students eat and products that they consume.

***Attending to Equity**

Universal Design for Learning: To support student *engagement* and *relevance*, if students live near large-scale soybean or canola farms, ask students to consider what the native habitat was in their area before these farming operations. Likewise, ask your students if they have ever driven through large-scale agriculture or seen what this looks like on television or the internet. Ask students if they have ever been to a tallgrass or shortgrass prairie. This can help students relate to people who live near palm oil farms by connecting to their own experiences of living near or experiencing large soybean or canola farms (or other crops).

Different	
Palm oil	**Canola oil / soybean oil**
• *Cut down rainforests* • *Uses less land (½ football field for 1 ton)* • *Affects orangutans* • *Comes from fruits and kernels*	• *Cut down prairies* • *Uses more land (2–4 football fields for 1 ton)* • *Affects bison and other species* • *Comes from seeds*

Discuss the similarities and differences as a whole class. Have a few groups of students share their responses about why palm oil is similar to and different from canola and soybean oils.

Discuss the differences involving the land required to produce canola, soybean, and palm oils. After students share the differences between the oils in terms of land use (e.g., when you hear students say, "Palm oil requires less land for the same amount of oil"), say, *I have additional information about land use. Let's see if this helps us understand these differences more clearly.* Project **slide H** and continue the whole-class discussion.

Suggested prompt	Sample student response	Follow-up questions
How do these oils compare in terms of how much land is used? How much oil is produced?	*Palm oil uses less land than the others. Palm oil produces more oil using the same amount of land.*	*Why might the amount of oil produced on the same amount of land matter?* *Why might the amount of land used matter?* *Who does it matter for?*

Additional Guidance

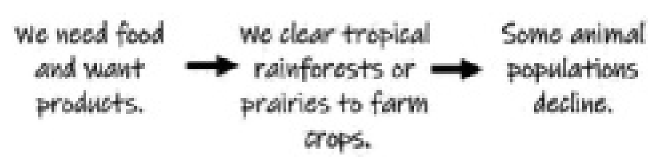
Soybean, corn, and oil palm farms are all operating at an industrial scale as part of a large global food system. Large-scale farms are often, but not always run by corporations with primarily economic interests. These kinds of farms may not match your students' understanding of "farm." Emphasize to students the magnitude of this scale when showing **slide H** and discuss the tons of oil that are produced on these large-scale farms.

3. Building Understandings Discussion

10 MIN

Materials: class whiteboard or chart paper, markers, initial consensus model (developed in Lesson 1)

Discuss patterns across the cases. Have groups return to a whole-class discussion to share the patterns and similarities they noticed across the cases. Then answer the lesson



***Supporting Students in Engaging in Argument from Evidence**
Ask students to make claims in response to the question "Is there

question (**slide I**).* As students share their thoughts about the patterns, chart the cause-and-effect relationships they share on the whiteboard or a piece of chart paper.

Display **slide J**. Then discuss if canola or soybean oil is a good substitute for palm oil (**slide I**). Have students share arguments based on the evidence they have gathered from the readings and infographics to answer the question “Is there a substitute for palm oil?”

a substitute for palm oil?” As students share oral arguments, push them for evidence from the readings and infographics to support their claims. Example prompts include:

- What’s your evidence?
- How does that idea fit with ____’s claim?
- Does anyone have additional evidence to support _____’s claim?

Key Ideas

Purpose of the discussion: To realize that humans depend on the land and the biosphere to get what we need, specifically to grow crops, and palm oil is more efficient in terms of land use than other vegetable oil crops. This is part of why its production is increasing and why it is not realistic to stop growing it.

Listen for students’ ideas:

- *All oils can be used for food or in other products.*
- *All oils come from plants grown as crops, and those crops need land to grow.*
- *To farm or grow crops, we need to clear land, which means cutting down native forests or grasslands.*
- *Palm oil uses less land and produces more oil, so it is more efficient than other oils.*

Suggested prompts	Sample student responses	Follow-up questions
What patterns do you notice that are similar across these three different types of oil?	*All three of these crops used to make oil are grown for food or used in products.* *All three of these crops need land to grow.* *We clear ecosystems to grow all three of these crops.*	*Are there patterns in what happens to the ecosystems that were there before farming happened?*
Is canola or soybean oil a possible substitute for palm oil?	*Yes, they can both be used in food or cosmetic products.*	*Are they a good substitute?* *What would make another oil a good substitute?*
Is canola or soybean oil a good substitute for palm oil?	*No, you also have to clear land to grow these oils, which is bad for ecosystems; it just involves different ecosystems in different parts of the world.* *Palm oil uses a lot less land and produces a lot more oil in the same amount of land as the other options.* *Yes, you could substitute them, but then we’d do even more harm to a different ecosystem and different organisms, because we’d need more land.*	*Which oil is better in terms of how much land is needed?*

***Supporting Students in Three-Dimensional Learning**
By comparing across three different cases, students see patterns in how converting native plant communities to agriculture for food production causes similar problems for animals in different ecosystems. They recognize and define this pattern as a problem across multiple systems, and one that affects the populations that live there.

Assessment Opportunity

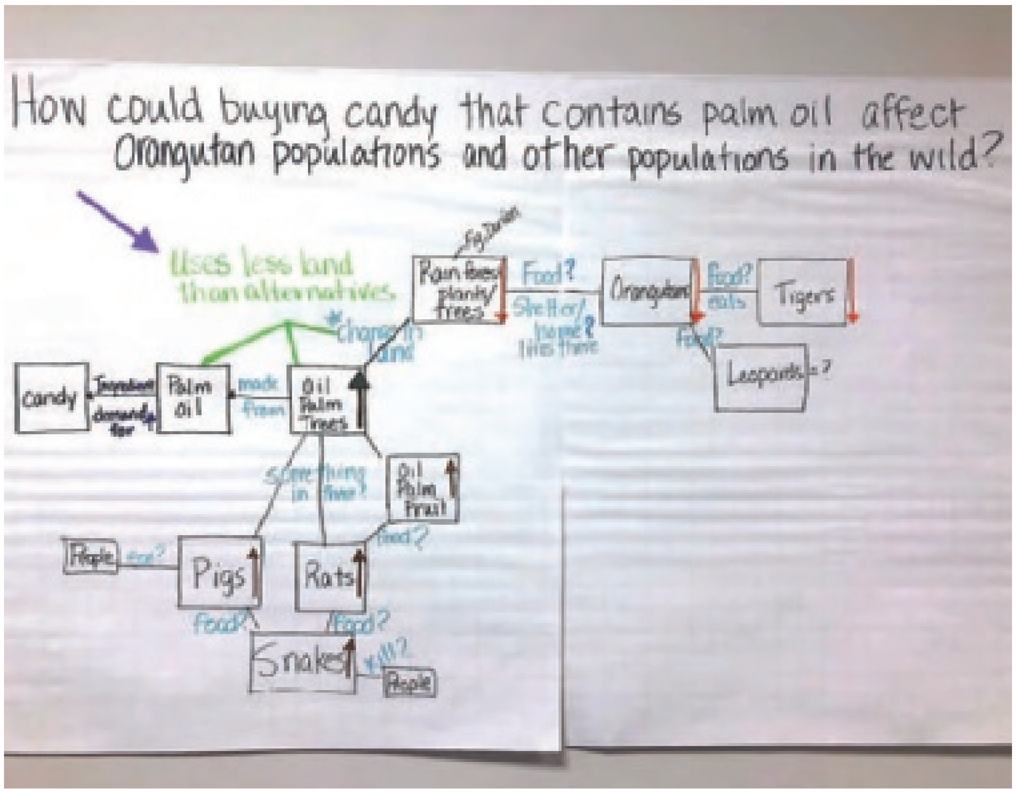
***Building towards:* 2.A** Define a pattern of design problems for systems that provide food resources that humans need (cause) but transform the land and the biosphere once occupied by native plants and animals (effect).

What to look/listen for: See the Key Ideas above.

What to do: If students are struggling to conclude that palm oil is more efficient than soybean or canola oil in terms of the amount of land it requires, help them connect the idea that more efficient plants mean less land is needed for agriculture by asking them, "How much tropical rainforest would need to be cut down to produce one ton of palm oil, and how much grassland would need to be cleared to produce one ton of soybean oil? What impact would that have on the populations living there?" If students wonder if it's better to clear more prairie land for soybean or canola oil compared to clearing tropical rainforests, be prepared to share about the biodiversity found on prairie land, such as diverse plant life, insects and pollinators, birds, burrowing mammals (e.g., prairie dogs), foraging herbivores (e.g., various species of deer and bison), and predators (e.g., coyote, fox, owls, and hawks, etc.)

Define "land-use change". At this point, define and discuss "land-use change". Add this term to your word wall.

Revise the Lesson 1 consensus model to add "land-use change." Add it to the Lesson 1 model, where there is a conversion from tropical rainforests to oil palm.



4. Add to our Progress Tracker.

5 MIN

Materials: science notebook

Revisit the DQB question and answer the lesson question individually. Remind students about how many of them wondered if there was a substitute and hence this was the lesson question.

Set up the Progress Tracker for an individual reflection. Explain to students that we want to take some individual time to capture what we have figured out from our reading about different types of oils. Have students turn to the Progress Tracker section in their notebooks. Use **slide K** to guide students in drawing a T-chart on the first page of this section and to complete the two columns, filling in the lesson question: "Is there a substitute for palm oil?" This should be followed by their response.*

Give students 3–5 minutes to quietly update their Progress Trackers, using words and drawings to show what they have figured out about possible palm oil substitutes. Ask students to draw a line underneath their responses when they are done. Prompt students to identify and use any patterns from the readings they have reviewed.

***Attending to Equity**
The individual Progress Tracker is a space for students to be creative and to synthesize learning in their own words and pictures. It is not supposed to follow a prescriptive plan or structure, and should be a low-stakes opportunity for students to make sense of what they are learning without the worry and anxiety that comes with knowing their work will be graded. Students have already engaged in discussion about this question, so the Progress Tracker provides an additional modality for students to express their understanding in their own way. Encourage students to express what they have learned using a mode that makes sense for them.

5. Navigation

2 MIN

Materials: science notebook

Revisit the DQB to navigate to the next lesson. Project **slide L**. Say, *It seems like palm oil is the most efficient oil and is a better ingredient than other oils. So the problem is more complicated, and it's unlikely that palm oil will go away. Let's revisit our DQB to see what other questions we had about palm oil.*

Give students a minute to review questions on the DQB and then take suggestions for future possible questions from the class. If no one brings up questions about trying to grow palm oil somewhere else, prompt students with "If palm oil is not going away, could we grow palm oil somewhere else to avoid cutting down the tropical rainforest and hurting orangutans?"

Have students share initial ideas about the next lesson question: "Could we grow palm oil somewhere else so we're not cutting down tropical rainforests?"

ADDITIONAL LESSON 2 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-LITERACY.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text that is distinct from prior knowledge or opinions.

Soybean Farms in the Midwest, *Canola Farms in Canada*, *Develop an Initial Model: Candy and Orangutans*, and the box and T-chart organizer provide an opportunity for students to synthesize the central ideas of the text regarding the question: "How is palm oil similar to and different from canola or soybean oil?"

SCIENCE LITERACY: READING COLLECTION 1

Using Earth

1 **Extracted Resources**

2 **Shopping for Oils**

3 **Once Hunted for Oil, Now an Ecotourism Draw**

4 **Land Cover Changes in the U.S.**

Literacy Objectives

- ✓ Read to find out how extracted resources affect ecosystems.
- ✓ Recognize that extracted resources come from a variety of sources.
- ✓ Read to describe how different extracted resources are produced.
- ✓ Read to explain different uses for extracted resources.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 1–2.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a chart to describe where different oils come from and how they are produced in response to the reading.

Instructional Resources

Student Reader Collection 1	**Science Literacy Student Reader, Collection 1** "Using Earth"
Exercise Page EP 1	**Science Literacy Exercise Page** EP 1

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 1: How could buying candy affect orangutan populations in the wild?
- Lesson 2: Can we replace palm oil with something else?

Standards and Dimensions

NGSS Performance Expectation

LS2-1: (Building toward) Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Disciplinary Core Idea LS2.A: Interdependent Relationships in Ecosystems

Science and Engineering Practice: Analyzing and Interpreting Data

Crosscutting Concepts: Cause and Effect; Patterns

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.W.7.2

Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

ecosystem dynamics

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

ecotourism **extraction**

land cover **resource**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Ecosystem Dynamics unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
    - *In "Extracted Resources," you will find out about living and nonliving resources that humans take from natural environments to produce energy for a variety of purposes.*
    - *In the second selection, you'll read about the resources people use to produce different kinds of foods.*
    - *"Once Hunted for Oil, Now an Ecotourism Draw" makes you think about what happens to resources when they are no longer needed for a given purpose.*
    - *In "Land Cover Changes in the U.S.," you'll read about how the uses of land change over time.*

Exercise Page

EP 1

- Distribute Exercise Page 1. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
    - *For this assignment you will be expected to generate a chart of different oil products used over the course of a week.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
    - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
    - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
    - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
    - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
    - *Revisit the reading selections to complete the writing exercise.*
    - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What is an extracted resource?	*It's something that is taken out of the place where it appears naturally.*
What are some different oils that you use or eat?	*vegetable oil, olive oil, canola oil, skin or baby oil, mineral oil, corn oil, motor oil, household penetrating oil*
Can you avoid using or eating products with oil in them?	*It would be very difficult because oil is a key ingredient in many foods. It is on the food pyramid, so you need it to be healthy. Also, many machines would not run without oil.*
What is an example of something you used to eat but don't anymore?	*baby food because I have teeth now* *cereal because I don't like it anymore* *cheese because it made me sick* *pickles because they are too sour*

Suggested prompts	Sample student responses
What would happen if everyone stopped eating that food?	*The company that makes that food would go out of business. The makers would have to find another use for it.*
How has land use changed where you live during your lifetime?	*A roundabout was built where there used to be trees. Farmland was used to build houses. A road near our school was widened.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
What do you eat or use that may have palm oil as an ingredient?	*chocolate, ice cream, cookies, bread, margarine, detergent, shampoo, soap*
What are the benefits of using palm oil?	*It is not expensive.* *It is easy to use with a variety of foods.*
What are some problems with using palm oil?	*Producing palm oil might be destroying rainforests and habitats for rainforest animals.*

- Refer students to the Exercise Page 1. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The writing expectation for this assignment is to create a chart of oils you eat or use in a week along with what you use them for and where they come from.*
    - *In the selections, you learn about products that are extracted for use by humans. You also think about what happens when certain resources are no longer needed and how land use is affected by extracting resources.*
    - *Think about what you read as you make a list of at least five oils you eat or use in a week.*
    - *You'll need to do some research to find out where those oils come from.*
    - *Then make a chart that lists each oil, how you use it, and where it comes from.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 1

4. Facilitate discussion.

(FRIDAY)

Facilitate class discussion about the reading collection and writing exercise.

The four reading selections help explain how products are extracted for human use and what effect that has on ecosystems.

Pages 6–9 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Extracted Resources"?	*It describes nonliving things, formerly living things, plants, and animals that are removed and processed for human use.*
Why do humans extract resources?	*Different resources provide food or food ingredients. Other resources provide building materials, and others provide energy for electricity, heat, and transportation.*

Pages 10–11 **Suggested prompts**	**Sample student responses**
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first selection was about extracting resources for human use. The second selection shows the huge variety of products that can be made from extracted resources.*
Which are better to use: plant or animal oils?	*It depends on what resources are available. It takes more resources to raise or hunt animals for their oil, so plant oils might be better to use for the environment.*
What is the difference between dairy milk or butter and plant milk or fats?	*Dairy milk comes from raising and milking animals like cows or goats and processing their milk.* *Plant milk comes from raising plants, such as soy, oats, or almonds.*
What types of milk and oils do you eat?	*vegetable, canola, or olive oil; cow's milk, almond milk*

Pages 12–13 **Suggested prompt**	**Sample student response**
What is the general purpose of the third article, "Once Hunted for Oil, Now an Ecotourism Draw"?	*It describes what happens to a resource that was no longer used by humans.*

Student Reader

Collection 1

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Review the meaning of the word *ecosystem* by breaking the word into its combining form and root: *eco* and *system*. Make a list of words that begin with *eco* (e.g., *ecology, ecotourism, eco-friendly*) to confirm that *eco* has to do with nature and environment. An ecosystem is a system or community of living things that interact with nonliving things in a certain location.

SUPPORT—Reinforce the concept of extraction by having students describe different types of extraction, such as a tooth extraction, a splinter extraction, washing clothes to extract dirt from fabric, and extracting seeds from fruit.

Pages 12–13 **Suggested prompts**	**Sample student responses**
What were the negatives about using shark or whale oil on a massive scale?	*They had to kill a lot of animals to provide the oil.* *As population and need for oil grew, the animal population decreased almost to extinction.*
What alternatives might be considered when a resource like shark oil is no longer used?	*allowing the sharks to return to the wild* *making the shark population a tourist attraction*

Pages 14–15 **Suggested prompts**	**Sample student responses**
How does the last selection relate to the other selections in this collection?	*It describes how land use has changed as resources have been extracted.*
What could happen if resources are not extracted and used thoughtfully?	*The land can change, and resources can become extinct.*
What would happen if people stopped extracting resources?	*There would not be enough food, building materials, or sources of energy to sustain the world's human population.*

CHALLENGE—Have interested students research products that have palm oil as an ingredient, using food labels and other resources. Ask them to present their findings to the class.

EXTEND—Have students watch a video showing how soy milk or other plant milks are made on a small or large scale.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 1, students create a chart that lists at least five different types of oil they use in a week, what they use them for, and where those oils come from.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 3

Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?

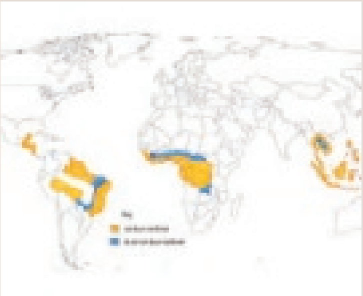
Previous Lesson

We wanted to figure out if there was a substitute for palm oil. We read and examined data about soybean and canola oil. We figured out that any oil would require clearing land for farming, which could harm animals, and that palm oil is very efficient, producing a lot of oil in a small amount of land. This made us wonder if there was somewhere else we could grow palm oil so we wouldn't harm orangutans.

This Lesson

Investigation

1 DAY



We decide that oil palm may be the best plant to grow compared to alternatives. We wonder if we can grow oil palm in other places. We obtain more information about the nonliving conditions that the oil palm plant needs to grow and examine maps that meet these conditions. We figure out that oil palm grows best in equatorial regions, which is also where tropical rainforests are located. We conclude that both kinds of plants share the same nonliving requirements and compete for the same space to grow. This makes us wonder how oil palm farmers and other farmers grow crops in places where they harm the ecosystem that was there first.

Next Lesson

We will hear from people who farm oil palms to learn the reasons why they cut down tropical rainforests, even though it is bad for the animals that live there. We will learn that many of these farmers are struggling to make ends meet and that the tropical rainforest is often the only resource from which they can make money. This will lead us to consider why people have changed the land where we live and how that has impacted the living things around us.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

3.A Define a problem in which oil palm is dependent upon the same environmental interactions with nonliving factors as other tropical rainforest plants (pattern).

What Students Will Figure Out

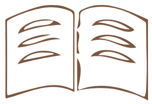
- Oil palm plants need a certain amount of sunlight, precipitation, and warm temperatures to grow.
- Oil palm plants grow in the same locations as tropical rainforests (near the equator) because of these good growing conditions.

Lesson 3 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Set the purpose for the lesson using questions from the DQB about growing oil palm plants somewhere else.	A	Driving Question Board
2	10 min	**IDENTIFY OIL PALM PLANT NEEDS** Students turn and talk about plant needs and then work together as a class to construct a list of plant needs.	B-C	*Farmer's Almanac: Oil Palm Plant*, chart paper, markers
3	8 min	**LOCATE PLACES TO GROW OIL PALM PLANTS** Students engage in analyzing and overlaying pre-colored solar radiation, precipitation, and temperature maps showing locations that meet the conditions required by the oil palm plant.	D-E, J	colored pencils, *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?*, Conditions to Grow Oil Palm Plants map, Location of Tropical Rainforest map
4	12 min	**FACILITATE A BUILDING UNDERSTANDINGS DISCUSSION ABOUT WHERE OIL PALM GROWS** Project a blank world map for the class to color together, coloring only locations suitable for growing oil palm plants. Then compare to tropical rainforest locations using a Building Understandings Discussion.	F-G, J-N	*Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?*, projected blank world map from student handout, markers, chart paper, initial consensus model (developed in Lesson 1 and modified in Lesson 2)
5	5 min	**ADD TO PROGRESS TRACKER** Record what we have figured out about the conditions needed to grow oil palm plants and the locations that meet the growing conditions of oil palm plants compared to tropical rainforest locations.	H	
6	5 min	**NAVIGATION** Students look back at the DQB to locate questions they had about how or why people/farmers cut down forests to grow oil palm. Have students complete an exit ticket with their initial thinking to their questions.	I	sticky note, Driving Question Board

End of day 1

Lesson 3 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Farmer's Almanac: Oil Palm Plant* • colored pencils • *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?* • sticky note	• Conditions to Grow Oil Palm Plants map • Location of Tropical Rainforest map	• Driving Question Board • chart paper • markers • Projected blank world map from student handout • initial consensus model (developed in Lesson 1 and modified in Lesson 2)

Materials preparation (15 minutes)

Online Resources

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

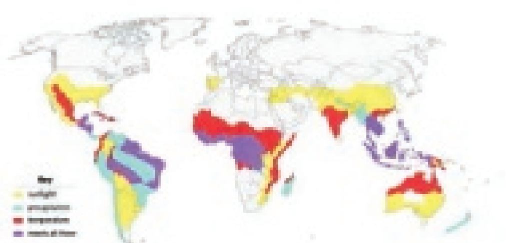
Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Prepare a space for the class to record a consensus map of locations suitable for growing oil palm plants. Options include (1) printing an 8.5-by-11 copy of *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?*, using a document camera to project the map on a screen or wall, coloring regions onto the map as the class agrees upon them; (2) projecting the map from a computer onto a whiteboard and coloring in regions on the whiteboard using dry erase markers; or (3) using an online program or app (e.g., Notability) that allows you to project the map and color regions with digital tools built into the app.

The *Farmer's Almanac: Oil Palm Plant* handout is designed to be cut in half, with one half of the page given to each student.

Make a decision about which maps to use for this activity. You need to decide (1) whether to use the color version or black-and-white version, and (2) for the *Conditions to Grow Oil Palm Plants* data map, whether to use all the data layers or the combined layer only.

Conditions to Grow Oil Palm Plants data map (choose 1 to print for students)

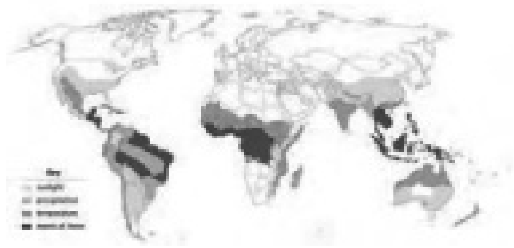


color map with all data layers

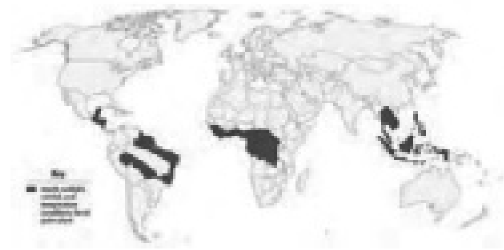
color map with only combined layer

Locations of Tropical Rainforests data map (choose 1 to print for students)

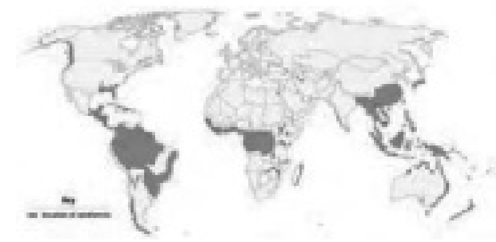
color map



black-and-white map with all data layers



black-and-white map with only combined layer



black-and-white map

All versions of the maps can be found on **slides J-P.**

Lesson 3 • Where We Are Going and NOT Going

Where We Are Going

Throughout this lesson, students progress toward answering their initial questions from Lesson 1 ("Can we just plant it somewhere else?"), while also further complicating the problem for them. Building on students' understanding of plant needs and growth from the *Unit 7.4: Where does food come from, and where does it go next? (Maple Syrup Unit)* unit, students come to realize that oil palm plants are dependent on nonliving conditions that are suitable for their growth. Oil palm plants' and tropical rainforests' interactions with the nonliving environment limits where they can grow, which is around the equator (LS2.A: Interdependent Relationships in Ecosystems). After analyzing a worldwide overlay map showing areas meeting the growing needs of oil palm (daily sunlight, temperature, and precipitation) and tropical rainforest location map, students identify a pattern: tropical plants that make up rainforests are located in similar areas suitable for oil palm plant growth, and thus they both require the same nonliving growing conditions. Thus the solutions to the palm oil problem are limited based on suitable nonliving conditions for growing crops. This lesson also sets students up for thinking about competition between plants grown in natural ecosystems, such as the tropical rainforest, and plants grown by humans for food, which is part of a human impact story that will be taken up further in the *Droughts and Floods Unit* unit.

Where We Are NOT Going

Students have not yet developed an understanding of a single organism versus a population of organisms, but they are working toward this understanding over the course of the next few lessons. Avoid focusing on the distinction between an organism (like an individual oil palm plant) and a population of organisms (oil palm farm) or a community of populations (tropical rainforest). Students will get to these distinctions in Lesson 7. However, keep this goal in mind as students share their thinking about plant needs and where certain "kinds" of plants can grow. Language such as "one plant," "many of the same kind of plant," and "many different kinds of plants" can be a useful way to distinguish at this point in the unit without using scientific terminology. This lesson uses "nonliving" as opposed to "abiotic". It is your discretion about whether your students need the term "abiotic" or you want to reinforce students using this term from their previous learning.

LEARNING PLAN FOR LESSON 3

1. Navigation

5 MIN

Materials: science notebook, Driving Question Board

Set the purpose for the lesson using questions from the DQB. Display **slide A**. Have the Driving Question Board (DQB) visible to students. Stand near the DQB and say, *Yesterday we figured out palm oil was a better ingredient than alternatives. Can someone remind us of why it was better than the alternatives?*

Listen for:

- *It requires less land compared to alternative crops.*
- *It is more efficient on less land.*
- *When we plant other crops, we are changing other ecosystems and affecting things that live in those locations.*

Say, *So there doesn't seem to be anything else that is better than palm oil. So if it's better than other crops for oil, it makes me wonder could we grow it somewhere else. And some of you were curious about this too. Let's take a look at some of your questions from the DQB*. Ask for one or two students who had a question in this category to share their thoughts about their question.

Establish the purpose to figure out more about the question, *Can we grow oil palm plants somewhere else so that we're not cutting down tropical rainforests?*

2. Identify oil palm plant needs.

10 MIN

Materials: science notebook, *Farmer's Almanac: Oil Palm Plant*, chart paper, markers

Transition to oil palm needs. Say, *To figure out if we can grow it somewhere else, we probably need a little information about what it needs to grow.*

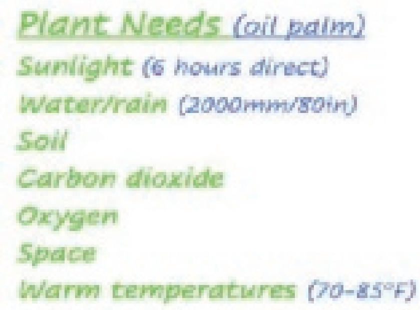
Turn and Talk. Display **slide B**. Have students turn and talk about the prompt on the slide, *What do we think the oil palm plant needs to grow?* This should be a brief opportunity for them to quickly articulate their thinking to a peer.

Develop a list of oil palm needs. Bring students back together. Elicit from the class a list of oil palm plant needs based on what they know about general plant needs. This should leverage what students know from the *Maple Syrup Unit* unit.* Record this list on chart paper. As you record the list, point out your own observation that all of the things on the list are nonliving.

Additional Guidance

The student handout used next, *Farmer's Almanac: Oil Palm Plant*, contains two almanac entries per page. Print copies and use a paper cutter to cut each page in half. Trim the white edges around the entry to make it fit in students' science notebooks".

Read more about palm oil needs. Display **slide C**. Arrange students in partners. Pass out 1 copy of *Farmer's Almanac: Oil Palm Plant* to each student. Students can attach this to their science notebook, following the directions on **slide C**. Prompt students to read the almanac entry and underline what the plant specifically needs to grow.



Discuss oil palm's needs to add specifics to a class chart. Bring students back to the whole group. Near the class list of plant needs, add the new information about specific oil palm plant needs. Use a different color to represent what we learned from the reading. Consider labeling these as "nonliving factors" just below the title "Oil palm needs" on the chart paper.

Say, *We have some of these data in our reference materials, like daily sunlight, precipitation, and temperature. If we were to examine those three things, how could we use the information to decide if we can grow it somewhere else?* (Display the prompt on **slide B**.) Listen for students to suggest:

- *We can find places that have all of these conditions.*
- *We look at the data to see if there are other places with this sunlight, rain, and temperature data.*

Say, *Let's take a closer look at the data to see where we can grow oil palm plants.*

***Attending to Equity**
Universal Design for Learning: It is beneficial for all students, but particularly emergent multilingual learners and students identified with special learning needs, to have the opportunity to *activate* and apply previously learned knowledge (*representation*). This allows students to contribute prior knowledge to the new context and to practice using previously learned specialized terminology in a new context, as well.

3. Locate places to grown oil palm plants. 8 MIN

Materials: science notebook, colored pencils, *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?*, Conditions to Grow Oil Palm Plants map, Location of Tropical Rainforest map

Additional Guidance

The maps needed for this activity are located in the reference section of the *Student Edition*. This includes both colored maps and black-and-white maps showing the locations that meet the sunlight, precipitation, and temperature conditions required for the oil palm plant, locations that meet all three conditions, and locations of tropical rainforests. You can provide each student or each group with a set of the colored maps or provide a copy of the black-and-white map that they can attach to their science notebooks.

Universal Design for Learning: You may want to first display the *Conditions to Grow Oil Palm Plants* (C) data map located on **slide J**, to orient students to the different data layers that match the plant needs previously brainstormed. Then have your students work with *C2: Conditions to Grow Oil Palm Plants*, which only includes a single data layer, as shown on **slide L**. The comparison between the *Conditions to Grow Oil Palm Plants (C2)* data map on **slide L** and the *Locations of Tropical Rainforests (C)* data map shown on **slide N** will make for the easiest two maps to have students compare to each other. If your students struggle with comparing the map layers, offer more *guidance on information processing* by looking at one or two parts of the world together and modeling for students how to compare the two maps to identify locations where there is overlap (*representation*).

***Supporting Students in Engaging in Analyzing and Interpreting Data**
Map overlaying can be challenging for some students, but students at this age are ready to learn these more sophisticated data analysis strategies. If students need more support, consider doing this as a whole class. For the first part of the activity, be sure students have examined the map key. Then, guide the students to look for patterns (as shown by the overlapping of colors) and identify and circle those areas on the map where all three conditions are met. Call on one student to identify

There are some locations near the equator that currently have too much cloud cover to grow oil palm. This is true of some places in South America, for example, the Amazon rainforest in Brazil. If students ask about these locations, share **slide J** and discuss which conditions were not met in the location and why that may be.

Prepare to examine mapped data. Arrange students into groups of 3. Pass out 1 copy of the *Conditions to Grow Oil Palm Plants* data map and 1 copy of *Location of Tropical Rainforests* data map to each student or to each group. Pass out 1 copy of *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?* to each student.

Scaffold the map comparison activity. Display **slide D**. Encourage students to do the following:

- Display **slide J** and have students recall from the class chart the needs of the oil palm plant (i.e., temperature, 70–85°F (22–30°C); daily sunlight average, 6 hours; and precipitation, 2000 mm (80 inches) of rainfall and 85% humidity).
- Then have students examine the key on the *Conditions to Grow Oil Palm Plants* data map and locate the regions on their *Conditions to Grow Oil Palm Plants* data map, where all three conditions to grow oil palm are met.
- Have students compare their *Conditions to Grow Oil Palm Plants* data map to the *Location of Tropical Rainforests* data map, with the purpose of identifying locations where oil palm grows but tropical rainforests do not already exist.
    - First, have students locate places where there is overlap and growing oil palms would require cutting down tropical rainforests. Have students pick one color and color these regions on their *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?* handout.
    - Next, have students locate places where if we grew oil palms, we would not have to cut down tropical rainforests (i.e., where there is no overlap). Have students pick a different color and color these regions on the *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?* handout.*
- Prompt students to add a key to show what the two colors mean. They can attach their individual handout maps to their science notebooks and prepare for a discussion about what they figured out (see **slide E**).

one area on the map; then allow students to identify the remaining areas with a partner/group. Check in as a whole class before moving on to complete the next map, and guide students in a similar way to compare the circle regions that meet the growing conditions of oil palm plants with the location of tropical rainforests.

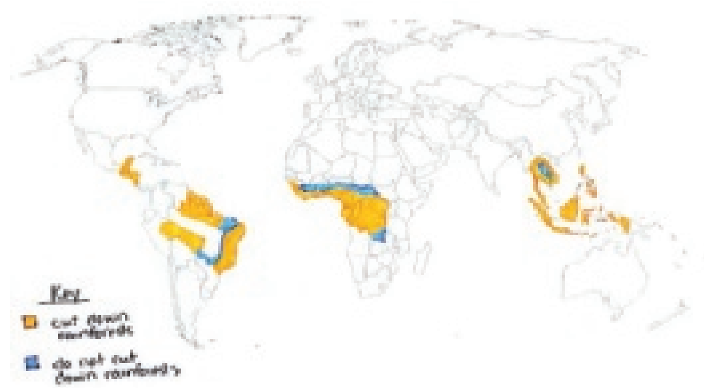
4. Facilitate a Building Understandings Discussion about where oil palm grows. 12 MIN

Materials: science notebook, *Can we grow oil palm trees somewhere else so that we are not cutting down tropical rainforests?*, projected blank world map from student handout, markers, chart paper, initial consensus model (developed in Lesson 1 and modified in Lesson 2)

Additional Guidance

The whole-group discussion does not need to be completed in a Scientists Circle but can be if you have class time for this transition. Importantly, you need a large wall space to project a blank map for the class to work with. This map should be visible to all students. You will “color in” the map together. Here are three suggestions for how to complete this learning activity: (1) use a document camera to project a blank 8.5-by-11 map and color it using colored pencils, (2) project a blank map from your computer onto a whiteboard and use dry erase markers to color in the map together (see **slide N**), or (3) use a computer app or program that allows you to import the blank map and use embedded tools to color the map together.

Prepare to make a class map. Display **slide F**. Have groups return to whole-class discussion. Remind students of the lesson question: *Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?* Ask groups to be prepared to share at least 1 place they identified where growing oil palms would mean cutting down tropical rainforests and places where we would *not* have to cut down tropical rainforests.



Share locations to create a class map. Project a blank map for the class using a document camera or a projector over the class whiteboard or chart paper. Have the first group start the discussion by identifying an area where we would need to cut down tropical rainforests to grow oil palms. A student can come to the front to point out their locations. This sharing of data should happen in about 3–5 minutes.

- Ask the other groups if they agree. If agreement is achieved, color in the location. If agreement is not achieved, ask the group that disagrees why.
- Have a second group identify an area where we would *not* need to cut down tropical rainforests to grow oil palms. A student can come to the front to point out these locations. If agreement is achieved, use a different color to color in their locations.

Say, *Now that we have mapped out the locations where oil palms grow and compared these areas with locations of tropical rainforests, let's talk about our understanding of what this means in terms of the needs of oil palm trees and tropical rainforests.*

Facilitate a Building Understandings Discussion about what oil palm plants need and what tropical rainforest plants need. On the class map, focus students on the data and patterns where they mapped oil palm and tropical rainforest. Use the data and patterns to discuss the shared nonliving growing needs of tropical plants, and thus the competition for space that happens between oil palm and other tropical rainforest plants.

Key Ideas

Purpose of the discussion: To use evidence from the mapped locations that meet nonliving conditions for growing oil palm and mapped tropical rainforest locations to conclude that tropical rainforest plants and oil palm require similar nonliving growing conditions, and thus prefer to grow in similar locations.

Listen for students' ideas:

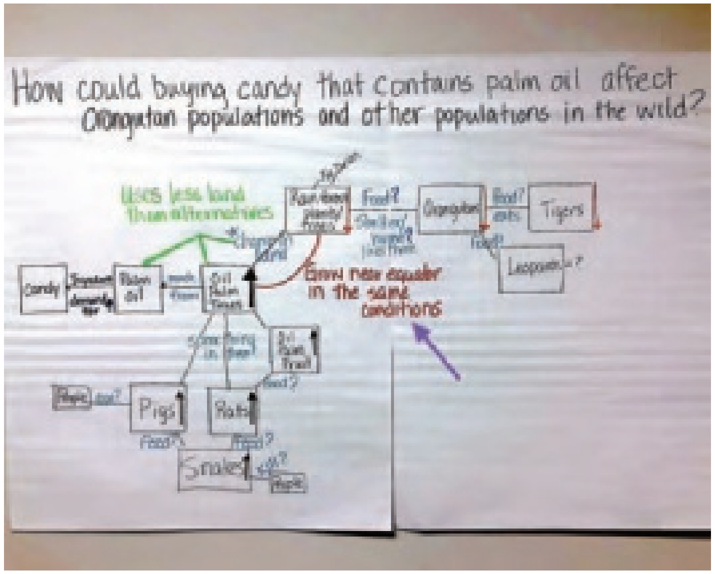
- *Rainforest and oil palm areas overlap more than they are separate.*
- *Rainforests are mostly found in warm areas of the world that receive a lot of sunlight and rain.*
- *There is a pattern in that a lot of plants or forests tend to grow near the equator for the same reasons.**
- *Planting oil palm farms requires the space that rainforests need.*
- *Oil palm plants compete for this space (and other* nonliving *conditions) and "win" with the help of farmers.*

***Supporting Students in Three-Dimensional Learning**

The purpose of this lesson is to support students' thinking about *patterns* in what oil palm plants need (sunlight, warm temperatures, rain) and the needs of tropical rainforest plants.
To do this, students engage in data analysis by using graphical displays of data showing locations that meet nonliving conditions to grow oil palms and tropical rainforest location maps. Then students identify a pattern: oil palms require the same nonliving conditions as tropical plants that make up rainforests (DCI: LS2.A). Students use what they figured out to answer some of their initial questions from the DQB about growing the oil palm somewhere else. They are working toward further defining the problem, which will help them see that there are additional factors to consider that may limit solutions to the problem.

Suggested prompts	Sample student responses
Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?	*Rainforests are located in most of the places where oil palm can grow.* *There are some (but only a few) places that may not overlap.*
Based on what we know about the needs of oil palm plants, what do you predict are the abiotic conditions needed for plants in tropical rainforests?	*warm temperatures, a lot of sunlight, and a lot of rain*
What pattern can you identify for where palm and tropical rainforests grow and what they need?	*They seem to mostly grow toward the middle or toward the equator. It seems like plants in rainforests and oil palm need similar abiotic conditions.*
If we want to plant oil palm in locations with good growing conditions, what are the chances that we may need to cut down forests?	*Pretty high, since they grow in the same places.*
When oil palm grows in its natural environment with other forest plants, why does it not overtake the whole forest like it does in these plantations?	*People make space for the oil palm, so it's the only plant left and does not have to compete with any other plants.* *Other plants take up some of the space, so there are only a few oil palm plants that can grow.*

Say, *So it seems like we're saying that planting oil palm farms requires the space that tropical rainforests need. These plants require and compete for the same nonliving resources, but oil palm is getting a boost from humans who want to grow it and clear out the competition from other plants. What other big conclusions would you add to this?*



Listen for students to summarize ideas related to tropical rainforest plants and oil palm needing the same kinds of growing conditions or places to grow. Use this to transition to updating the class model.

Update the class model. As the discussion comes to a close, Say, *It looks like we just figured out the answer to our question: Can we grow oil palm trees somewhere else so that we're not cutting down* tropical *rainforests? Let's see where we can add this information to our model.* Have 1 or 2 students suggest consensus ideas to represent on the class's model. Pose those ideas to the class and allow others to offer suggestions. Record an agreed-upon idea to represent on the model.

Assessment Opportunity

***Building towards:* 3.A** Define a problem in which oil palm is dependent upon the same environmental interactions with nonliving factors as other tropical rainforest plants (pattern).

What to look/listen for: Students share ideas, such as (1) rainforest and oil palm areas overlap more than they are separate, (2) rainforests are mostly found in warm areas of the world that receive a lot of sunlight and rain, (3) there is a pattern in that a lot of plants or forests tend to grow near the equator for the same reasons, (4) planting oil palm farms requires the space that rainforests need, and (5) oil palm plants compete for this space (and other nonliving conditions) and "win" with the help of farmers.

What to do: If students are struggling to conclude that the oil palm needs to grow near the equator, bring the issue closer to home. Ask them, *Why do we not grow oil palm in the United States or near our school? What* nonliving *condition does the plant need that our location may not provide? What if we were to plant large farms of oil palm near our school—how would that change the ecosystem around us?*

Answer the lesson question together or complete the alternative activity below. Display **slide G**. Ask students to offer a couple of answers to the lesson question.

Then say, *Let's go back to some of the questions on our DQB and your ideas about planting oil palm in other places. Now that we know more information, how does this change the problem for you? What new ideas do you have about how to solve this problem?*

Listen for students' ideas:

- *We can't stop using oil palm because it's better than other stuff, and we can't plant it somewhere else without probably cutting down forests.*
- *Maybe we can plant it better.*
- *Maybe we can plant it with the rainforests, since they grow in similar places.*

5. Add to Progress Tracker.

5 MIN

Materials: science notebook

Set up the Progress Tracker for an individual reflection. Explain to students that we want to take some individual time to capture what we have figured out regarding the locations that meet the growing conditions of oil palm plants compared to tropical rainforest locations. Have students turn to the Progress Tracker section in their science notebooks. Use **slide H** to guide students to write and draw what they have figured out about the lesson question, *Can we grow palm oil somewhere else so that we're not cutting down tropical rainforests?* This should be followed by their response.*

Give students 3 minutes to complete their Progress Tracker. Ask students to draw a line underneath their responses when they are done. Say, *So what did we figure out today?* Call on 1–2 students to share.

***Attending to Equity**
Universal Design for Learning: Allow students to use any modality to express their understanding and reasoning in their own way. The Progress Tracker is one option, and can use text or visual images. Encourage students to express what they have learned using a mode that makes sense for them.

Additional Guidance

Extension Opportunity: Your students may wonder if they can design large greenhouses to grow oil palm plants somewhere else. Allow your students time to explore this design solution using mathematical reasoning. Provide students with information about cost to build a typical commercial greenhouse. The price is roughly $25 per square foot. Ask your students to calculate the cost for a greenhouse to replace 1 hectare of oil palm plantation (1 hectare = approximately 108,000 square feet). Students should calculate roughly $2,700,000 price for a hectare of greenhouse. Then provide students with the current hectares of oil palm in Indonesia. In 2019 the land area was 14.6 million hectares. Their calculators likely will not compute a number so large. Then discuss the following:

- Who would pay for the greenhouses?
- Who would be willing to give up their land to install the greenhouses?
- This may be a solution for orangutans, but would anything in the new location potentially be harmed?
- Do we see this as a realistic solution to push forward? Why or why not?

6. Navigation

5 MIN

Materials: sticky note, Driving Question Board

Navigation. Return to the DQB. Say, *It seems like the only places to plant this oil palm tree are where tropical rainforests also grow. Some of you had questions about how people could cut down tropical rainforests to grow this plant when it hurts animals. I'm wondering what your current thinking is about these questions.*

Display **slide I.** Read the prompt on the slide: Farmers grow crops, like palm, canola, and soy, to make oil. They need land to do this, but it seems like this means we have to cut down forests and prairies, and this hurts the animals that live there. Why do farmers clear forests or other natural ecosystems to grow crops? Have students respond to the prompt as an exit ticket using a sticky note or index card.

Have students give you their exit ticket before leaving class.

ADDITIONAL LESSON 3 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.

Students should be able to read the farmer's almanac entry to identify the specific growing conditions for the oil palm plant.

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.

Students will have opportunities to engage in both small group and whole-group discussion to answer their questions about whether planting oil palm elsewhere is an option.

Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?

Previous Lesson

We wanted to figure out how to grow oil palm in another location. We examined data on the nonliving conditions suitable for oil palm and found that the plant grows best near the equator, which is also where tropical rainforests are located. We concluded that these kinds of plants have similar nonliving factor requirements, like sunlight, rain, and temperature, and compete with each other for space. We wondered how farmers can grow crops in places where they harm the ecosystem that was there first.

This Lesson

Investigation

1 DAY

After brainstorming about reasons why people in different contexts grow crops in places where they harm the ecosystem that was there first, we decide we need to learn more about the people who farm oil palms. We watch interviews with a few farmers, who live in developing countries and struggle to make ends meet. We learn that cutting down tropical rainforests to sell or grow resources is sometimes the only way for people in these areas to support themselves, and we revisit our original problem with a new priority: We need to make sure that our solution allows those who depend on palm oil to support themselves and their families. This makes us consider how and why people have changed the land where we live, and how that has impacted the living things around us.

Next Lesson

We will share our murals and make observations outdoors. We will share what we notice about patterns in plant and animal life around our school, and we will hypothesize about how these patterns relate to changes to the land. We will revise our model and add questions to the DQB about our local community. We will wonder if humans could use the land better to benefit ourselves and other organisms.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

4.A Define a new criterion for a solution to more sustainably grow oil palm in ways that protect the tropical rainforest ecosystem but that also recognize the needs of local farmers, who are part of the palm oil production system.

What Students Will Figure Out

- In many places where oil palms are grown, like Indonesia, people do not have a lot of opportunities to make money to support their families.

- Cutting down tropical rainforests to grow and sell resources may be the only way for people in these areas to support themselves.
- If we want a solution for the current problems with growing oil palms, we will have to make sure that these farmers can still support themselves and their families.

Lesson 4 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Students revisit their ideas from the last lesson and construct a list of ideas for why people would harm ecosystems to grow crops.	A	chart paper, markers
2	15 min	**HEAR FROM OIL PALM FARMERS** Students watch a video interview of oil palm farmers in Indonesia who explain their reasons for oil palm farming and how they use the income from farming. Students share what new information they have learned from the video.	B-D	computer and projector, Interviews with Palm Oil Farmers video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
3	15 min	**FACILITATE A CONSENSUS DISCUSSION** Display data about the lack of financial opportunities for people living in places like rural Indonesia and facilitate a discussion about why people in these places have to use tropical rainforests for resources to support themselves.	E-F	initial consensus model (developed in Lesson 1 and modified in Lessons 2–3)
4	3 min	**NAVIGATION** Students consider what changes they or other people have made to the environment around where they live.	G	
5	7 min	**HOME LEARNING** Students begin sketching murals (or landscapes) to show how the living and nonliving factors where they lived have been changed by people over time.	H	*How have people changed the land where we live?*

End of day 1

Lesson 4 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *How have people changed the land where we live?*		• chart paper • markers • computer and projector • Interviews with Palm Oil Farmers video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • initial consensus model (developed in Lesson 1 and modified in Lessons 2–3)

Materials preparation (15 minutes)

Online Resources

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.

Test the *Interview with Palm Oil Farmers* video ahead of time. This video is linked on **slide C**. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

In the home learning assignment at the end of this lesson, students will need resources for information about what the land was like where they lived before people started to change it for their purposes. Consider doing some research on the places where your students live prior to this lesson so you can provide more detailed information to your students about where to find helpful resources.

Lesson 4 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, it is crucial for students to understand the human considerations that limit the types of solutions for the problems presented by growing oil palms. For the purposes of this unit, students should identify that there are many people, especially people living in poverty in the developing world, who derive money to support themselves from tropical rainforest resources, including those who grow oil palms. Students need to agree that these peoples' needs are important and that it is an important criterion of our solution that they can support themselves through whatever solution the class suggests. This lesson encourages students to begin to add criteria to the unit's design problem and drive the class forward in trying to figure out how oil palms could be grown in a way that does minimal harm to local animals, as well as to people who depend upon the tropical rainforest for resources. Students will build upon and articulate the criteria further in the next lesson, so the purpose of this lesson is to have students recognize that there are social and economic dimensions to these problems.

Where We Are NOT Going

For our purposes, it is not necessary for students to delve further into the causes of poverty in these developing nations (though those conversations may come up); nor do students need to unpack why so many nations with tropical climates have high populations of people living in poverty. Another tangential issue that is not targeted in this lesson is how these people make money from the growing of oil palms. This lesson also does not account for the complicated relationship between farmers, Indigenous peoples, and the tropical rainforest in Indonesia. When we design solutions later in the unit, students will investigate Indigenous perspectives on resource extraction and farming methods. For now, students only need to consider the people who use tropical rainforest resources (including those farming oil palms) and their ability to make money to support themselves and their communities.

1. Navigation

5 MIN

Materials: chart paper, markers

Recall ideas about why farmers might cut down tropical rainforests to grow crops. Show **slide A**. Remind students that during the last class, they wondered why farmers would cut down tropical rainforests to grow plants like oil palms if they knew that this would hurt animals. Call on 1-2 students to remind the class about the possible reasons for the farmers' actions, which they brainstormed about during the previous class.

Ask students to share ideas about why farmers would grow crops when it hurts animals, and record suggestions on chart paper for the class to see.

Suggested prompt	Sample student responses
Why do you think that farmers, like the ones growing oil palms, would cut down tropical rainforests (or other ecosystems) to grow crops?	*They could be doing it so that they could eat the food they grow.* *They could sell the food to make money or because it's their job.* *Farmers need to grow things so that we can make products, like how we need palm oil for candy and other stuff.* *Maybe they don't know that it's hurting the animals that live there.* *Maybe they don't care or they're greedy.* *Maybe they don't like the animals living there or the animals are eating their crops.*

Brainstorm ways to investigate our predictions. After brainstorming some ideas, ask students to turn to a partner and discuss how the class could figure out if any of the reasons why farmers are doing this are supported by evidence.

Suggested prompt	Sample student responses
How would we figure out why farmers are doing this? What evidence would we need?	*We could survey some of these farmers and see what their reasons are. We could see if they know about the orangutans.* *We could ask some farmers ourselves, but they live far away; it doesn't seem like it would be easy to get in touch with them.*

Come to an agreement as a class that it would be helpful to hear from some real farmers and see what their reasons are for cutting down tropical rainforests to make room to grow oil palms.

2. Hear from oil palm farmers.

15 MIN

Materials: science notebook, computer and projector, Interviews with Palm Oil Farmers video

Introduce video of oil palm farmers. Say, *One way that we thought we could figure out more about why people cut down tropical rainforests to grow oil palm was to ask some of them directly*. Display **slide B**. Tell students that the class is going to watch a short video in which a few of these farmers are interviewed about how the opportunity to grow oil palms has affected their lives and the lives of their families.*

Ask students to record noticings and wonderings from the video in their science notebooks. Display **slide C.** Instruct students to make a table like the one on the slide to record their noticings and wonderings as they watch the video. Play the *Interviews with Palm Oil Farmers* video. Play the video twice. Students should watch for the main ideas of the video on the first pass and then use the second pass as an opportunity to record noticings and wonderings related to our question: "Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?" (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Turn and talk to share noticings and wonderings. Display **slide D.** Have students turn and talk for a minute or two to discuss the question on the slide, which asks students to consider what they noticed during the video that could help answer why farmers would clear tropical rainforests, even though it is hurting local animals. After students discuss with a partner, have them share with the class what their partner noticed that might help us answer our question.

Suggested prompts	Sample student responses
What did your partner notice in the video that might help us answer our question: "Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?"	*The narrator said that the company that makes palm oil employs a lot of people. The farmers probably get money from that company for growing oil palms.*
What did you notice from the video about what the farmers gain from growing palm oil?	*The farmers said that growing oil palms have helped them get more money for themselves and their families.* *A farmer talks about how growing oil palms has allowed farmers to get houses that they can live in.* *They can pay for their kids to go to school and get diplomas.*
Are these farmers the only ones who gain something from palm oil being made? *Who else benefits from palm oil being made?*	*The farmers' children get to go to school and live in better houses.* *The people who sell the palm oil benefit, too, since they get money from candy companies or whoever is using the palm oil.* *The companies that use the palm oil get something, too, since they can't make their stuff without palm oil.* *A lot of stuff we use has palm oil in it, so we benefit as well. Without palm oil, we might not have all the different products that we use.*

***Attending to Equity**

In the video and in other media about palm oil, the term *plantation* is used to describe the farms in which oil palms are grown in Indonesia and other countries. After Lesson 1, the students have discussed this term and recognize the negative historical and social meanings of the word. You will want to clarify that the use of *plantation* in the video doesn't necessarily mean that the people working the land or harvesting crops are enslaved, as was the case in pre–Civil War America. It is also worth noting that there is an ongoing effort to secure safety and equity for people working on oil palm plantations, who are almost all people of color living in low-socioeconomic status areas in developing countries. Though the human rights discussion around oil palm farming is not central to this unit, students may ask questions and want to follow up with discussions about how the people working on these farms are treated, how much they get paid, and how their lives differ from workers in the United States.

Problematize. Come to an agreement with students that the farmers who grow oil palms get important things with the money that they make from clearing tropical rainforests to grow these plants. Problematize with students by pointing out that this still doesn't fully explain why they are choosing to make their money this way, as opposed to doing something else for money. Say to students, *It might be helpful to learn more about where these farmers live if we want to understand why they would cut down tropical rainforests to make money.*

3. Facilitate a Consensus Discussion.

15 MIN

Materials: science notebook, initial consensus model (developed in Lesson 1 and modified in Lessons 2-3)

Read more information and share what is noticed. Display **slide E.*** Give students a minute or two to read through the information on the slide about how growing oil palms impacts the amount of money that a farmer, like those in the videos, can make to support themselves. Consider asking a few students to share what they noticed that surprised them or helped them form a new connection to the lesson question.

Facilitate a Consensus Discussion focused on answering the lesson question.* Focus students on explaining why farmers continue to grow oil palms even if it means cutting down tropical rainforests and hurting the animals that live there. Display **slide F**. Before beginning the discussion, tell students that they are going to use the key points that the class raises in this discussion to update their Progress Trackers. Encourage students to jot down any important ideas raised during the discussion if they think that those ideas would be important to add to their Progress Trackers.

Key Ideas

Purpose of the discussion: To come to a consensus as a class that growing oil palms provides a valuable opportunity for farmers and other people to make money to support themselves, their families, and their communities.

Listen for students' ideas:

- In many places in which oil palms are grown, like Indonesia, people do not have a lot of opportunities to make money to support their families.
- Cutting down tropical rainforests to sell or grow resources may be the only way for people in some areas to support themselves.
- If we want a solution for the current problems with growing oil palms, we will have to make sure that these farmers can still support themselves and their families.

Suggested prompt	Sample student responses
What did the farmers that we heard from say about why they grow oil palms?	*They grow the oil palms to make money for themselves and their families.* *The farmers can use the money they make from growing oil palms to buy food and houses and also to send their children to school.*

***Attending to Equity**

Universal Design for Learning: The data shared with students on **slide E** may evoke connections with students, particularly those from farming communities, migrant communities, and newcomers, about poverty and inequality in developing and majority-nonwhite countries compared to the United States (supporting *engagement, relevance, minimizing threat*). Students may notice, for example, that the countries listed with very low median incomes are countries with majority-nonwhite populations, or that no majority-white countries have major oil palm producing regions. For our purposes, it is not necessary for students to delve further into the causes of poverty in these developing nations (though those conversations may come up); nor do students need to unpack why so many nations with tropical climates have high populations of people living in poverty. The focus of this lesson is simply to identify the reasons that people in these areas would cut

Suggested prompts	Sample student responses
Why do these people (and others) cut down tropical rainforests to make money?	*The tropical rainforest is an area with the right conditions for oil palms, so they have to cut down tropical rainforests to make room to grow oil palms.* *Farming oil palms makes a lot more money than most people earn in many countries.* *They might not have any other choice, since sometimes the tropical rainforest is the only resource people have to make money from.*
Have you heard or seen other examples in which people use the land around them to make money to support themselves?	*There are farmers in a lot of places who use their land to grow plants for food or to make money.* *Some people cut down the trees to sell the wood for houses.* *In some places, they pull oil or gas out of the ground and sell it to make money.* *There are a lot of examples where people use the land for resources or to make money.*
What do you think would happen if, all of a sudden, these people couldn't grow oil palms anymore?	*The farms would have to start growing different crops, which would mean they would make a lot less money.* *There would be fewer ways for all the people who rely on tropical rainforests to make money to support themselves.* *Some people wouldn't have any way to make money, and they would need to find another job.*
How does this change what we know about the system that connects our candy purchases to orangutans being endangered?	*Farmers support their families by making palm oil that's in the products we buy.* *When we buy candy, we are supporting those farmers and helping them earn a living.*

down tropical rainforests to grow oil palms and the tension that emerges from wanting to protect ecosystems while also supporting economic growth. However, students may bring up questions around the ethics and history of poverty in majority-nonwhite and developing countries, and you may want to discuss these issues further in this class or their social science class.

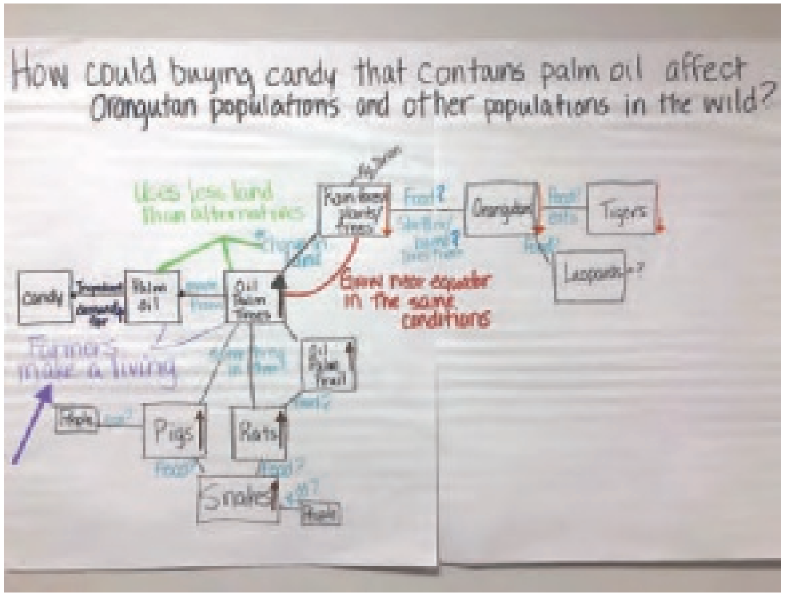
***Attending to Equity**

Universal Design for Learning: As part of their Consensus Discussion, students are asked to identify examples in which people other than those in Indonesia use the land around them to make money to support themselves. This provides an opportunity to help students think about land use in their own communities or areas with which they are familiar (*relevance*).

***Supporting Students in Three-Dimensional Learning**

Students are working to define a new criterion for their emerging design solutions to grow palm oil in a way that protects the living things in tropical rainforest ecosystems (SEP 1). Questions about why people are choosing to farm in a way that harms animals, along with subsequent interviews with oil palm farmers, lead students to identify and consider factors involved in these tropical

Update the class model. As the discussion comes to a close, have 1 or 2 students suggest consensus ideas to represent on the class model. Pose those ideas to the class and allow others to offer suggestions. Record an agreed-upon idea to represent on the model.*



Assessment Opportunity

Building towards: **4.A** Define a new criterion for a solution to more sustainably grow oil palm in ways that protect the tropical rainforest ecosystem but that also recognize the needs of local farmers, who are part of the palm oil production system.

What to look/listen for: See key ideas above.

What to do: Use the Consensus Discussion and Progress Tracker entry for formative assessment. If students struggle to identify or justify reasons why farmers feel they need to cut down tropical rainforests to grow oil palms, prompt them to consider how they might react if they only had the land around them as a resource to support themselves. Remind them that we have previously figured out that the tropical rainforest has optimal conditions for growing oil palms, and point out the vast numbers of people who would be left without income if these plants could no longer be farmed. Provide cases of what happens when disease or drought keeps key crops from being harvested, along with the fallout that these events have for farmers.

rainforest systems that have not been included in their models for those systems up to this point (CCC 4). From these interviews, students draw out the connection between increased use of tropical rainforest resources by humans (due to both monetary pressure on individuals/communities and increases in human population) and the disruption of tropical rainforest ecosystems (DCI).

Learning about the needs of and resources available to people living in these regions in Indonesia encourages students to add a new criterion to account for the well-being of the humans who rely on tropical rainforest resources for income (SEP 1). Adding this constraint narrows the range of solutions available to students and causes students to reevaluate some design solutions that would leave people living in these regions without income or resources to care for themselves and their communities (DCI).

In their effort to develop and refine this new criterion (SEP 1), students draw on their knowledge of the human impact on and interaction with natural systems from prior grade bands (DCI). Students must also leverage and consider the limitations of their emerging models for tropical rainforest systems (CCC 4), as developed in prior lessons of this unit.

4. Navigation

3 MIN

Materials: None

Draw students' focus to changes to the environment near where they live. Say, *Now we've heard from some farmers in Indonesia about why they're changing the land where they live. Indonesia is pretty far away from where we live, and sometimes when things happen far away, it can be easier to say that people shouldn't do things we think are wrong.* Display **slide G**. Ask students, *If people living in Indonesia, like the farmers we heard from, got a chance to look at the land where we live, would they find evidence that we've changed the land in ways that impacted living things?*

Suggested prompts	Sample student responses	Follow-up questions
If people living in Indonesia, like the farmers we heard from, got a chance to look at the land where we live, would they find evidence that we've changed the land in ways that impacted living things?	*I think so—people have changed a lot about by building stuff like roads and houses.* *Maybe. I don't really know what it was like before, so I don't know how it changed.* *I don't think so. It's not like there were rainforest trees here that we cut down.*	*What changes do you think they might notice? How do you think those changes impacted living things?* *What do we know about what living things were here in this place 50 years ago? 100 years ago? 1,000 years ago?*
How could we better understand how people have changed the land where we live over time?	*We could go around where we live and find evidence of people changing the land.* *We could talk to people who have lived here for a long time to hear what they know.* *We could see if there's information online about what used to live here or what it was like a long time ago.*	*What do you know about who changed the land where we live? Why did they make those changes?* *What would we want to look for? Where would we want to look if we want to see changes?*

Say, *It sounds like we have some different ideas about what changes people might notice in the place where we live.* Come to an agreement that it would be helpful to have a better idea about how the land where we live has changed, so we can better understand how people have changed the land and how it has affected living things.

5. Home Learning

7 MIN

Materials: *How have people changed the land where we live?*

Introduce a home learning assignment for next class. Distribute 1 copy of the *How have people changed the land where we live?* handout to each student. Say, *If we want to see how people change (or have changed) the land where we live, it sounds like it would help to have a better picture of what the land looked like long ago versus how it looks now.*

Point out on the handout that there are two places for students to draw and write. On one side of their handout, students will sketch a mural (or landscape) to show what the land looked like a long time ago in the place where they live. At the top of this side of the handout, instruct students how long ago they should draw (depending on the place where students in your class live). Tell students that on the other side of the handout, they should draw what the land looks like now in the place where they live.

Additional Guidance

On the handout, students need to write in the timeframe for their “before” mural. This timeframe may be different for different places across the country, based on how and when the land there was colonized. Some communities may choose to look back 50 or 100 years ago, where other communities may have to rewind further to consider what the land looked like before humans began to significantly shape and change it for their use. Consider the history of the land where your students live as you decide the timeframe for the “before” mural on this handout.

As an example, a class in Chicago may choose to set the timeframe of the “before” mural to the year 1700, before Europeans arrived in Chicago. A class in New York City, however, may place their murals earlier (say, in 1500), since the land where they live was colonized much earlier by Europeans.

In many cases, this decision may also prompt discussion about how the land looked and was used when Indigenous communities lived in your area. These communities often viewed and used natural resources very differently compared with white colonizers, who violently seized much of their land and transformed it for use in commercial agriculture and industry. When deciding the timeframe for these models, your class may consider which Indigenous communities lived on the land where your students live, how those communities used or changed the land, and how their use of the land differed from that of later European colonizers.

For this reason, avoid phrasing this model as “before/after people lived here,” since this implies that people must inherently alter or exploit natural resources where they live. Across the world, there is enormous diversity in how people use and change the land where they live, and there are many examples (particularly in Indigenous communities) where people prioritize preserving the natural systems and land where they live.

Ask students to help brainstorm what kinds of things, living and nonliving, could be included in these murals if the class is trying to figure out how people have changed the land where they live.

Suggested prompt	Sample student responses	Follow-up questions
If we’re trying to show how people have changed the land where we live, what would we want to show in our “before” mural?	*I think we might want to show what the land looked like. We should draw the grass or trees or rivers or whatever was there.* *We should probably also draw the animals and plants and stuff that lived here before.* *We could include people who were living there. We know that there were people living in this place before Europeans arrived.*	*Why do you think we should include that in our mural?* *How can we represent that in our mural? Could we use a drawing or a symbol or words?*

Suggested prompts	Sample student responses	Follow-up questions
What should we show in our "now" mural?	*We should draw what it looks like now, including all the natural stuff but also buildings and roads and all that.* *We should include people, since there are more of them living here.* *We should include the living things that we see where we live, like plants and animals.*	*Why do you think we should include that in our mural?* *How can we represent that in our mural? Could we use a drawing or a symbol or words?*
How could we get information about what the land looked like a long time ago in the place where we live?	*We could ask people who are older or who have lived here for a long time.* *We could look up to see if there are pictures or simulations of what the land looked like here a long time ago.*	

Direct students toward resources for this assignment. Before students begin working, discuss what resources the class has brainstormed about that they could use to create their murals. Share any resources (electronic or otherwise) that students may find useful for the specific place where they live. Emphasize to students that older people in their home, neighborhood, or community may also provide useful insight into how the land where they live has changed over the years.

Tell students that they will be sharing and discussing this assignment further in the next class.

Additional Guidance

The specific websites and resources that students can use for this assignment differ from place to place. Students in many places may find Google Maps (satellite view) or Google Earth useful for understanding what the land looks like now where they live. They may also choose to use their own observations from living in and traveling around the area.

Many cities and towns have historical records or websites that maintain detailed histories about how these places have changed over time. Some explicitly mention what the land looked like (and who lived there) prior to European colonization. Consider doing some research on the places where your students live prior to this lesson so you can give more detailed information to your students about where to find helpful resources.

LESSON 5

How have changes in our community affected what lives here?

Previous Lesson

We watched interviews with people who farm oil palms and learned that many of them live in developing countries and struggle to make ends meet. We learned that cutting down tropical rainforests to sell or grow resources is sometimes the only way for people in these areas to support themselves. As a result, we decided that our design solution had to account for supporting these farmers and their families, who make money entirely from cutting down tropical rainforests to grow oil palms. This made us consider how and why people have changed the land where we live, and how that has impacted living things.

This Lesson

Investigation

2 DAYS

We share our murals documenting changes in our own community since major disturbance by humans. We make observations outdoors of evidence of plant and animal life around the school, and evidence of changes humans have made to the land. We share what we notice and compare the changes in our own community to those in Indonesia. We modify our model, and then we add questions to the DQB about our local community. Given that agriculture and human communities are not going away and are still expanding, we wonder how humans could use the land in better ways to benefit ourselves and other organisms.

Next Lesson

We will reflect on what we have figured out to define the problems associated with palm oil farms. We will discuss how we can design a better palm farm system that will support both the farmers and the orangutan and tiger populations, and will co-construct criteria and constraints to guide our design decisions. We will revisit our Driving Question Board and add new questions that will help us design a system that is more stable and will help us refine our criteria and constraints.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

5.A Ask questions to clarify and/or refine a model for explaining how (patterns in) human activities have altered the biosphere and changed habitats locally and in Indonesia.

What Students Will Figure Out

- People in our community have changed natural habitats for their homes, buildings, roads, etc.
- Some plants and animals are still around, despite the changes, but others have disappeared from the area.

Lesson 5 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**SHARE HOME LEARNING** Students share murals in small groups and then examine photographs of their community before human disturbance.	A-B	*How have people changed the land where we live?* home learning
2	5 min	**PREPARE FOR OBSERVATIONS** Establish the purpose of the outdoor observations and then spend the remainder of the class period observing both the organisms who live around the schoolyard and evidence of human-made changes to the area.	C-D	*Observations around Our School* handout
3	25 min	**OBSERVATIONS AROUND SCHOOL** Monitor students as they make observations of the plant and animal life and humanmade changes around their schoolyard.		*Observations around Our School* handout
4	5 min	**RETURN TO CLASS AND ASSIGN HOME LEARNING** Assign students to choose one organism or group of organisms that they observed and to imagine how the organism(s) views the changes made by humans.	E	
				End of day 1
5	10 min	**ENGAGE IN PERSPECTIVE TAKING** Students individually complete Part 3 of their *Observations around Our School* handout, and then share with a partner and the whole class.		*Observations around Our School* handout
6	12 min	**SHARE LOCAL OBSERVATION DATA** Gather students around a space to share their outdoor observations.	F-H	*Observations around Our School* handout, sticky note, Our Local Observations chart, markers
7	18 min	**FACILITATE A CONSENSUS DISCUSSION AND ADD TO DQB** Compare the local changes to the palm oil case, add to the consensus model, and add new questions to the DQB.	I-J, L	*Observations around Our School* handout, marker, sticky note, initial consensus model (developed in Lesson 1 and modified in Lessons 2-4), markers, Driving Question Board
8	5 min	**NAVIGATION** Elicit students' ideas about what could be done differently to support both humans and other living things, and add a new unit driving question.	K	
				End of day 2

Lesson 5 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide Student Work Pages	• science notebook • *How have people changed the land where we live?* home learning • *Observations around Our School* handout • sticky note • marker		• Our Local Observations chart • markers • initial consensus model (developed in Lesson 1 and modified in Lessons 2-4) • Driving Question Board

Materials preparation (25-45 minutes)

Online Resources

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.

Gather 2-4 images of what your local ecosystem may have looked like *before* major human disturbance. These may be landscape images and images of particular populations that still live in the area or once lived in the area. The images may match what you think students will include in their murals from Lesson 4 and could include new things not yet discussed. Place these images on **slide B** and make additional slides as needed.

Example landscape image.

Additional advance preparation time will vary, depending on whether you use the lesson as is to make outdoor observations or if you choose to do an alternate activity. For the outdoor observation activity (as written), you will need to do the following advance prep:

- Identify the space you want your students to observe.
- Identify the boundaries of this space.
- Talk with your school administration about the students going outdoors and discuss safety precautions to take.
- If a water feature (e.g., pond) is located nearby, recruit a teacher aide or parent volunteer to be present and supervise that area for the duration of the activity.

Follow these additional safety guidelines, along with any safety guidance from your school:

- Inspect the area where students will complete observations. Identify any species that could be an issue for participants (e.g., poisonous plants, such as mold/mildew, or harmful animals, such as mosquitos, ticks, reptiles).
- Identify any standing water, such as ponds, that could pose a safety hazard. Set the boundary to avoid this area or have adequate adult supervision present if students will visit the area.
- Inspect the site for handicap accessible options to accommodate students with physical limitations.

Apps are available to use in addition to the outdoor activity. If the outdoor activity is not available to you, these apps can be used to replace it:

- Students can explore iNaturalist to make observations of local plant and animal life that have been uploaded in your area by community members. This tool is for 13+ and may be a tool to explore together as a class. To familiarize yourself with this tool, visit iNaturalist's Teacher Guide. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) iNaturalist also provides a set of video tutorials to guide you through the use of the app. Watch the *iNaturalist Orientation* video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
- The Seek app is the kid-friendly flora and fauna identification tool developed by iNaturalist and may be more appropriate for student use. There is no login required. Seek is a fun way to get families involved in student learning too. The Seek app is used on a mobile device. Learn more about Seek by reading the Seek User Guide and watching the *Seek Orientation* video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)
- Students can use Google Earth to make observations of land-use change in their community. Visit Google Earth ahead of time to see what options are available for your community, such as street view. Check to see that students can access Google Earth from their device. To familiarize yourself with this tool, watch the *Google Earth Orientation* video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Lesson 5 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students will broaden their understanding of ecosystem change to their local community. While students may be aware of changes in their area, this lesson will draw their attention to those changes for a focused observation activity. Students will work toward extending disciplinary core ideas they've been building in previous lessons with the palm oil case—particularly the following:

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats.
- Changes to Earth's environments can have different impacts (negative and positive) on different living things.

Students will extend their understanding of these disciplinary core ideas in the context of local change, which may or may not include changes from agriculture. This move will support students in generalizing the disciplinary core ideas beyond the palm oil case specifically.

Students will use their observations to generate additional questions about changes in their local community and impacts, both positive and negative, on local plant and animal populations. These questions should derive from a recognition that the model they have generated to explain the problem in Indonesia is one that could represent a bigger problem of ecosystem change across human development.

They will use the crosscutting concept of patterns to help them hypothesize different causes of changes in the plant and animal life they observe in their own community. Their initial hypotheses can be translated into questions to add to the DQB for further investigation.

Where We Are NOT Going

Students will not determine, with certainty, the causes of population changes in their area. They only make observations about plant and animal life and changes by humans. These observations can be used as initial data for generating hypotheses that could be investigated in later lessons.

1. Share home learning.

10 MIN

Materials: science notebook, *How have people changed the land where we live?* home learning

Share students' home learning experiences in small groups. Display **slide A.** Say, *We were wondering what kinds of environmental changes an Indonesian farmer might observe in our community if they were to visit our area, along with whether these changes affect living things. Let's see what kinds of information you were able to gather and document in your murals.*

Ask students to retrieve their home learning *How have people changed the land where we live?* handout, and arrange students in groups of 3. Give students about 5 minutes to share Part 1 of their murals with each other. As students discuss, encourage them to share their sources of information, such as family members they spoke with, books they consulted, or internet searches they conducted.*

Discuss and examine photographs of the area before major human disturbance. Bring the students back together for a whole-class discussion. Ask the following questions from Part 2 of students' handouts.

Suggested prompts	Sample student responses
*How did people change the land where you live?**	*cut down trees to build buildings and homes* *put in roads* *put in power lines* *flattened the land to build buildings* *made parks* *fill in the land where it was swampy* *made a canal for the river*
Why do you think people made these changes to the land where you live?	*needed shelter and a place to live* *needed roads to travel around* *needed to make the land flat so the buildings would be stable* *needed to control the water so it wouldn't flood*

Display **slide B** with the images you collected of the ecoregion that once existed in your area before major human disturbance or that still exists on the periphery of your community. Say, *I did some research last night and learned that*

*** Attending to Equity**
Universal Design for Learning: This home learning is used to broaden students' understanding of the anchoring phenomena and extend it to changes happening in their own community. Connecting the anchoring phenomena to changes in their community can help the phenomenon become more personally meaningful to each student, supporting their *engagement* with it. It also provides students an opportunity to talk about the anchoring phenomena, and related phenomena in their community, with family members and other community members.

*** Attending to Equity**
Indigenous peoples have lived with ecosystems for thousands of years. While Indigenous peoples altered the land in ways to cultivate food, medicines, and other resources from natural systems, the alterations largely benefitted other organisms. Today, the land that is managed by Indigenous peoples has the same, if not more, biodiversity than other protected lands on Earth. Monitor how students talk about human alterations to land, and remind

our area used to be _____ and we used to have ___ kind of organism here. Does this match what you learned? Have a few students share what they learned about the region, and how the images on the slide match or are different from what they learned about the area.

Have students attach their murals to their science notebooks.

them that the major changes to the land happened in relatively recent years, since colonization, and that Indigenous peoples' relationship to land has a very different history.

2. Prepare for observations. 5 MIN

Materials: science notebook, *Observations around Our School* handout

Frame the outdoor observation activity. Display **slide C**. Say, *Oil palm farms have created a lot of change in the Indonesian ecosystems. But we've identified that our own community has changed the ecosystem in various ways too. We're going to make some additional observations around the school to get a sense of the changes that have occurred here and the living things that are still present or not present in our area.* Conduct a brief discussion to establish the purpose for making observations outdoors and how to look for evidence of organisms, beyond seeing plants and animals directly. Reinforce the term "land-use change" from the word wall. Encourage students to notice land-use change around their school, and to use the term, if needed, to describe changes they observe.

Suggested prompts	Sample student responses
If we went to an oil palm farm in Indonesia, what would we observe living there?	*oil palm trees, rats, maybe snakes*
Would we see evidence of orangutans or tigers?	*No. Probably not.*
If we go outside and look around here, what will we observe right now?	*Probably things that are doing well. Things that live around here. Squirrels, birds, insects, common plants, etc.*
We're going to go outside now and try to document as much evidence of our own ecosystem—what the land looks like and what is living here now, including actual organisms or evidence of organisms. What might evidence of organisms living here look like?	*see plants growing in the ground or leaves on the ground* *bird poop, feathers, or nests* *insects in the soil or around the grounds* *leaves that have bites in them* *spiders or spider-webs*

Preview the outdoor activity. Pass out 1 copy of the *Observations around Our School* handout to each student, and preview Parts 1 and 2 only (Parts 3 and 4 will be completed on day 2). Have students take something firm to write on (e.g., clipboard, book, or binder) and pencil with them outdoors. Set a time for observations to be made and a plan to return to the classroom. Modify and use **slide D** to preview safety precautions.

Safety Precautions

Review safety precautions for going outdoors. Set boundaries for the observation space. Remind students to remain with an adult at all times. Follow the safety guidance below and additional guidance from your school:

- Students should not touch plants or fallen leaves.
- Students should keep a safe distance from all live animals, birds, or insects. Students should not try to touch, catch, or pick up any critters.
- Do not let students visit sites with water without adult supervision.
- Students should wash their hands after being outside.

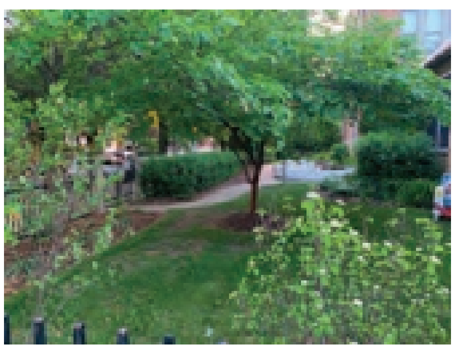
3. Observations Around School

25 MIN

Materials: science notebook, *Observations around Our School* handout

Make observations around the schoolyard. Supervise students and monitor them for safety purposes as they make observations outdoors. As you interact with students, consider the following prompts to support their observations:

- Imagine you are someone who has never traveled here before and you are seeing this space for the first time. What would you notice about the organisms?
- Are you seeing a pattern in the number and kinds of plants?*
- Are you seeing a pattern in the number and kinds of animals, birds, and insects?
- What natural kinds (e.g., water, rocks, soil, sunlight) are you observing?

Urban schoolyard site	Suburban/rural schoolyard site
	

*** Supporting Students in Developing and Using Patterns**

Prompt students to use the lens of patterns as they document their observations. Cue them to pay attention to:

- patterns in kinds of plants or location of plants;
- patterns in kinds of birds, insects, or animals, along with the location of those organisms; and
- patterns in changes humans have made to the land and if this seems to be related to patterns in organisms.

Use the following prompts:

- What patterns are you observing?
- What does the pattern you observed allow you to conclude? What are you uncertain about?

Additional Guidance

The term *natural kinds* refers to natural objects or processes that are nonliving (or abiotic) beings (Learning in Places, 2020). These natural kinds have their own rhythms to observe, such as the flow of water in a creek, the change in sunlight across the day and year, and the change in rocks and soil as they interact with other kinds (wind and rain) in their environment. Observing the rhythms of natural kinds can better help us understand organisms in the environment. For more information about natural kinds, visit the following:

- Learning in Places (2020). LE 3.A Taking a focused walk together: Species, kinds, and behaviors.
- Learning in Places (2020). Learning Framework: Phenology. (See the **Online Resources Guide** for links to these items. **www.coreknowledge.org/cksci-online-resources**)

To give more structure to the outdoor activity, consider one of the following formats:

- Have students work on their own for 10 minutes, and then partner up for an additional 10 minutes of observation and discussion together.
- Have students begin in partners for the first 10 minutes and then connect with another partner pair for the remainder of the observation time. Focus partners on first making observations together for about 5 more minutes, and then sharing and comparing for the last 5-10 minutes.

Alternate Activity

The purpose of making outdoor observations is for students to document (1) evidence (or lack thereof) of living things around the community and schoolyard, and (2) evidence of changes made by humans in the community. You can use the apps described below to deepen students' experience of their outdoor space. If the outdoor activity is not available to you, you can accomplish the same goals using apps and observations made by community members. Consider the following:

- **Google Earth.** Have your students make observations using Google Earth. Students can view satellite views and, if available, street views. Some locations also offer 3D view. Focus students on using Google Earth to identify land-use changes made in and around their community.
- **Google Earth + iNaturalist.** In addition to Google Earth, use iNaturalist as a tool to observe species documented in the community. iNaturalist includes mapped photographs for flora and fauna recorded by local citizen scientists. Gather students in a Scientist Circle and project both Google Earth and iNaturalist for the class to make observations. iNaturalist can be used in addition to the existing outdoor activity too as a way for your class to upload and contribute data for your community.
- **Seek**. The Seek app by iNaturalist is an image-recognition technology that is kid- and family-friendly. No account registration is required. A device with a camera (e.g., a mobile phone or tablet) is required. The Seek app can be used when students make outdoor observations around the schoolyard. Seek will allow your students to scan an object, such as a plant, in their environment to identify it.
- **Virtual field trip.** Pre-record a "virtual field trip" video for students to watch. Make sure to record plant life, birds, insects, and animals, as well as evidence of these organisms (e.g., bite marks, webs, nests, scat). If possible, make a

- What are some similarities and differences?
- What question could you ask next to further investigate the pattern?

*** Attending to Equity**

Framing students' families and communities as legitimate sources of knowledge can serve multiple purposes. It can (1) help students feel like they belong in the science classroom by situating their family/community knowledge as productive for science, (2) engage students' families in conversations about what their child is learning in the classroom, and (3) help students make connections between the science classroom and their everyday lives. Be inclusive of the different ways students can make their observations outside the classroom, including with friends or teachers in afterschool programs, with friends in their neighborhoods, at or around their churches or other significant community centers that are important to their families.

map of your school and pin locations. In each of these pinned locations, link to a video taken there. Free programs are available to create virtual tours, such as Google's Tour Creator or Google Expeditions.

- **Invite an expert to class**. Invite an expert to visit your class or conduct a virtual Q&A with students. Experts may include individuals with extensive knowledge of the local flora and fauna of the community. Prepare your students by asking them to pre-plan their questions. Prepare the expert by sharing the purpose of the lesson and where students are in the storyline, so as not to give away any important ideas students will figure out in later lessons (e.g., Lesson 10).

Additional Guidance

To engage your students' families or friends, ask them to conduct similar observations around their homes, churches, community centers, sports fields and parks, or places of work. Students and parents can document on paper or take photographs to share with the class. This will allow the class to build a more complete understanding of populations that are still present in the local community and local community changes.*

4. Return to class and assign home learning.

5 MIN

Materials: None

Assign home learning. Once the class has returned indoors and washed their hands, display **slide E.** Assign students their home learning if time permits. Ask students to review their observations on Parts 1 and to pick 1 organism or group of organisms they observed, and to imagine how changes by humans are viewed by that organism or group of organisms. Students should be prepared to complete Part 3 of their handouts at the start of the next class period.

End of day 1

5. Engage in perspective talking.

10 MIN

Materials: science notebook, *Observations around Our School* handout

Engage students in perspective taking. Say, *In the last class, we made some observations around our community. We probably saw some things we thought could be both good or bad for other living things. But good or bad for whom? And from whose perspective? Let's relook at the changes we documented yesterday and the evidence we collected of plant and animal life, considering how these changes are viewed by other living things.*

Direct students to Part 3 of their handout. Give them about 3-4 minutes to work individually to answer the following questions:

- From a human's perspective, do these changes help or harm any plants or animals?
- Pick 1-2 organisms you observed or didn't observe (such as those shown on **slide B**). From the perspective of these organisms, were the changes made by humans helpful or harmful?

After 4 minutes, allow students to share their ideas with a partner located near them for about a minute.

Then, elicit from students what they shared in partners. Listen for students to share the following:

- Human perspective:
  - *We helped some plants by planting them around our school.*
  - *We helped the squirrels by planting certain kinds of trees.*
  - *We hurt the [large predator] by destroying its home/habitat.*
  - *We hurt [local plant] by cutting it down.*
- Organism perspective:
  - *Answers will vary. Listen for students to offer that (1) organisms benefitted when the changes humans made increased the supply of essential resources (e.g., food) or provided new habitats, and (2) organisms were harmed when resources and habitats were taken away.*

Say, *As we continue to learn more about the changes humans make to the land, we're going to decide if those changes are good or bad. It may be helpful for us to clarify the perspective we are using when we decide if something is good or bad. Some ways we can do this is by imagining ourselves in different shoes—for example, maybe we imagine ourselves as the orangutan, the palm oil farmer, or the person who wants to protect orangutans. When we share an idea, we can clarify this by saying, "From my perspective," or "My experience has been," or "I think the orangutans' perspective would be," or "If I'm a farmer, I might think." This will help us keep track of how the different humans and organisms involved might view things differently.*

6. Share local observation data. — 12 MIN

Materials: science notebook, *Observations around Our School* handout, sticky note, Our Local Observations chart, markers

Share patterns from outdoor observations. Gather students in a Scientist Circle. Ask students to bring their *Observations around Our School* handout and science notebook with them. Share a space (e.g., whiteboard or chart paper) that will serve as a record of "Our Local Observations." Sample chart:

Our Local Observations	
Present	Absent
Changes to the land	

Display **slide F**. Have students share what they noticed was present around the schoolyard and record a list. Alternatively, provide students with a sticky note to post under the "present" section of the chart. Repeat the same sharing process for what students noticed was missing that once lived in their ecoregion. Finish by sharing observations students made about land-use changes.

Once observations are recorded, transition to identifying patterns. Example prompts are on **slides G-H.**

Suggested prompts	Sample student responses
What pattern of organisms are we noticing that are present?	*Answers will vary. Likely include animals and reptiles (squirrels, lizards, geckos), birds (pigeons, gulls, robins, starlings, doves, sparrows), insects (crickets, beetles, flies, ants, grasshoppers), plants (grass, shrubs, certain trees in your area, school landscaping plants), various spiders.*
What initial ideas do we have that could help us explain this pattern?	*Certain trees and bushes are present because we planted them.* *Grass is present because we planted it.* *Birds are not really affected because they can fly to new places or live anywhere.* *There are a lot of squirrels because they get what they need from the trees we planted.* *Crickets or other insects are present—not sure why.* *Deer are present because people feed them or there are no predators.* *There are a lot of grassy areas for grasshoppers.* *Buildings have a lot of places for spiders to make cobwebs.*
Is there a pattern of organisms missing from our observations? *(Return to the images on **slide B** as needed.)*	*There are no large predators, like foxes, bears, mountain lions, or wolves.* *There are not a lot of large herbivores, like bison.* *There are not a lot of butterflies or moths.* *There are only a few kinds of trees or plants.*
What might explain those patterns?	*We scared the predators away, or we hunted them.* *They don't like to be near people, and they have no food here.* *They don't have a habitat anymore.*
How do we think the changes humans made to the land impact the plants and animals we see? *(Use **slide H** as needed.)*	*When we put in pavement, we had to clear trees or forest.* *When we put in roads, we broke up the animals' habitat.* *Some animals can eat our trash, so they've been fine staying in our communities.*

7. Facilitate a Consensus Discussion and add to DQB.

18 MIN

Materials: *Observations around Our School* handout, marker, sticky note, initial consensus model (developed in Lesson 1 and modified in Lessons 2-4), markers, Driving Question Board

Facilitate a Consensus Discussion. Compare changes in the local ecosystem to the palm oil case. Display **slide I.** Say, *We've been investigating palm oil in Indonesia, but it seems we have some similar things happening here. So how is what we observed here similar to or different from what's going on in Indonesia? How is it different?*

Give students 1-2 minutes to Turn and Talk. Then bring the students back for a whole-class discussion.

Suggested prompts	Sample student responses
How is what we observed here similar to the palm oil case?	*Answers will vary.* *They are similar because some organisms are doing well with the changes but other organisms are not doing well. Some have left completely.*
How is it different?	*Answers will vary.* *In the palm oil case, humans changed tropical rainforests to palm oil farms. Here we are changing [insert your ecosystem] to homes, buildings, and towns.*

Come to an agreement about what to represent in the class model. Say, *How can we represent what is similar or different in our class model?* Elicit students' suggestions. As students make suggestions, pose their ideas to the class until everyone agrees on what to represent in the model. Add to the class model. A visual example is provided here, for reference.

Generate new questions to add to the DQB. Add a new section to the DQB for questions about changes in the local ecosystem and how those changes impact local populations. The questions can be recorded on Part 4 of students' handouts, too, or simply added to the DQB.

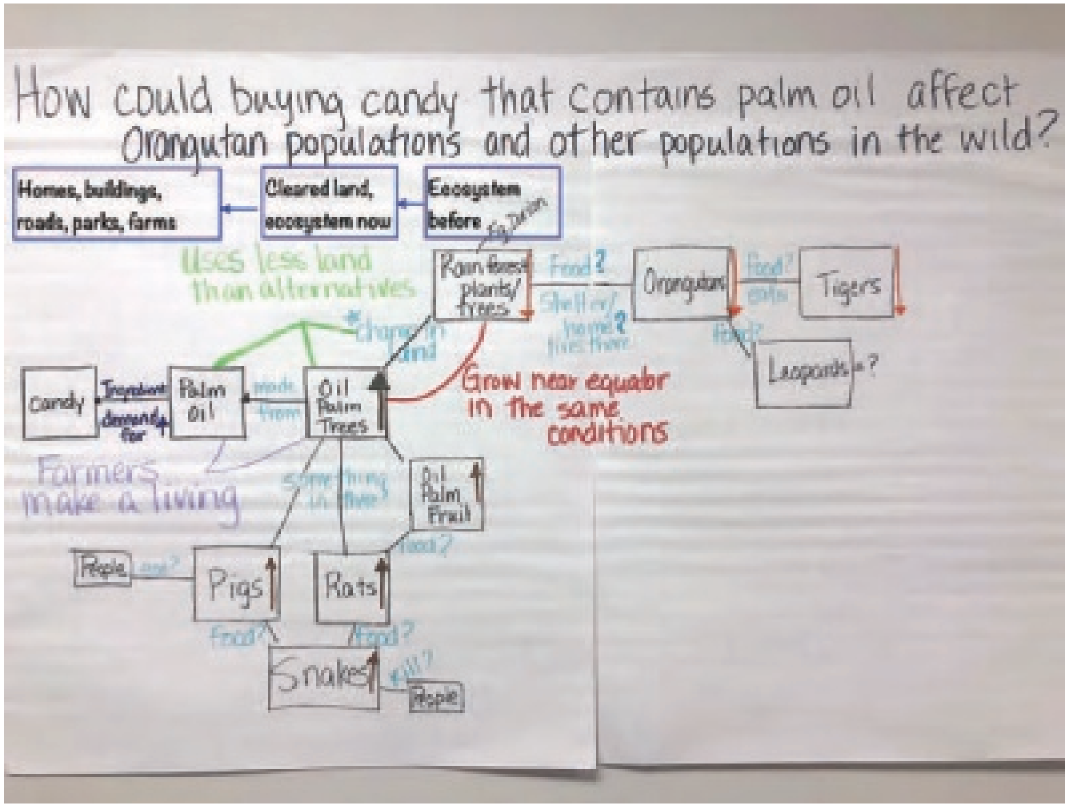
Display **slide J**. Give students about a minute to jot down a question (or 2) with a partner. Have 1 partner post to the DQB, and encourage students to post their questions near similar questions. As students post their new questions, share some of the questions aloud. As students share more questions, cluster the questions into related groups. As students share, prompt them to consider how learning more about palm oil in Indonesia might help them understand local change and vice versa:

- *You asked a question about [local organism]. Which organism from the Indonesia case can we compare to this?*
- *You asked a question about [local change]. How is that land-use change similar to or different from what we are researching in Indonesia?*

Say, *We still have some lingering questions about orangutans and palm oil and how to solve that problem, along with some new questions about changes in our own ecosystem. As we keep figuring out more about these problems, let's see which ideas help us understand either our local or the Indonesian ecosystem changes, or possibly both.*

*** Supporting Students in Three-Dimensional Learning**

The three-dimensional learning goal in this lesson is to guide students to see both patterns of change within their community and patterns of change across cases. This shift from a single observation of the palm oil case to a larger pattern will help students generate new questions about their own community context or patterns of human activity in the biosphere. It may prompt them to ask questions about how these patterns of change are related to the concept of certain populations thriving while others struggle to survive.



Assessment Opportunity

***Building towards:* 5.A** Ask questions to clarify and/or refine a model for explaining how (patterns in) human activities have altered the biosphere and changed habitats both locally and in Indonesia.*

What to look/listen for: This lesson expands students' understanding of impacts from human activities on the biosphere, resulting in new questions concerning the local ecosystem. Students should do the following:

- Articulate a change in the local ecosystem similar to the palm oil case and represent it in their model.
- Articulate how changes in their local ecosystem may be different from those in Indonesia.
- Recognize that the problem is bigger than changes from agriculture.
- Ask new questions about changes in their local ecosystem that may map to questions they originally asked about palm oil.
- Ask questions about a pattern of change that relates to both palm oil and their local ecosystem.

What to do: If the class is struggling to see patterns across the two cases, have students select questions from the DQB that are related to the palm oil case. Have them work with a partner to write a new question that is similar to the first question but applies to their local context. For example, consider the original question "Do orangutans live in other places?" Have students map this question to their local context to identify a population that appears to be struggling (e.g., Louisiana black bears) and to craft new questions regarding the new population (e.g., "Do Louisiana black bears live in other places?").

Additional Guidance

A Progress Tracker entry would be valuable if time permits (see **slide L**). Remind students of the lesson question, *How have changes in our community affected what lives here?* Encourage them to write and draw what they have figured out about the lesson question in their science notebooks. Use their entries to informally assess what ideas they took away from the lesson, such as:

- Humans have altered natural ecosystems.
- Humans have damaged or destroyed natural habitats.
- Some organisms have benefited from the changes created by humans, and we see patterns in which organisms are doing well.
- Some organisms have not benefited from the changes created by humans.

8. Navigation

5 MIN

Materials: None

Elicit student ideas for solutions. Display **slide K.** *Say, This seems like a real problem—not just in Indonesia but even here in our own community. People need land to grow food, build houses, and create roads, but this seems to impact a lot of living things. And it seems the problem may only get worse as humans expand. Let's imagine what could be done differently to have less impact on other species.* Listen for students to suggest:

- We could farm differently.
- We could plant more trees.
- We could protect more land and habitats for animals.

Direct students' attention to the unit question on the DQB. The unit question, added in Lesson 1, should be similar to "How does changing an ecosystem affect what lives there?"

Say, *We're going to continue to need land for humans, and we know this will further change the ecosystem. What if we add another question to our mission to try and figure out better ways to use the land? What about adding the question, "How can we use land in ways that work for humans and other living things?"* See if students want to make changes to this question before posting it to the DQB and a second unit driving question.

LESSON 6

If palm oil is not going away, how can we design palm farms to support orangutans and farmers?

Previous Lesson

We shared our murals and made observations outdoors. We shared what we noticed about patterns in plant and animal life around our school, and we hypothesized about how these patterns related to changes to the land. We revised our model and added questions to the DQB about our local community. Given that agriculture and human communities are not going away and are still expanding, we wondered how humans could use the land in better ways to benefit ourselves and other organisms.

This Lesson

Problematizing

1 DAY

We reflect on what we have figured out to define the problems associated with palm oil farms. We think about how we can design a better palm farm system that will support both the farmers and the orangutan and tiger populations. We use what we learn to co-construct criteria and constraints to guide our design decisions. We revisit our Driving Question Board to add new questions that will help us design a system that is more stable and will help us refine our criteria and constraints.

Next Lesson

We will wonder about the typical number of orangutans and will examine a StoryMap showing the number of orangutans in four protected tropical rainforest areas. We will notice some fluctuation and that larger areas have larger populations. We will calculate the ratio of orangutans to land area. We will also make predictions that this ratio is based on food availability and brainstorm how to test our ideas in a simulation.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

6.A Define a problem that can be solved through designing a palm farm that will maintain the stability of orangutan populations and support farmers who depend on the farms for their livelihoods (criteria).

What Students Will Figure Out

- A better-designed palm farm needs to support living things in the tropical rainforest and farmers, too.

Lesson 6 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	3 min	**NAVIGATION** Connect back to the palm oil problem and share new ideas that we have learned about it.	A	initial consensus model (developed in Lesson 1 and modified in Lessons 2-5)
2	10 min	**DEFINE THE PROBLEM** Work with a partner and then the class to identify what we have figured out about the palm oil problem.	B	
3	12 min	**IDENTIFY GOAL, CRITERIA, AND CONSTRAINTS FOR BUILDING A BETTER PALM FARM** Identify the goal for the design, and co-construct initial criteria and constraints.	C-D	*Palm Farm Designs*
4	17 min	**REVISIT THE DRIVING QUESTION BOARD** Add questions to our Driving Question Board that will help us with our design challenge to build a better palm farm.	E-F	sticky notes, markers, Driving Question Board
5	3 min	**NAVIGATION** Problematize the need to better understand what constitutes a healthy orangutan population and what orangutans depend on for survival.	G	*Palm Farm Designs*
				End of day 1
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 6, students are ready to read Student Reader Collection 2 and then respond to the writing exercise.		Student Reader Collection 2: *Changing Ecosystems*

Lesson 6 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Palm Farm Designs* • sticky notes • markers		• initial consensus model (developed in Lesson 1 and modified in Lessons 2-5) • Driving Question Board

Materials preparation (15 minutes)

Online Resources

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.

Plan to retain the Criteria and Constraints chart you record in this lesson. You will need it for Lesson 17.

Lesson 6 • Where We Are Going and NOT Going

Where We Are Going

This lesson marks the beginning of the second lesson set and serves as a problematize moment to refocus learning on the design challenge. The lesson allows students to synthesize what they have figured out to clearly define the palm oil problem and begin to think about the goal of designing a better palm farm. As students define criteria and constraints for their palm farm designs, they realize there is more they need to figure out about the ecosystem and the populations of orangutans and other organisms that live there. This prompts students to add to the DQB, which will provide a path forward into the next lessons.

In this lesson, the crosscutting concept of stability and change is used to think about how to design a palm system that is more stable for orangutans over time. Students pose questions and consider ideas for how small changes, such as adding more tropical rainforest trees to the palm farm, might help keep orangutan populations stable.

Where We Are NOT Going

Students will know the language of criteria and constraints and understand what they mean prior to this unit from their experience with the *Cup Design Unit*, *Tsunami Unit*, and *Homemade Heater Unit*. For this reason, the discussion of criteria and constraints is brief and assumes students' prior knowledge. If your class is not familiar with these terms, you will need to build in more support for co-constructing definitions of these terms together, modeling for students how to come up with and write criteria and constraints for a design challenge.

LEARNING PLAN FOR LESSON 6

1. Navigation

3 MIN

Materials: science notebook, initial consensus model (developed in Lesson 1 and modified in Lessons 2-5)

Turn and talk about the palm oil problem. Display **slide A**. Say, *Over the past several lessons, we have figured out that changing the land can impact living things. We were left wondering how we can use the land in ways that work for both people and other living things. Let's return to the palm oil problem and think about what we have figured out about the problem that makes it more complicated than we originally thought*. Prompt partners to discuss the following question:

- What is one new thing we have learned about this problem, and how did it make the problem more complicated to solve?

As pairs discuss, listen for students to share with each other ideas related to Lessons 2, 3, and 4, such as the following:

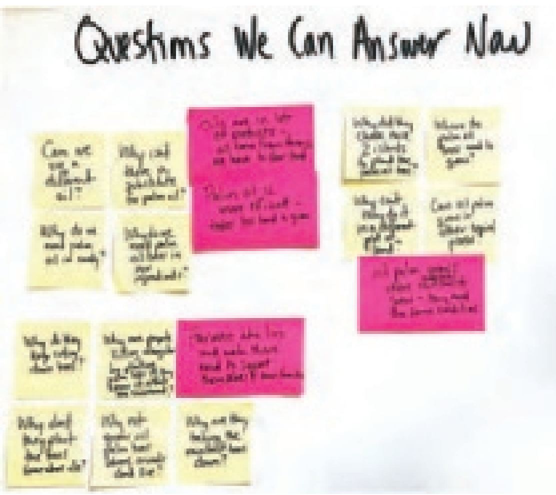
- *Palm oil is an ingredient from oil palm, and oil palm plants take up less land than alternative crops.*
- *Oil palm plants need the same growing conditions as tropical rainforest plants.*
- *Farmers near the equator see palm oil as a source of steady income to support their families.*

2. Define the problem.

10 MIN

Materials: science notebook

Work with a partner to identify what we have figured out about the palm oil problem. Say, *It sounds like we have made some progress answering our questions from the DQB, and in the process, we noticed that this problem is complex. Let's take stock of what we have figured out and see if we can more clearly define the problem*.



Display **slide B**. Ask students to work with a partner and use their Progress Trackers to go through each lesson and identify what we figured out. Ask students to record each idea we figured out on separate sticky notes.

Add sticky notes to the DQB with their partner. As pairs finish, ask them to take turns adding their sticky notes for what they figured out on the DQB, near the questions they feel it helps answer. For example, if a pair wrote "We can't use another oil," they might place it on the DQB near the cluster of questions about why there is palm oil in candy and if we can grow it somewhere else.*

Discuss as a whole group to define the problem and move DQB questions we have answered. Bring students together so

*** Attending to Equity**
Universal Design for Learning: To support *engagement*, ask pairs to choose a specific lesson or lessons (2, 3, or 4), for which they record what they figured out, instead of having each pair do all three lessons. This choice gives students an opportunity to name an important takeaway or insight they had during the first set of lessons. Additionally, it might be helpful to *represent* what they figured out using a different color sticky note from the ones used on the DQB. This can help students more easily identify and attend to the ideas figured out by this point in their investigations.

that they can see the DQB and new sticky notes. Say, *Let's see if we can summarize our ideas to more clearly define the problem.* Work together to summarize what the class has figured out. As ideas are discussed, move the questions we think we can now answer to a new space (e.g., a chart paper titled "Questions We Have Answered"), with the sticky notes for what the class has figured out next to the appropriate questions. Anticipated ideas include the following:

- We can't use another oil—oil palm is more efficient.
- We can't grow it somewhere else—it will be bad everywhere.
- Farmers need to earn an income.
- People need food, which often has palm oil in it.
- When the land is cleared to plant oil palm, orangutan and tiger populations decrease.

Summarize the problem and set the stage for the design challenge. Say, *This is a really complicated problem. We want to protect tropical rainforests and the animals that live there, and we don't want to harm them when we buy candy or anything else with palm oil. But we understand why this is happening, because palm oil is an efficient crop and brings Indonesian farmers a good income to support their families. Palm oil is not going away, so it sounds like we are going to need to design a better palm farm that can support both the humans who depend on it and the animals that live there.*

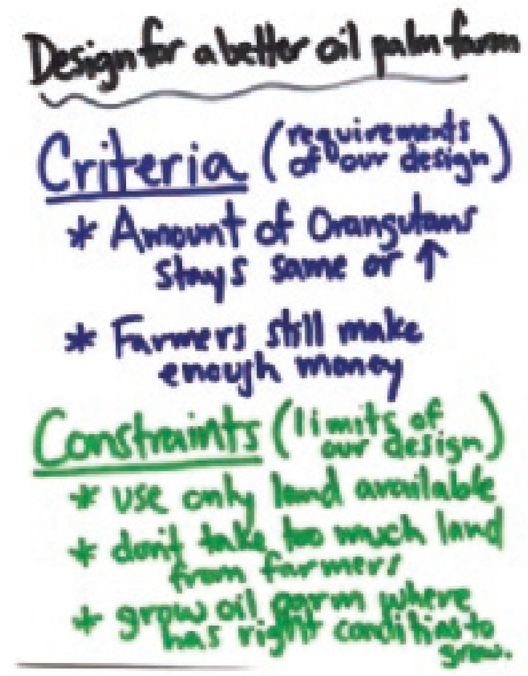
3. Identify goal, criteria, and constraints for building a better palm farm. 12 MIN

Materials: science notebook, *Palm Farm Designs*

Focus students on designing better palm farms. Say, *If palm oil is the best option right now, I'm wondering: Could we somehow plant these oil palm farms in a way that would protect the tropical rainforest and still give the farmers income? What would be something we could do?* Listen for students to suggest the following:

- *Planting more or different kinds of plants in the palm farm*
- *Protecting some rainforests along the edges of the farm*
- *Using part of the land for forests and part for farm*
- *Planting more oil palm on less land so that we don't have to cut down more rainforests*
- *Protecting enough rainforests so that orangutans and tigers can survive*

Review the problem and set a goal for the palm farm design. Display **slide C**. Pass out 1 copy of *Palm Farm Designs* to each student. Direct students' attention to Part 1: Define the Problem. Read the problem together, and ask students if they have anything they want to add to or change about the problem as it's currently written. Give students a minute or so to edit the problem description based on what the class just discussed.



*** Supporting Students in Three-Dimensional Learning**
Students work toward developing their understanding of the criteria and constraints for a design problem with limited possible solutions. They engage with the practice of defining a complex problem to design agricultural systems that work for both humans and other populations, which furthers their understanding of criteria and constraints. They realize that for a solution to be successful, it must meet human and other populations' needs. They also realize that the easiest solutions, such as using an alternative or planting the oil palm elsewhere, are not viable options,

Brainstorm a goal for the palm farm design in partners and then with the whole group. Have students talk with a partner about the goal of our palm farm design. Give each pair a chance to share their idea with another pair before eliciting ideas from the whole group. The goal needs to focus on both the needs of tropical rainforest plants and animals and the needs of farmers.

Example goal: a palm farm that meets a farmer's need for crops to sell and also keeps orangutan populations steady (or increasing).

Discuss criteria and constraints. Display **slide D**. Say, *We know from our work in the Cup Design Unit, the Tsunami Unit, and the Homemade Heater Unit that whenever we want to solve a problem, we need to first define the criteria and constraints of the solution.* Remind students that the criteria are the requirements of our design, while the constraints describe the limits to our designs or what we can and can't do.

Given the goal, ask students to think individually about some criteria that we could measure to see if the palm farm design has met the goal and constraints or limits to our design. Then record ideas as students share and retain this chart for future use in Lesson 17.*

Suggested prompts	Sample student responses
What are some criteria for our oil palm farm designs to be considered successful?	*We need to help the orangutan population.*
What would it mean to design an oil palm farm system that is more stable for orangutans?	*We don't want the number of orangutans to go down. The number of orangutans that live in the area needs to go up.*
What changes might you make to the oil palm farms to help keep orangutan populations stable?	*Maybe we could plant more rainforest trees.*
What other criteria do you think we need to decide if the designs are successful?	*Farmers still make money from their land.*
So, we need to keep the orangutan population the same or higher, and the farmers still need to make enough money to support their families. What about constraints that might limit what we can design?	*We can't take away too much land from the farmers, because then they won't be able to make enough money.* *We have to do this in the rainforest—because that's where these plants grow.* *I'm not sure.*

Example criteria include:

- Farmers have the same amount of crops to sell.
- Farmers still make money from their land.
- The number of orangutans stays the same or goes up.

Example constraints include (You may need to help students articulate these constraints.):

- Use only the land available to us.
- Do not plant in new tropical rainforest areas.

thus necessitating a solution that will meet the criteria to stabilize orangutan populations and also benefit humans who depend on the palm oil industry.

- Do not take away too much land from farmers.
- Grow the oil palm in a place where it will do well (has the nonliving conditions needed).

Additional Guidance

Students should be familiar with the terms *criteria* and *constraints,* and understand what they mean prior to this unit from their experience with the *Cup Design Unit*, *Tsunami Unit*, and *Homemade Heater Unit*. For that reason, this discussion is brief and assumes students' prior knowledge. If your students are not familiar with these terms, you will need to build in more support for definitions and model for students how to come up with and write criteria and constraints.

Students may suggest that a criterion is to protect the tiger populations. However, the simulations used for testing the designs will not include tigers. If you decide to include tiger populations as a criterion, you may need to find additional resources (such as research on efforts to protect tiger populations) for your students to explore in order to feel satisfied that their design would also protect tigers.

If time permits, brainstorm initial ideas for tests to run to measure whether a farm has met the criteria and constraints. Students can write down these notes now.

Tell students that they will be designing farms in a simulation test environment later in the unit, but first we need to learn more about tropical rainforests and palm farms to know precisely what to test. Have students attach their design handouts to their science notebooks.

Assessment Opportunity

***Building towards*: 6.A** Define a problem that can be solved through designing a palm farm that will maintain the stability of orangutan populations and support farmers who depend on the farms for their livelihoods (criteria).

What to look/listen for: When defining the problem, students should identify the multiple aspects of the problem that make it complex to solve. Students should set a goal for the design that functions for farmers, orangutans, and other living things. Students should also suggest criteria that are in line with this goal, such as (1) the newly designed palm farm supports animal populations like orangutans and tigers, and (2) the newly designed palm farm supports the farmers' income. Students may struggle to suggest constraints, and that is OK at this point. Students may suggest constraints, such as not taking land away from farmers, not cutting down new forests, and so forth.

What to do: If students are uncertain about constraints, suggest that they will redesign a single farm with a set amount of land, so that their land area cannot increase. Also, students will be limited to plants that can grow in tropical areas. As students share their thinking about the criteria, use a stability and change lens for thinking about supporting the animal populations. Pose questions such as the following:

- What would it mean to design a palm system that is more stable for orangutans?
- How does your design idea keep the orangutan population from decreasing?
- What do you need to look for to explain why the orangutan population stops declining when you design the farm this way?
- What would you look for in the farmer's income over time to feel your design is successful for them?

4. Revisit the Driving Question Board. 17 MIN

Materials: sticky notes, markers, Driving Question Board

Revisit and add to the Driving Question Board. Say, *So we think we're going to be able to tackle this problem and design a solution: We can design palm farms that support the humans who depend on them, while also protecting orangutan and tiger populations. But I know we still have questions. For example, how are we going to know what constitutes a good number of orangutans, to meet our criteria? There's a lot we need to figure out to design a palm farm system that is more stable for the organisms that once lived there. Let's take a couple of minutes to write our questions so that they'll be clear to others when we want to get them organized.*

Display **slide E**. Give students 2-3 minutes to individually record 1-2 new questions that, if answered, would help them design a better palm farm. Use the following prompts, as needed, to help students generate questions.

- What questions do you have about palm farms or the animals and plants that live there?
- What will we need to investigate in order to solve this problem?
- What else do we need to know to refine our criteria and constraints?

Display **slide F** and facilitate another sharing of questions to place on the DQB. Help the class organize these questions as they are shared.

5. Navigation 3 MIN

Materials: science notebook, *Palm Farm Designs*

Generate next steps. Display **slide G** and focus students on the criteria they listed on the design handout and the questions they just generated. Say, *We have questions about orangutans and what constitutes a "good number" of orangutans. What information would help us answer this question and help us refine our criteria?*

Allow students to make suggestions for additional information that we need to learn about orangutans (and tigers) that would help with their designs. Listen for ideas such as researching how many orangutans live in tropical rainforests or how many orangutans were in the tropical rainforest before farmers cut down the trees.

Say, *Let's start here next to see if we can get a sense for what we need to aim for as a good number of orangutans on our redesigned palm farms.*

SCIENCE LITERACY: READING COLLECTION 2

Changing Ecosystems

1 **From *The Log from the Sea of Cortez***
2 **The History of Ecology**
3 **Habitat Fragmentation**
4 **Native, Non-Native, and Invasive Species**
5 **Right Whales, Wrong Place, Wrong Time**

Literacy Objectives

- ✓ Read to find out about unintended consequences of human development in an ecosystem.
- ✓ Outline major developments in the history and understanding of ecology.
- ✓ Compare native, non-native, and invasive species.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 3–6.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a narrative to relate the story of an unintended consequence of human development in an ecosystem in response to the reading.

Instructional Resources

Student Reader
Collection 2

Science Literacy Student Reader, Collection 2
"Changing Ecosystems"

Exercise Page
EP 2

Science Literacy Exercise Page
EP 2

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 3: Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?
- Lesson 4: Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?
- Lesson 5: How have changes in our community affected what lives here?
- Lesson 6: If palm oil is not going away, how can we design palm farms to support orangutans and farmers?

Standards and Dimensions

NGSS Performance Expectation

LS2-1: (Building toward) Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Disciplinary Core Idea LS2.A: Interdependent Relationships in Ecosystems

Science and Engineering Practice: Analyzing and Interpreting Data

Crosscutting Concepts: Cause and Effect; Patterns

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.W.7.3

Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

ecology

habitat fragmentation

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

endemic species

invasive species

non-native species

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Exercise Page

EP 2

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Ecosystem Dynamics unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
  - *In "From* The Log from the Sea of Cortez,*" you will find out how some methods for extracting animals for human consumption can be very harmful to an ecosystem.*
  - *In the second selection, you'll review key developments in the history of awareness and concern about nature.*
  - *"Habitat Fragmentation" makes you think about how ecosystems are broken or fragmented by human development.*
  - *In "Native, Non-Native, and Invasive Species," you'll find out what can happen when certain plants or animals become established in an ecosystem.*
  - *In the last selection, you'll read about how some species can be affected by the extraction of another species in an ecosystem.*
- Distribute Exercise Page 2. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to write a story or narrative about an unintended consequence of a change in an ecosystem.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What is an unintended consequence? What are examples of unintended consequences?	*when you try to solve one problem and create a new situation* *Example: spraying insecticide to kill bugs but causing respiratory problems for animals or humans*
What are the causes of many of the key moments in the history of ecology?	*basic human interest and curiosity and a desire to understand the world; observations of changes in nature and looking for causes; desire to protect habitats and certain plants and animals*
What are examples of major changes in a habitat?	*A highway is built through a desert.* *A river or creek is dammed up to provide water for a city.* *A forest fire destroys hundreds of acres of trees.*
What are consequences of a major change in a habitat?	*Plants and animals that live there may die, must move, or adapt to the changes.*
How can people avoid unintended consequences of human development or resource extraction?	*They can study the habitat before the changes begin and plan for accommodations.*
How can invasive species cause major disruption to an ecosystem?	*If a species has no natural predators in an ecosystem, its population can explode and kill off other species.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
Why might invasive species create so much destruction to native species in some areas but not in others?	*The climate may be favorable to an invasive species in some places but not in others. A tropical plant that is an invasive species will not survive in a cold climate but may cause great change in a tropical climate.*
How are people affected by changes in an ecosystem?	*Humans have to move or adapt just like other living things if there are no longer the resources needed to survive in an ecosystem.*
What are examples of wildlife that live in areas developed by humans?	*Mice, birds, raccoons, snakes, rabbits, insects, opossum, fox, deer, and even coyotes, bears, and wolves live in areas developed by humans.*

- Refer students to the Exercise Page 2. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to compose a story about an unintended consequence in an ecosystem.*
  - *In the selections, you learn about unintended consequences of extracting fish from the sea for human consumption and about invasive species that have affected ecosystems.*
  - *Think about what you read as you research instances of unintended consequences in an ecosystem. The example you choose to focus on may be local, global, recent, or in the past. The unintended consequence can have a positive or negative effect on the ecosystem.*
  - *Your story should have a beginning that describes the ecosystem before the disruption. The story should have a middle that explains how the ecosystem was disrupted and an ending that tells the results and unintended consequences.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 2

4. Facilitate discussion. (Friday)

Facilitate class discussion about the reading collection and writing exercise.

The five reading selections help to describe intended and unintended consequences of different types of changes in an ecosystem.

Student Reader

Collection 2

Pages 16–17 Suggested prompts	Sample student responses
What is the general purpose of the first selection, Steinbeck's "The Log from the Sea of Cortez"?	*It describes how many animals are killed as an unintended consequence of fishing for one specific resource.*
How could the death of so many other fish be avoided?	*Find ways to use different kinds of nets and procedures so not as many unwanted fish are caught.* *Find ways to safely release unwanted fish.*
Why would people allow so many unwanted fish to be killed?	*Money is paid for specific fish, and other animals are not valuable in the area of human economics.*
Are the unwanted fish valuable?	*They have a role to play in the ecosystem and as such are necessary for ecosystem health.*
What can happen if the shrimping practices John Steinbeck described did not change?	*Many species of fish might become extinct, and the ecosystem that produced the valuable shrimp could be destroyed.*

Pages 18–19 Suggested prompts	Sample student responses
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first selection was about shrimping practices that could destroy an ecosystem. The second selection shows that people have had an interest in and concerns about ecology for thousands of years.*
What is conservation?	*Conservation is prevention of wasteful resource use so that ecosystems are protected, are maintained, and continue to thrive.*
What are some conservation and eco-friendly practices that ecologists have promoted that you know and use?	*turning off water when brushing your teeth, using reusable lunch bags, throwing trash in trash cans, recycling*

Pages 20–21 Suggested prompts	Sample student responses
What is the general purpose of the third article, "Habitat Fragmentation"?	*It describes what happens to some plants and animals when land is developed.*
What is habitat fragmentation?	*It is the breakup of a natural habitat into smaller pieces mainly because of human development.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Have students watch a video about wild animals, like foxes, that live in developed areas. Discuss how some animals have adapted to human development.

SUPPORT—Compare with students the terms *endemic, native, non-native,* and *invasive* as they relate to a particular ecosystem. Students should recognize that an endemic species occurs only on one location. A native species lives in an area naturally with no human intervention. Non-native species have been intentionally or accidentally introduced to an area, and an invasive species is a non-native species that causes harm to an ecosystem.

CHALLENGE—Have interested students research how the shrimp industry has changed since John Steinbeck wrote about it in the 1940s. Have them report their findings to the class.

Pages 20–21 Suggested prompt	Sample student responses
Why might some animals be able to adapt to habitat fragmentation while others cannot?	*Small animals, like ants and mice, that do not have a wide range can find ways to survive even when a habitat is fragmented.* *Other animals and plants that need a wide range may be destroyed or need to relocate to survive.*

Pages 22–23 Suggested prompts	Sample student responses
What is the general purpose of the fourth selection, "Native, Non-Native, and Invasive Species"?	*It explains the differences among native, non-native, and invasive species with examples of each and how they can affect an ecosystem.*
How do non-native and invasive species get established in an ecosystem?	*Some plants and animals are introduced to solve a problem or provide a resource.* *Birds and fish also spread non-native species.* *Some animals and plants accidentally get loose in an ecosystem and then populate.*
What can happen when a non-native species becomes established in an ecosystem?	*The ecosystem changes. Plants and animals may adapt to the new ecosystem, die, or move.*

Pages 24–25 Suggested prompts	Sample student responses
How does the last selection relate to the other selections in this collection?	*It describes unintended consequences of whales being harmed by boats and fishing nets.*
How do fishing practices that harm whales in the Northeast compare to the shrimping practices that Steinbeck described?	*In shrimping, all fish were caught in nets and then discarded. In lobstering, the boats harm slow-moving whales, or the whales become entangled in nets.*

SUPPORT—Have students watch a video about manatees that are harmed by boats in Florida. Discuss what is being done to protect them.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 2, students should research and write a story about an unintended consequence in an ecosystem. The story should have a beginning, middle, and end.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 7

How many orangutans typically live in the tropical rainforest?

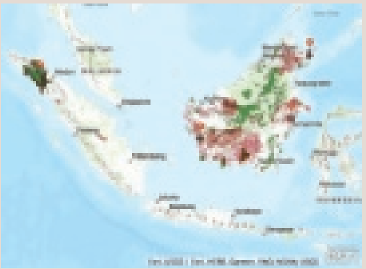
Previous Lesson

We reflected on what we figured out to define the problems associated with palm oil farms. We discussed how we can design a better palm farm system that will support both the farmers and the orangutan and tiger populations. We used what we learned to co-construct criteria and constraints to guide our design decisions. We revisited our Driving Question Board and added new questions that will help us design a system that is more stable and will help us refine our criteria and constraints.

This Lesson

Investigation

2 DAYS



In this lesson, we examine a StoryMap that presents information about the number of orangutans in four protected areas with intact tropical rainforests. We notice that the number of orangutans in each area fluctuates some but is relatively steady. We notice that larger areas have more orangutans. We calculate how many orangutans are in 1 km^2 (100 hectares) for each park and realize that this trend is similar across parks, with only about 1-3 orangutans able to live in 1 km^2 or 100 hectares. We wonder if this is because of food limitations and consider what we would need in a simulation to test this idea.

Next Lesson

We will gather data from a computer simulation in which individual orangutans compete with each other for food resources (rainforest fruit and termites). We will run multiple trials of experiments to test three different environmental conditions. We will examine how well individual orangutans and the orangutan population overall respond by analyzing averages and ranges of orangutan energy points for each environmental condition (dependent variables).

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

7.A. Apply mathematical concepts (ratio) to find patterns in numerical relationships about the number of orangutans that can live in a 1 km^2 or 100 hectare area.

What Students Will Figure Out

- Populations of organisms are made up of many individuals living in the same area.
- Individual organisms and populations of organisms are dependent on a certain amount of space.

Lesson 7 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	3 min	**NAVIGATION** Review that we need data to figure out the typical number of orangutans in a given area.	A	
2	20 min	**INVESTIGATE ORANGUTANS IN PROTECTED AREAS** Watch a video and explore a StoryMap to find out how many orangutans are in different protected areas in Borneo and Sumatra.	B-D	Orangutans in Protected Areas of Borneo and Sumatra StoryMap, How to Count Orangutans video, computer and projector
3	10 min	**INITIAL IDEAS DISCUSSION ABOUT THE STORYMAP** Introduce the term "population," and share observations and patterns about orangutan populations in four different protected areas.	E-G, Q-T	Orangutans in Protected Areas of Borneo and Sumatra StoryMap, Word Wall
4	10 min	**CALCULATE THE SPACE ONE ORANGUTAN NEEDS** Focus on what the different park areas mean and calculate how many orangutans are in 1 km^2 in each park.	H-J	calculator, chart paper, markers
5	2 min	**NAVIGATION** Remind students of the revised lesson question and foreground where we are headed in the next class period.	J	
				End of day 1
6	2 min	**NAVIGATION** Review the lesson question and take stock of what we were trying to figure out in comparing orangutans in the four protected areas.	J	
7	18 min	**ANALYZE ORANGUTANS PER AREA DATA** Use the Identify and Interpret (I^2) sensemaking strategy to analyze and interpret the range of orangutans per area across different years at four different parks.	K	*Orangutan Populations in Protected Areas in Indonesia* handout, tape, Orangutans per Area Chart (made on day 1)
8	10 min	**BUILDING UNDERSTANDINGS DISCUSSION** Make sense of patterns and come to a consensus that 1-3 orangutans can live in 1 km^2. Discuss what this means in terms of hectares when we start designing farms.	L-M	*Palm Farm Designs* handout
9	5 min	**ADD TO THE PROGRESS TRACKERS** Add new ideas to individual Progress Trackers.	N	
10	10 min	**PREDICT WHY ORANGUTANS NEED SO MUCH SPACE** Have students generate ideas about why orangutans need so much tropical rainforest area and how to test these ideas in a simulation.	O-P	*Orangutan* reference card (from Lesson 1), chart paper
				End of day 2

Lesson 7 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide Student Work Pages	• Orangutans in Protected Areas of Borneo and Sumatra StoryMap • science notebook • *Orangutan Populations in Protected Areas in Indonesia* handout • tape • *Palm Farm Designs* handout • *Orangutan* reference card (from Lesson 1)	• calculator	• How to Count Orangutans video • computer and projector • Word Wall • chart paper • markers • Orangutans per Area Chart (made on day 1)

Online Resources

Materials preparation (30 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.

Test the video *How to Count Orangutans*. Be prepared to project this video for your students to watch. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

If you have access to computers for students in groups of 2-3, practice opening the *Orangutans in Protected Areas of Borneo and Sumatra StoryMap* and review it so that you know how to help students navigate the StoryMap. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

If you do not have access to computers, consider the following options or a combination of them:

1. Project the StoryMap for the whole class to examine together.
2. Have students use their personal phones to view the StoryMap.
3. Use the hardcopy references in the Reference section of the *Student Edition* so that students can look at the same information presented in the StoryMap.
    a. **Slides Q-T** are optional slides that you can use if you are not using the StoryMap.
    b. *Map of Protected Areas and Orangutan Distribution* and *Orangutans in Four Protected Areas in Indonesia* contain the same information in the StoryMap for students to read.

Make a chart with the names of the four protected areas on it so that it will be easy to fill in during the discussion.

Be prepared to add “population” to the class Word Wall on day 1.

Lesson 7 • Where We Are Going and NOT Going

Where We Are Going

At the start of this lesson, students may use language about the "numbers of orangutans" their design needs to support. As students explore the StoryMap, they start to notice different geographic areas within which orangutans live (e.g., four different parks that are very far apart). After this exploration, students will transition from talking about numbers of orangutans to thinking about populations living in specific geographic areas. Moving from thinking about individual organisms to many orangutans is an important conceptual shift that is the focus of this lesson.

In the StoryMap, students will observe some data about orangutan populations in four different geographic areas and will notice that the populations fluctuate a little. This idea is introduced in this lesson briefly but will be intentionally developed in Lesson 9 when students engage with a computer simulation that shows orangutan populations over a 5-year time period.

Students in this grade band are developing an understanding of ratios as a means to compare quantities, as well as to compare a part to a whole. In grade 6 under Common Core, they learn to define and calculate ratios, a skill that they apply in this lesson to figure out how many orangutans live in a given area, as well as to find equivalent ratios and use these comparisons to describe relationships (like the one between the number of orangutans and the size of an area). Using ratios in this specific scenario underscores to students that there is a relationship between orangutans and land area that scales as land area increases, which is an understanding that supports students in figuring out that the number of organisms that can survive in an area depends on the amount and availability of resources (i.e., land). You will need to model how to translate data from a table (like how many orangutans there are) into one side of a ratio whose other side is another value (land area). It is important to emphasize the meaning of the order of this ratio, as it relates to the question that the class is trying to answer.

Students may also need support in finding equivalent ratios (specifically, unit ratios), in order to find out how many orangutans are in 1 unit of area. You can support your students by modeling or recalling strategies for finding equivalent ratios, such as bar or block models, ratio tables, and double-tape diagrams. In this case, students may need to see a sample calculation from a classmate or you in order to work through the math required to tabulate data. Calculating these ratios is a secondary skill compared to being able to understand the mathematical meaning of the value of "orangutans per unit area" and use these data as evidence to draw a scientific conclusion about the relationship between the number of orangutans and the amount of available land.

The area will be provided in km^2, a unit used by biologists for calculating population density, and hectares, a unit used by farmers and landowners. The conversion between the two is simple: 1 km^2 = 100 hectares. In this lesson, you can focus on km^2; however, when students start working with the simulations in Lessons 8, 9, and 12, they will need to convert km^2 to hectares. An example of this conversion in Lesson 12 is 3 orangutans per km^2 = 3 orangutans per 100 hectares. The combined farm and tropical rainforest area in the Lesson 12 simulation is 400 hectares, so the combined farm and tropical rainforest area should aim to support 12 orangutans. That will become students' target goal for a successful design.

Where We Are NOT Going

Students calculate ratios of orangutans to land areas to compare how many orangutans are in four different protected tropical rainforest areas. We do not use the language "population density," though students do develop a conceptual understanding of what that ratio means. Using this language is not necessary and will not be revisited during the unit.

Students calculate and analyze two different ratios during their investigation: one using km^2 and one using 100 hectares. We intentionally do not ask students to reduce the latter ratio, as it will be helpful information when they return to their farm designs in Lesson 12, using hectares as their unit of area.

LEARNING PLAN FOR LESSON 7

1. Navigation

3 MIN

Materials: None

Review the information needed about orangutans. Project **slide A**. Have students briefly turn and talk about the prompt on the slide, and then share out with the whole class. Listen for and draw out the idea that we need information about how many orangutans live in tropical rainforests that have *not* been impacted by oil palm plantations, as that is where we anticipate finding "typical" numbers of orangutans. These "undisturbed" tropical rainforest areas are likely in protected areas, like national parks.

Suggested prompt	Sample student response	Follow-up question
How are we going to find out the number of orangutans that typically live in the tropical rainforest?	*Look at places where there are healthy orangutans and see how many orangutans are there.*	*Where should we look for healthy orangutans? Where would we expect to find healthy ecosystems?*

Introduce the lesson question. Say, *In the last class, you had some really interesting ideas about how to meet our criteria for supporting orangutans. But we decided we needed to know more about what we are aiming for.* Remind students that we were wondering, *How many orangutans typically live in the tropical rainforest?*

2. Investigate orangutans in protected areas.

20 MIN

Materials: Orangutans in Protected Areas of Borneo and Sumatra StoryMap, science notebook, How to Count Orangutans video, computer and projector

Watch a video describing how scientists count orangutans. Say, *Let's first see how scientists actually do this work and the methods they use to collect data about the places where orangutans live and how many live there. They used to try to count orangutans by locating all their nests, but scientists now have new methods via new technologies that are available.* Tell students to be prepared to share at least one thing they found interesting about the work the scientists are doing. Project **slide B** and view the *How to Count Orangutans* video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) After the video, project **slide C** and ask students to share what they found interesting about the work the scientists are doing.

*** Attending to Equity**

Universal Design for Learning: Some students may benefit from a scaffolded approach to the StoryMap investigation. To support *representation,* consider using strategies to guide students' information processing of the data in the StoryMap. For example:

Prepare to explore the StoryMap. Say, *Now that we know how scientists collect data about orangutans, let's explore some of the data on orangutan numbers that have been generated by these scientists.*

Project **slide D** and remind students that the question we are trying to answer is "How many orangutans typically live in the tropical rainforest?"

Open the *Orangutans in Protected Areas of Borneo and Sumatra* StoryMap. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Review a process for students to explore the StoryMap.* One process might include that students read the StoryMap once, and then discuss with their partner what information is important to record and how to best organize the information. Then, students read the StoryMap a second time, documenting important information in their science notebooks. Update **slide D** to reflect the process you want students to use.

Alternate Activity

If you do not have enough computers for students to work in groups of 2-3, there are three alternative ways to facilitate this activity: (1) project the StoryMap for the whole class to investigate together, (2) have students use personal phones or tablets to view the StoryMap, or (3) use paper versions of the materials. See the preparation section of this lesson for more information.

Explore the StoryMap in partners.* Give students time to review the *Orangutans in Protected Areas in Borneo and Sumatra StoryMap,* in partners or a group of 3. Encourage students to record important information in their notebooks in a way that makes sense to them and to follow the agreed-upon process.

Supporting Students in Making Connections in ELA

A StoryMap is an interactive, web-based text that helps students explore a specific geographic story. This StoryMap is a new kind of informational text for students that integrates text, maps, images, and graphs to help students interpret key science ideas.

- Co-construct a process for working through the StoryMap, then proceed through each step in a "chunk".
- Use an explicit prompt at each step to guide students' analysis of the data in that moment. For example, if students are struggling to identify what information to record in their notebooks, remind them of what we are trying to figure out ("How many orangutans typically live in the tropical rainforest?").
- Model for students the analysis of one location in the StoryMap, then let students work in small groups to analyze another location following a similar procedure.
- Allow students to choose whether they want to explore the data using the interactive StoryMap or prefer the handout alternatives provided in the *Student Edition*.

3. Initial Ideas Discussion About the Storymap

10 MIN

Materials: Orangutans in Protected Areas of Borneo and Sumatra StoryMap, science notebook, Word Wall

Additional Guidance

Consider projecting the StoryMap throughout the discussion as a way of looking at the locations as students share their thinking. Optional **slides O-R** are available to support discussion if you choose not to project the StoryMap during the discussion.

Facilitate an Initial Ideas Discussion. Project **slide E** and bring the class together for an Initial Ideas Discussion. Start the discussion with an open-ended prompt about what students noticed about the number of orangutans.

Key Ideas

The purpose of this discussion is to foreground three ideas:

1. We can think about the number of organisms in an area as a *population*.
2. Population sizes can vary over time.
3. Populations seem to be larger in areas with more space.

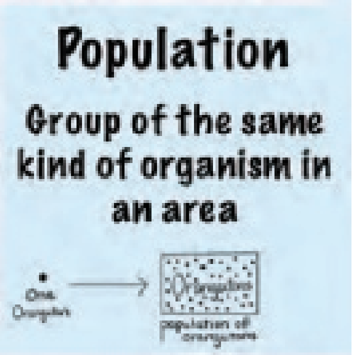
Listen for these ideas:

- There is a certain number of orangutans in each different park or reserve.
- The number of orangutans within specific parks sometimes stays the same but sometimes goes down or up.
- The number of orangutans in each park is different from the others.
- The Leuser Ecosystem is the biggest park and seems to have way more orangutans than the other smaller parks.

The final idea will prompt a need to calculate the ratio of orangutans to land area to figure out if there actually are more orangutans in larger areas.

Suggested prompt	Sample student responses
What do you notice about the number of orangutans in each area?	*They are changing each year in most locations.* *They are different sizes in different areas.* *The biggest population is located in Leuser. The smallest population is located in Kutai.* *There is not that much data, and they only seem to count every few years.*

Introduce the term "population." Before continuing the discussion, focus the students on the idea that there are specific areas (protected national parks and wildlife reserves) that have numbers of orangutans within them and that individual orangutans are not moving in between each park. They are their own distinct groups. Introduce the scientific term "population." Emphasize that the four different park areas have their own populations of orangutans.



Develop a shared representation for the idea of population. Project **slide F** and have students briefly discuss how to represent the idea of population with a partner. Then have students share out and develop a class consensus representation. One example representation is shown here.

Suggested prompts	Sample student responses
How can we represent the idea of a population of orangutans?	*Show a lot of dots to represent many different orangutans.* *Add a circle around the outside to show that the orangutans are all in the same place.*
How is a population different from one individual orangutan?	*A population is many different orangutans, not just one orangutan.*

Add "population" to your class Word Wall or other public vocabulary tracking system (e.g., glossary). Then help students practice using the word throughout the rest of the discussion.

Additional Guidance

Universal Design for Learning: The word "population" has been occasionally used throughout the unit. After looking at examples of four distinct geographic areas in which orangutans live, students should start to have a conceptual understanding that a population is the number of organisms in a specific area. This is why the vocabulary is introduced *after* the StoryMap. By pausing to introduce this term, you provide an opportunity to *clarify vocabulary and language* for students and to give them practice using the term "population" as you continue the Initial Ideas Discussion. If students continue to talk about the "number of orangutans," that is OK. You can model the use of the term "population" by restating what students say and adding the scientific language (e.g., "The number of orangutans in Kutai, or the population of orangutans in Kutai, is the smallest.").

Continue the discussion of orangutan populations in four protected areas. Project **slide G** and continue discussing what students noticed in the StoryMap. You can project the StoryMap and use it to zoom into areas as students share their ideas.

Suggested prompts	Sample student responses
Which area had the largest population (the most orangutans)? The smallest population (the least)? (if not previously mentioned)	*Leuser had the most.* *Kutai had the least.*
What was the approximate population size or number of orangutans in each area?	*It's different in each area. Gunung Palung was around 2,500.* *Kutai was 600.* *Tabin was around 1,300.* *Leuser varied a lot, between 4,700 and 12,000.*
Why do you think the population of orangutans in an area didn't always remain the same?	*Orangutans are born and die, so it's not always exactly the same.* *Maybe something happened to the orangutans in a year during which there were a lot fewer.*
Why do you think some areas have larger populations of orangutans than others?	*Larger areas had more orangutans. Maybe a bigger area can have more orangutans.*

4. Calculate the space one orangutan needs.

10 MIN

Materials: calculator, chart paper, markers

Review differences in the size of the protected areas. Summarize by saying, *We think that larger protected areas have larger orangutan populations. Let's take a closer look at the sizes of these different protected areas*. Project the *Orangutans in Protected Areas StoryMap* tab and draw students' attention to the sizes of the four different protected areas. As students share out the size of each area, record the name and area on a piece of chart paper. Leave space between each area to add more information later.

Discuss what these areas mean. The purpose of this discussion is to help students understand the idea of area in general and the differences in the sizes of these four areas.

Suggested prompts	Sample student responses
The units of the sizes are km^2. Let's break that apart. What is a kilometer?	*like a mile but shorter* *not sure*
What does a "square kilometer" mean?	*A km^2 is an area.* *Four kilometers make a box.* *that is made up of two length units squared*

Additional Guidance

Help students understand how big these areas are by relating each area to places with which students are familiar (cities, states, parks, etc.). A quick Google search should give you the local information students will need. Some examples are

- 187 football fields are 1 km^2,
- the state of Delaware is 6,500 km^2,
- Los Angeles is 1,300 km^2, and
- New York City is 780 km^2.

Note that we are using km^2 for this scenario because km^2 is a common area measurement used by scientists around the world, particularly outside the United States. Later in this lesson, we will have students think about the relationship between 1 km^2 and 100 hectares. Hectares is another measurement unit commonly used by farmers and landowners, and the conversion will be helpful later when students design their farms.

*** Supporting Students in Engaging in Asking Questions and Defining Problems**

Use this as an opportunity to remind students that in science, we pose questions that make sense to us, but as we gather more evidence, we may need to revise those questions so that we can answer them.

*** Supporting Students in Engaging in Using Mathematics and Computational Thinking**

Students may also need support in finding equivalent ratios (specifically, unit ratios) in order to find how many orangutans are in 1 unit of area. Teachers can support students by modeling or recalling strategies for finding equivalent ratios, such as bar or block models, ratio tables, and double-tape diagrams. In this case, students may need to see a sample calculation from a classmate or their teacher in order to work through the math required to tabulate data. Calculating these ratios is a secondary skill compared to being able to understand the mathematical meaning of the value of "orangutans per unit area" and use these data as evidence to draw a scientific conclusion about the relationship between the number of orangutans and the amount of available land.

Introduce the idea of calculating the ratio of orangutans to land area. Say, *It's hard to compare the orangutan populations in each park because the areas are so different. We think the protected areas that are larger have more orangutans than smaller areas. But that may just be because there is more space for them to live. So is the Leuser Ecosystem orangutan population larger because the area is just bigger? How can we standardize the area so that we can compare the different parks?* Project **slide H** and have students share some ideas. Listen for ideas related to division, fractions, ratios, and density.

Suggested prompts	Sample student responses
How many orangutans do you think we would find in 1 km² in each of these parks?	*Accept all ideas and probe for reasoning.*
How can we determine this?	*not sure* *Divide the number of orangutans by the amount of space for each area.*

Project **slide I.** If students have not already brought up the idea, introduce the concept of dividing the population number of orangutans by the total area as a way to compare the different populations. Add the areas to the population chart under the park or preserve name.

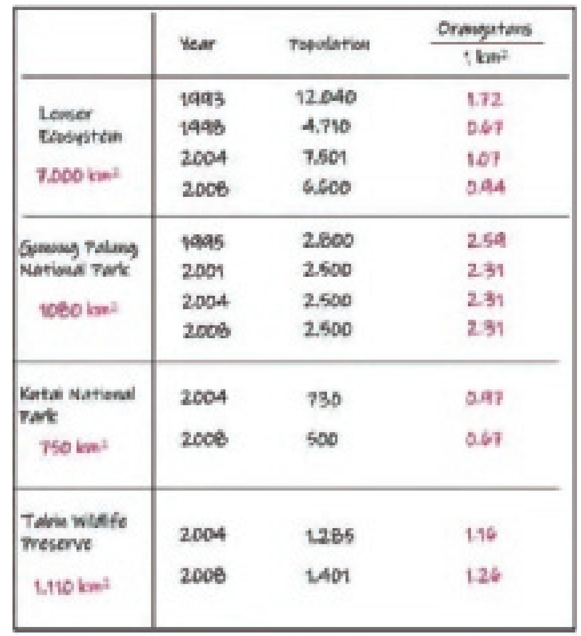
Have students practice a calculation together. Have students calculate the number of orangutans in 1 km² in the Leuser Ecosystem in 1993 and, with a partner, discuss what the number means. Then, have students share out, emphasizing that the number means that only 1-2 orangutans live in a 1 square kilometer area in the Leuser Ecosystem.

Reframe the question to explore the ratio of orangutans to given area.* Say, *We've figured out that there were 1-2 orangutans in Leuser in 1993 per 1 square kilometer. Let's return to our lesson question, which is "How many orangutans typically live in the tropical rainforest?" Is that what we've been calculating?* Have students share ideas. Emphasize that they are not just calculating how many orangutans typically live in healthy tropical rainforests but calculating how many can live in a given area of healthy tropical rainforest, like 1 km². Ask students how they could change their question to reflect this new focus on a given area (e.g., *How many orangutans live in a given area of tropical rainforest?*). Explain that this new question will help them better compare the number of orangutans in each protected area.

Chart the population sizes on the board. Ask for students to share the population information in each year for each ecosystem. Add this information in a chart you have started (shown in black font in the example).

Calculate the ratio of orangutans to land area for each year and location.* Divide students into partners and have each partner use a calculator to determine the ratio of orangutans to land area for a single year in one location. Then have one partner add their data to a class chart (shown in red font in the example). Title the chart "Orangutans per Area Chart" and save it to use the following day.

	Year	Population
Leuser Ecosystem 7,000 km²	1993	12,040
	1998	4,710
	2004	7,501
	2008	6,600
Gunung Palung National Park 1080 km²	1995	2,800
	2001	2,500
	2004	2,500
	2008	2,500
Kutai National Park 750 km²	2004	730
	2008	500
Tabin Wildlife Preserve 1,110 km²	2004	1,286
	2008	1,401



	Year	Population	Orangutans / 1 km²
Leuser Ecosystem 7,000 km²	1993	12,040	1.72
	1998	4,710	0.67
	2004	7,501	1.07
	2008	6,600	0.94
Gunung Palung National Park 1080 km²	1995	2,800	2.59
	2001	2,500	2.31
	2004	2,500	2.31
	2008	2,500	2.31
Kutai National Park 750 km²	2004	730	0.97
	2008	500	0.67
Tabin Wildlife Preserve 1,110 km²	2004	1,286	1.16
	2008	1,401	1.26

Example of completed chart

5. Navigation

2 MIN

Materials: None

Remind students of the new lesson question. Display **slide J**. Remind students that we revised the lesson question and that we will analyze the data we just calculated to answer this new question in the next class.

End of day 1

6. Navigation

2 MIN

Materials: None

Remind students of the new lesson question. Display **slide J** again. Remind students that we revised the lesson question. Ask students, *Why did we think we needed a new question as we started to compare the different ecosystems?*

Listen for students to share:

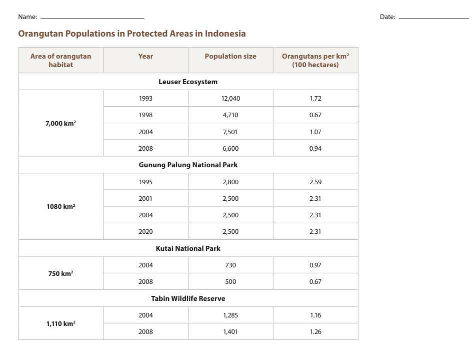
- *We wanted a way to standardize the area so we could compare.*
- *We wanted to understand why the larger areas have more orangutans.*
- *We wanted to figure out how much rainforest each orangutan needs.*

Remind students that the previous day, we calculated these ratios for all of the different locations and times, and that we calculated the ratios using 1 km^2 because that is how scientists who study ecosystems measure area.

7. Analyze orangutans per area data.

18 MIN

Materials: *Orangutan Populations in Protected Areas in Indonesia* handout, science notebook, tape, Orangutans per Area Chart (made on day 1)



Name: ______ Date: ______

Orangutan Populations in Protected Areas in Indonesia

Area of orangutan habitat	Year	Population size	Orangutans per km^2 (100 hectares)
Leuser Ecosystem			
7,000 km^2	1993	12,040	1.72
	1998	4,710	0.67
	2004	7,501	1.07
	2008	6,600	0.94
Gunung Palung National Park			
1080 km^2	1995	2,800	2.59
	2001	2,500	2.31
	2004	2,500	2.31
	2020	2,500	2.31
Kutai National Park			
750 km^2	2004	730	0.97
	2008	500	0.67
Tabin Wildlife Reserve			
1,110 km^2	2004	1,285	1.16
	2008	1,401	1.26

15

Introduce and prepare for the Identify and Interpret (I^2) sensemaking strategy. Say, *I made a handout of the data we gathered yesterday so that we can mark it up.* Pass out 1 copy of *Orangutan Populations in Protected Areas in Indonesia* to each student. Have the class's original *Orangutans per Area Chart* displayed. Students can tape the handout in their science notebooks. Project **slide K** to students and remind them how to use the I^2 strategy to analyze and interpret data.*

Make observations of the graph using "What I See" statements.
Prompt students to write "What I See" (WIS) statements in their small groups. Remind students to write directly on the data tables, drawing arrows to their observations. After about 4-5 minutes, bring students together to discuss their observations of the data (e.g., "What patterns did you notice? Did anybody else notice something similar?"). Focus the discussion on the range of orangutans to area ratios.

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
Students will use the Identify and Interpret (I^2) sensemaking strategy to analyze the data table. Consider modeling one observation (WIS) and one interpretation (WIM) with your students before they begin small-group work. This strategy helps students break down an information-rich data set into smaller pieces to interpret, which will allow them to use the data to provide evidence for a phenomenon.

Interpret observations using "What It Means" statements. Have students write "What It Means" (WIM) statements next to each of their "What I See" statements. These statements are students' initial explanations of what they think is happening to cause the patterns in the data. Give groups 4-5 minutes to work on their interpretations; then have several groups share some of their interpretations aloud. Probe deeper into a few of the interpretations, specifically about the range of orangutans to area ratios and what they mean across the four protected tropical rainforests.

	Year	Population	Orangutans / 1 km²
Leuser Ecosystem 7.000 km²	1993	12.040	1.72
	1998	4.710	0.67
	2004	7.501	1.07
	2008	6.600	0.94
Gunung Palung National Park 1080 km²	1995	2.800	2.59
	2001	2.500	2.31
	2004	2.500	2.31
	2008	2.500	2.31
Kutai National Park 750 km²	2004	730	0.97
	2008	500	0.67
Tabin Wildlife Preserve 1.110 km²	2004	1.285	1.16
	2008	1.401	1.26

WIS: The overall range of orangutans is 0.67 - 2.59.
WIM: 0.66-2.59 orangutans is about 1-3 orangutans in 1 km².

WIS: The number of orangutans changes over the years.
WIM: When population size is higher there are more orangutans in a given area. Orangutans may be more crowded.

WIS: The highest number of orangutans is 2.59.
WIM: About 2-3 orangutans can live in 1 km².

WIS: The lowest number of orangutans is 0.67.
WIM: This is about 1 orangutans in 1 km².

WIS: There are 1.16-1.26 orangutans.
WIM: This is about 1 orangutan in 1km²

Example I2 annotations

8. Building Understandings Discussion

10 MIN

Materials: *Palm Farm Designs* handout, science notebook

Make sense of the patterns in the data. Project **slide L.** Facilitate a Building Understandings Discussion in which students share their interpretations of the ratio data. This discussion can piggyback off of the sharing of "What It Means" statements but with the intention of steering the students toward noticing certain patterns if they have not yet emerged during class discussions. Emphasize that across the protected tropical rainforests, the population stays relatively stable within a range of about 1-3 orangutans per 1 km², and that when populations remain relatively stable, we refer to them as "healthy populations."

Key Ideas

Purpose of this discussion: Help students estimate a range of how many orangutans can live in 1 km^2.

Listen for these ideas:

- The range of orangutans in 1 km^2 is between .66 and 3.
- There is a maximum number of about 3 orangutans in 1 km^2.
- In three cases, there is around 1 orangutan in 1 km^2.
- The range fluctuates a little over time.
- Across all areas, there are about 1-3 orangutans per 1 km^2.

Suggested prompts	Sample student responses
What patterns did you notice about the range of orangutans that can live in 1 km^2?	*In most places, it's a little under or over 1 orangutan per km^2. The maximum was 3 in one of the parks, but that was abnormal compared to the others. It fluctuates a little.*
Do you think that 20 or more orangutans could live in that same 1 km^2 space? Why?	*Probably not. They would get really crowded.*

Discuss the relationship between km^2 and hectares. Say, *When we calculated the number of orangutans in a given area, we used the unit square kilometers, because that's what scientists use to measure area. Farmers in Indonesia use hectares, and that's what we'll use when we design our farms. 1 km^2 is equal to 100 hectares*. Ask students to discuss how this new unit relates to the ratios we calculated for "orangutans per 1 km^2."

Suggested prompt	Sample student responses
Farmers use a different measurement called hectares. 1 km^2 is equal to 100 hectares. Many large farms and tropical rainforest areas are hundreds of hectares large. Based on what we figured out about orangutans per 1 km^2, how many could live in a large tropical rainforest that is 100 or 200 hectares? In 500 hectares?	*1-3 orangutans could live in an area of 100 hectares.* *2-6 orangutans could live in an area of 200 hectares.* *5-15 orangutans could live in an area of 500 hectares.*

Additional Guidance

Scientists use a variety of units to measure the kinds of things they are interested in, and those measurements are oftentimes dependent on the country or countries in which the scientists work or the standard units of measurement for their respective fields. In this case, orangutans have a large range, so measuring population density in km^2 makes sense because it allows scientists to examine very large space. However, landowners and farmers in Indonesia use hectares as the measurement for area. Luckily, the conversion is a simple one: 1 km^2 = 100 hectares. As students convert their findings to hectares, it may be tempting to reduce the ratio, but keeping it at 100 hectares will pay off later when students are designing their farms.

If students are struggling to understand this conversion and relate square kilometers to hectares, you can revisit the previously used examples:

- 187 football fields are 1 km^2 or 100 hectares.
- The state of Delaware is 6,500 km^2 or 650,000 hectares.
- Los Angeles is 1,300 km^2 or 130,000 hectares.
- New York City is 780 km^2 or 78,000 hectares.

Discuss the lesson question in small groups. Project **slide M**. Bring students together to discuss the new overarching lesson question: "How many orangutans live in a given area?" They should also discuss a related question: "Why is it important to think about the number of orangutans per area?" Have students discuss these questions with a partner first and then share their ideas with the whole class. Have students discuss why we could not answer the original lesson question. Listen for:

- ideas about how populations are different sizes in different areas, so we have changed the question to account for area, and
- that 1-3 orangutans in 1 km^2 seems about normal for intact tropical rainforests.

Assessment Opportunity

***Building towards:* 7.A** Apply mathematical concepts (ratio) to find patterns in numerical relationships about the number of orangutans that can live in a 1 km^2 or 100 hectare area.

What to look/listen for: See the Key Ideas listed above

What to do: If students are struggling to understand the concept of the ratio of orangutans to land area, model the ways in which students can represent ratios (including as fractions, as numbers separated by a colon, etc.), emphasizing the importance of preserving the order of the quantities and labeling them in calculations. Consider drawing a square (labeling the area), populating that square with a certain number of orangutans, then modeling how to represent the ratio of the number of orangutans to the land area. You can also model how to translate data from a table (like how many orangutans there are) into one side of a ratio whose other side is another value (land area). In this step, it is important to emphasize the meaning of the order of this ratio as it relates to the question that the class is trying to answer.

9. Add to the Progress Trackers.

5 MIN

Materials: science notebook

Update individual Progress Trackers for reflection. Explain to students that we want to take some individual time to capture what we have figured out from the StoryMap and these data analyses about our questions: "How many orangutans typically live in the tropical rainforest? How many orangutans live in a given area?"

Have students turn to the Progress Tracker section in their notebooks. Use **slide N** to guide students in drawing a line before the last entry from Lesson 4 and to complete the 2 columns, filling in both lesson question(s) and their responses. Give students 3-5 minutes to quietly update their Progress Trackers using words and drawings to show what they have figured out. Ask students to draw a line underneath their responses when they are done. Prompt students to use evidence from the StoryMaps and data that we calculated as a class.

10. Predict why orangutans need so much space.

10 MIN

Materials: *Orangutan* reference card (from Lesson 1), chart paper

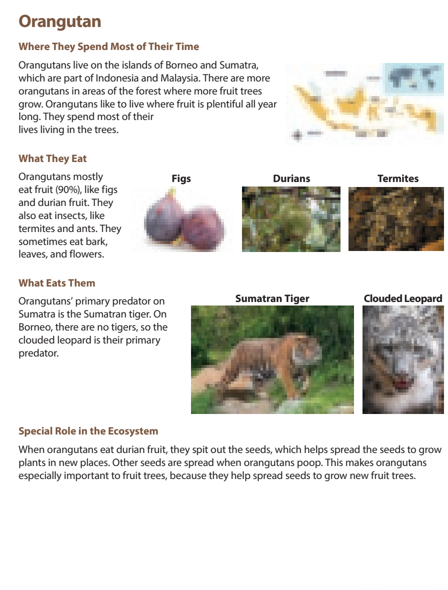
Discuss why orangutans need so much space. Project **slide O** and emphasize that 1 km^2 or 100 hectares is a lot of space. In pairs, prompt students to predict why orangutans need so much space. Then have students share their ideas with the class. Chart ideas on the board. Listen for students bringing up ideas about food and draw those ideas out.

Suggested prompts	Sample student responses
1-3 orangutans in 1 km^2 or 100 hectares is really big. That's only 1-3 orangutans in a space that is 187 football fields. Why do we think orangutans need so much space?	*Maybe they need a lot of food, there are only so many homes they can live in, or they fight with each other.*
Why would they need so much space if they fought with each other?	*Maybe they would need more space to avoid each other.*
Why would they need so much space to get food?	*Maybe the food is spread out, and they need to go a long way to get enough food. Maybe there's not very much food in the rainforest.* *The very first video said that fruit is widely scattered and only 1 or 2 orangutans can feed on a single fruit tree.*

Discuss how we could test the food idea in a simulation. Project **slide P**. Tell students that tomorrow they will have a chance to test this idea using a computer simulation. In the computer simulation, they will start to see the tropical rainforest area in terms of hectares. Have students discuss what they would want in a simulation first in partners and then as a class. Students may want to reference the information about orangutans, reading the *Orangutan* reference card as a reminder about which foods orangutans eat.

Suggested prompt	Sample student responses
If we were going to test the idea that orangutans need so much space to get the food they need in a simulation, what would we need to have in the simulation?	*Different types of food that orangutans eat—figs and termites.* *a set amount of space* *orangutans* *a way to spread out the food in the space*

Record class ideas on a chart paper. Use this to help students remember these ideas at the start of Lesson 8.


Orangutan

Where They Spend Most of Their Time

Orangutans live on the islands of Borneo and Sumatra, which are part of Indonesia and Malaysia. There are more orangutans in areas of the forest where more fruit trees grow. Orangutans like to live where fruit is plentiful all year long. They spend most of their lives living in the trees.

What They Eat

Orangutans mostly eat fruit (90%), like figs and durian fruit. They also eat insects, like termites and ants. They sometimes eat bark, leaves, and flowers.

What Eats Them

Orangutans' primary predator on Sumatra is the Sumatran tiger. On Borneo, there are no tigers, so the clouded leopard is their primary predator.

Special Role in the Ecosystem

When orangutans eat durian fruit, they spit out the seeds, which helps spread the seeds to grow plants in new places. Other seeds are spread when orangutans poop. This makes orangutans especially important to fruit trees, because they help spread seeds to grow new fruit trees.

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ADDITIONAL LESSON 7 TEACHER GUIDANCE

Supporting Students in Making Connections in Math

CCSS.MATH.CONTENT.6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

CCSS.MATH.CONTENT.6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems, for example, by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

On day 1, after realizing that four different protected areas have very different orangutan population sizes and areas, students use ratio concepts to calculate the number of orangutans per area of the four protected areas. On day 2, students analyze patterns in orangutans per area ratios across four parks to understand how many orangutans 1 km^2 or 100 hectares can support.

LESSON 8

Why do orangutans need so much forest space?

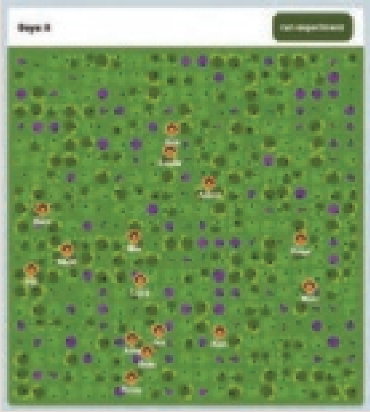
Previous Lesson

We examined a StoryMap with data about orangutan populations in four parks and noticed that larger areas had larger populations. We calculated the ratio of orangutans to land area and realized that only 1-3 orangutans can live in 1 km^2 or 100 hectares. We wondered if that is because of food limitations and considered what we would need in a simulation to test this idea.

This Lesson

Investigation

2 DAYS



We gather data from a computer simulation in which individual orangutans compete with each other for food resources (rainforest fruit and termites). In the simulation, orangutans gain energy points when they consume food and lose energy points when they move. We run multiple trials of experiments to test three different environmental conditions (independent variables), including (1) a five-year period with normal fruit production, (2) a five-year period with fewer fruit trees than normal, and (3) a five-year period with more fruit trees than normal. After constructing class histograms using data from each trial, we examine how well individual orangutans and the orangutan population overall responded by analyzing averages and ranges of energy points for orangutans in each environmental condition (dependent variables). We make claims about food resources and competition between individuals within a population.

Next Lesson

We will conduct experiments in a simulation, manipulating the amount of food resources (independent variable) over a 5-year period of time to observe how populations increase or decrease (dependent variable). We will notice that population sizes increase when resources are plentiful and decrease when resources are limited. We will also notice that all populations have natural fluctuations in size. We will connect our findings to the differences in population sizes in the different ecosystems from Lesson 7.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

8.A Carry out a series of investigations using a simplified computer simulation (system model) to produce data about how individual orangutans compete with each other for food resources in three different environmental conditions to answer a question about forest space.

8.B Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to three different environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population.

What Students Will Figure Out

- Orangutans in the same population compete with each other for food.
- Orangutans like food sources that give them more energy but can eat things with less energy to survive.
- Competition between individual orangutans within a population increases when the availability of resources is limited.
- If orangutans do not get enough energy from food resources, it may constrain growth or limit the potential for survival.

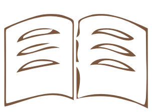
Lesson 8 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	3 min	**NAVIGATION** Establish the purpose of the lesson by reviewing our ideas about why orangutans need so much space and how we might test our ideas in a computer simulation.	A	Class chart from Lesson 7 outlining class ideas for a computer simulation
2	5 min	**ORIENT TO THE COMPUTER SIMULATION** Orient students to the computer simulation by introducing the various components in the simulation and the interactions between the components.	B-C	computer and projector, Orangutan Energy Model 1 simulation
3	10 min	**COMPARE THE SIMULATION TO A REAL ECOSYSTEM** Have students compare the simulation to a real ecosystem and consider how the simulation will be useful in helping us make sense of what is happening in a real ecosystem and what the limitations might be.	D-E	chart paper, markers
4	10 min	**PREPARE FOR EXPERIMENT A: NORMAL FRUIT PRODUCTION** Gather the class around the projected simulation, assign each student to an orangutan to track, and make predictions.	F-G	*Why Do Orangutans Need So Much Forest Space?*, computer and projector, Orangutan Energy Model 1 simulation, *Orangutan Name Cards*
5	17 min	**CONDUCT EXPERIMENT A: NORMAL FRUIT PRODUCTION** Run the experiment in the simulation and create a class histogram based on the results. Draw conclusions based on the data.	H-K	*Why Do Orangutans Need So Much Forest Space?*, sticky notes, marker, computer and projector, Orangutan Energy Model 1 simulation, class whiteboard, chart paper, markers
				End of day 1

Part	Duration	Summary	Slide	Materials
6	15 min	**CONDUCT EXPERIMENT B: FEWER FRUIT TREES** Test the question, “What happens to the orangutans if there are fewer fruit trees?” Make predictions, run the experiment, and create a class histogram based on the results. Draw conclusions based on the data from the simulation.	L-M	*Why Do Orangutans Need So Much Forest Space?*, sticky notes, marker, computer and projector, Orangutan Energy Model 1 simulation, class whiteboard, chart paper, markers
7	15 min	**CONDUCT EXPERIMENT C: MORE FRUIT TREES** Test the question, “What happens to the orangutans if there are more fruit trees?” Make predictions, run the simulation, and create a class histogram based on the results. Draw conclusions based on the data from the simulation.	N-O	*Why Do Orangutans Need So Much Forest Space?*, sticky notes, marker, computer and projector, Orangutan Energy Model 1 simulation, class whiteboard, chart paper, markers
8	12 min	**BUILDING UNDERSTANDINGS DISCUSSION** Make sense of patterns in the data to draw conclusions about why orangutans need so much space to survive.	P-Q	
9	3 min	**NAVIGATION** Predict what might happen to the orangutan population if we add births and deaths to the simulation.	R	

End of day 2

Lesson 8 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Why Do Orangutans Need So Much Forest Space?*	• sticky notes • marker	• Class chart from Lesson 7 outlining class ideas for a computer simulation • computer and projector • Orangutan Energy Model 1 simulation • chart paper • markers • *Orangutan Name Cards* • class whiteboard

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.

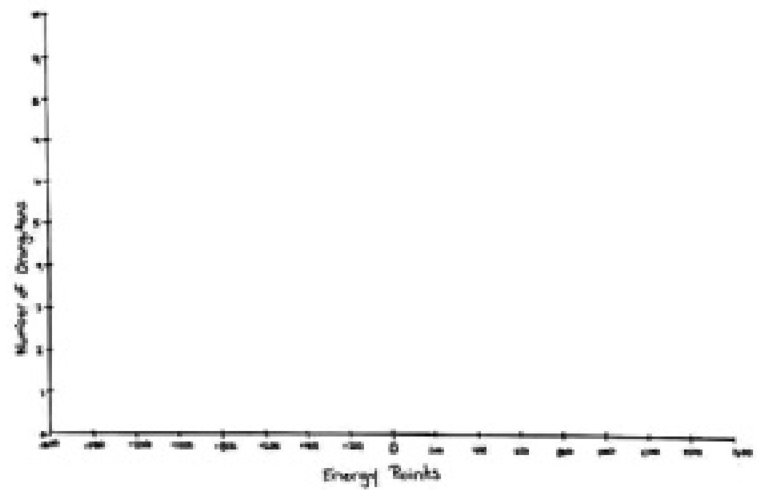
Online Resources

Print and cut out the *Orangutan Name Cards*. Prepare enough sets of the *Orangutan Name Cards* for every student to receive 1 card. There are 15 name cards, so if you have a class of 30 students, you will need 2 sets of cards. You may wish to laminate the name cards for future use.

Make sure you can open the *Orangutan Energy Model 1* and can project it on a large enough screen so that everyone in the class can see it. Make space around the screen so that students can form a semicircle to view the simulation. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

If students are absent or need to review the simulation outside of class, they will use the *Orangutan Energy Model 2* simulation. This version of the simulation will construct histograms for students who are unable to build the histograms together as a class. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Spend some time playing with *Orangutan Energy Model 1* and *Orangutan Energy Model 2* prior to day 1 to familiarize yourself with the simulations and controls. Run each experiment outlined in the lesson on your own prior to running the experiments with the class.



Prepare three axes on your whiteboard or chart paper for the class to build the histogram using sticky notes. Use a range of -1600 to 1600 on the x-axis. Make sure to space your units on the x-axis every 200 energy points and use a 2-by-2 sticky note to space each unit far enough apart so that when students build the histogram, the sticky notes within a certain 200-block range (e.g., 0-200) do not overlap with neighboring ones (e.g., 200-400 and 400-600). Include up to at least 10 orangutans on your y-axis.

If using composition notebooks, print 1 copy of the *Why Do Orangutans Need So Much Forest Space?* handout for each student. This handout will be folded and then glued or taped in students' science notebooks. You will only pass out the *Experiment A: Normal Fruit Production* pages on day 1 and will need the *Experiment B: Fewer Fruit Trees* and *Experiment C: More Fruit Trees* pages on day 2. Have glue or tape readily available for students to attach the handouts to their notebooks.

Review *Key: Why Do Orangutans Need So Much Forest Space?* for anticipated student responses.

Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

In Lesson 7, students figured out that populations of orangutans refer to groups of orangutans that live in a certain area. They also figured out that larger areas of intact tropical rainforests support larger populations of orangutans, but that orangutans generally have a density of 1-3 per 1 km^2 or 100 hectares. Students were left wondering whether the need for available food is the reason orangutans require so much space. This lesson allows students to test their ideas about food availability using a computer simulation to manipulate the amount of food in a given area to see how it impacts how many energy points orangutans earn (a sign of health).

This lesson builds from previous lessons to specifically target these important DCIs:

- Competition for resources, primarily food resources, exists within a population.
- Individual organisms have preferred food resources but can survive on different food resources, if necessary.
- Resource availability affects an individual organism's growth and potential for survival.

These science ideas are part of LS2.A Interdependent Relationships in Ecosystems. The lesson focuses on figuring out important aspects of these DCIs with respect to competition within populations and individual organism survival. Students will connect organism survival to population growth and decline in the next lesson. This lesson builds on the 5th grade DCI *Organisms can survive only in environments in which their particular needs are met*. This lesson extends students' understanding by connecting organism survival to resource availability in the ecosystem.

This lesson requires students to apply mathematical concepts, like mean and range, and build and interpret mathematical representations, like histograms, to make sense of the science ideas described herein. The use of mathematics to make sense of population shifts may be new or unfamiliar to your students, as this is new territory for students in middle school science. This is why the lesson includes intentional scaffolding by you to support your students as they work together as a class to gather, represent, and interpret data from the computer simulation.

Two crosscutting concepts will be valuable to your students in this lesson: "System and System Models" and "Stability and Change." At the beginning of this lesson, students are introduced to a computer simulation that represents a complex system in the real world. Take this opportunity to have students reflect on the limitations of a simulation that includes only four components of the ecosystem (orangutans, rainforest fruit trees, rainforest trees, and termites). Through a Stop and Jot and a whole-class discussion, have your students consider the advantages and limitations of using a simulation that represents only certain aspects of the ecosystem. Later in the lesson, guide students in using the lens of Stability and Change as they interpret data collected from the simulations to draw conclusions. In particular, question prompts are provided to help you support students to consider how small changes to environmental conditions such as the percentage of food availability can cause large changes in the energy points earned by individual orangutans, shifting the averages and ranges of energy points in notable ways.

Where We Are NOT Going

You may be tempted to make connections between the energy points earned by individual orangutans and the potential for survival, population growth, and decline. Avoid making these connections for students in this lesson, as that is the focus of Lesson 9. If students make these connections in this lesson, use their ideas to motivate them to want to test the survival of individual orangutans as it relates to population growth and decline, which they will do in the next simulation.

In terms of resource availability, the focus of this lesson and Lesson 9 is food resources. Students will layer on other resources and factors influencing population growth and decline, such as shelter, safety, hunting, and other relationships between organisms (e.g., predation), in Lessons 10 and 11.

LEARNING PLAN FOR LESSON 8

1. Navigation

3 MIN

Materials: Class chart from Lesson 7 outlining class ideas for a computer simulation

Establish the purpose of the lesson by reviewing our ideas about why orangutans need so much space. Have the class chart created at the end of Lesson 7, which outlined class ideas for a computer simulation, visible to students. Project **slide A** and say, *Yesterday we shared some of our ideas about why we think orangutans need so much forest space. We also brainstormed some ideas about what we would want to see in a simulation that could help us test why orangutans need so much forest space. Let's review some of our ideas.*

As a whole group, have students share some of their thoughts about both questions. Start with the first question on **slide A**, *What were some of our ideas about why orangutans need so much forest space?* When students are ready, progress to the second question on **slide A**, *What were some of our ideas about what we would want to see in a simulation that could help us test why orangutans need so much forest space?*

Suggested prompts	Sample student responses
1 km^2 or 100 hectares is a really big area for only 1-3 orangutans. That's only 1-3 orangutans in a space that spans 187 football fields. Why do we think orangutans need so much forest space?	*Maybe they need a lot of food, there are only so many homes they can live in, or they fight with each other.*
If we were going to test the idea that orangutans need so much space to get the food they need using a simulation, what would we need to have in the simulation?	*Different types of food that orangutans eat—figs and termites.* *a set amount of space* *orangutans* *a way to spread out the food in the space*

Tell students, *I have a simulation that may have some of the components that we wanted in it. Now that we have specified what we think such a simulation should include, we can think critically about how the simulation will be useful for helping us make sense of what is happening in a real ecosystem.*

2. Orient to the computer simulation.

5 MIN

Materials: computer and projector, Orangutan Energy Model 1 simulation

Orient students to the computer simulation by introducing the various components in the simulation. Direct students' attention to the center image on **slide B.** This image is a screenshot taken from the computer simulation. The simulation includes four main components: (1) orangutans, (2) rainforest fruit trees (e.g., fig, durian, and other rainforest fruits), (3) termites, and (4) non-fruiting rainforest trees. The images show how the icons used in the simulation map to their counterparts in a real ecosystem. Prompt students to consider the ways in which orangutans interact with the other components in the ecosystem (termites, rainforest non-fruit trees, and rainforest fruit trees).

Suggested prompts	Sample student responses
How do you think orangutans and rainforest fruit trees interact?	*Orangutans probably eat the fruit from the fruit trees.* *Fruit trees probably lose fruit when orangutans eat the fruit. We think the fruit should be able to grow back.*
How do you think orangutans and termites interact?	*Orangutans probably eat the termites.* *I remember that the video at the beginning of the unit said orangutans can eat termites too.* *Termites probably die when orangutans eat them.*
How do you think orangutans and non-fruit rainforest trees interact?	*Orangutans can probably swing through the rainforest trees but can't eat anything off of them.*

Say, *Those are really interesting ideas! Let's check to see if our ideas are consistent with how this model actually works.*

Orient students to the computer simulation by introducing the rules of the simulation. Project **slide C** and give students some time to read through the rules of the simulation. You may wish to read the rules out loud.

Open the *Orangutan Energy Model 1*. Click "Run Experiment" so that students can see how orangutans move around the screen. Do not let the experiment run to completion, so that students do not see results before they have had a chance to make a prediction. To avoid allowing the experiment to run to completion, be sure to click "Cancel—do not record" before day 1825. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

3. Compare the simulation to real ecosystem.

10 MIN

Materials: science notebook, chart paper, markers

Compare the components and interactions in the simulation to a real ecosystem. Present **slide D** and say, *Computer simulations are one way of helping us think about what is happening in real ecosystems. Simulations allow us to speed up time and eliminate some complicating variables, but they also have limitations. Identifying the strengths and limitations of our simulation will help us think about how this simulation will be useful in helping us make sense of what is happening in a real ecosystem. Let's start by considering how our simulation is a good representation of a real ecosystem and then consider how it might be a limited representation of a real ecosystem.*

Prompt students to recreate the table on **slide D** in their science notebooks. Then give students time to individually jot down their ideas about how the simulation is a good representation of or a limited representation of a real ecosystem.

After jotting their ideas in their notebooks, have students share their ideas with the whole class. Encourage students to record additional ideas in their notebooks based on their classmates' contributions.

*** Supporting Students in Engaging in Planning and Carrying Out Investigations**
Students carry out experiments in a simulated space and may not view these as "lab experiments." Use this opportunity to broaden students' understanding of different ways that scientists investigate the world, particularly through the use of computer

Suggested prompts	Sample student responses
How is this simulation a good representation of a real ecosystem?	*The simulation includes many of the key components of the ecosystem—orangutans, rainforest fruit trees, other rainforest trees, and termites.* *When orangutans eat food, they get more energy. Orangutans get more energy from fruit than from termites.* *When orangutans eat termites, the termites die. When orangutans eat fruit, the fruit tree loses fruit.* *It takes energy for orangutans to move.*
How is this simulation a limited representation of a real ecosystem?	*The simulation is missing many of the other living and nonliving things in the ecosystem.* *Orangutans eat more than just fruit and termites.* *Orangutans move around their environment in many different ways, not just when they are looking for food.* *Orangutans can reproduce and die, but we haven't seen that in the simulation.* *Termites also depend on food sources.* *Rainforest trees and rainforest fruit trees depend on water and sunlight availability, which aren't included in the simulation.* *Orangutans spend more energy walking on the ground than swinging through trees. We don't see a difference in the simulation.*

simulations that allow multiple scenarios and trials to be run. It's important to also share that computer simulations are based on estimates from field data, so at some point research on orangutans in their real environment was used to create the computer model.

*** Supporting Students in Developing and Using Systems and System Models**

During this discussion, students uncover the idea that the simulation is limited in that it only represents certain aspects of the ecosystem. The simulation focuses specifically on the orangutans, so it doesn't account for all of the variables related to the other components in the ecosystem. It is important to help students understand that there are both advantages and limitations to using simulations to model a system.

Additional Guidance

The simulation limits the percentage of rainforest fruit trees available in the tropical rainforest. In many ways, this is similar to a real ecosystem in that the ecosystem has limited resource availability for tree growth (e.g., space, water, access to sunlight). It is important to note, however, that it is an oversimplification of the amount and distribution of fruit trees in the tropical rainforest.

Prompt students to consider the advantages and limitations of using the simulation to help us understand what is going on in the ecosystem.* Present **slide E** and say, *It sounds like our simulation is a very simplified model of the actual ecosystem. There can be some advantages to using a simulation like this. There can also be some limitations. Let's keep track of the advantages and limitations so that we can keep them in mind as we use the simulation.*

Suggested prompts	Sample student responses
What are the advantages of using a simulation to study this ecosystem?	*By simplifying our ecosystem, we can think more clearly about the interactions in the ecosystem and how they might lead to particular outcomes.* *We are able to focus closely on the orangutans without getting distracted by too many other interactions in the ecosystem.* *We are able to speed up time and repeat trials without actually harming the ecosystem.*
What are the limitations of using a simulation to study this ecosystem?	*The simulation doesn't account for all of the various interactions taking place in the ecosystem (e.g., termites eating food, trees getting enough water, etc.), so we need to be careful about drawing conclusions without considering how our results might change if the other components in the ecosystem change.* *Our simulation shows only one small part of a much larger ecosystem, so we need to be careful about generalizing to a larger ecosystem.*

As students share their ideas, keep track of the advantages and limitations of using a computer simulation by constructing a T-chart on the class whiteboard or chart paper.* Summarize by saying, *Even though we know that there are some limitations to using a simulation, it sounds like there are many advantages. Let's do some investigating with this simulation to help us focus closely on what is happening with the orangutans in the ecosystem.*

4. Prepare for Experiment A: Normal Fruit Production.

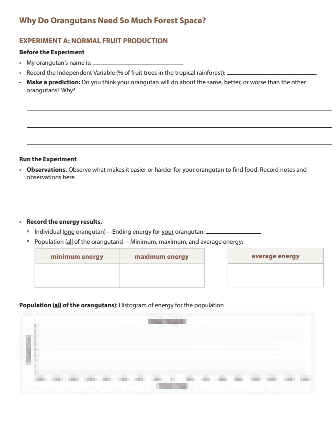
10 MIN

Materials: science notebook, *Why Do Orangutans Need So Much Forest Space?*, computer and projector, Orangutan Energy Model 1 simulation, *Orangutan Name Cards*

Orient to the investigation by reminding students that our goal is to figure out why orangutans need so much forest space. To figure this out, we are going to conduct a series of experiments using a computer simulation. For each experiment, we will need to record the percentage of fruit trees in the tropical rainforest (independent variable), make predictions, record our findings, and make sense of our findings.

Handout 1 copy of *Experiment A: Normal Fruit Production* from *Why Do Orangutans Need So Much Forest Space?* to each student. Keep the *Experiment B: Fewer Fruit Trees* and *Experiment C: More Fruit Trees* pages for later use on day 2. Use **slide F** to prompt students to paste each page of the handout into their science notebooks.

Project the *Orangutan Energy Model 1* simulation on a larger screen and gather students in a semicircle around the screen. Use the default values (25% fruit trees in the tropical rainforest) for the first experiment. Double-check your setup for *Experiment A* using the following image.


Why Do Orangutans Need So Much Forest Space?

EXPERIMENT A: NORMAL FRUIT PRODUCTION

Before the Experiment

- My orangutan's name is: ____________.
- Record the Independent Variable (% of fruit trees in the tropical rainforest): ____________.
- **Make a prediction:** Do you think your orangutan will do about the same, better, or worse than the other orangutans? Why?

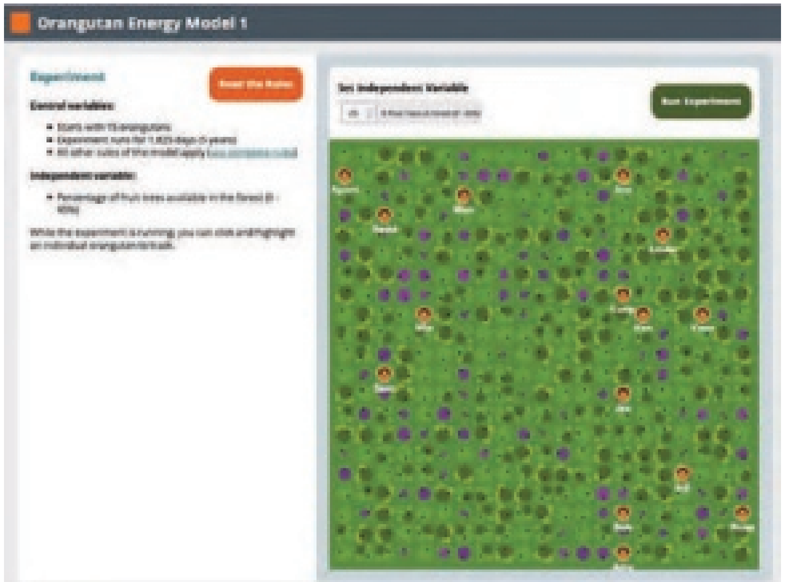
Run the Experiment

- **Observations.** Observe what makes it easier or harder for your orangutan to find food. Record notes and observations here.
- **Record the energy results.**
  - Individual (one orangutan)—Ending energy for your orangutan: ____________
  - Population (all of the orangutans)—Minimum, maximum, and average energy:

minimum energy	maximum energy	average energy

Population (all of the orangutans): Histogram of energy for the population

17



25% fruit trees

Additional Guidance

This activity is structured so that all students observe orangutans competing in the same environment. Having all students track one orangutan in the same environment as the rest of the class generates the feeling of competition between the orangutans. Competition for resources between individuals in a species is a key idea developed in this lesson, so it is significantly more effective if students can feel this sense of competition. In many field test classes, students enjoyed cheering loudly for their orangutan. If space is limited and it is not possible for students to gather around a screen, consider projecting the simulation using a screen share feature on a video conferencing platform. Students can log in to the video conferencing platform on a device from their desk or table.

If students have difficulty locating their orangutan, you can click on an individual orangutan to highlight it. Consider using this feature to help students track an individual orangutan.

Pass out one *Orangutan Name Cards* to each student. Have students locate their orangutan on the screen and write the name on their handout. When assigning more than one student to an orangutan, have students with the same orangutan stand or sit next to each other. Say, *In the wild, scientists gather data on orangutan individuals and populations by carefully observing them in their natural habitat. We are going to do the same in our simulation. Each of you will be assigned one orangutan to carefully monitor throughout the simulation. It is your job to pay close attention to what your orangutan eats, which other orangutans your orangutan comes into contact with, and the energy of your orangutan.*

Record the independent variable. Explain that the independent variable in this simulation is the percentage of rainforest fruit trees in the tropical rainforest. During a normal year, approximately 25% of the trees in this simulated forest are fruit trees that produce fruit. We are going to run our first experiment assuming that we will observe a series of five normal years. Instruct students to record the percentage of fruit trees available in the tropical rainforest on their handout.

Make a prediction. Project **slide G**, and using the prompts on *Why Do Orangutans Need So Much Forest Space?*, have students record a prediction for *Experiment A*.

5. Conduct Experiment A: Normal Fruit Production. 17 MIN

Materials: science notebook, *Why Do Orangutans Need So Much Forest Space?*, sticky notes, marker, computer and projector, Orangutan Energy Model 1 simulation, class whiteboard, chart paper, markers

Conduct *Experiment A: Normal Fruit Production*. Project the *Orangutan Energy Model 1* simulation large enough for all students to see it. You may wish to orient students to the steps needed to conduct the experiment using **slide H.** Before pressing "run experiment," remind students that it is their responsibility to carefully watch their assigned orangutan. When students are ready, press "run experiment". The simulation will automatically end after 5 years (1825 days). This will take about 1 minute. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

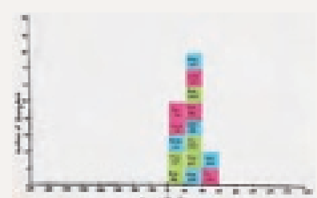
Record the results from the experiment. At the end of the experiment, have students record their individual results on the handout. Students can find the ending energy of their orangutan by checking the number next to their orangutan's name or by looking at the "Show Orangutan Energy" chart in the simulation. Next, have students record the population results. Students can find the maximum, minimum, and average energy for the orangutan population on the simulation interface. You may wish to orient students to the steps in recording results using **slide I**.

Additional Guidance

If students struggle to understand the measurement of orangutan energy, consider referring to the energy measure as "energy points." You can explain that orangutans gain or earn energy points when they eat termites or fruit, and that they lose energy points when they move.

Create a class histogram. Pass out one sticky note per orangutan (for a total of 15 sticky notes). If more than one student is watching the same orangutan, the students should share one sticky note between them. Instruct students to write the name and energy of their orangutan on the sticky note.

Have students add their sticky notes to the histogram according to the energy of their orangutans. For example, if Jax earned 250 energy points, the sticky note for Jax should be placed in the space between 200 and 400. If Sam earned 350 energy points, the sticky note for Sam should be placed directly above the sticky note for Jax, thus indicating that two orangutans had ending energies between 200 and 400. It may help to demonstrate how to do this by adding the first and second sticky notes as a class.

Blank chart	Individual stickies	Class histogram
		

*** Attending to Equity**

Universal Design for Learning: The simulation can be sped up or slowed down to support students in processing what is happening with the orangutans as they move through the simulation. In addition, clicking on an individual orangutan will highlight the orangutan, making it easier to see. The ability to adjust digital information in this way can provide increased access for the diverse learners in your classroom. Consider including any of the following options to support students in accessing the simulation:

- Run the simulation on the slowest setting first so students can follow their orangutan and get a sense of what the visual is representing.
- Have students talk with a partner between trials to discuss what they are noticing.
- For learners with visual disabilities, provide a spoken description of what is happening with the orangutans in the simulation.
- Provide a link to the simulation so that students can watch more closely and adjust the speed as needed.

After generating the class histogram, prompt students to sketch the histogram in their science notebooks in the space indicated on *Why Do Orangutans Need So Much Forest Space?*.

Additional Guidance

A histogram is a graphical display of data. The bars in histograms represent numbers in ranges. In this case, the bars represent the numbers or orangutans with energies in a particular 200 energy point range. Bar graphs differ from histograms in that the bars in bar graphs represent numbers in categories. In this activity, the teacher and/or computer simulation (if using *Orangutan Energy Model 2*) generate(s) the axis for the histogram. In order to further extend the mathematics connections in this lesson, consider extending the histogram construction to further build graphing skills. Rather than creating the axes ahead of time, have students provide input on how to create and label the axes.

Additional Guidance

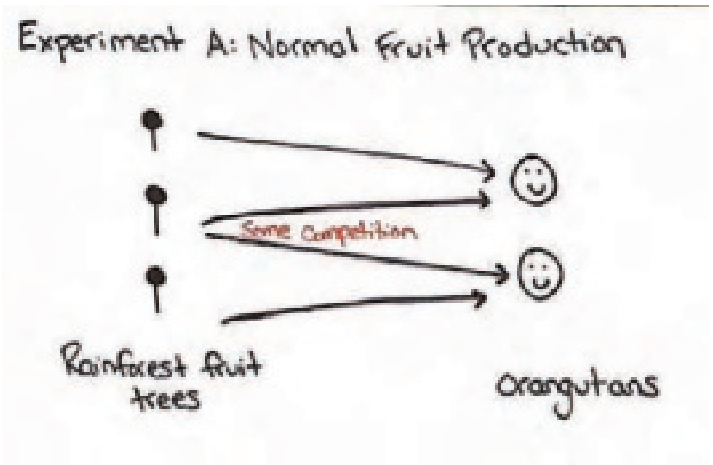
You may wish to run multiple trials of the experiment. To do so, use the *Orangutan Energy Model 2* simulation. This simulation automatically builds the class histograms. Additional trials are added to the histogram in different colors. This enables students to compare results across trials. Note that teachers in the field test, however, found building the histogram using the sticky notes to be a powerful way to demonstrate what the data represented in the histogram means. If you choose to use the Orangutan Energy Model 2 simulation, it is suggested to use it in conjunction with the class-developed histograms.

You may also wish to use this simulation option for students who may miss the class build or need additional reinforcement.

Lead a class discussion to reflect on the findings. Project the discussion prompts on **slide J.** Start by focusing on the extremes—orangutans that were very successful at getting food and orangutans that were not very successful at getting food. Select one student watching an orangutan in each category to share their observations. Then progress to the orangutans who were moderately successful at getting food.

Suggested prompts	Sample student responses
How do orangutans gain energy? How do they lose energy?	*Orangutans gain energy by eating food. They gain lots of energy by eating fruit and only a little bit of energy by eating termites.* *Orangutans lose energy by swinging through the trees.*
What caused orangutans to lose a lot of energy in the simulation?	*When an orangutan had to travel a long distance to find food.*
What does it mean if an orangutan has negative energy?	*It means that the orangutan's energy fell below 0. This can't actually happen with real orangutans! In our simulation, orangutans can't die, but we think they should die at 0.* *We want to see a revision to the simulation that would show orangutans dying at 0 energy.*
Which orangutans were most successful at finding food? What made it so they could get a lot of food?	*There were many fruit trees around my orangutan, so my orangutan could easily move back and forth between the fruit trees.* *There weren't many other orangutans around my orangutan, so my orangutan wasn't competing with anyone to get food.*
Which orangutans were least successful at finding food? What prevented your orangutan from finding food?	*There weren't many fruit trees around my orangutan, so my orangutan had to travel a long distance to find fruit trees.* *There were a lot of other orangutans around my orangutan, and they kept stealing my orangutan's food!*
Which orangutans were moderately successful at finding food? What made it so that your orangutan could get food when your orangutan needed it?	*There were fruit trees around my orangutan, but my orangutan sometimes had to travel longer distances to get to other fruit trees.* *There were lots of fruit trees around my orangutan, but there were also some other orangutans around my orangutan, so my orangutan couldn't eat all of the fruit.* *My orangutan ate a mixture of termites and fruit.*

Summarize by saying, *It sounds like the orangutans that did really well had better access to food because there were either more fruit trees around them or fewer orangutans. Orangutans that were the least successful either had access to fewer fruit trees or were near another orangutan that got to the fruit first—meaning that they had to compete with many other orangutans for the fruit.*



Generate a representation of what we figured out. During the discussion, generate a shared class representation to represent competition between individual orangutans with normal fruit production. An example representation has been provided. It is important to show that two orangutans may compete for the same rainforest fruit tree. Under normal conditions, there is some competition between individual orangutans.

Make sense of results.* In the space provided on *Why Do Orangutans Need So Much Forest Space?*, prompt students to make sense of the data from *Experiment A*. Project **slide K** to guide student work. Students should circle the claim that they most agree with, provide data from the experiment to support their claim, and then list factors that may have contributed to the outcomes that they observed. Be sure to prompt students to make sense of data for both their individual orangutan and the orangutan population as a whole.

Assessment Opportunity

Building towards: 8.B Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to three different environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population.

What to look/listen for:

- Students cite the averages and ranges of energy points for the orangutan population to support their claims.
- Students reference their individual orangutan's energy points in relation to the averages and ranges of energy points for the orangutan population (e.g., orangutans with lower-than-average energy were not successful at competing for food; orangutans with higher-than-average energy were more successful at competing for food).
- It seems typical to have a range of energy points among the orangutan population in all environmental conditions, meaning that some orangutans are more or less successful at competing for food, which could vary depending on whether there is a lot of food or little food available.

What to do: If students are struggling to find the connection between their individual orangutan and the orangutan population as a whole, point out their orangutan's sticky note on the class histogram. Ask students whether the orangutan did better, worse, or about the same as the rest of the class. Prompt students to explain how they know. Consider drawing a vertical line in the class histogram to delineate the average energy for the population.

End of day 1

6. Conduct Experiment B: Fewer Fruit Trees. 15 MIN

Materials: science notebook, *Why Do Orangutans Need So Much Forest Space?*, sticky notes, marker, computer and projector, Orangutan Energy Model 1 simulation, class whiteboard, chart paper, markers

Establish a purpose for new experiments. Say, *In the last class we tested how a population of orangutans moved around the tropical rainforest to get fruit and termites in a typical year with 25% fruit, and we noticed some orangutans did better than others at getting to the fruit. We've been thinking that cutting down rainforest fruit trees or planting more rainforest fruit trees could be helpful for orangutans, but we haven't tested these ideas yet.*

Pass out the *Experiment B: Fewer Fruit Trees* handouts to students (from *Why Do Orangutans Need So Much Forest Space?*). Have students attach the handouts to their notebooks.

20% fruit trees

Orient to the experiment by reminding students that fruit trees in tropical rainforests were cut down to make space for oil palm trees. You may wish to outline the steps in the experiment by projecting **slide L.** Show students that we can partially mimic this scenario by reducing the number of fruit trees in the simulation. Project the simulation on the screen and change the "% of fruit trees" to 20%. Double-check your setup for *Experiment B* using the image provided. Remind students that it is their job to closely track one orangutan in the simulation. Students should continue tracking the same orangutan that they tracked in *Experiment A*.

Record the independent variable. Remind students that the independent variable in this simulation is the percentage of fruit trees in the tropical rainforest. Since we are testing what happens to the orangutans when there are fewer fruit trees, we have adjusted the percentage of fruit trees in the tropical rainforest to 20%. Instruct students to record this on their handout.

Make a prediction. Using the prompts on *Why Do Orangutans Need So Much Forest Space?*, have students record a prediction for *Experiment B*.

Conduct *Experiment B: Fewer Fruit Trees*. Project the *Orangutan Energy Model 1* simulation large enough for all students to see it. Before pressing "run experiment," remind students that it is their responsibility to carefully watch their assigned orangutan. When students are ready, press "run experiment" and run the simulation. The simulation will automatically end after 5 years (1825 days). This will take about 1-2 minutes. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Record the results from the experiment. At the end of the experiment, have students record their individual results on the handout. Next, have students record the population results.

Create a class histogram. Use the same process to create a class histogram that you used in *Experiment A*. Pass out one sticky note per orangutan (for a total of 15 sticky notes).

Use one of the blank axes that you prepared prior to class. Have students add their sticky notes to the histogram according to the energy of their orangutans.

After generating the class histogram, prompt students to sketch the histogram in their science notebooks in the space indicated under "Results" for *Experiment B*.

Lead a class discussion to reflect on the findings. Project the discussion prompts on **slide M.** Prompt students to consider the ways in which the orangutans' diet changes when there are fewer fruit trees and how that might be related to the orangutans' chance for survival.

Suggested prompts	Sample student responses
When there were fewer fruit trees, what happened to the energy of individuals? The population?	*The energy of individual orangutans and the orangutan population as a whole went down drastically. This is because orangutans don't get much energy from termites.* *When there were fewer fruit trees, there were more orangutans competing for the same resources. This increased competition between the orangutans for the fruit trees.*
How might the energy of orangutans in this experiment relate to their chance for survival?	*The energy of the orangutans decreased below 0. We think that this means that the orangutans should die. So, when there are fewer fruit trees available, the orangutans run out of available food and are more likely to die.*

Summarize by saying, *It sounds like reducing the number of fruit trees caused increased competition between orangutans, even though orangutans could get some energy from the termites. This meant that orangutans were less likely to gain energy, and we think that this could ultimately lead to the death of individual orangutans.*

Generate a representation of what we figured out. During the discussion, generate a shared class representation to represent competition between individual orangutans with fewer fruit trees. An example representation has been provided. It is important to show two orangutans competing for a limited resource. Under conditions with limited resources (e.g., fewer rainforest fruit trees), there is more competition between individual orangutans.

Make sense of results. In the space provided on *Why Do Orangutans Need So Much Forest Space?*, prompt students to make sense of the data from *Experiment B*. Students should circle the claim that they most agree with, provide data from the experiment to support their claim, and then list factors that may have contributed to the outcomes that they observed. Be sure to prompt students to make sense of the data for both their individual orangutan and the orangutan population as a whole.

Assessment Opportunity

Building towards: **8.B** Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to three different environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population.

What to look/listen for:

- Students cite the averages and ranges of energy points for the orangutan population to support their claims.

- Students reference their individual orangutan's energy points in relation to the averages and ranges of energy points for the orangutan population (e.g., orangutans with lower-than-average energy were not successful at competing for food; orangutans with higher-than-average energy were more successful at competing for food).
- It seems typical to have a range of energy points among the orangutan population in all environmental conditions, meaning that some orangutans are more or less successful at competing for food, which could vary depending on whether there is a lot of food or little food available.

What to do: If students are struggling to draw the connection between their individual orangutan and the orangutan population as a whole, point out their orangutan's sticky note on the class histogram. Ask students whether the orangutan did better, worse, or about the same as the rest of the class. Prompt students to explain how they know. Consider drawing a vertical line in the class histogram to delineate the average energy for the population. To compare across experiments, consider placing the class histograms directly next to one another so that students can compare the placement of their individual sticky notes and the placement of the histogram on the axis.

7. Conduct Experiment C: More Fruit Trees

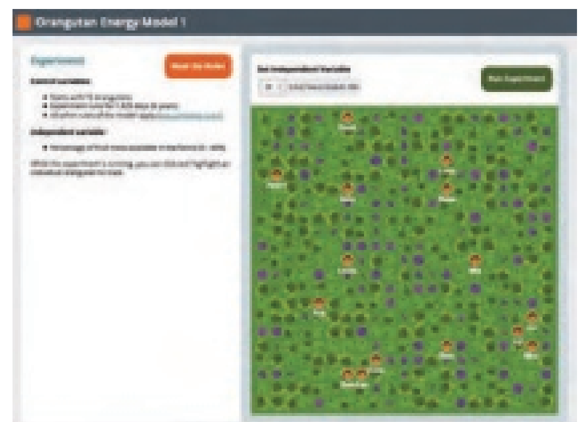
15 MIN

Materials: science notebook, *Why Do Orangutans Need So Much Forest Space?*, sticky notes, marker, computer and projector, Orangutan Energy Model 1 simulation, class whiteboard, chart paper, markers

Pass out *Experiment C: More Fruit Trees* handouts to students (from *Why Do Orangutans Need So Much Forest Space?*). Have students attach the handouts to their notebooks.

Orient to the experiment. Summarize the previous experiments by saying, *In our first experiment, we figured out that orangutans need a lot of space because they compete for food resources. In our second experiment, we figured out that when there are fewer fruit trees, orangutans struggle to find food even though they can eat termites. This increases competition between orangutans in the population. Now let's investigate what might happen if we increase the number of fruit trees in the environment.*

You may wish to outline the steps in the experiment by projecting **slide N.** Project the simulation on the screen and change the "% of fruit trees" to 30. Make sure to press "setup" so that students can see the changes reflected on the screen. Double-check your setup for *Experiment C* using the following image.


30% fruit trees

Remind students that it is their job to closely track one orangutan in the simulation. Students should continue tracking the same orangutan that they tracked in *Experiments A* and *B*.

Record the independent variable. Remind students that the independent variable in this simulation is the percentage of fruit trees in the tropical rainforest. Since we are testing what happens to the orangutans when there are more fruit trees, we have adjusted the percentage of fruit trees in the tropical rainforest to 30%. Instruct students to record this on their handout.

Make a prediction. Using the prompts on *Why Do Orangutans Need So Much Forest Space?*, have students record a prediction for *Experiment C*.

Conduct *Experiment C: More Fruit Trees*. Project the *Orangutan Energy Model 1* simulation large enough for all students to see it. Before pressing "run experiment," remind students that it is their responsibility to carefully watch their assigned orangutan. When students are ready, press "run experiment" and run the simulation. The simulation will automatically end after 5 years (1825 days). This will take about 1-2 minutes. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Record the results from the experiment. At the end of the experiment, have students record their individual results on the handout. Next, have students record the population results.

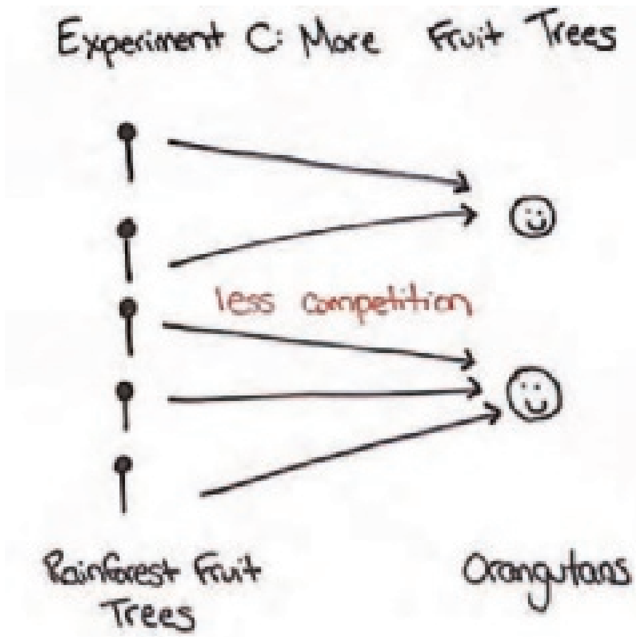
Create a class histogram. Use the same process to create a class histogram that you used in *Experiment A*. Pass out one sticky note per orangutan (for a total of 15 sticky notes).

Use one of the blank axes that you prepared prior to class. Have students add their sticky notes to the histogram according to the energy of their orangutans.

After generating the class histogram, prompt students to sketch the histogram in their science notebooks in the space indicated under "Results" for *Experiment C*.

Lead a class discussion to reflect on the findings. Project the discussion prompts on **slide O.** Prompt students to consider the ways in which the orangutans' diet changes when there are more fruit trees and how that might be related to the orangutans' chance for survival.

Suggested prompts	Sample student responses
When there were more fruit trees, what happened to the energy of individuals? The population?	*The energy of individual orangutans and the orangutan population as a whole went up drastically. This is because orangutans were easily able to access fruit trees and didn't have to compete with one another for limited resources.*
How might the energy of orangutans in this experiment relate to their chance for survival?	*The energy of the orangutans increased significantly. This could increase their chance for growth and survival, and potentially reproduction.*



Summarize by saying, *It sounds like increasing the number of fruit trees reduced competition between orangutans, which allowed the overall energy of the population to increase.*

Generate a representation of what we figured out. During the discussion, generate a shared class representation to represent competition between individual orangutans with normal fruit production. An example representation has been provided. It is important to show that two orangutans have plenty of available resources. Under conditions with many available resources (e.g., rainforest fruit trees), there is less competition between individual orangutans.

Make sense of results.* In the space provided on *Why Do Orangutans Need So Much Forest Space?*, prompt students to make sense of the data from *Experiment C*. Students should circle the claim that they most agree with, provide data from the experiment to support their claim, and then list factors that may have contributed to the outcomes that they observed. Be sure to prompt students to make sense of the data for both their individual orangutan and the orangutan population as a whole.

Assessment Opportunity

Building towards: **8.B** Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to three different environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population.

What to look/listen for:

- Ideas that carry forward from Experiments A and B:
  - Students cite the averages and ranges of energy points for the orangutan population to support their claims.
  - Students reference their individual orangutan's energy points in relation to the averages and ranges of energy points for the orangutan population (e.g., orangutans with lower-than-average energy were not successful at competing for food; orangutans with higher-than-average energy were more successful at competing for food).
  - It seems typical to have a range of energy points among the orangutan population in all environmental conditions, meaning that some orangutans are more or less successful at competing for food, which could vary depending on whether there is a lot of food or little food available.
- New ideas that should emerge from Experiment C:
  - Students conclude that small changes in environmental conditions can have large impacts on their individual orangutan and on the orangutan population as a whole.

What to do: If students struggle to make a connection between their individual orangutan and the orangutan population, point out their orangutan's sticky note on the class histogram. Ask students whether the orangutan did better, worse, or about the same as the rest of the class. Prompt students to explain how they know. Consider drawing a vertical line in the class histogram to delineate the average energy for the population. To compare across experiments, place the class histograms directly next to one another so that students can compare the placement of their individual sticky notes and the placement of the histogram on the axis.

8. Building Understandings Discussion

12 MIN

Materials: science notebook

Make sense of the patterns in the data.* Project **slide P.** Facilitate a Building Understandings Discussion in which students share their interpretations of the simulation data and make claims about why orangutans need so much forest space, how changing environment conditions (independent variable) affected individual orangutan energy, and the energy of the orangutan population as a whole (dependent variable). This discussion can piggyback off of the make-sense discussion after each experiment.

Assessment Opportunity

Building towards: **8.A** Carry out a series of investigations using a simplified computer simulation (system model) in which individual orangutans compete with each other for food resources in three different environmental conditions.

What to look/listen for:

- Students cite data from the trials the class ran together in order to answer the lesson question.
- Students explain why multiple trials are necessary to feel confident that the data help them answer the lesson question.
- Students use data from the simulation to explain that orangutans need large areas of tropical rainforest because they compete with each other for food.
- Students explain that if too many orangutans are in a small forest space with too little food, then many will struggle to survive.

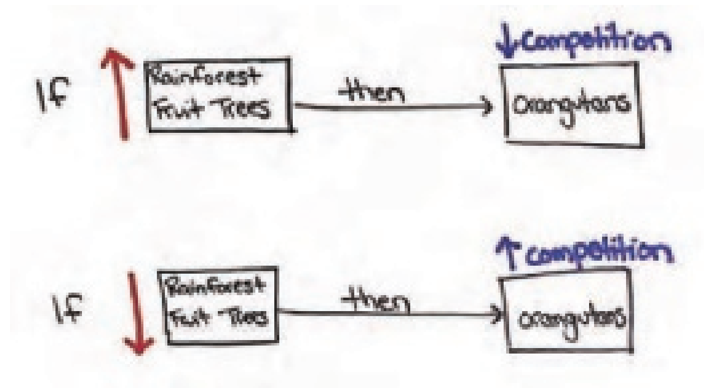
What to do: If students struggle to compare outcomes from plentiful resources to outcomes with limited resources, consider placing the class histograms from each experiment next to one another and having the students note the similarities and differences between the histograms. Then support students in describing *why* they think they noticed those differences. It might help to have students focus specifically on what happened to their individual orangutan before generalizing to the population of orangutans.

Suggested prompts	Sample student responses
What claim can you now make about why orangutans need so much forest space?	*Orangutans need so much forest space because individual orangutans within the population compete for limited food resources (fruit trees and termites). In order for an orangutan to access the energy it needs, there must be enough fruit trees per orangutan for the orangutan to get fruit. Otherwise, the orangutan will lose energy by moving around, which could make the orangutan slower and could potentially cause the orangutan to die.*
What claim can you now make about how changing the percentage of fruit trees in the tropical rainforest (independent variable) affected individual orangutan energy and the orangutan population as a whole (dependent variable)?	*When there are more food resources (e.g., more fruit trees) available, orangutans compete less for resources and end up with higher energy.* *When there are fewer food resources available, orangutans compete more for resources and end up with lower energy.* *When there are fewer food resources available, orangutans eat more termites than fruit.*

Generate a representation of what we figured out. During the discussion, generate a shared class representation of the relationship between competition between individuals within a species (e.g., orangutans) and the availability of different food sources (e.g., rainforest fruit trees). An example representation has been provided. You may wish to draw on the three previously generated representations in this lesson.

Summarize by saying, *We have figured out some really important ideas about how individual orangutans compete with each other in a population! Competition increases when food resources are limited. In our simulation, though, we noticed that the energy of orangutans could get really high or could fall below 0. We identified this as a potential issue in our simulation and wondered if the high and low energy might be related to birth and death rates.*

Update Progress Trackers. Give students 3–5 minutes to quietly update their Progress Trackers using words and drawings to show what they have figured out. Project **slide Q** to guide student work. Ask students to draw a line underneath their responses when they are done.



9. Navigation

3 MIN

Materials: None

Lead a whole-class discussion to predict how our results might change if we add births and deaths into the simulation. Project **slide R** and say, *Imagine that orangutans with enough energy could reproduce (by splitting in half) and that orangutans whose energy fall below 0 would die. How might this change the results of our experiments?*

Suggested prompts	Sample student responses
What do you predict will happen to the orangutan population when there are many fruit trees available?	*We think that the overall size of the orangutan population would increase and stay high because there are more resources available.*
What do you predict will happen to the orangutan population when there are NOT many fruit trees available?	*We think that the overall size of the orangutan population would decrease and stay low because there are fewer resources available. It is possible that the orangutan population might disappear completely!*

Summarize by saying, *It sounds like we should do some investigating to focus more specifically on the* population *of orangutans when we add in the opportunity for orangutans to reproduce and die. Let's start there next time!*

ADDITIONAL LESSON 8 TEACHER GUIDANCE

Supporting Students in Making Connections in Math

CCSS.Math.Content.6.SP.A.2: Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

CCSS.Math.Content.6.SP.B.4: Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

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.

CCSS.Math.Content.7.SP.A.1: Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population.

In this lesson, students dive deeply into the mathematical concepts of central tendency and range. Students primarily engage with the math concepts they developed in 6th grade. Students use data from simulations to identify ranges (maximum and minimum) and means (average) for the orangutan populations, with respect to the energy they obtain from their environment. Use this opportunity to help students understand that measurements such as mean and range are useful measurements when looking at larger groups of things (e.g., populations of orangutans). This will push your students into 7th grade statistical math concepts. Students also construct class histograms. By constructing the histogram, students are building mathematical ideas related to graphing data—in this case, how data from individuals will map to graphs for populations. The transition between individual outcomes and population outcomes is a focus of students' make-sense questions. Students learn that this transition also influences the kinds of conclusions we can draw from graphs.

LESSON 9

Would planting more rainforest fruit trees help the orangutan population increase?

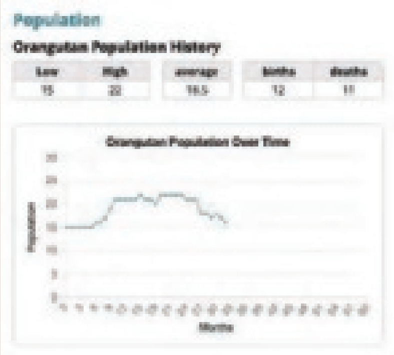
Previous Lesson

We gathered data from a computer simulation in which individual orangutans competed with each other for food resources (rainforest fruit and termites). We ran multiple trials of experiments to test three different environmental conditions. We examined how well individual orangutans and the orangutan population overall responded by analyzing averages and ranges of orangutan energy points for each environmental condition (dependent variables).

This Lesson

Investigation

2 DAYS



In order to figure out how food availability affects population size, we conduct experiments in a simulation, manipulating the amount of food resources (independent variable) over a 5-year period to observe how orangutan population sizes increase or decrease (dependent variable). 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 sizes in the different ecosystems from Lesson 7. We think we have figured out how resource availability could support healthier orangutan populations.

Next Lesson

We will analyze cases where other populations change and connect those changes to the availability of key resources. Afterward, 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, MS-ESS3-3, MS-ETS1-1

What Students Will Do

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

9.B Use mathematical representations to draw conclusions about trends in orangutan population sizes over time, depending upon resource availability.

What Students Will Figure Out

- It's normal for population sizes to fluctuate (i.e., go up and down).
- If there are a lot of resources available, population sizes go up. If the resources are limited, population sizes go down.
- When there aren't enough resources, orangutans have to compete for them, and some orangutans don't get what they need to survive.
- When an orangutan gets enough resources, it survives and reproduces.
- If an orangutan can't get what it needs, it may not reproduce. Over the years, that means that the population goes down as orangutans die and not enough are born to keep the population stable.
- Minor disruptions in resource availability may lead to small fluctuations in population sizes, while major disruptions in resource availability may cause populations to increase or decrease drastically in number.
- Running multiple trials on an experiment can provide more data to get more certainty about the conclusions being drawn from the data.

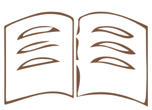
Lesson 9 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Establish 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 "allow orangutans to die if their energy points drop to 0 and reproduce if their energy points reach 200" feature.	B	computer and projector, Orangutan Population Model simulation
3	15 min	**CONDUCT EXPERIMENT 1** In small groups, run the simulation to examine what will happen to the orangutan population if we add births and deaths to our simulation with normal fruit availability. Engage in a discussion about fluctuation and stability.	C-E	*Would planting more rainforest fruit trees help the orangutan population increase?*, colored pencils, computer, Orangutan Population Model simulation, computer and projector, Word Wall
4	20 min	**CONDUCT EXPERIMENT 2** In partners, plan and run an experiment to examine the question, "Would 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	*Would planting more rainforest fruit trees help the orangutan population increase?*, colored pencils, computer, Orangutan Population Model simulation

End of day 1

Part	Duration	Summary	Slide	Materials
5	20 min	**CONDUCT EXPERIMENT 3** In small groups, plan and run an experiment 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 those data.	H-I	*Would planting more rainforest fruit trees help the orangutan population increase?*, colored pencils, computer, Orangutan Population Model simulation
6	10 min	**BUILDING UNDERSTANDING: CONNECTING OUR FINDINGS TO REAL ECOSYSTEMS** Look back to the four ecosystems we investigated in Lesson 7 and try to make sense of why each ecosystem supported a slightly different number of 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 7)
7	10 min	**UPDATE PROGRESS TRACKER** Update Progress Trackers, summarize what we figured out, and represent it in words and pictures.	L	
8	5 min	**NAVIGATION** Brainstorm where our class representation could be useful in explaining other systems.	M	
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 9, students are ready to read Student Reader Collection 3 and then respond to the writing exercise.		Student Reader Collection 3: *Counting and Sampling Populations*

Lesson 9 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Would planting more rainforest fruit trees help the orangutan population increase?* • colored pencils • *Orangutan Populations in Protected Areas in Indonesia* (already in science notebooks) • access to *Orangutans in Four Protected Areas in Indonesia* (from Lesson 7)	• computer • Orangutan Population Model simulation	• computer and projector • Orangutan Population Model simulation • Word Wall

Online Resources

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.

Make sure you can access the *Orangutan Population Model* simulation and that students' devices can access this URL too. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Review the *Orangutan Population Model*. Spend some time familiarizing yourself with the simulation and the controls. Run each experiment outlined in the lesson on your own prior to running the experiments with the class.

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 *Experiment 2* and one in *Experiment 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 7. Make sure students can revisit *Orangutan Populations in Protected Areas in Indonesia*, which should already be attached in their science notebooks.

Be prepared to add "fluctuation" and "stable" to your Word Wall on day 1 as your students discuss results from *Experiment 1*. Be prepared to add "trend" to your Word Wall on day 2 as your students discuss results from *Experiment 2*.

Lesson 9 • Where We Are Going and NOT Going

Where We Are Going

In Lesson 8, students figured out that when certain food resources (rainforest fruit trees) are plentiful, individual orangutans have higher energy points. When food resources are scarce, their energy points decline. At the end of the lesson, students are left wondering how food availability affects population size. This lesson allows students to test their ideas about how food availability affects orangutan population sizes.

This lesson layers on population size and growth to previous ideas about organism energy and growth. Specifically, this lesson targets the same DCIs that are part of LS2.A Interdependent Relationships in Ecosystems, with an additional discussion on how resource availability impacts population.

By the end of this lesson, students should be prepared for Lesson 10, a lesson that puts different pieces together and solidifies students' understanding about the following concepts:

- 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; a lack of access to these resources 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 11 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 the 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 population sizes and normal fluctuation and unusual trends in populations based on resources.

The lesson advances students' practice of Planning and Carrying Out Investigations using computer simulations to run multiple trials. Computer simulations are computer models representing real-world systems. They will allow students to test their ideas, collect data, and answer scientific questions, but the computer models are limited representations of the real-world systems. Students will consider these limitations as they draw conclusions from their data. Students will advance their practice of Using Mathematics and Computational Thinking by analyzing normal fluctuations and trends from population line graphs, which are mathematical representations of orangutan populations in the real world. Students will connect these representations to population sizes per area (ratio), which they figured out in Lesson 7.

In this lesson, students use Grades 3-5 Stability and Change thinking: *Students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change*. They deepen their understanding of Stability and Change by considering how *small to extreme changes in one part of a system (like a 5% drop or 20% drop in fruit availability) might cause large changes in another part (orangutan population growth or decline).*

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 a small to extreme change in resource availability can greatly impact populations, but does not yet connect this to human-caused disruptions. Human-caused disruptions will be introduced in Lesson 11, as students build out ecosystem webs for the tropical rainforest and oil palm farms. Disruptions and ecosystem health will continue to be the focus in Lesson Set 3.

LEARNING PLAN FOR LESSON 9

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. Remind students that in the previous lesson, they observed the energy points of individual orangutans change, but because orangutans could not reproduce or die, they did not see any changes in population size. In the previous lesson, they were left wondering how food availability might impact population size. Project **slide A** and have students consider ways they might increase the size of orangutan populations.

Suggested prompts	Sample student responses
Based on our experiments yesterday, what are some of your ideas about how we could increase the orangutan populations?	*Since orangutan energy points 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 deaths to our simulation so that we can see changes to orangutan population size.*

Summarize by saying, *It sounds like we are wondering, "Would 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: computer and projector, Orangutan Population Model simulation

Orient students to the updates in the computer simulation. Project **slide B** to show students the new features added to the simulation in the *Orangutan Population Model*. The slide shows screenshots of the new features and the ways to monitor population size:

- In "Setup," students can check a box to "allow orangutans to die if their energy points drop to 0 and reproduce if their energy points reach 200."

- A new rule was added to the simulation. Now you can adjust whether orangutans reproduce and die. When checked, orangutans die if they run out of energy points and reproduce when they earn 200 energy points. When unchecked, orangutans do not die or reproduce.
- Population sizes are tracked using an "Orangutan Population Over Time" line graph.*

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. The image on **slide B** shows the orangutan population starting to increase.

Open the *Orangutan Population Model*. Click "Run Experiment" so that students can see how orangutans move around the screen. Run the simulation long enough so that students can see a heart appear when an orangutan reproduces and an "X" appear when an orangutan dies. Do not let the experiment run to completion, so that students do not see results before they have had a chance to make a prediction. To avoid allowing the experiment to run to completion, be sure to click "Cancel—do not record" before day 1,825. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Finally, frame the experiment 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 7.

*** Supporting Students in Engaging in Using Mathematics and Computational Thinking**
In the *Orangutan Population Model* simulation, a line graph (rather than a histogram) is used to track changes in the population size over time. This is because line graphs are used to show information that changes over time.

3. Conduct Experiment 1.

15 MIN

Materials: science notebook, *Would planting more rainforest fruit trees help the orangutan population increase?*, colored pencils, computer, Orangutan Population Model simulation, computer and projector, Word Wall

Orient students to the experiment. Share the experiment question*, "What will happen to the orangutan population if we add births and deaths to our simulation with normal fruit availability?"* 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.

Distribute *Would planting more rainforest fruit trees help the orangutan population increase?* and use **slide C** to prompt students to paste each page of the handout into their science notebooks.

Additional Guidance

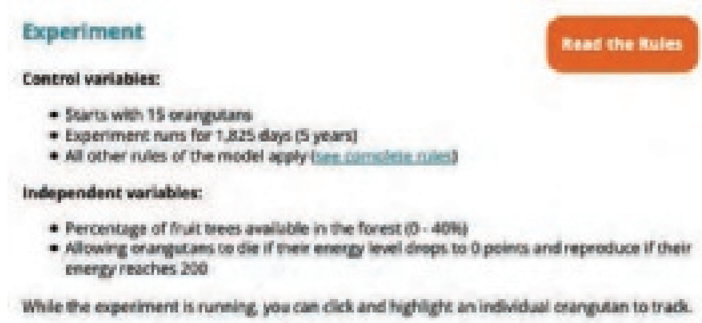
Decide whether you want students to paste all experiment pages (e.g., Experiment 1, Experiment 2, Experiment 3) into their notebooks now, or wait and paste the pages as you proceed through the experiments.

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 percentage of rainforest fruit trees for each experiment. Demonstrate how to open the simulation as students follow along on their own computers.

Additional Guidance

Universal Design for Learning: Having students share one computer between two students, as opposed to having each student work independently, will help generate more dialogue between students as they plan, observe, gather data from, and analyze their experiments. When carefully structured, such peer cooperation can significantly increase the available support for sustained engagement. Consider having students alternate who “drives” the computer for each trial or each experiment, so that each student is actively participating in the process.

Set the context for the experiment. 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 with normal fruit availability. The goal of* Experiment 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 experiment. Prior to directing students to work in groups on *Experiment 1*, preview the experiment and some of the procedural details. First, direct students to *Experiment 1* on *Would planting more rainforest fruit trees help the orangutan population increase?*. Explain that for this first experiment, we are just trying to get a sense of how the population changes when births and deaths are added. Students should test normal fruit availability, or 25% fruit trees in the tropical rainforest. The default settings for *Experiment 1* are illustrated in the image.

Preview the following experiment pattern: (1) before the experiment, (2) run the experiment, and (3) make sense. Show students that on *Would planting more rainforest fruit trees help the orangutan population increase?* under *Experiment 1*, the first step is to plan their experiment by identifying the percentage of fruit trees in the tropical rainforest. Once the experiment is planned, students should make predictions using the prompts on the handout. Next, students should run two trials of their experiment and record data from both trials. Finally, students should work with their partner to analyze their results using the prompts in the make sense section.

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

Suggested prompt	Sample student responses
You probably noticed that in the handout, you are prompted to run two trials of your experiment. 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 experiment and analyze the results. Students can access the *Orangutan Population Model* simulation. They should aim to complete *Experiment 1* (pages 1 and 2) on *Would planting more rainforest fruit trees help the orangutan population increase?*. As students work, circulate among groups to push their thinking forward. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

When students are making predictions, consider the following prompts:

Suggested prompts	Sample student responses
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 points of the orangutans stayed about the same in our experiment from Lesson 8, with 25% 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:

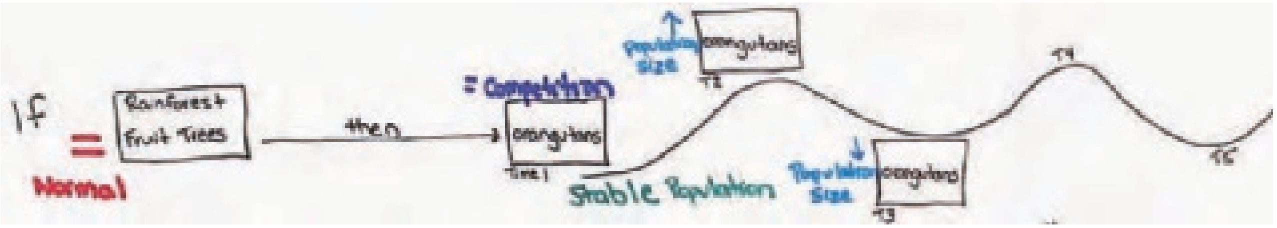
Suggested prompts	Sample student responses
Wow—it looks like the population size is going up and down! That is different from your prediction. Why do you think that happened?	*Maybe as more orangutan babies are being born, the orangutan population eats more fruit, making fruit less plentiful. That means 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.*
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 8.*

After running the experiment, students should work on the "Make 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 expand upon their thinking once they discuss with their partner and the class.

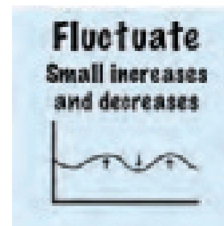
Make sense of the data from *Experiment 1*. After students have had the opportunity to work in pairs on the "Make Sense" section of the handout, lead a class discussion to make sense of findings from the experiment. Project **slide E** during the discussion. Prompt students to use a different colored pen or pencil to add ideas from the class discussion to the "Make Sense" portion of their *Would planting more rainforest fruit trees help the orangutan population increase?* handouts.

Suggested prompts	Sample student responses
What claims can you make about the question, "What will happen to the orangutan population if we add births and deaths to our simulation, with normal fruit availability?"	*When we add in birth and deaths to the simulation, the size of the orangutan population stays about the same.* *There are some ups and downs (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.*

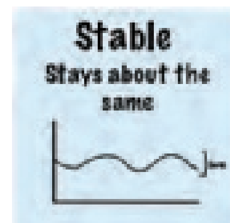
Generate a representation of what we figured out. During the discussion, generate a shared class representation to represent fluctuations in population size with normal fruit availability. An example representation has been provided. It is important that there is some competition between individuals, but it will stay about the same with normal fruit availability. As resources become slightly more or less plentiful, there will be small increases or decreases in the population sizes. These increases and decreases are called *fluctuations*. In this experiment, it is important to emphasize that the small ups and downs that we see are due to very small changes in resource availability.



Additional Guidance



The term *fluctuations* may be new to students. As students discuss the small increases and decreases in population sizes, you may wish to introduce the term *fluctuations* by saying, *We are noticing that the population size goes up a little bit and then down a little bit. These small ups and downs are called* fluctuations.



The term *stable* may also be new to students in this context. As students observe that the population size stays about the same, you may wish to introduce the term *stability* or *stable* by saying, *We are noticing that on average, the population size stays about the same. This can be referred to as a* stable population.

Consider adding the terms to the Word Wall.

Summarize results from *Experiment 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!*

Assessment Opportunity

***Building towards*: 9.A** Collect data from an investigation to draw conclusions about how stable populations of orangutans fluctuate over time based on resource availability.

What to look/listen for:

- It's normal for population sizes to go up and down (fluctuate).
- When there are more orangutans, they are competing for the food, so some struggle to get to the fruit first and their energy goes down and they may die.
- When there are fewer orangutans, there is more food available, so they don't have to compete as much.
- It's important to run more than one trial because results are slightly different each time. Running multiple trials on an experiment can provide more data to give you more certainty about the conclusions being drawn from the data because you start to see some of the same trends.

What to do: If students are struggling to understand how a population can remain stable yet still fluctuate, consider demonstrating the concept using a cereal box with a bag of coins in the box. Push slightly on the side of the box, temporarily disrupting the box. Then, let go. The box will wobble back and forth until it reaches its stable state. In this analogy, the box is still stable, even though a minor disruption caused small fluctuations in the box. Another option is to use a dropper to drop water into a dish. The drops of water create a ripple that eventually settles out. Using the water dropper approach may be more analogous to the upward and downward wave motion of the population graphs.

4. Conduct Experiment 2.

20 MIN

Materials: science notebook, *Would planting more rainforest fruit trees help the orangutan population increase?*, colored pencils, computer, Orangutan Population Model simulation

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

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

Preview *Experiment 2*. Prior to directing students to work in groups on *Experiment 2*, preview the experiment and some of the procedural details. Utilize **slide F** to guide the discussion. Direct students to *Experiment 2* on *Would planting more rainforest fruit trees help the orangutan population increase?*. Explain that for this experiment, we are trying to see if increasing the percentage of fruit trees in the tropical rainforest might help the orangutan population size increase. Students will need to decide with their partners how they would like to change the percentage of fruit trees. Remind students of the following experiment pattern: (1) before the experiment, (2) run the experiment, and (3) make sense. Orient students to where on their handouts they can find this pattern.

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

*** Supporting Students in Engaging in Planning and Carrying Out Investigations**
It is important that students notice that they are *only* changing the percentage of fruit trees (independent variables), while the simulation holds 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 experiment when we are manipulating one of them as an independent variable. If we change any of the control variables in addition to the 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 prompts	Sample student responses
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?	*The number of fruit trees only increased a little bit, so maybe that doesn't affect orangutans very much.* *We added a lot of fruit trees and it seemed to cause a big difference.*
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
27%	18.5	15-22
30%	22.5	15-30
32%	22.5	15-30
35%	25.5	15-36
40%	26	15-37

After running the experiment, students should work on the "Make 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 expand upon their thinking once they discuss with their partner and class.

Make sense of the data from *Experiment 2*. After students have had an opportunity to work on the "Make Sense" section of the handout in pairs, lead a class discussion to make sense of the findings from the experiment. 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 "Make Sense" portion of their *Would planting more rainforest fruit trees help the orangutan population increase?* 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 the percentage 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 line graphs. The following is a suggestion for how to approach refining the range of the orangutan population size to reflect the range of the stable population.

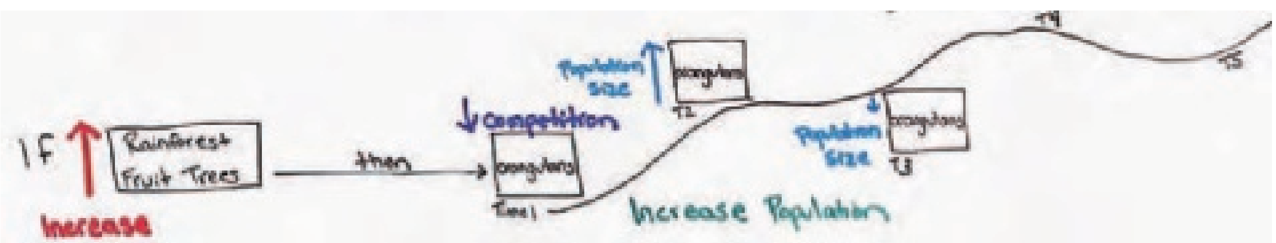
Take a moment during the whole-group discussion to demonstrate the range of the "stable population" after the sharp initial increase. For example, run the model at 40 percent of fruit trees until you get the line graph and low and high values. The low and high values will indicate a range of 15-37 orangutans. Look at the line graph to confirm this. Then,

% Fruit Trees	Average Orangutan Population Size	Range of orangutan Population Size
27%	18.5	15-22
30%	22.5	15-30
32%	22.5	15-30
35%	25.5	15-36
40%	26	25 ~~15~~-37

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 a stable population.

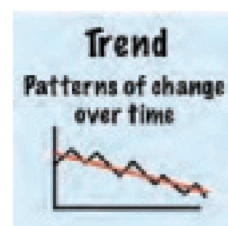
Suggested prompts	Sample student responses
What trends do you notice in the class data table?	*We notice that as the percentage of fruit trees increases, the average size of the orangutan population increases. This must mean that our idea of adding more fruit trees to help the orangutans could work.*
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 experiment and the class's experiments, which show that as the 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?* *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 can add that could still sustain a healthy orangutan population?*

Generate a representation of what we figured out. During the discussion, generate a shared class representation to represent increases and fluctuations in population size when the percentage of fruit trees increases. An example representation has been provided.



Additional Guidance

The term *trend* may be new to students in this context. In addition to the fluctuations in population size, students will observe patterns of change over time. These patterns of change can be described as *trends*.



Consider adding the term to the Word Wall.

Summarize the findings from *Experiment 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 we would need to still support a stable orangutan population. Let's investigate that next.*

End of day 1

5. Conduct Experiment 3.

20 MIN

Materials: science notebook, *Would planting more rainforest fruit trees help the orangutan population increase?*, colored pencils, computer, Orangutan Population Model simulation

Preview the experiment. Prior to directing students to work in groups on *Experiment 3*, preview the experiment and some of the procedural details. Use **slide H** to guide the discussion. Direct students to *Experiment 3* on *Would planting more rainforest fruit trees help the orangutan population increase?*. Explain that for this experiment, we are trying to determine the smallest percentage of fruit trees that would still support an orangutan population. 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 experiment pattern: (1) before the experiment, (2) run the experiment, and (3) make sense. Orient students to where on their handouts they can find this pattern.

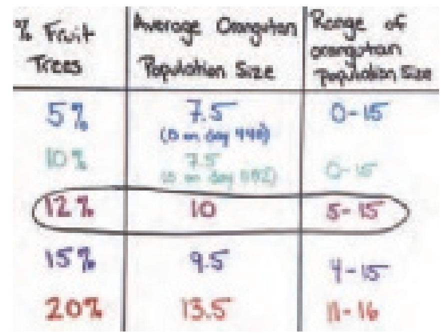
Have students work in pairs to run the third experiment and analyze the results. Students should aim to complete *Experiment 3* on their handout. As students work, circulate among groups to push their thinking forward. Consider the following prompts:

Suggested prompts	Sample student responses
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.*

*** Supporting Students in Three-Dimensional Learning**
Throughout this lesson, monitor how students use the lens of stability and change to make sense of the data they have collected from the simulated and the line graph representations. Listen carefully to how they talk about changes in one part of the system (fruit availability, independent variable) and outcomes in another part of the system (orangutan population). Encourage students to use data from their investigations to draw conclusions about resource availability, orangutan growth, survival, and reproduction, and orangutan population sizes over time.

Suggested prompt	Sample student responses
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.



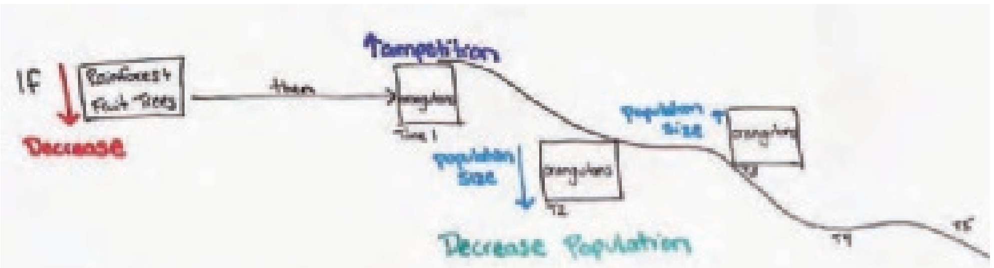
After running the experiment, students should work on the "Make Sense" section of the handout in pairs. Students should use one color of pen or pencil to indicate the ideas that they came up with, and use a second color of pen or pencil to expand upon their thinking once they discuss with their partner and class.

Make sense of the data from *Experiment 3*. After students have had an opportunity to work on the "Make Sense" section of the handout in pairs, lead a class discussion to make sense of the findings from the experiment. 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 "Make Sense" portion of their *Would planting more rainforest fruit trees help the orangutan population increase?* handouts.

Suggested prompts	Sample student responses
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 be somewhere slightly above that point.*
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 12%. 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 12%, all the orangutans died. When we stayed at 15% or higher, the population leveled off. It was a low number, but a few stayed alive and the line graph seemed steady or stable.*

Suggested prompt	Sample student responses
How might our findings help us design a solution to the palm oil problem?	*In a real ecosystem, is it possible to establish a specific number of fruit trees that will keep the orangutans alive?* *How could we plant the fruit trees in a real ecosystem so that the orangutans can access them?*

Generate a representation of what we figured out. During the discussion, generate a shared class representation to represent decreases and fluctuations in population size when the percentage of fruit trees decreases. An example representation has been provided.



Summarize the findings from the experiment 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 also 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 7.*

Assessment Opportunity

***Building towards*: 9.B** Use mathematical representations to draw conclusions about trends in orangutan population sizes over time, depending on resource availability.

What to look/listen for:

- When there aren't enough resources, orangutans have to compete for them, and some orangutans don't get what they need to survive.
- When an orangutan gets enough resources, it survives and reproduces.
- If an orangutan can't get what it needs, it may not reproduce. Over the years, this means the population decreases as orangutans die and not enough are born to keep the population stable (i.e., it trends downward or declines).
- Minor disruptions in resource availability may lead to small fluctuations in population sizes, while major disruptions in resource availability may cause populations to increase or decrease drastically in number.
- If there are a lot of resources available, population sizes increase over time. If the resources are limited, population sizes decrease over time (trends).

- A trend downward over time is not a normal fluctuation, and means the population is not stable. A trend upward over time means the population is increasing above its typical size.

What to do: If students are struggling to understand the differences between minor disruptions leading to small fluctuations in ecosystems and major disruptions, which lead to significant changes in population sizes, consider extending the cereal box example. Push hard on the cereal box so that it falls over. This push represents a major disruption. The cereal box cannot return to its stable state. Link this demonstration back to the concepts of fluctuation and stability within populations. Additionally, you can zoom in on a section of the graph that shows a steep decline in the population. Point out that even during the decline, there are some upward and downward trends happening (i.e., it is not a straight line down). Ask students to explain why this might be.

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 7)

Look back at the four ecosystems from Lesson 7 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 an average of just over 2 orangutans per square kilometer, while Kutai National Park had about 1 orangutan per square kilometer. 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 more or less orangutans per area compared to other areas. 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 experiment in this lesson to the real ecosystems from Lesson 7.

Suggested prompt	Sample student response
Why could some ecosystems support more orangutans per square kilometer than others?	*The ecosystems with more orangutans per area must have more fruit trees than the ecosystems with fewer orangutans in an area. 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 line graphs they saw in *Experiments 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. Update Progress Tracker.

10 MIN

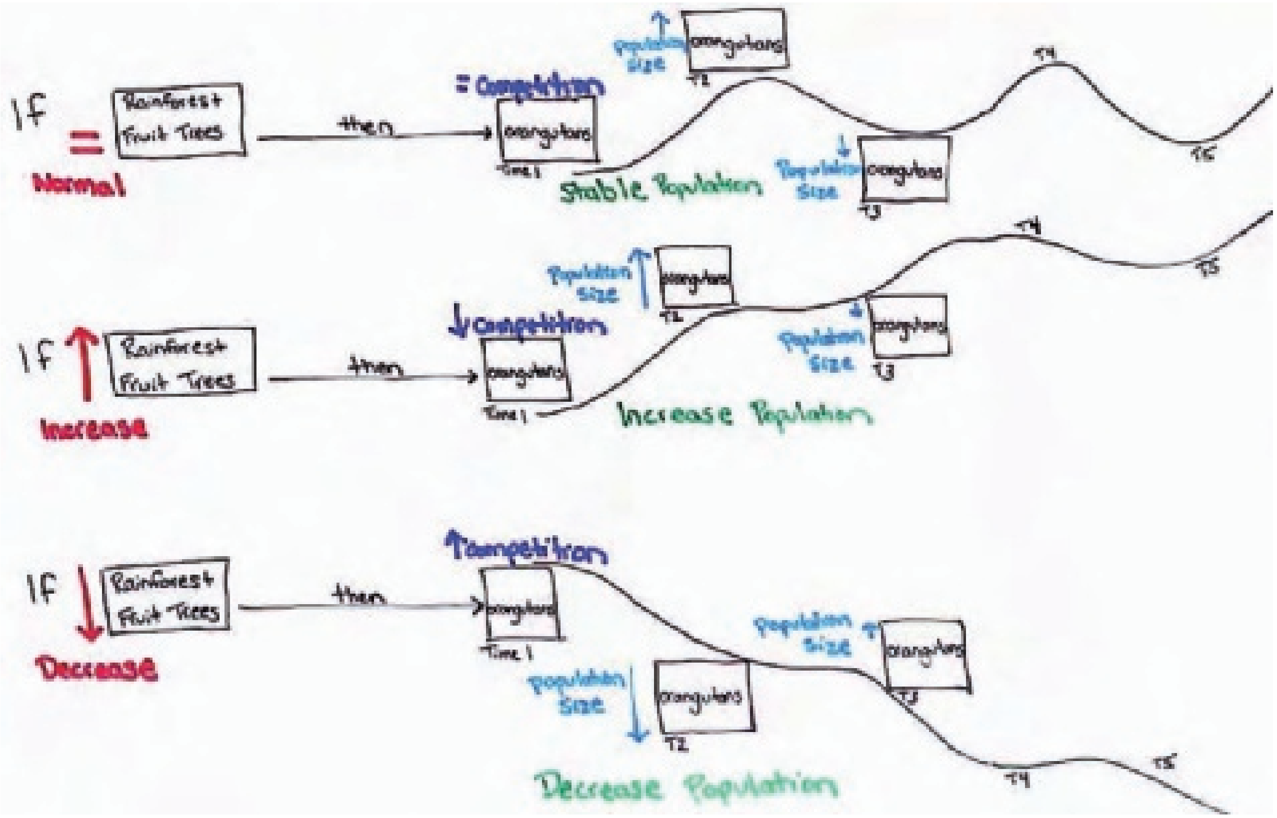
Materials: science notebook

Update Progress Trackers using words and drawings to show what they have figured out. Project **slide L** to guide student work. You may wish to direct students back to the representations that they developed throughout the lesson. Ask students to draw a line underneath their responses when they are done.

After students update their Progress Trackers, have students share 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 fewer 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 produce 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 below.



Additional Guidance

In this lesson, the representation that students generate should be specific to rainforest fruit trees and orangutans. In Lesson 10, students will broaden their understanding of this model as they apply it to different populations. At that point, students can replace the label of *rainforest fruit trees* with a more general term of *food resource* and the term *orangutan* with a more general *organism.*

8. Navigation

5 MIN

Materials: None

Motivate applying this model to other cases. Say, *Now we've developed a model for explaining the decline in orangutan populations due to palm oil farming.* Recall with students the related phenomena that they explored in previous lessons. You may wish to revisit your list of related phenomena if you have it posted.

Display **slide F**. Give students a minute to turn and talk, focusing on the prompt on the slide: "Where else can we use this model (or a similar model) to explain changes in populations?"

Elicit 3-5 ideas from students but keep this sharing brief. Example student ideas could include:

- Decline in bear population
- Increase in deer, turkey, squirrel, and pigeon populations
- Decline or increase in a wolf population
- Decline and then increase in bobcat population

You may wish to record these ideas on chart paper so that you can use them in Lesson 10.

Say, *Let's apply our model to a new case to see where it's similar or different. Some ideas may be very similar, and other ideas may need to change for the new system.*

ADDITIONAL LESSON 9 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 experiment, 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 orangutan population size (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.

Counting and Sampling Populations

1 **School Study: Grasshopper Population**
2 **What Are Transects?**
3 **Counting Animals**
4 **Science Interviews Podcast**

Literacy Objectives

- ✓ Read to find out about techniques used to count populations of organisms.
- ✓ Compare techniques for counting populations of species that can and cannot be seen.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 7–9.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a poster to explain how to determine the population of a particular species in response to the reading.

Instructional Resources

Student Reader
Collection 3

Science Literacy Student Reader, Collection 3
"Counting and Sampling Populations"

Exercise Page
EP 3

Science Literacy Exercise Page
EP 3

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 7: How many orangutans typically live in the tropical rainforest?
- Lesson 8: Why do orangutans need so much forest space?
- Lesson 9: Would planting more rain forest fruit trees help the orangutan population increase?

Standards and Dimensions

NGSS Performance Expectation

LS2-1: (Building toward) Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Disciplinary Core Idea LS2.A: Interdependent Relationships in Ecosystems

Science and Engineering Practice: Analyzing and Interpreting Data

Crosscutting Concepts: Cause and Effect; Patterns

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.W.7.2

Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

population sampling

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

population **quadrat** **transect**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Exercise Page

EP 3

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Ecosystem Dynamics unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
  - *In "School Study: Grasshopper Population," you will find out how one group of students estimated how numerous a population of grasshoppers was.*
  - *In the second selection, you'll learn more about how to estimate populations of specific organisms in large areas.*
  - *"Counting Animals" offers more information about how to estimate populations of animals that cannot be easily seen.*
  - *In the last selection, you'll read about what you can learn about populations by tagging them and examining their diet.*

- Distribute Exercise Page 3. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to make a poster that describes an unwanted animal and explains how to estimate its population in a living space.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
Why might it be important to know the number of a specific organism that lives in a defined area?	*It helps track the health of an ecosystem.* *Too few predators may predict an infestation of prey.* *Knowing populations of species can help determine if there are enough resources to maintain the ecosystem.*
Why is it important to randomize a series of counts of a population?	*A realistic count could be wildly off if a particular place or time were set up beforehand.*
How can you determine populations of animals if you can't see them easily?	*You can count animal tracks, animal waste, or feeding activity.*
What can an animal's diet tell you about populations of other animals?	*By studying what animals eat in each area, you can determine how many other animals live in the area.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
Why do some organisms need more space than others?	*Some organisms, like worms, can find all they need to survive in a small space. Other organisms, like some birds, need a wide range of space to find food, water, and shelter.*
How does competition for food affect population?	*If there is not enough food in an area, some animals will not get enough to eat and will either starve or move, thus decreasing the population.*
What is the effect on a population in an ecosystem if it provides the food, water, and shelter that the population needs?	*The population will be healthy, grow, and reproduce.*

- Refer students to the Exercise Page 3. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The expectation for this assignment is to make a poster that outlines how to determine the population size of an unwanted animal in a human living space.*
    - *In the selections, you learn about techniques for counting populations of insects and other animals that can be seen and not seen.*
    - *Think about what you read as you research how to determine if you have a population of a certain kind of animal in your own home, your own school, or a nearby area.*
    - *Your poster should include what kinds of evidence to look for to determine how large a population of ants, roaches, mice, termites, snakes, deer, raccoons, foxes, or another unwanted species is.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 3

4. Facilitate discussion. (Friday)

Facilitate class discussion about the reading collection and writing exercise.

The four reading selections help to describe different techniques for effectively counting populations in a particular habitat.

Student Reader

Collection 3

Pages 26–29 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "School Study: Grasshopper Population"?	*It describes how to mark off quadrats to randomly count a particular population.*
Are animal populations consistent, or do they change?	*They may be consistent for a period and then change when seasons change or when an ecosystem is disrupted.*
How would you be able to tell that an area is overpopulated with grasshoppers?	*Much of the food that grasshoppers eat would be gone.* *You might find dead grasshoppers in the area.*
Why did the class tag or mark each grasshopper they captured in a quadrat?	*so they did not double-count the same grasshoppers* *to get an accurate number of grasshoppers in each quadrat*
Why would a quadrat be sampled more than once?	*to make the estimate more accurate* *Grasshoppers may have been eaten or the weather may have affected the count.*
Why would data from the quadrat be valuable in generating estimates for the larger habitat?	*It is a sample of the entire habitat. You could assume that the number of grasshoppers found in one quadrat of a habitat would be similar in every other quadrat in a habitat.*

Pages 30–31 **Suggested prompts**	**Sample student responses**
How does the second selection help you build knowledge on top of what you learned in the first selection?	*It shows another way to estimate population size over a larger area.*
What is a transect?	*A transect is a narrow path randomly placed across a large area. Observers collect population data along the transect to estimate population size.*
Would the quadrat or transect method be more effective for counting species that don't move very much?	*The quadrat method might provide a better count, because it allows you to count small individuals or plants.*
Is using a quadrat or transect method of counting better or worse than counting every individual in a habitat?	*It would be too expensive and, in many cases, impossible to count every individual in a habitat. That's why techniques, like quadrats and transects, for estimating populations are used.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Have students watch a video about home infestations of a pest, like termites. Discuss how to determine the size of the population.

SUPPORT—Compare with students the terms *quadrat* and *transect*. Point out that the words are comprised of root words *quad, trans,* and *sect* that provide clues to word meaning. *Quad* means "four," *trans* means "across," and *sect* means "break." A quadrat is one four-sided square of a particular space. A transect is a narrow section that breaks across a habitat along which observations can be made.

Pages 32–33 Suggested prompts	Sample student responses
What is the general purpose of the third article, "Counting Animals"?	*It presents a way of using sonar to count animals underwater.*
How does sonar work?	*It sends sound waves in a specific direction. When the waves hit something, they bounce back so you can estimate the shape and depth of an object.*
Is there one best way to estimate population sizes?	*No, it depends on what you are trying to count, how big it is, where it is, and if it moves a lot or not.*

CHALLENGE—Have interested students research orangutans to find out how intelligent they are, where they live, how long they live, and what their behaviors are like. Have them share their findings with the class along with video, audio, and images.

Pages 34–35 Suggested prompts	Sample student responses
What is the general purpose of the fourth selection, "Science Interviews Podcast"?	*It describes tagging to track the movements of animals.*
What is tagging?	*It is placing an identifier on an animal so it can be tracked and studied. Some tags are colorful and can be seen from a distance. Others, like some electronic dog tags, have GPS trackers.*
What is a niche?	*A niche is an organism's place or role in an ecosystem.*
What can you learn about species populations from studying what animals eat?	*You can learn about the population of other animals and plants in the environment and recognize the importance of the balance in a food web.*

SUPPORT—Have students watch a video of how crowds of people can be estimated. Compare the techniques of counting populations.

SUPPORT—Have students watch a video about the Great Backyard Bird Count. Discuss what estimation techniques are used and how accurate the count may be. Consider participating in a future Bird Count.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 3, students should research and develop a poster about how to tell if there is an unwanted population in their living space and how large that population is.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 10

How do changes in the amount of resources affect populations?

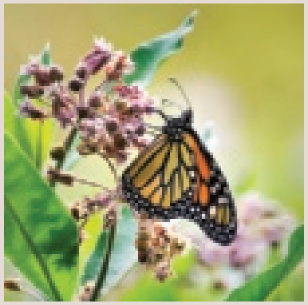
Previous Lesson

We conducted experiments in a simulation, manipulating the amount of food resources (independent variable) over a 5-year period of time to observe how population sizes increased or decreased (dependent variable). We noticed that population sizes increased when resources were plentiful and decreased when resources were limited. We also noticed that all populations have natural fluctuations in size. We connected our findings to the differences in population sizes in the different ecosystems from Lesson 7.

This Lesson

Putting Pieces Together

2 DAYS



In this lesson, we analyze other cases where populations have changed due to a change in available resources. Across these cases, we see a pattern that connects the population of an organism to the availability of resources that organism needs. Afterward, we apply these understandings to an assessment in which we explain why the loss of short and tallgrass prairies has caused monarch butterfly populations to decrease.

Next Lesson

We will be curious about other populations affected by the palm oil industry. We will develop system models for the oil palm system and will realize that when there are unlimited resources, both predators and prey do well. We will develop a rainforest system model and realize more competition within this system keeps populations at a stable size. We will compare the two systems, and wonder about what would happen if orangutans went extinct.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

10.A Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short and long term.

What Students Will Figure Out

- Organisms, and populations of organisms, are dependent on their environmental interactions.
- Organisms with similar requirements for food compete with each other for limited resources. A lack of access to these resources consequently constrains their growth and reproduction.

- Growth of organisms and population increases are limited by access to resources.
- It is normal for populations to fluctuate, depending on resource availability from year to year. Drastic changes to resource availability can cause unusual and unstable changes in populations.

10 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Students review the phenomenon and what they've figured out so far about what's causing the orangutan population to decrease.	A-C	
2	5 min	**INTRODUCE CASE STUDIES** Introduce the case studies and then provide guidance for analyzing the data.	D-E	*Case Study Cards*, *Population Case Template*
3	15 min	**ANALYZE CASE STUDIES** Allow students time to work with their group to read and analyze their case studies of how different populations changed when there was a change in the amount of available resources.	F	*Case Study Cards*, red and blue pens or pencils
4	10 min	**JIGSAW DIFFERENT CASE STUDIES** Students regroup with classmates to share findings and look for patterns across different case studies.	G	*Case Study Cards*
5	10 min	**FACILITATE A CONSENSUS DISCUSSION** Students use patterns across case studies to come to a consensus about how the amount of available resources affects populations of organisms.	H-J	
				End of day 1
6	12 min	**REVISE THE MODEL FOR THE MONARCH BUTTERFLY AND PRAIRIE** Work together to draw parallels between palm oil farming and soybean farming. Revise the model from day 1 to explain the monarch butterfly decline.	K-P	chart paper, markers
7	28 min	**INDIVIDUAL ASSESSMENT: BUTTERFLIES ON THE SHORTGRASS PRAIRIE** Have students individually complete an assessment to demonstrate their learning about resource availability, competition, and population size change.	Q-T	*Monarch Butterflies on the Shortgrass Prairie*

Part	Duration	Summary	Slide	Materials
8	5 min	**NAVIGATION** Students were curious about other populations in the tropical rainforest and oil palm farm, such as tigers, rats, snakes, and pigs. Predict how changes in resources might relate to these other populations.	U	Driving Question Board

End of day 2

Lesson 10 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *Case Study Cards* • red and blue pens or pencils • *Monarch Butterflies on the Shortgrass Prairie*		• *Population Case Template* • chart paper • markers • Driving Question Board

Online Resources

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.

Display the model that students created in Lesson 9 in a place that is visible to all students.

Select the cases you will use with your students. There are seven case studies available to use. Consider choosing four cases based on your student's interests and what's most relevant to them. Make enough copies of the cases you select from *Case Study Cards* for each group. Each student receives only 1 of the cases.

If you would like to create a case for a local population or for a population of particular interest to your students, use a layout parallel to the cards.

Be prepared to annotate the graphs in this lesson either using a document camera or a similar digital space.

Lesson 10 • Where We Are Going and NOT Going

Where We Are Going

In Lesson 9, students figured out that resource availability affects orangutan population size and that there is a normal fluctuation in population size based on resource availability and death and birth rates, but drastic changes in resource availability can cause unusual and unstable changes in populations.

This lesson has students test these ideas across cases with different organisms and resources. By analyzing patterns across these cases, students will generalize their model for population change to explain that the population size (of any organism) depends on the availability of resources that organisms need to survive and reproduce. Students also extend these ideas to a related phenomenon of monarch butterflies and milkweed availability on the prairie.

By the end of this lesson, students should solidify their understanding about the following:

- "Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving 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 11 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 prior to the lesson. They are applying ideas in this lesson to move toward a more generalized understanding, beyond orangutans.

This lesson builds on fifth-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.

Throughout the lesson, students use graphs and maps to identify patterns of change in populations and amounts of resources to explain relationships between the two. They will analyze text and graphs to better understand both temporal relationships between resources and population size. Some of these cases draw on large data sets, while other data sets are more limited. Some cases, particularly the monarch assessment case, also pushes students to look for spatial patterns and relationships between resources and population size.

Students investigate cases that are not simple stories with one obvious cause and one obvious effect. These cases are multi-faceted. The lesson targets this Cause and Effect crosscutting concept element: *Cause and effect relationships may be used to predict phenomena in natural or designed systems*. However, you may also find it helpful to support students with using this element to guide their thinking, too: *Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.* There are multiple causes for the population declines and growth that students will investigate. We foreground resource availability, but students may want to think more about how different factors contribute to the change in population. Furthermore, as students work through their data analyses, support them in using Stability and Change to make sense of sudden and gradual changes in both resources and populations over time.

Where We Are NOT Going

This lesson focuses on normal and unusual fluctuation 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 11 as students build out ecosystem webs for the tropical rainforest and oil palm farms and consider how unlimited resources in human-designed systems can lead to unexpected population changes (e.g., both predator and prey increasing at the same time). Disruptions and ecosystem health will also be the focus of Lesson 13.

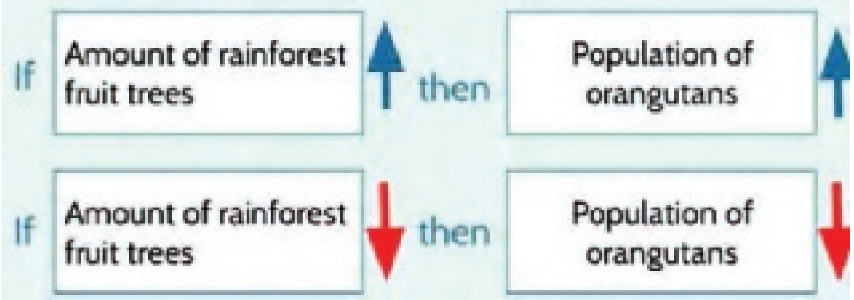
1. Navigation

5 MIN

Materials: science notebook

Recall what the class learned last time about why orangutan populations have declined. Project **slide A**. Ask students to recap what the class figured out during the last lesson about the question, "Why is planting oil palm trees making the number of orangutans go down?" Come to agreement as a class that the number of orangutans decreases when the amount of available trees (food) decreases. When people cut down rainforest fruit trees to grow oil palms, there's less food for orangutans and less of them can survive and reproduce.

Recall with students the model the class made during the last lesson to show this relationship, like the one below:



Say, *In the previous class, we started thinking about how this model might help us explain changes in other populations. I have some data for some other populations. But before we look at those, let's capture what we know about resources and the orangutans.*

Show **slide B.** Have students make a table like the one on slide B in their science notebooks, leaving plenty of room to add more rows. Say, *So far, we've been focused on one organism: orangutans. Let's add "orangutans" to the first row under "organism".*

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans			

Then, point to the first row under "Resource the organism needs." Say, *In our simulation, we were changing the amount of rainforest fruit trees, which we know are important resources for orangutans because they provide food and shelter.* Direct students to write "rainforest fruit trees" under the "Resource the organism needs" header.

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*		

Show **slide C.** Use the following prompts to guide the class through completing the final two columns. Ask students to record the class's ideas in the first row of their table.

Suggested prompts	Sample student responses
How did the amount of this resource (the rainforest trees) change?	*The amount of rainforest fruit trees went down.* *It decreased because people cut them down to make room for oil palm trees and farms.*
How did the population of this organism change?	*The number of orangutans went down, too.* *The orangutans started to die off because there wasn't enough food to eat for them to survive and make babies.*

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees decreased because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*

Say, *From our work last time, we know that when the amount of resources (in this case, rainforest fruit trees) decreases, so does the population of orangutans.* Then, ask students to consider, *Do you think this would be true for other populations? What do you think would happen to a different organism if there was a change like this in the amount of resources? How could we test to see if this rule is true for other organisms and other resources?*

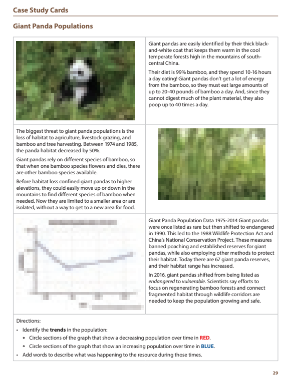
Listen for student ideas, and come to agreement that it would be helpful to see some other cases where there was a change in the amount of a resource (like the fruit trees) that organisms need to survive and reproduce.

2. Introduce case studies.

5 MIN

Materials: science notebook, *Case Study Cards*, *Population Case Template*

Introduce the resource change case studies.* Arrange students into four or eight small groups, depending on the size of the class. Give each student in each group 1 copy of the group's assigned case study from *Case Study Cards*. Case assignments can be driven partly by student choice, but make certain each case is taken up by a group.



Additional Guidance

There are seven case studies available to use. Consider choosing four cases based on your class's interests and what's most relevant to your students. Additionally, you can create your own cases using Population Case Template. If you have four small groups, give each group a different case study. If you have eight small groups, give a different case study to pairs of groups.

Later in this lesson, students will share what they learned with classmates from other groups in a jigsaw discussion. Distributing four different case studies allows for jigsaw groups to remain small (one student for each case study makes four total) while still providing numerous examples for students to analyze and identify patterns across examples.

Show **slide D.** Point out to students that there is a name of an organism at the top of their handout. Ask students to make a new row in the table they made in the last step and add their organism's name under the "organism" heading.

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
Ex: Louisiana black bears			

Explain to students that each group has a different case study of an example where there was a change in the amount of resources that an organism needed. Point out to students that each case study has words, images, and graphs. Direct students to annotate and label important information as they read. Ask students to identify what each group should look for as they read and analyze their case study.

*** Attending to Equity**
The orangutan decline and palm oil farming may still feel faraway for some students, so use this opportunity to bring it closer to home. In this lesson, students will encounter similar changes in ecosystems across different parts of the United States, including some places they may have been to or heard of before. This may help students make connections back to the palm oil example, and it may provide insight on what kinds of local phenomena students are interested in exploring further.

*** Supporting Students in Engaging in Analyzing and Interpreting Data**
In this part of the lesson, students circle sections of the graph that show patterns of increase or decrease in populations over time. Consider analyzing an example together before giving students time with their groups, since that may help draw students' attention toward which parts of the graphs to look for and what visual cues to look for in order to find increasing and decreasing patterns.
Follow the Additional Guidance suggestion.

Suggested prompts	Sample student responses
*What are we trying to figure out by looking at these different case studies?**	*We're trying to figure out if populations of other organisms besides orangutans would go down if they had fewer resources.* *We're trying to see if the same rule that applies to orangutans also applies to other organisms.*
If we're trying to figure out what happens to other organisms when there's a change in their resources, what should we look for?	*We should look for what resources they need and how those have changed.* *We should look for how the population of the organism changed.* *We should compare what happened in our cases to what we saw with the orangutans.*

Show **slide E.** Direct students to the directions at the bottom of their case study. Say, *One way that we can look for how the population changed is by using the graph of population versus time at the bottom of each case study. On that graph, you should circle the sections of the graph that show a decreasing pattern in the population in red. Then, you should circle the sections of the graph that show an increasing pattern in the population in blue. Be sure to also add words or labels to the graph to describe what was happening to that population's resources during those times.*

Additional Guidance

Draw students' attention to the axes of the graphs. Point out that the y-axis shows the population of an organism, and that the further up we go on the axis, the more of that organism are in the population. Since the x-axis is time, the graph shows how the population changes over time. When the population goes from a lower number to a higher number, we call that "increasing," and it's marked on the graph by sections with a positive slope. When the population goes from a higher number to a lower number, we call that "decreasing," and we can see this pattern on the graph in regions with a negative slope.

Students may fixate on small changes on the graphs as being "increases" or "decreases." It may be helpful to remind them that we're looking for *overall* trends in the population. Ask, *Overall, is the population going up, down, or staying the same?* This may help draw students' focus to the most important trends in the population, rather than focusing on small fluctuations year to year.

Consider making an anchor chart or other support for students so they can apply these ideas of increasing and decreasing patterns to understanding what's happening to the population of the organism in their case study.

Tell students that their group is going to have some time to read and analyze their case study. Then, the class will come back together so each group can share what they figured out and the class can look for patterns across all the different cases.

3. Analyze case studies.

15 MIN

Materials: science notebook, *Case Study Cards*, red and blue pens or pencils

Give groups time to read and analyze their case studies. Direct students to start by reading the case study, either aloud with their group or on their own. As they read, they should annotate and label important ideas in the text. When they reach the graph in their group's case study, they should annotate the graph, following the directions at the bottom of the case study.

Additional Guidance

In the previous step, the class brainstormed what students should look for as they read. Some students may struggle to identify what information is important in these case studies, especially since some are short and information-dense.

As you circulate to different groups, prompt students with the ideas that the class brainstormed:

- *We should look for what resources they need and how those have changed.*
- *We should look at how the population of the organism changed.*
- *We should compare what happened in our cases to what we saw with the orangutans.*

Direct students to annotate, underline, and/or label where they see this information in the reading. This will help support students in making sense of their case studies and conveying key information to their classmates later in the lesson.

Show **slide F**. When groups have a few minutes left, ask students to pause and record what they've learned in the second row of the table they made before reading. Ask students to reflect on key information from their case study. Say, *In the second row of your table, record what resource changed for the organism in your case study. Then, record how that resource changed and how the population of the organism changed.*

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
Ex: Louisiana black bears	*Forest trees*	*The amount of forest trees decreased because people were cutting them down.* *Then the amount of trees went up because the habitat was protected.*	*The number of black bears went down because they didn't have as much food and people were hunting them.* *The number of bears went back up.*

Let students know that they will share this row from their table with other students who didn't read their case study, so it's important that their observations be specific and detailed.

Assessment Opportunity

Building towards: **10.A.1** Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short and long term.

What to look/listen for: (1) Students using the structure of different data representations (graphs, tables, maps) to identify patterns of stability and change in population and resource availability. (2) Students connecting these patterns of change to textual evidence as a means of establishing a cause-and-effect relationship between resource availability and population size, using mechanisms they have discussed in prior lessons for how changes to ecosystem factors cause changes to the amount of organisms an ecosystem can sustain.

What to do: If students struggle to find patterns of change in graphical displays, ask them to begin by identifying key structures (axis labels, scale, table headers, symbols) that help them make sense of these displays. Then, ask students to connect the visual patterns of change to their physical meaning for the size of the population in question. Encourage students to draw connections between these patterns of change and the changes mentioned in textual evidence to establish relationships between changes in resources and changes in population.

Prompt students to look back through their work on analysis questions and Progress Trackers from these and other investigations during which students discussed the mechanisms that explain how changes to key ecosystem factors caused changes to the size of local populations.

4. Jigsaw Different Case Studies

10 MIN

Materials: science notebook, *Case Study Cards*

Regroup students for a jigsaw discussion of their case studies. Create the same number of small groups, made up of one student from each case study. Direct students to bring their science notebooks and their respective case studies with them to share with their new group members.

Show **slide G.** Tell students that they are going to share the key information from their case study with their jigsaw group. Instruct them to give each group member two minutes to share what they learned before rotating to the next person.

Before starting, ask students to create three more rows in their table from earlier in the lesson. Tell them they will use their table to share what they learned and to record what their group members learned from their case studies.

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
Ex: Louisiana Black Bears	*Forest trees*	*The amount of forest trees decreased because people were cutting them down.* *Then the amount of trees went up because the habitat was protected.*	*The number of black bears went down because they didn't have as much food and people were hunting them.* *The number of bears went back up.*

Remind students, *Your new group members haven't read your case study, since they were each reading a different one. As you share what you learned, remember to give specific details to help your group members understand your organism, the resources it needs, and what changed in your case study.*

Say, *If you're having trouble understanding what someone in your group is describing, make sure to ask them to explain or give evidence from their case study.* Tell students they could ask questions like, *What did you see in your case study that showed you that?*

Point out to students that they might need to answer questions from their group members to clarify their thinking, and that their table and case study would be good resources for answering those questions and providing further information.

Give students time to share and record findings from their case studies. As students share, direct their group members to record what they learn in their tables.

Additional Guidance

Some students may need support in describing the overall patterns of change from their case study or giving specific evidence to support the patterns they recorded in their tables.

As you circulate, prompt students to use the work they did with their case study group to help explain their ideas:

- *What was the organism your case study was focused on?*
- *What resources does this organism need? Where can we see these resources in the text of your group's case study?*
- *How did the amount of resources change in your case study? Where can we see a description of this change in the text?*
- *Overall, How did the population of this organism change? Where can we see this change on the graph?*

5. Facilitate a consensus discussion.

10 MIN

Materials: None

When students are ready, have them share their ideas with the class. Lead a discussion to help students find patterns across their different case studies.

Say, *Our case studies focused on different organisms, but we were looking for some of the same patterns. Remember, we said we were looking to see if populations of other organisms besides orangutans would decrease if they had fewer resources.*

Begin by asking students to help build a class table to show important information from all the case studies. As students share what happened in each case study, add the information to a class table like the one below. An empty class table can be found on **slide H** to fill out as a class digitally, if desired.

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
Ex: Louisiana black bears	*Forest trees*	*The amount of forest trees decreased because people were cutting them down.* *Then the amount of trees went up because the habitat was protected.*	*The number of black bears went down because they didn't have as much food and people were hunting them.* *The number of bears went back up*
Ex: Giant pandas	*Bamboo plants*	*The amount of bamboo decreased because people cut down forests for farming.*	*The number of giant pandas decreased because there was less food available to them.*

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Ex: Kit fox	*Small rodents (for food)*	*The amount of small rodents like rabbits went down because of habitat loss and people using pesticides and rodenticides.*	*The number of kit foxes went down, too, because there were fewer rodents for them to eat.*
Ex: Giraffes	*Savannah trees*	*The amount of savannah trees has decreased as people turn savannahs into farms.*	*The number of giraffes has gone down because they have less of the food they need to survive.*

Show **slide I.** Then, ask students to describe the patterns they see across case studies.

Suggested prompts	Sample student responses
What patterns do you see in how the amount of resources has changed in different case studies?	*Mostly the amount of resources went down.* *A lot of the time, the resources decreased because people were cutting down trees or changing the land, like in our orangutan example.* *Sometimes the amount of resources went up and down, like with the pandas or the bobcats.*
What patterns did you see in how the population of different organisms changed when the amount of resources changed?	*The population went down when there were fewer resources, like when the black bear population decreased because the forests were being cut down.* *Resources going down meant there wasn't enough food or space for the organisms and so they started to die off, like what's happening to the orangutans.* *Sometimes the population went back up because there were more resources again.*

Say, *Let's go back to the rule we started with for orangutans. We said that as the amount of rainforest trees, which are a resource orangutans need, went down, the population of orangutans also decreased.*

Ask students, *Can we make this a rule for other organisms, too, and not just orangutans? Do we have evidence that other populations decrease when they have less resources or increase when they have more resources?*

Show **slide J**. Come to a consensus as a class that this rule applies to other organisms besides just orangutans. Collaborate with students to make a more general model for how the population of organisms, not just orangutans, changes with the number of resources, not just rainforest fruit trees.

End of day 1

6. Revise the model for the monarch butterfly and prairie. 12 MIN

Materials: science notebook, chart paper, markers

Introduce the purpose of revising the model for a new case. Display **slide K.** Recall with students the model the class made yesterday, showing the relationship between the amount of resources and the population of an organism that depends on those resources. Emphasize that the model showed that when the amount of resources decreases, the population decreases (and vice versa).

Say, *We have this model for how the population of an organism, like orangutans, changes when there's a change in the amount of available resources, like rainforest fruit trees.* Recall that earlier in this lesson, the class saw similar patterns across case studies with different organisms in different ecosystems. Say, *One way that we can test and use our model is to see if there are similar components and interactions in another ecosystem that's experiencing a problem similar to the palm oil problem.*

Introduce the monarch butterfly and prairie ecosystem. Display **slide L**. Introduce students to the pattern of migration for the monarch butterfly between the United States and Mexico. Display **slide M** and then **slide N**, and have students read aloud to the class the information on each slide about the butterflies' interaction with the milkweed plant and the range of this milkweed plant in the Midwest of the United States.

Record a list of analogical components in each system. Show **slide O.** Have the updated model from the end of the last day visible for students. Ask students to return to the table they made to record their findings about different case studies. Have students add a final row to the bottom of this table. As a class, add "monarch butterflies" to the table under "organism."

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
...	...	...	...
Monarch butterflies			

Then, ask students, *We've already established that orangutans need rainforest fruit trees. Similarly, what resource does the monarch butterfly need?* As a class, add "milkweed" as the resource for the monarchs in the table.

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
…	…	…	…
Monarch butterflies	*Milkweed*		

Connect the monarch-milkweed relationship to other case studies. Show **slide P.** Lead a discussion to connect the monarchs to the milkweed in their ecosystem and make comparisons to the cases students analyzed earlier in this lesson.

Suggested prompts	Sample student responses	Follow-up questions
How are the monarch butterflies and the milkweed connected in this ecosystem?	*The butterflies eat milkweed and other plants.* *The butterflies can only lay their eggs on milkweed plants.* *The milkweed makes the butterflies poisonous to animals that might eat them.*	*Who is this interaction beneficial for?* *Who is this interaction bad for?* *Which of these interactions could impact the population of butterflies in these areas?*
How does this relationship compare to other examples from our table of organisms and resources? *How is it similar? How is it different?*	*The monarchs depend on milkweed, just like pandas depend on bamboo and bears depend on forest trees.* *It's different because monarchs can fly between different places.*	

Ask students to keep this table handy to use for their individual assessments.

7. Individual Assessment: Butterflies on the Shortgrass Prairie

28 MIN

Materials: *Monarch Butterflies on the Shortgrass Prairie*, science notebook

Introduce the individual assessment. Display **slide Q**. Pass out 1 copy of *Monarch Butterflies on the Shortgrass Prairie* to each student. Say, *The monarch butterfly population changes every year, and scientists are concerned about what might happen to their population over time. Scientists who study the eastern monarch butterfly population can't simply count the number of butterflies because there are so many butterflies so close together. Instead, they have to use a different method of measuring the population. To estimate the size of a population of butterflies, they measure the area of land taken up by a "colony" (or group) of butterflies. Then, they use the number of butterflies that can fit per area of land to get the total number of butterflies in a population.*

Ask students to make a prediction about how the number of butterflies changed, based on how much land they took up. Come to a consensus that the population of monarchs increased since they took up more land and the number of butterflies per area of land stayed the same.

Supporting Students in Making Connections in Math

In this assessment, the area taken up by monarchs is used as a way to measure the population of monarchs. The idea that the monarch population is greater when the amount of land they take up is greater is a rate concept that students should recall from sixth-grade math. Rate and ratio language is used in other places on this assessment, such as when comparing the amount of milkweed plants per acre across different years. If students need extra support with rate and ratio reasoning or representations, consider using targeted questioning and anchor charts on ratio language or graphing on the coordinate plane so that students can demonstrate their understanding of key science concepts through mathematical language and representations. Support may focus on helping students identify ratio language like "per" or two quantities separated by the word "to," and then translating these ratios to make sense of how one quantity is compared to another (e.g., making sense of "milkweed plants per acre" to mean how many of these plants there are in an area of 1 acre).

As a class, go through the individual assessment. Show **slide R.** Depending on your students' comfort with graphs and with this ecosystem, you may want to pause the class after question 2 and take a moment to read questions 3 and 4 from the assessment together.*

Slide S is an optional slide. This graph corresponds to the graph on question 3 and could be a useful visual to help your students as they complete item 5. Consider displaying it, if necessary.

Ask students to complete the assessment.* Have students individually complete *Monarch Butterflies on the Shortgrass Prairie.*

Assessment Opportunity

Building towards: **10.A.2** Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short and long term.

***Attending to Equity**
Universal Design for Learning: This assessment encourages students to demonstrate their understanding of key skills and concepts from the unit so far through multiple modalities, including writing to explain and drawing models. Some students may benefit from using multiple modalities to illustrate their thinking for any or all of the questions on this assessment. You may consider allowing some students to present their answers verbally with you or with another student acting as a scribe to record their thinking on paper. Some students may benefit from using gestures, images, or manipulatives to support their explanations, as opposed to written text. In each case, encouraging students to use multiple modalities to show their thinking creates a clear, accessible, equitable pathway for all students to demonstrate proficiency.

***Attending to Equity**
For some students, particularly students with learning differences, below-grade-level reading, or students who are emergent multilingual learners, this assessment may require more

What to look/listen for: See *Scoring Guidance: Monarch Butterflies on the Shortgrass Prairie* for scoring guidance.

What to do: Prior to the first question on the assessment, there's a graph that shows how the area taken up by monarchs changed over time. As before, consider discussing the axes of this graph with students to draw focus to what a point on this graph means. By reviewing the axes of the graph or summarizing a specific point in words, students can make clearer connections between the visual patterns they see on the graph and the physical meaning of the data in the context of the ecosystem. Students may need similar support interpreting the final graph on this assessment—in this case, reviewing the axes and scale of the graph can also help draw a distinction between what's being graphed in this example compared to the earlier graph before question 1. Specifically, this graph covers a greater amount of time. This graph also has a trendline that shows the overall shape of the population change. Consider reviewing the idea of a trendline with students and clarify that a trendline shows the overall pattern of change in a data set on a graph.

In the table in the middle of the assessment, students are prompted to look for patterns of change in the amount of milkweed. Consider asking students to use arrows and labels to note the change between years on the table. For example, they could label the change from 2009 to 2010 as "+2,500" because there were 2,500 (3,750 - 1,250) more milkweed plants per hectare in 2010 compared to 2009. This may help students see patterns of change between the points in the table that might not be apparent to those who see values in a table as discrete points rather than part of larger patterns.

Debrief findings from the assessment. Once students have had time to finish, show **slide T.** Ask students to share what happened to the amount of milkweed and the population of monarchs in the assessment. As students share, have them add their findings to complete the bottom row of the table.

Organism	Resource the organism needs	How did the amount of this resource change?	Overall, how did the population of this organism change?
Orangutans	*Rainforest fruit trees*	*The amount of rainforest fruit trees went down because people cut them down to grow oil palm trees.*	*The number of orangutans went down, too, because they didn't have the food and space they needed to survive.*
...	...	...	...
Monarch butterflies	*Milkweed*	*The amount of milkweed has gone down over time because people are planting farms where there used to be prairies.*	*The number of monarchs has decreased over time because they don't have as much milkweed for food and to lay their eggs.*

time than that which is provided for this lesson, because there is a heavy reading component. Consider allowing students to finish this assessment as home learning or providing extra time for these students to demonstrate their full understanding. These students would benefit from reading the introductory text and item prompts together, and then allowing them to ask clarifying questions.

8. Navigation

5 MIN

Materials: Driving Question Board

Navigate to investigate other populations in the tropical rainforest and oil palm farm. Display **slide U**. Recall that other populations in the tropical rainforest were impacted besides orangutans, including tigers, and that students were curious about populations in the oil palm farms, too. Say, *Now that we know more about resources, how could resources help us explain these other populations too? What can we predict right now?*

Have the DQB visible to all students. Give students time to turn and talk about the prompts on the slide:

- How could our new understanding of changes in resources help us explain the other populations in the rainforest and oil palm ecosystems that we were curious about (like rats, snakes, and tigers)?
- What questions on our DQB do we still need to answer about these populations?

Say, *In the next lesson, let's revisit some of the questions we had about these other populations to see what we might be able to explain now, or what we still don't quite understand.*

ADDITIONAL LESSON 10 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

In this unit, students will frequently engage in speaking, listening, and responding to others as part of their participation in scientific and engineering practices. In this instance, students engage in peer-to-peer discussion to share, express, and refine their thinking. As they do this, they must develop, present, and defend their ideas to one another verbally in a focused, coherent manner with relevant evidence; sound, valid reasoning; and well-chosen details (CCSS.ELA-Literacy.SL.8.1). Using the Communicating in Scientific Ways sentence starters can help facilitate the discussion between and among students.

As students work on their individual assessments on day 2, they are working toward the following:

- CCSS.ELA-LITERACY.W.7.2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- CCSS.ELA-LITERACY.W.7.2.A. Introduce a topic; organize ideas, concepts, and information, using strategies, such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
- CCSS.ELA-LITERACY.W.7.2.B. Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples.
- CCSS.ELA-LITERACY.W.7.2.D. Use precise language and domain-specific vocabulary to inform about or explain the topic.

Supporting Students in Making Connections in Math

CCSS.Math.Content.6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

In their individual responses on their assessments, students apply grade-appropriate mathematical concepts, namely rate and ratio reasoning, to describe and explain phenomena. For example, students parse descriptions of quantities that use rate language (like "plants per area of land") and understand how relating these two quantities as a ratio helps us analyze changes to plant populations in specific areas. In each case, the rate and ratio reasoning supports students in making sense of how resource availability changes and how resources are allocated between changing numbers of individuals in populations.

CCSS.Math.Content.6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems (e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations).

In addition to using key science concepts from across the unit to explain why populations change in response to changes to ecosystem factors, students represent these changes in population mathematically using rate and ratio concepts. For example, on their individual assessments, students are making connections between patterns of increase and decrease in specific quantities (i.e., time, amount of forest) and qualitative descriptions of phenomena. For example, in question 1, students are asked to connect a region of positive slope on the graph to an increase in the population of monarch butterflies. This correlation relies on students' understanding of increasing and decreasing patterns in functions on the coordinate plane, as well as the rate concepts needed to connect an increase in land occupied by butterflies to an increase in the population of butterflies.

If students need extra support with rate and ratio reasoning or representations, consider offering math supports, like targeted questioning or anchor charts on ratio language or graphing on the coordinate plane, so that students can demonstrate their understanding of key science concepts through mathematical language and representations. Support may focus on helping students to identify ratio language like "per" or two quantities separated by the word "to," and translating these ratios to make sense of how one quantity is compared to another (for example, making sense of "milkweed plants per acre" to mean how many of these plants there are in an area of 1 acre).

How does planting oil palm affect other populations?

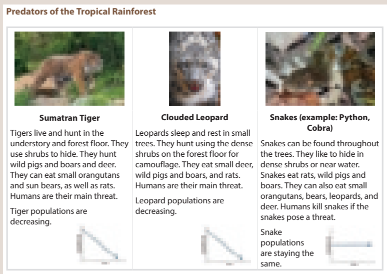
Previous Lesson

We analyzed cases where populations changed and connected those changes to differences in resource availability. Afterward, we applied these understandings on an assessment to explain why the loss of short and tallgrass prairies has caused monarch butterfly populations to decrease.

This Lesson

Investigation

2 DAYS


Predators of the Tropical Rainforest

Sumatran Tiger	Clouded Leopard	Snakes (example: Python, Cobra)
Tigers live and hunt in the understory and forest floor. They use shrubs to hide. They hunt wild pigs and boars and deer. They can eat small orangutans and sun bears, as well as rats. Humans are their main threat. Tiger populations are decreasing.	Leopards sleep and rest in small trees. They hunt using the dense shrubs on the forest floor for camouflage. They eat small deer, wild pigs and boars, and rats. Humans are their main threat. Leopard populations are decreasing.	Snakes can be found throughout the trees. They like to hide in dense shrubs or near water. Snakes eat rats, wild pigs and boars. They can also eat small orangutans, bears, leopards, and deer. Humans kill snakes if the snakes pose a threat. Snake populations are staying the same.

We are curious about other populations affected by the palm oil industry. In particular, we wonder about rats, snakes, and tigers. We use what we know right now to predict different causes of the populations' increase or decrease. We develop system models for the oil palm system and realize that when there are unlimited resources, both predators and prey do well. We develop system models for the rainforest system and realize more competition within this system keeps populations at a stable size. We decide that the rainforest system has more components and interactions than the oil palm system, but there are some similar types of interactions in both systems. We think about how a system might change if one component, like the orangutan, were to become extinct.

Next Lesson

We will wonder what would happen if orangutans go extinct. We will read an interview with Dr. Andrea Blackburn, who studies orangutans. We will watch videos, examine images, and make noticings from data tables from her research. We will figure out that orangutans are seed dispersers and spread seeds over great distances throughout the tropical rainforest. These seeds often grow into healthy new plants. We will wonder what would happen if something changed with other populations in the systems we are investigating.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

11.A Develop a system model for a palm farm to explain why both snake (predator) and rat (prey) populations are increasing at the same time.

11.B Develop a system model to explain how populations in a complex rainforest ecosystem interact to keep populations stable, compared to interactions in an agricultural system where some of the same populations are increasing.

What Students Will Figure Out

- When there are many resources, like in the palm farm, both snakes (predators) and rats (prey) do well.
- Palm farms have benefitted rats and snakes while harming orangutans and tigers.
- When there is competition between populations for the same resource, it keeps numbers from increasing too much.
- The tropical rainforest is a lot more complex than the palm farm, with a lot more plants and animals interacting with each other.
- Populations interact for more than resources (like shelter and safety).
- If one population like orangutans were to go extinct, it could cause changes to other populations because everything is connected.

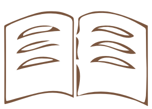
Lesson 11 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**NAVIGATION** Revisit questions from the DQB about how other populations, such as rats, snakes, and tigers, are affected by the palm oil industry and surface students' initial thinking.	A	Driving Question Board
2	20 min	**DEVELOP AN OIL PALM SYSTEM MODEL** Engage students in an Initial Ideas Discussion about the causes of the growth and decline of populations and the different kinds of relationships between populations in the ecosystems.	B-C	*Reference: Oil Palm Farm Plants and Animals*, large piece of whiteboard or chart paper, 3-4 colored dry erase markers or alternative, towel or rag, Resource Availability Model from Lesson 10
3	12 min	**FACILITATE A BUILDING UNDERSTANDINGS DISCUSSION TO EXPLAIN INCREASES** Ask students to first examine the different system models developed by groups, and then draw conclusions to explain how both predator and prey populations could increase at the same time.	D-E	*Reference: Oil Palm Farm Plants and Animals*, Group Oil Palm System Model (made in this lesson), Resource Availability Model from Lesson 10, space to record a Consensus Oil Palm System Model (optional)
4	5 min	**SELF-ASSESS PARTICIPATION IN DISCUSSION** Give students time to self-assess their participation in the small-group and whole-group discussion and make a plan for participation in the next class.	F	*Self-Assessment for Classroom Discussions*
				End of day 1

Part	Duration	Summary	Slide	Materials
5	22 min	**CONSIDER THE SAME POPULATIONS IN THE TROPICAL RAINFOREST** Have students develop a rainforest system model for the same populations to explain why those populations don't increase like they do in the oil palm farm.	G-I	*Reference: Rainforest Plants and Animals*, large piece of whiteboard or chart paper, 3-4 colored dry erase markers or alternative, towel or rag, Oil Palm System Model (from day 1)
6	18 min	**COMPARE SYSTEMS IN A CONSENSUS DISCUSSION** Facilitate a Consensus Discussion about the two system models to identify different kinds of interactions between populations and patterns of interactions across the systems that keep populations stable.	J-M	*Reference: Rainforest Plants and Animals*, Group Rainforest System Model (made in this lesson), Oil Palm System Model (made on day 1), Resource Availability Model from Lesson 10, space to record a Consensus Rainforest System Model
7	5 min	**NAVIGATION** Return to the questions from the DQB about orangutan populations going extinct. Have students turn and talk about what they think could happen if orangutans go extinct.	N	Driving Question Board

End of day 2

Lesson 11 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Reference: Oil Palm Farm Plants and Animals* • *Self-Assessment for Classroom Discussions* • *Reference: Rainforest Plants and Animals*	• large piece of whiteboard or chart paper • 3-4 colored dry erase markers or alternative • towel or rag • Group Oil Palm System Model (made in this lesson) • Group Rainforest System Model (made in this lesson)	• Driving Question Board • Resource Availability Model from Lesson 10 • space to record a Consensus Oil Palm System Model (optional) • Oil Palm System Model (from day 1) • space to record a Consensus Rainforest System Model

Materials preparation (25 minutes)

Online Resources

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.

Prepare a whiteboard kit for each group. The kit should contain a large piece from your whiteboard roll (ideally at least 18″ x 24″ or larger), 3-4 colored dry erase markers, and paper towels or old cloth to clean the boards. Alternatively, if whiteboard is not available students can complete the same models using chart paper, sticky notes for components, and pencils/markers for interactions. If using the paper option, have students place sticky notes down first and draw interactions using pencil. Then they can use marker once they are more certain about the interactions.

Prepare a space to document the class consensus system models for the oil palm system on day 1 and the rainforest system on day 2. These can be documented on chart paper, whiteboard, or piece of paper that is projected via a document camera. Alternatively, you may choose to select and work from 1 group model (Lessons 12, 13, and others will continue to reference these models so find a way to retain at least 1 model to the next lesson).

The oil palm farm and rainforest handouts used in this lesson are printed in color in the reference section of the *Student Edition*, but can also be printed as a handout. You can print a class set for use over multiple science sections.

Reinforce the term “ecosystem” with your students and consider adding it to the class Word Wall.

Lesson 11 • Where We Are Going and NOT Going

Where We Are Going

In Lesson 10, students figured out that changes to resource availability affect populations in good and bad ways, which is true in many cases beyond the rainforest fruit trees and orangutan case. In this lesson, students will extend their resource availability model to explain why predator (snakes) and prey (rats) populations can increase simultaneously. When students encountered this part of the anchoring phenomenon in Lesson 1, they were likely confused about how both rats and snakes increased, which is counterintuitive to their understanding of how predator-prey relationships work. Day 1 will support students in exploring this part of the phenomenon to make sense of how unlimited resources can result in rapid population explosions for both predator and prey at the same time. Students then work to explain how these populations remain more stable in rainforest ecosystems, given increased competition for resources between more populations.

This lesson builds on 5th grade DCIs: “Organisms are related in food webs, in which some animals eat plants for food and other animals eat the animals that eat plants.” Organisms can survive only in environments in which their particular needs are met. This lesson extends students’ understanding by moving beyond food webs to add other interactions between populations and to compare the components and interactions of two different systems. Students also extend their understanding that some populations can survive in different ecosystems, while other populations are more dependent on one system or one component of the system and, therefore, cannot flexibly move between systems. This lesson should set students up for deeper learning about carrying capacity and limiting factors that they will engage with in high school biology (see the high school lesson *LS2.A Interdependent Relationships in Ecosystems* to bound how deep you go in this lesson).

The system models developed in this lesson allow students to identify similar patterns across the two systems, but also important differences, such as the complexity of components and interactions in the rainforest system compared to the oil palm system. Even given the complex model students develop for a rainforest system, students will reflect on the limits of their model in capturing the true complexity of the system in the real world. Having your students evaluate the limitations of systems models used to explain phenomena is an important step during grades 6-8.

Where We Are NOT Going

Students begin to represent mutually beneficial relationships in their rainforest food web model but will not explore this further until Lesson 12. The ecosystem models also do not include abiotic interactions, but these components and interactions could be added, particularly for the plant populations, if time permits. Students will recognize that the tropical rainforest has more components or populations than the oil palm system (more boxes). It is intentional that they only identify this difference in this lesson. In subsequent lessons, students will figure out that the number of components in a system refers to the system's biodiversity.

LEARNING PLAN FOR LESSON 11

1. Navigation — 8 MIN

Materials: Driving Question Board

Identify questions from the DQB about other populations. Display **slide A** and make sure the DQB is visible to all students. Say, *In the last class, we realized that our new understanding of resources helps us explain a lot of the changes—good and bad—that we observe in populations. We thought we might be able to explain some of our original questions about rats, snakes, and tigers, now that we understand the connection.*

Ask students who had questions about rats, snakes, and tigers to share their questions aloud. Some questions may include:

- Why is the rat population increasing? Do snakes eat rats? How is the number of both rats and snakes increasing? Why is the rat population still increasing when there are a lot of snakes?
- Why does the oil palm farm attract pigs, rats, and snakes, and not other animals?
- Why are the oil palms also killing tigers?

Surface initial ideas about these populations. Say, *It seems like we're curious about why rats and snakes could be increasing at the same time. Could someone say more about why that's confusing?* Listen for students to share prior ideas about predator-prey relationships, such as:

- Prey can increase when there is no predator.
- Predators keep prey from increasing.

Say, *This is curious because it doesn't match what we'd expect if snakes are a predator of rats. What initial ideas do we have for how both could increase at the same time?*

- *Maybe snakes don't eat rats.*
- *Maybe they both are eating the palm and not each other.*
- *Maybe there is so much food that they are all getting plenty.*

Say, *Let's investigate a little further to see if there is a predator-prey connection and, if so, why these populations seem to be doing so well.*

2. Develop an oil palm system model.

20 MIN

Materials: *Reference: Oil Palm Farm Plants and Animals*, large piece of whiteboard or chart paper, 3-4 colored dry erase markers or alternative, towel or rag, Resource Availability Model from Lesson 10

Introduce the modeling task. Display **slide B**. Preview the instructions with students. Explain that students are going to receive more information about these populations and work in their small groups to develop a system model for the oil palm system. Review with students what a system model represents using the conventions your class agreed upon in Lesson 1. For example:

- Components or parts of the system may be represented by a box. In this case, students determine that a box is often a population in the system.
- Interactions between components (or populations) may be represented by a line between boxes.

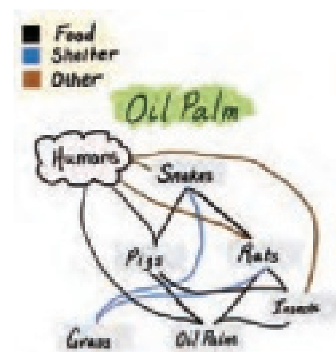
Raise the issue that there are different ways populations could interact. Ask students to share what they know right now about ways populations interact. For example, food and shelter or safety may be two kinds of interactions students know about. If students mention predation, help them classify that as a food interaction. Agree upon colors to use for different kinds of interactions, such as:*

- Black lines for food interactions
- Blue lines for safety, shelter, and homes
- Brown, or a third color, for any other interactions
- Students may also want to label the line to describe the interaction.

Arrange students into groups to model the oil palm system. Keep **slide B** displayed with instructions for students. Place students in groups of three. Pass out 1 copy of the *Reference: Oil Palm Farm Plants and Animals* handout to each student. Provide each group with a large piece of whiteboard or chart paper, 4 colored markers, and a towel, rag, or dry eraser (sticky notes are optional).

Have students work for about 5 minutes to read their reference sheets and discuss the populations and interactions first, before recording on their group whiteboard or paper. After about 5 minutes, prompt them to begin recording their oil palm system model on their whiteboard/paper, if they have not started yet.

*** Attending to Equity**
Universal Design for Learning: When you decide on *representation* conventions, (1) choose a colorblind-friendly palette, such as black, blue, orange, and brown, and avoid red and green together and/or (2) add labels to the lines (e.g., food, shelter, safety).



Oil palm system model

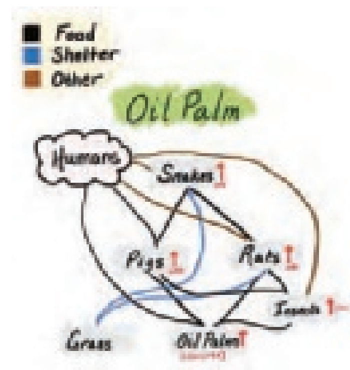
Additional Guidance

The students' system model may look more disorganized than the example provided. This will be particularly true for the rainforest system model students will develop in the next class. Avoid focusing students on getting the model neat and orderly. Rather, use the "messiness" of their models to emphasize the complex nature of systems, and to point out that they are also working with very simplified versions of the real thing. The whiteboard is a handy tool for students to revise their models if they want to make changes.

Have students add their ideas about resource availability to explain why rats and snakes could increase at the same time. With at least 5 minutes remaining, display **slide C**. Remind students that here they are trying to explain the simultaneous increase in rats and snakes. Prompt students to use the resource availability model from Lesson 10 to try to explain this increase. Direct them to use a new dry erase marker color to add:

- A label to the resource box
- Big or little up or down arrows to the resource box
- Big or little up or down arrows to the population boxes

When the groups complete their models, direct them to place their group's model in a designated location with other groups' models. They should be lined up in a row to make for easy comparisons across all group models.



Oil palm system model with resources highlighted

3. Facilitate a Building Understandings Discussion to explain increases. 12 MIN

Materials: *Reference: Oil Palm Farm Plants and Animals*, Group Oil Palm System Model (made in this lesson), Resource Availability Model from Lesson 10, Space to record a Consensus Oil Palm System Model (optional)

Additional Guidance

You will need at least 1 copy of the *Oil Palm System Model* for future use. Either select one of the group models to retain or record a class consensus model together at this time. You will continue to work with these models in Lessons 12 and 13 so make certain to retain at least 1 copy.

Give students time to examine other models. Ask students to examine the group models for about 1-2 minutes and jot down their noticings.

Facilitate a brief sharing of noticings across the models. Display **slide D.** Invite a few students to share their noticings aloud.

Suggested prompt	Sample student responses
What do you notice is similar?	*Snakes (pythons, cobras) are on top.* *There are only 1 or 2 kinds of plants.* *There are only a few things that the snakes can eat.* *There is only 1 thing that the rats and pigs can eat.* *Mostly everyone marked the oil palm as the main resource.*

*** Supporting Students in Three-Dimensional Learning**

Students will identify changes to resources in their system model. Prompt students to use the lens of a system model, where parts are interconnected. As a change in one part (or population) occurs, they should explain (or be able to predict) changes to other parts (or populations).

To engage students in using the crosscutting concepts of Systems and System Models, consider adding the following kinds of prompts to the discussion:

- What would happen in this system if you increased [component of the system]?

Suggested prompt	Sample student responses
What do you notice is different?	*We didn't include grass, but others included it as shelter.* *We weren't sure if rats and pigs were resources for snakes.* *Some groups included humans at the top as the predator of everything in the system.*

- What would happen in this system if you decreased [component of the system]?
- How do you think [component] would respond to [change in another component of the system]?

Transition to explaining population changes and recording a class consensus model. Display **slide E**. Say, *We started out with questions about how both rats and snakes could increase at the same time because that seems counter to what we know about predators and prey. Let's think more about the resource in this system, how the resource has changed, and then see if we can answer our questions.**

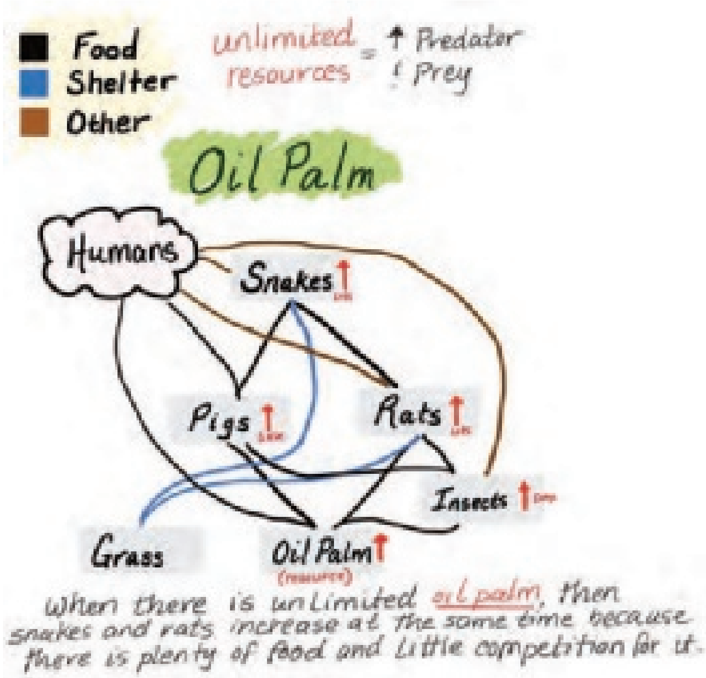
Key Ideas

Purpose of the discussion: To extend the resource availability model that students developed in Lessons 9 and 10 to explain increases in predators and prey at the same time when resources are unlimited.

What to look/listen for:

- At the start of the lesson, students should be confused about how the population of both snakes (predators) and rats (prey) increased. At this point, you should hear students be able to explain that resources are unlimited in oil palm farms, which causes both predators and prey to increase at the same time.
- Noticings that there are very few populations in the oil palm system, and that the oil palm has only benefited a few populations.
- Students using their system models not to simply represent a food web, but rather to answer questions about other populations, like rats and snakes.

Use the prompts on the slide to guide the discussion. As the class agrees upon what is happening in the system and how populations interact, record a class consensus *Oil Palm System Model*. This can be recorded on the whiteboard, chart paper, or piece of paper projected using the document camera. Alternatively, choose to work with one group's model. A final system model is shown here. Additional systems-thinking prompts that you may want to add to this discussion are shared to the right.



Class consensus oil palm system model

Suggested prompts	Sample student responses
What is the main food resource in this system, and how is it changing?	*Oil palm—it's the only plant with food in the system and it's everywhere.* *Rats and pigs are food resources for snakes, and their numbers are increasing.*
Why can both predators and prey increase at the same kind in this kind of system?	*There is plenty of food for everyone.* *There is plenty of food for the rats and pigs, which gives plenty of food for the snakes.* *There is nothing killing the predators, except people.*
Let's summarize what we figured out using an if/then statement like we've done before. If ___ resource changes, then what happens to prey? And predators? Why?	*If there is a lot of oil palm [resource], then prey and predators increase because they have a lot of food.* *If there is unlimited food for everyone [resources], then prey and predators can increase at the same time because there is nothing to stop their populations from increasing.*
How can we answer our DQB questions that we started with?	*Snakes do eat rats.* *Rats and pigs are attracted to oil palm because there is a lot of food for them. Snakes are attracted because there are a lot of rats and pigs, which are food for them.* *When there is a lot of resources or food, then there is a lot of prey (like rats) and plenty of food for snakes too.* *We didn't really answer our question about tigers yet.*

Assessment Opportunity

Building towards: **11.A** Develop a system model for a palm farm to explain why both snake (predator) and rat (prey) populations are increasing at the same time.

What to look/listen for: See the Key Ideas above.

What to do: In Lessons 9 and 10, students explained the effect of a change in 1 resource on a change in 1 population. This lesson has students extend their understanding to explain changes in multiple populations, and in the context of predators and prey, which goes counter to the initial ideas. If students struggle to conclude that in a system where there are essentially unlimited resources, both predators and prey populations can increase at the same time, consider breaking apart the explanation into 3 chunks: (1) first explain changes to oil palm and how that relates to the rat population, (2) then connect oil palm to the pig population, and (3) then ask students to identify the main food resources for the snake population, and connect the change in those resources to the change in the snake population.

Conclude the discussion by prompting students to think about why these populations are exploding in the oil palm system and not the tropical rainforest. Keep **slide E** displayed.

Suggested prompt	Sample student responses
Why do we think these populations don't increase like this in their natural rainforest habitat?	*There is not enough food.* *There is more competition for food.* *It's harder to find food.* *Maybe, there are more predators in the rainforest.*

Say, *Let's check our thinking in the next class to see how these populations interact in their natural ecosystem.*

Make sure to save time at the end of this class period to engage students in self-assessment of their participation during small-group and whole-group discussion.

4. Self-assess participation in discussion. 5 MIN

Materials: *Self-Assessment for Classroom Discussions*

Give students time to reflect on their participation in discussion.* Display **slide F**. Pass out 1 copy of the *Self-Assessment for Classroom Discussions* handout to each student. Allow students time to reflect on their participation and brainstorm ways to improve or change participation in the next class period, where students will again be engaging in small group and whole group work. You may want to ask students to attach this handout to their science notebooks so they can reread their reflection at the start of the next class.

*** Attending to Equity**
Universal Design for Learning: The template used here guides students in self-reflection. It will draw their attention to the quality of their participation in small-group and whole-group discussions and offer a chance to reflect on what went well and where they may want to improve. Including these moments for self-reflection, and using templates to guide the reflection, can enhance students' capacity to monitor their own progress (*action and expression*).

End of day 1

5. Consider the same populations in the tropical rainforest. 22 MIN

Materials: *Reference: Rainforest Plants and Animals,* large piece of whiteboard or chart paper, 3-4 colored dry erase markers or alternative, towel or rag, Oil Palm System Model (from day 1)

Take stock of your progress. Display **slide G**. Say, *Yesterday we started to answer some questions from our DQB.* Use the prompts below to establish the purpose of this class period.

Suggested prompts	Sample student responses
Can someone summarize a few things we figured out?	*Snakes do eat rats; they are a predator of rats. Snake, rat, and pig populations can increase at the same time because there are a lot of resources for them in the oil palm system.*
And why do we think these populations do not increase in the tropical rainforest?	*There are more predators.* *There are fewer resources, or cutting down the rainforest is causing it to have fewer resources.* *There is more competition for resources.*

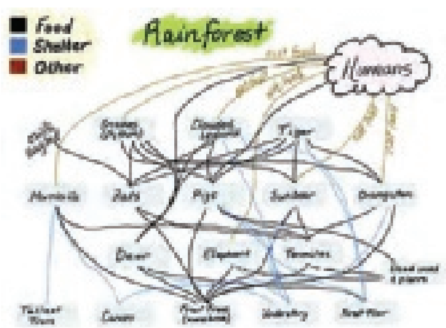
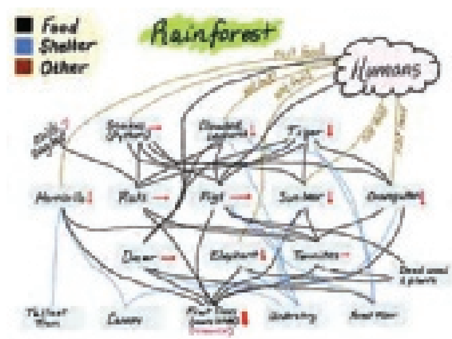
Establish the goal for the small group work and get groups started. Say, *So we were wondering why these populations are not increasing in the rainforest, and we have a few ideas as to why. We're going to check our thinking today by developing a system model for the tropical rainforest, similar to what we did previously for oil palm.*

To get groups started, display **slide H**. Preview instructions and remind students of the modeling conventions (i.e., boxes, arrows, colors) to use. Arrange students in groups of three. Pass out 1 copy of the *Reference: Rainforest Plants and Animals* handout to each student. Provide each group with a large whiteboard or paper, 3-4 colored markers, and a towel, rag, or dry eraser.

Have students work for about 8 minutes to read their reference sheets and discuss the populations and interactions first, before recording them on their group whiteboard. After about 8 minutes, prompt them to begin recording their oil palm system model on their whiteboard or paper if they have not started yet. This will take more time compared to the *Oil Palm System Models*.

Add their thinking about resource and population changes. With 5 minutes to spare, display **slide I** and ask students to follow instructions to label resource changes and population changes on the system model using a different color dry erase marker.

When the groups complete their models, direct them to place their group's model in a designated location with other groups' models. They should be lined up in a row, to make for easy comparisons across all group models.

Rainforest system model	Rainforest system model with resources highlighted
	

6. Compare systems in a consensus discussion.

18 MIN

Materials: *Reference: Rainforest Plants and Animals*, Group Rainforest System Model (made in this lesson), Oil Palm System Model (made on day 1), Resource Availability Model from Lesson 10, space to record a Consensus Rainforest System Model

Give students time to examine other models. Ask students to examine the group models for about 1-2 minutes and jot down their noticings.

Facilitate a sharing of noticings across tropical rainforest system models. Display **slide J**, which includes initial discussion prompts.

Suggested prompts	Sample student responses
What do you notice is similar?	*They are all messy!* *lots of lines between everything* *Many of the lines are black, representing food connections.* *It's a food web.* *Humans are the top predators of many things.*
What do you notice is different?	*We put things in different places.* *We weren't sure what to do with owls and eagles.* *Some of us included wood in our models.*

Transition to explaining why snakes and rats are not increasing, and record a class consensus model. Display **slide K.** Say, *Let's return to our question about why rat and snake populations are not increasing a whole lot in the tropical rainforest. We had some ideas about resources or food, predators, and competition. Did you notice any evidence that these ideas might help explain why they are not increasing?* *

Key Ideas

Purpose of the discussion: To identify that competition and predation are ways populations stay stable in a natural ecosystem.

What to look/listen for:

- To explain the rat population trend, students should identify that there are many more predators of rats in the tropical rainforest and that rats are competing for food with other populations.
- To explain the snake population trend, students should identify that there are not many predators of snakes, but snakes are competing with other predators for food sources.
- Students may wonder why snakes are not increasing, since many of their competitors are on the decline.

***Supporting Students in Three-Dimensional Learning**

Students will use their system models to explain why rat and snake populations are staying stable, narrowing in on competition for food to explain snake population trends and both competition and predation to explain rat population trends. Students may also point to the idea that there are many more living things in the tropical rainforest that balance each other's populations. To elevate the concepts of Systems and Systems Models, additional prompts could include:

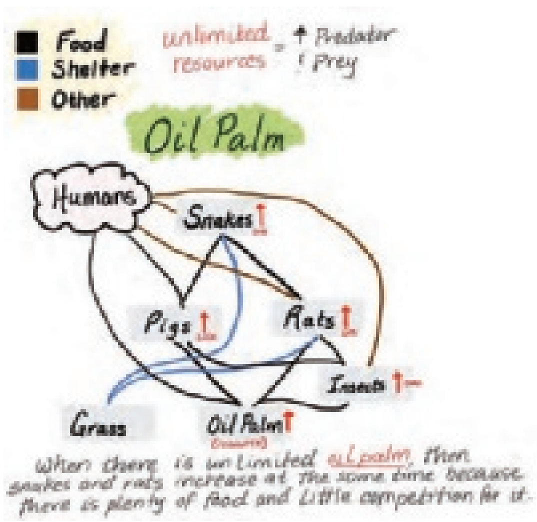
- What would happen in this system if you increased [component of the system]?
- What would happen in this system if you decreased [component of the system]?
- How do you think [component] would respond to [change in another component of the system]?

- Cue students to also look at what is occurring with their food resources, with some food sources also on the decline.
- Similarly, students may wonder why the rat population is not increasing, given the changes occurring with many of their predators. Cue them to look at the key food resource for rats, which is the declining rainforest fruits.

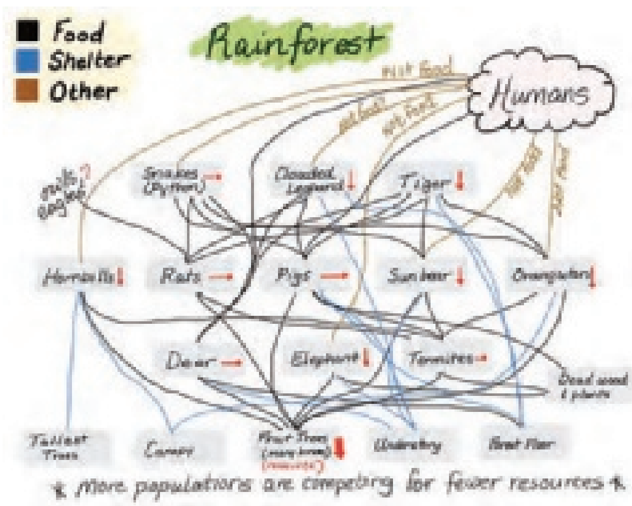
Suggested prompts	Sample student responses
What is the main food resource in this system, and how is it changing?	*Fruit trees, and their numbers are decreasing.*
Why do we think the rat population is not increasing in the tropical rainforest?	*There are a lot more predators eating them.* *They are competing for fruit with a lot more animals.* *And their main food source—fruit—is declining.*
Why do we think the snake population is not increasing in the tropical rainforest?	*They don't really have predators, so it doesn't seem to be a predator thing.* *They have to compete with other predators for food.* *Some of their food sources are declining too.*

As the class agrees upon what is happening in the system and how populations interact, record a class consensus *Rainforest System Model*. This can be recorded on the whiteboard, chart paper, or piece of paper projected using a document camera. Alternatively, choose to work with one group's model. You will need at least 1 copy of the *Tropical Rainforest System Model* for use in subsequent lessons, so do not erase the model after this class is over. Retain one group's model or a class-level model for future use. A final system model is shown below, alongside the *Oil Palm System Model*.

Oil Palm System Model



Rainforest System Model



*** Attending to Equity**

In 5th grade, students developed the idea of an "ecosystem" (LS2.A: "A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life."). During this Building Understandings Discussion, you may want to reinforce what it means to be an ecosystem and add it to your Word Wall. It is recommended to do this after students have developed models for each system. You may need to remind students that ecosystems also include the abiotic components, which may or may not be represented in their models.

*** Supporting Students in Three-Dimensional Learning**

Use this opportunity to discuss the limitations of the two system models. Both models are overly simplified compared to the real systems that they represent. Yet the rainforest system model may still feel quite complicated and messy, even with only a few populations represented. Engage your students in thinking about how complicated it may be to trace all the interactions—such as competition and prediction—in the real system. Pose questions to students about how models, even if they are limited, can be useful for understanding the relationships in ecosystems (e.g., *Even though we*

Compare the two system models.* Display **slide L**. Use the prompts on the slide for students to identify similarities and differences between the two kinds of systems.

Key ideas

Purpose of the discussion: To establish that there are similar predation and competition relationships in both systems, but the rainforest system is much more complex, with more populations and more interactions compared to the oil palm system.

Listen for:

- When there is competition between populations for the same resource, like in the tropical rainforest, it keeps numbers from increasing too much.
- The tropical rainforest is a lot more complex than the oil palm farm, with a lot more plants and animals interacting with each other.
- There is only one kind of plant in the oil palm farm, but there are many kinds of plants in the tropical rainforest.
- Populations interact for more than resources (like shelter and safety).
- If one population (like orangutans) were to go extinct, then this could cause changes to other populations because everything is connected.

Suggested prompts	Sample student responses
What is similar between the oil palm system and rainforest system?	*Both have plants at the bottom.* *Both have predators.* *Both have animals competing for food.* *There is a resource change in both systems, in terms of the plants. This is changing the other populations.*
What is different?	*There are a lot more populations in the rainforest.* *There are a lot more interactions or lines between them.* *The main resource in the oil palm system is going up, while the main resource in the rainforest is going down.*
*How is this model limited compared to the real ecosystem?**	*We only have a few things in our system models, but in the real world, there are a lot more plants and animals.*

don't have everything represented here, how is this model useful for our thinking? What might we want to be careful about while drawing conclusions?).

Assessment Opportunity

Building towards: **10.B** Develop a system model to explain how populations in a complex rainforest ecosystem interact to keep populations stable, compared to interactions in an agricultural system, where some of the same populations are increasing.

What to look/listen for: See the Key Ideas above.

What to do: If students are struggling to understand how populations can stay stable in the tropical rainforest, have them work with a partner to dig deeper into one population. Have partners work through these questions about the population:

- What is the population's main food resource(s), and is the resource changing?
- If one food resource is changing, does the population have another food resource option?
- Who is the main competitor? Are there changes happening to the competitor population?
- Does it have a predator, and if so, what is happening to the predator population?
- What might be missing from our model to help us clearly understand this population?

Additional Guidance

If time permits, a Progress Tracker entry could be added to support students in individually processing what they learned. Have students turn to the Progress Tracker section in their science notebooks. Use **slide M** to guide students in drawing a line before the last entry. Give students 3-5 minutes to quietly update their Progress Trackers, using words and drawings to show what they have figured out.

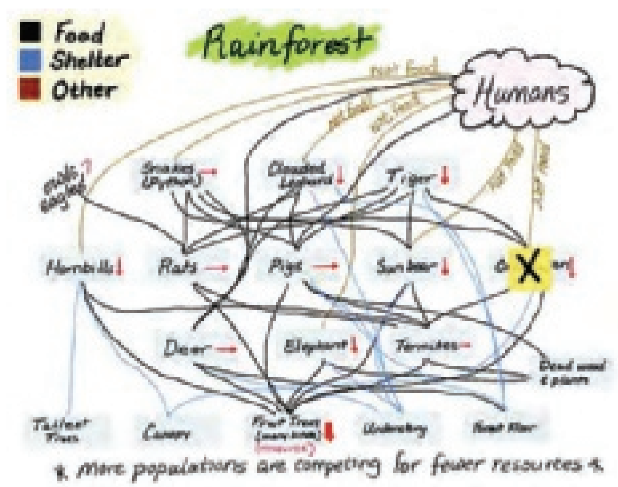
7. Navigation

5 MIN

Materials: Driving Question Board

Focus on the orangutan in the rainforest system model. Stand near the DQB. Say, *We've been concerned about orangutans in particular. At the start of the unit, many of you expressed concern that orangutans may go extinct, or disappear, altogether.* Share a few of the questions from the DQB, such as:

- *What would happen if orangutans went extinct?*
- *What happens to the tropical rainforest if the orangutans die out?*
- *Is the orangutans going extinct a bad thing?*



Display **slide N.** Place a sticky note with an “X” over orangutans. Give students time to turn and talk about what they predict would happen if orangutans were to go extinct.

Say, *Let’s dig into the questions further in the next class period to see how a loss of orangutans would or would not affect the ecosystem.*

ADDITIONAL LESSON 11 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

In order for students to develop their system models, they must decipher technical information from a text that describes populations in each system and how those populations interact with one another. Students transfer that information to a graphical representation, or system model, using the agreed-upon modeling conventions to show components and interactions in the system. They layer on information about resource and population changes in the model.

LESSON 12

What would happen if orangutans go extinct?

Previous Lesson

We were curious about other populations affected by the palm oil industry. We developed system models for the oil palm system and realized that when there are unlimited resources, both predators and prey do well. We developed a rainforest system model and realized more competition within this system keeps populations at a stable size. We compared the two systems and wondered about what would happen if orangutans went extinct.

This Lesson

Investigation

1 DAY

We are curious about what would happen if orangutans go extinct. We learn that scientists are curious about these same questions. Dr. Andrea Blackburn and the Gunung Palung Orangutan Conservation Program team are researching orangutans' ecological role in the tropical rainforest, which is one way to better understand how a disruption to the orangutan population might affect the whole system. We read an interview with Andrea Blackburn to learn about her research. We watch videos, examine images, and make noticings from data tables from her research. We figure out that orangutans are seed dispersers and spread seeds over great distances throughout the tropical rainforest. These seeds often grow into healthy new plants. We then wonder what would happen if something changed with other populations in the systems we are investigating.

Next Lesson

We will wonder how the rainforest system changes if the fruit populations change. We will make predictions and test ideas using our rainforest and oil palm system models. We will figure out that the rainforest system can withstand some disruptions, but the oil palm system cannot. We will apply these ideas to a new case and complete a short individual assessment. We will summarize what we know about monocrop oil palm farming to motivate us to design a better way to farm it.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

12.A Gather information from text, images, and data tables to clarify claims that a change in the orangutan population could affect fruit trees because there is a mutually beneficial relationship between the two.

What Students Will Figure Out

- Orangutans disperse seeds throughout the tropical rainforest by spitting and defecating.

- Both orangutans and fruit trees benefit from each other because orangutans get food from fruit trees and fruit trees get their seeds spread throughout the tropical rainforest.
- If orangutans go extinct, some fruit tree populations may decrease because seeds may not get spread and grow into trees, which could affect other populations.

Lesson 12 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Have students share their initial ideas about what may happen if orangutans go extinct.	A	Driving Question Board, Rainforest System Model (from Lesson 11), word wall
2	10 min	**MEET A SCIENTIST STUDYING ORANGUTANS** Introduce students to Andrea Blackburn, who studies the orangutans' role in the tropical rainforest ecosystem. Have students read about Andrea and her research.	B-C	*Interview with a Scientist Studying Orangutans* handout
3	16 min	**ANALYZE DATA FROM ANDREA'S RESEARCH** Analyze data from Andrea's research and complete a claim-pass in small groups.	D-I, M-S	*Sample Data from Dr. Andrea Blackburn's Research* handout, claim-pass (developed in this lesson), computer and projector, Orangutan Spitting Seeds video
4	10 min	**FACILITATE A BUILDING UNDERSTANDINGS DISCUSSION** Have students share and critique the claims each group made. Elicit additional questions they have and evidence they would need to collect to support their hypotheses. Update the system model.	J-S	claim-pass (developed in this lesson), Rainforest System Model (from Lesson 11)
5	4 min	**NAVIGATION** Have students predict what would happen to the tropical rainforest if fruit tree populations change, and brainstorm how to test these ideas.		Rainforest System Model (from Lesson 11), sticky note with an X
				End of day 1
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 12, students are ready to read Student Reader Collection 4 and then respond to the writing exercise.		Student Reader Collection 4: *Population Dynamics*

Lesson 12 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• *Interview with a Scientist Studying Orangutans* handout • *Sample Data from Dr. Andrea Blackburn's Research* handout	• sticky notes • marker	• Driving Question Board • Rainforest System Model (from Lesson 11) • word wall • computer and projector • Orangutan Spitting Seeds video • sticky note with an X

Materials preparation (20 minutes)

Online Resources

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.

Be prepared to add "extinct" and "endangered" to the class word wall at the start of the lesson.

Preview the *Orangutan Spitting Seeds* video. Be prepared to share this video with students if time permits. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

The *Interview with a Scientist Studying Orangutans* handout and the *Sample Data from Dr. Andrea Blackburn's Research* are printed in color in the reference section of the *Student Edition*, but can also be printed as a handout. Students can, but do not need to, retain these in their science notebooks. For that reason, you can print a class set to distribute and recollect for use in multiple science sections.

Lesson 12 • Where We Are Going and NOT Going

Where We Are Going

Early in the unit, students were likely curious about what would happen if orangutans became extinct. Other students may question whether losing the orangutan matters. This lesson is intended to investigate the orangutans' ecological role as one way to answer students' questions. This lesson draws upon real research conducted by Andrea Blackburn and her colleagues at Boston University and the Gunung Palung Orangutan Conservation Program research team. The purpose of the lesson is for students to examine the data shared by Andrea and her team (which is part of a longer ongoing research project) to draw tentative claims to answer their questions. Because this research is ongoing and findings are still emerging, it is important to support students in thinking of their claims as tentative and to suggest additional evidence that could bolster their claims.

This lesson allows your students to develop ideas about mutually beneficial relationships between populations (LS2.A: Interdependent Relationships in Ecosystems) and speculate on what may happen to some fruit tree populations and the overall rainforest structure should orangutan populations dwindle or go extinct and no longer disperse fruit seeds throughout the tropical rainforest. The idea of mutually beneficial relationships is new for middle school.

As students engage with the lesson materials, they will obtain information from written text, data tables, and images in order to make claims to answer their questions. By analyzing Andrea's current data and information, students can generate tentative claims grounded in the evidence collected so far. Because research is ongoing, students can brainstorm new questions and about the data needed to more fully understand the orangutans' ecological role.

When students participate in the Building Understandings Discussion, cue your students to see through the lens of Stability and Change as they consider whether the loss of one seed disperser population among other seed dispersers in the tropical rainforest matters to the overall rainforest system (e.g., if seemingly small changes in one part of the system could lead to larger changes throughout the whole system). Suggested prompts are provided to support students to use this crosscutting concept as they share their claims.

Where We Are NOT Going

Some arguments for orangutan conservation are not taken up in this lesson. For example, the orangutan is a national icon in Indonesia. It has cultural significance to many Indonesians. For this reason alone, conserving the orangutan is important. Likewise, orangutans are a critical species to better understanding human evolution. The genomes of humans and orangutans are 97% identical, making the orangutan an important species to study so that we can learn about our own genetic history. Both of these concepts—the cultural and biological significance of orangutans—provide a means of responding to questions about whether it matters if a species goes extinct. The current lesson does not include either.

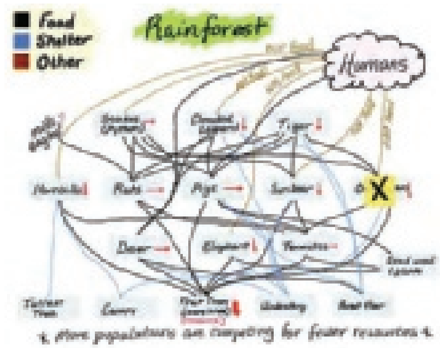
This lesson does not address various kinds of symbiotic relationships, instead focusing on one mutually beneficial relationship in the context of the anchoring phenomenon. A broadening move to other mutually beneficial seed dispersal cases in the local community is offered as an extension opportunity at the end of the Building Understandings Discussion.

LEARNING PLAN FOR LESSON 12

1. Navigation

5 MIN

Materials: Driving Question Board, Rainforest System Model (from Lesson 11), word wall



Highlight questions from the DQB related to orangutans going extinct. Have the DQB visible to students. Focus students on questions from the DQB related to orangutans going extinct. For example:

- *What would happen if orangutans went extinct?*
- *What happens to the rainforest if the orangutans die out?*
- *Is the orangutan going extinct a bad thing?*

Use the prompts on the slide to facilitate a brief sharing. Display **slide A**. First, ask students who originally posed these questions to share more about their initial wondering. Then transition to looking at the *Rainforest System Model* from Lesson 11, which has a sticky note with an X over the orangutan. Ask students to share their initial predictions about what they think would happen if orangutans go extinct and brainstorm about any additional information they need to better understand the problem.

Suggested prompts	Sample student responses
What were we wondering about when we posed these questions?	*I was thinking that if they keep clearing the rainforest, orangutans won't have anywhere to live.* *It seemed like the numbers were going down so much that there were not many orangutans left.* *I was wondering whether it mattered if orangutans went extinct.* *Would anything really happen?*
Based on our Rainforest System Model, what did we predict could happen if orangutans go extinct?	*Maybe, there would be more fruit for other populations to eat.* *There may be less food for tigers.* *People would be sad because once an animal goes extinct, it never comes back.* *It may not matter because there are a lot of other animals in the rainforest.*

***Attending to Equity**

Universal Design for Learning: It may be helpful to discuss and define the terms "extinct" and "endangered" to clarify vocabulary and promote understanding. You can support all students, particularly emerging multilingual learners, in forming a deeper understanding of vocabulary by representing the new term in multiple ways. For example, students can (1) write the term, (2) draw a representation of the term, (3) use their own words to write an explanation for what the term means, and (4) use the new term in a sentence. Developing a shared understanding of the term will allow for students to practice using it throughout the remainder of this lesson.

Suggested prompt	Sample student responses
What more information do we need to better understand what could happen?	*We need to know whether orangutans do anything special in the rainforest.* *We need to know all the things they are connected to in the rainforest, to see how their extinction would affect other populations.*

Say, *Scientists have been curious about similar questions and studying orangutans closely for many years. Let's take a look at their research to see if we can answer our questions about what would happen if orangutans went extinct.**

2. Meet a scientist studying orangutans. 10 MIN

Materials: *Interview with a Scientist Studying Orangutans* handout

Introduce students to Dr. Andrea Blackburn. Display **slide B**. Say, *I found a scientist who is currently researching orangutans in one of Indonesia's National Parks. It's one of the protected areas that we explored in an earlier class: Gunung Palung National Park. The scientists there have been tracking and recording data from the orangutans for years. Let's take a look at her research to see what she's studying about orangutans and how this could help us answer our questions.*

Read more about Andrea Blackburn's work. Pass out 1 copy of the *Interview with a Scientist Studying Orangutans* reference sheet to each student. Give students about 5 minutes to read on their own about Andrea Blackburn and her research questions and methods, or read together as a class.

Share connections from the interview to DQB questions. Display **slide C**. Prompt students to share how Andrea's research could connect to their questions.

Suggested prompts	Sample student responses
What is Andrea researching?	*She's trying to understand the role orangutans play in the ecosystem.* *She is looking at how they spread fruit tree seeds throughout the rainforest.* *She is looking at whether they do spread fruit seeds or if they just chew them up, like other scientists think.*
Given our Tropical Rainforest System Model, why is spreading fruit seeds potentially important for the ecosystem?	*They are the main resource in the rainforest.* *A lot of populations depend on fruits.*

Suggested prompts	Sample student responses
How does this relate to the questions we had?	*We were wondering how the extinction of orangutans would affect the ecosystem. If they are spreading fruit seeds, that could be important because fruit trees are the main resource for animals in the rainforest.* *We were wondering if they had a special role in the ecosystem or if their role didn't really matter. Andrea is studying the special role orangutans play in the spreading of seeds.*
If we examine her data, what do we need to pay attention to in order to answer our questions?	*We need to see if the orangutans are doing anything special with the fruit seeds.* *We need to see how they are related to fruit trees because that is the main resource for a lot of populations in the tropical rainforest.*

3. Analyze data from Andrea's research.

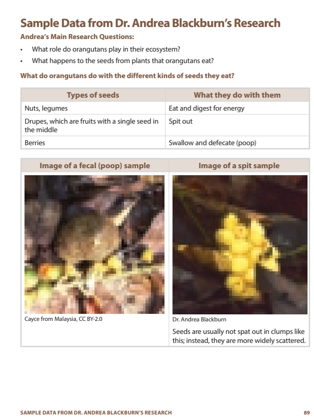
16 MIN

Materials: *Sample Data from Dr. Andrea Blackburn's Research* handout, claim-pass (developed in this lesson), computer and projector, Orangutan Spitting Seeds video

Examine some data together. Say, *Andrea is in the middle of her research. She has not found out all the answers yet. But she was willing to share some of her data with us. Let's see what she's finding out about orangutans spreading seeds around the tropical rainforest, and how the data she's collected could help us answer our questions.*

Elicit what students already know about the rainforest fruits orangutans eat. Listen for students to suggest figs and durian fruits.

Display **slide D** with images of these known food sources. Then display **slide E** with images of food sources that will be new and unfamiliar to students. It's OK if you and your students cannot pronounce these new fruit names. The purpose is to show more variety in the fruits from the tropical rainforest and to start to identify that the "fruit trees" represented on the system model produce hundreds of different kinds of fruit.


Sample Data from Dr. Andrea Blackburn's Research

Andrea's Main Research Questions:

- What role do orangutans play in their ecosystem?
- What happens to the seeds from plants that orangutans eat?

What do orangutans do with the different kinds of seeds they eat?

Types of seeds	What they do with them
Nuts, legumes	Eat and digest for energy
Drupes, which are fruits with a single seed in the middle	Spit out
Berries	Swallow and defecate (poop)

Image of a fecal (poop) sample — Cayce from Malaysia, CC BY-2.0

Image of a spit sample — Dr. Andrea Blackburn

Seeds are usually not spat out in clumps like this; instead, they are more widely scattered.

SAMPLE DATA FROM DR. ANDREA BLACKBURN'S RESEARCH 89

Display **slide F**. Say, *This data comes from Andrea's research on what she noticed orangutans do with seeds.* Give students 1-2 minutes to turn and talk with a partner about their own noticings from the data. Then bring students back together for brief sharing.

***Supporting Students in Engaging in Obtaining, Evaluating, and Communicating Information**

The claim-pass activity can help structure the conclusions that students draw from Andrea's research. It can focus students on using data and technical information to generate and clarify claims that can be made. Using this structure in small groups can prepare students for more active discussion as they share their own claims and listen to those made by other groups.

Suggested prompts	Sample student responses
What do you notice from Andrea's data on what orangutans do with seeds?	*They mostly chew and digest them.* *They spit out a lot of seeds.* *They only swallow seeds about 14% of the time.* *Sometimes, they do both: They spit out seeds and they swallow them.*
What do you think happens to the seeds that they spit out or swallow and defecate later?	*They land on the ground.* *They may go into the soil and start a new plant.*

Watch a video of an orangutan spitting seeds while eating. If time permits, display **slide G** to watch the *Orangutan Spitting Seeds* video. This video can provide context for what the researchers observe in the field and how they collect spit samples for their research. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Have students examine additional data in small groups. Display **slide H**. Say, *Since we're trying to understand what might happen if orangutans go extinct, let's focus on this question as we examine more of Andrea's data.* Preview the instructions with students. Arrange students in groups of 3-4. Provide each student with 1 copy of the *Sample Data from Dr. Andrea Blackburn's Research* handout, and provide each group with an index card or piece of paper for the claim-pass activity.

Allow groups about 4-5 minutes to scan the data and share their noticings.

Have groups complete a claim-pass to make a tentative claim from the data.* With at least 4-5 minutes remaining, display **slide I.** Preview instructions for the claim-pass activity. Emphasize that students should respond to the prompt: What claim can you *tentatively* make from this data about what *could* happen if orangutans go extinct. Have students follow these procedures on the slide.

Images and data tables from the student packets can be found on **slides N-S**. **Slide M** includes a photo of researchers in the field.

4. Facilitate a Building Understandings Discussion.

10 MIN

Materials: claim-pass (developed in this lesson), Rainforest System Model (from Lesson 11)

Additional Guidance

The research by Andrea Blackburn and the Gunung Palung Orangutan Conservation Program is ongoing. While data from this lesson support that orangutans are seed dispersers in the tropical rainforest, the team is still conducting research to better understand the orangutan's overlapping role with other seed dispersers in the ecosystem. You can

*** Supporting Students in Developing and Using Stability and Change**
Support your students in using a Stability and Change lens during this discussion, by adding probing questions like the ones below:

use this opportunity to allow students to suggest tentative claims they can support with Andrea's current data, and also to suggest where they would want to go next if they were to continue to research these questions.

Have each group share their claims while other groups pose questions. Display **slide J.** Say, *Remember we are looking at what could happen if orangutans go extinct. Based on Andrea's current research, what claims can we start to make? If you hear a claim that you don't agree with or don't understand, pose questions to help clarify the claim for the class.* **Slides N-S** contain enlarged images and data tables from students' data packets to support the discussion as needed.

Key Ideas

Purpose of this discussion: To conclude that orangutans have a special role to disperse fruit seeds in the tropical rainforest. The seeds, which become new plants, are important for many tropical rainforest populations. Fruit trees depend on orangutans to disperse their seeds.

Look/listen for:

- Orangutans disperse seeds throughout the tropical rainforest by spitting and defecating.
- The defecated seeds seem to grow better than the control seeds.
- If orangutans go extinct, fruit tree populations may decrease, which would affect several populations.

Suggested prompts	Sample student responses	Follow-up questions
What claims can we make?	*Orangutans are spreading seeds by pooping in the rainforest.*	*How does this relate to what would happen if they go extinct?*
	If orangutans go extinct, fruit trees will die.	*Say more about who will "die"? What evidence did you see to support that fruit trees will die?*
	If orangutans go extinct, fewer seeds could be spread in the rainforest to grow into plants.	*What evidence did you have to support that conclusion?*
What questions or uncertainties do we have?	*Are orangutans the only thing that spread seeds?*	*Looking at our system model, what other things could we predict might spread seeds?*
	Is this the way all fruit trees grow in the rainforest?	
What additional data would we want to collect to know for sure?	*We need to see who else is spreading the seeds and whether those populations would still spread them if orangutans were gone.*	
	We need to know how trees grow from the seeds that orangutans poop out and if they become fruit trees that animals can eat from.	

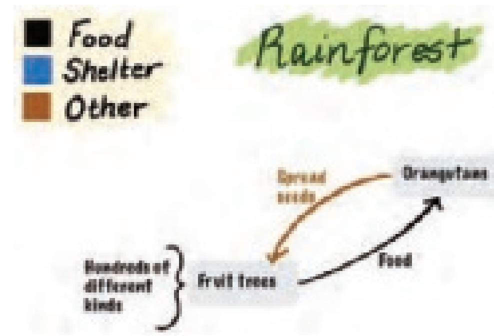
- How might this system be affected in the short term by the loss of the orangutans?
- How might this system be affected in the long term by the loss of the orangutans?
- How might this system be affected by a change in the seed dispersal throughout the tropical rainforest?
- Is the loss of the orangutan disruptive enough to affect the whole system? Why or why not?

If your students have used Stability and Change frequently during the school year, elicit from them what questions they should ask using this lens that would help them better understand if the system is (or would be) stable or if it would change as a result of alterations to the state of one of its components (the orangutans).

Revise the Rainforest System Model. A last move to close out the discussion is to update the *Rainforest System Model* from Lesson 11. Display **slide K**. Prompt students to make suggestions for revising the model:

- What can we say about the relationship between orangutans and fruit trees?
- If orangutans go extinct, how would that affect fruit trees? How would that affect the rest of the rainforest ecosystem?*
- How should we represent this relationship in our system model?

Add a two-way connection to the model to show that fruit trees get their seeds dispersed by orangutans in the tropical rainforest.



Assessment Opportunity

Building towards: **12.A** Gather information from text, images, and data tables to clarify claims that a change in the orangutan population could affect fruit trees because there is a mutually beneficial relationship between the two.

What to look/listen for: See the Key Ideas above, plus the following:

- There is a two-way relationship between orangutans and fruit trees: orangutans get food, and fruit trees get their seeds spread throughout the tropical rainforest.

What to do: If students struggle to understand that fruit tree populations depend on orangutans, add a deeper discussion about how plant populations may increase or decrease over time. First, elicit from students their prior knowledge and experiences of plants that could be useful to their thinking. To do this, ask the following probing questions: *Have you ever noticed a young plant growing in a new area? How did it get there? Have you ever noticed some plants, like dandelions, becoming more and more prevalent, year after year? How does that happen? How does a plant population in our community (for example, dandelions, sticker burrs, or grass) get larger or smaller over time? If seeds from a large plant, like a tree, drop on the ground below the tree, why might those seeds grow or not grow into adult plants?* Once students more fully understand that plant populations increase by seed dispersal away from parent plants, have students then connect back to why fruit tree populations in the tropical rainforest would be dependent on the orangutans to spread their seeds.

Brainstorm related phenomena and cases we know about (optional). If time permits and/or you choose to add the extension opportunity below, ask your students to brainstorm other mutually beneficial seed dispersal relationships they know about or have seen or heard about. Keep a list charted on the class whiteboard or chart paper for use in the extension opportunity.

Alternate Activity

Extension Opportunity: To deepen students' understanding of mutually beneficial relationships, extend these ideas to other cases students know about or ones relevant in their community (e.g., squirrels and acorns, birds and seeds, humans spreading seeds). This kind of extension could benefit high-interest learners, those who have shown mastery of the current lesson content, and/or all your students, to increase their understanding of the lesson's relevance. If you choose to extend this lesson, add 1 class period. The extra class period could include the following elements:

- Introduce your students to a local related case and/or a case of seed dispersal they bring up during the brainstorm.
- Investigate the new case by watching a short video and/or reading about the case on the web.
- Compare the new case(s) to the orangutan seed dispersal case. Ask questions: *What did you notice about the new case? What is similar about the new case to the orangutan case? What is different?*
- Generalize the model. Ask students to suggest ways to generalize the idea they developed from the specific case of orangutans and rainforest fruit seeds to a more general representation of fruit consumers (orangutans, birds, squirrels, humans) and fruit/seed producers.

5. Navigation

4 MIN

Materials: Rainforest System Model (from Lesson 11), sticky note with an X

Make new predictions. Display **slide L**. Say, *We just figured out that orangutans have a pretty unique role in the tropical rainforest to spread seeds and that the seeds they spread tend to grow into new plants. We're thinking that because so many of our rainforest populations depend on fruit, there's a chance that if orangutans were to go extinct, it would not be a good thing for other populations. Fruit trees seem to play an important role in keeping the tropical rainforest healthy. Lots of populations depend on them, and they are the base of our system.*

Place a sticky note with an X over the fruit trees in the *Rainforest System Model*. Say, *If we start messing with this part of the model, what do we think could happen in the tropical rainforest?* Listen for students to suggest:

- *Everything would die without the fruits as food.*
- *It wouldn't matter because there are lots of different kinds of fruit.*
- *Somewhere in between or not certain.*

Say, *This is tricky to figure out because our model lumps all fruit trees together. If we update the model, what would we need to show to test our ideas?* Listen for additional ideas:

- *Break apart the fruit trees.*
- *Add the new fruit trees we learn about.*
- *Get more information about which fruit trees are affected most.*

ADDITIONAL LESSON 12 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Students will work with a set of data that includes technical information from an interview with a scientist, quantitative data, and observational data, such as photographs. Students will work with their group members to develop a claim from these data. To do so, students will need to integrate the technical information about seed dispersal with the data and images in order to generate their claim.

SCIENCE LITERACY: READING COLLECTION 4

Population Dynamics

1 **Leave Nature Alone**

2 **Harmony in Nature**

3 **The Bottleneck Effect**

4 **Strategies for Survival and Reproduction**

5 **Extinction Events**

Literacy Objectives

- ✓ Read to find out how interactions of organisms in an ecosystem affect population sizes.
- ✓ Compare organisms that produce many offspring with those that produce only a few.
- ✓ Identify periods and causes of mass extinction.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 7–9.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Write a science fiction story about a mass extinction in response to the reading.

Instructional Resources

Student Reader

Collection 4

Science Literacy Student Reader, Collection 4
"Population Dynamics"

Exercise Page

EP 4

Science Literacy Exercise Page
EP 4

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 10: How do changes in the amount of resources affect populations?
- Lesson 11: How does planting oil palm affect other populations?
- Lesson 12: What would happen if orangutans go extinct?

Standards and Dimensions

NGSS Performance Expectation

LS2-1: (Building toward) Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

LS2.C Ecosystem Dynamics, Functioning, and Resilience

ESS3.C: Human Impacts on Earth Systems

Science and Engineering Practice: Analyzing and Interpreting Data

Crosscutting Concepts: Cause and Effect; Patterns

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.W.7.3

Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

strategy

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

bottleneck effect
***K*-selection species**
***r*-selection species**
extinction
reproduction
social media

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Exercise Page

EP 4

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Ecosystem Dynamics unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
    - *In "Leave Nature Alone," you will discover how different people interpret the same scientific event in very different ways.*
    - *In the second selection, you'll learn more about why organisms interact in an ecosystem and why animal populations rise and fall.*
    - *"The Bottleneck Effect" describes what might happen to future populations when the size of a population decreases and the genetic diversity is reduced.*

- *In "Strategies for Survival and Reproduction," you'll read about organisms that produce lots of offspring or eggs that require little care and those that produce very few offspring that require a great deal of care.*
- *In the last selection, you'll read about different periods of mass extinction in Earth's history and consider why they occurred.*

- Distribute Exercise Page 4. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to write a science fiction story about a mass extinction.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
Why would different people react differently to the same event?	*Some might react emotionally and not look for causes. Some may have had experience or prior knowledge about why something happened. Some may be looking for confirmation that their opinions about something are correct and not consider the evidence.*
What experience do you have of seeing populations rise and fall? How do you explain it?	*One fall after a wet summer, we had a lot of orange ladybugs, Asian lady beetles, in our house. The next fall, there were just a few. They didn't have as much to eat this year as last year, so there weren't as many.*
What can happen to populations if there is not enough genetic diversity?	*The later generations become weaker and are less able to resist disease. Any genetic problems are passed on and become more and more serious.*

Suggested prompts	Sample student responses
Why might some animals like ants, mice, frogs, rabbits, fish, snakes, and turtles produce so many eggs or offspring?	*The chances that a species will survive are higher when there are more offspring. Many offspring are eaten or will not thrive because there is not enough for them to eat.*
Why do plants and animals become extinct?	*They are killed off by other animals, they can't find enough food, or the climate changes and they can't adapt or move.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
What could happen to predators like owls if all the mice were killed off in an ecosystem?	*The owls would starve or have to move to find other food sources.*
What could happen to mice in an ecosystem if pesticides killed all the plants they eat?	*The mice would starve or have to move.*
What could happen to plants and animals if a large area of land was cleared for a single crop?	*All the other plants would die. The animals that ate those plants would starve or have to move. The animals that ate those animals would also starve or have to move.*

- Refer students to the Exercise Page 4. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The writing expectation for this assignment is to write a science fiction story about a mass extinction.*
    - *In the selections, you learn that the interactions of organisms in an ecosystem affect population size and that smaller populations of organisms in an ecosystem affect genetic diversity, which can weaken subsequent generations.*
    - *Think about what you read as you imagine how a mass extinction could happen and what the aftermath of that would be.*
    - *Your story should include a beginning that describes the before times, a middle that explains how and why the mass extinction occurred, and a conclusion that describes what Earth is like afterward.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 4

4. Facilitate discussion.

(Friday)

Facilitate class discussion about the reading collection and writing exercise.

The five reading selections help to describe how population size is affected by many factors, including the population of other organisms in an ecosystem.

Student Reader

Collection 4

Pages 36–37 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Leave Nature Alone"?	*It presents an event from different points of view.*
What does it mean for an animal to be beached?	*It is stuck on a beach, unable to swim back into the water.*
What scientific evidence did the wildlife journalist provide that the others did not?	*The wildlife journalist explained different reasons for animal beaching, some human-related and some not.*
Would banning fishing from the pier have kept the whale from beaching?	*probably not* *There are many reasons the whale may have beached that should be studied before action is taken.*

Pages 38–39 **Suggested prompts**	**Sample student responses**
How does the second selection help you build knowledge on top of what you learned in the first selection?	*It explains how interactions in the ecosystem affect organism health and population size and why it is important to study those interactions before drawing conclusions about why an animal may have died.*
What does dynamic equilibria *mean? Note that* equilibria *is the plural of* equilibrium.	Dynamic *means constant change, activity, or progress. Equilibrium is a state of balance. So, dynamic equilibria would be situations in which things are constantly rebalancing as a result of changes.*
What are the dynamic factors that can increase and decrease population size in an ecosystem?	*Immigration and birth increase the population size. Death and emigration decrease the population.*

Pages 40–41 **Suggested prompts**	**Sample student responses**
What is the general purpose of the third article, "The Bottleneck Effect"?	*It explains what happens to populations over time if there are too few parents.*
Why is genetic diversity important in the survival of a species?	*Lack of genetic diversity can result in decreased population size, ability to reproduce, and problems with adapting to environmental change.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Have students watch a video about Asian lady beetle infestations. Discuss reasons for changes in the population size of the insects in a certain location.

SUPPORT—Compare with students the terms *immigration* and *emigration*. Point out that the words are comprised of prefixes *im-* and *em-* that provide clues to word meaning. *Im-* means "in," and *em-* means "out." Immigration is moving into a location, and emigration is moving out of or away from a location.

CHALLENGE—Have interested students research diseases that have been found to be passed on genetically, such as certain cancers related to the BRCA gene, Huntington's disease, and sickle cell disease. Have them report their findings to the class.

Pages 42–43 Suggested prompts	Sample student responses
What is the general purpose of the fourth selection, "Strategies for Survival and Reproduction"?	*It explains how different organisms reproduce in different numbers as a strategy for survival.*
What is a reproductive strategy in science?	*It refers to the way a species over time are adapted to their best way to survive.*
What types of animal babies do you know of that rely on the care of their parents to survive?	*birds, mice, wolves, cats, opossum, raccoons, elephants*
What types of animals do not care for their offspring?	*snakes, turtles, salmon, frogs, ants, Asian lady beetles, spiders*

SUPPORT—Have students watch a video about animals that are endangered or near extinction. Discuss what changes in the ecosystem are causing animal populations to be endangered and what would happen to the genetic diversity as the population dwindles.

Pages 44–45 Suggested prompts	Sample student responses
How does the last selection relate to the other selections in this collection?	*It describes when and why populations of organisms were reduced to extinction.*
What is one reason a population might become extinct?	*Extinction occurs after a large-scale natural disaster or event that dramatically changes the ecosystem so that organisms cannot find food or shelter and cannot reproduce in numbers to survive.*
How do people know that mass extinctions occurred?	*Fossilized bones and evidence of species that are not alive today have been found all over the world.*
Was all life destroyed after each mass extinction on Earth?	*No, just specific species that could not adapt to the sudden changes. Species that could adapt continued to live and reproduce.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 4, students should use what they know scientifically about mass extinction to write a science fiction story about a mass extinction.

Use the rubric provided on the Exercise Page to supply feedback to each student.

How does an ecosystem change when the plants change?

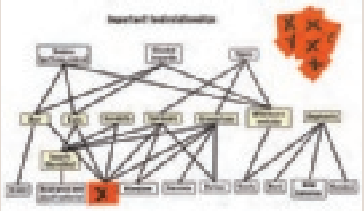
Previous Lesson

We were curious about what would happen if orangutans go extinct. We read an interview with Dr. Andrea Blackburn, who studies orangutans. We watched videos, examined images, and made noticings from data tables from her research. We figured out that orangutans are seed dispersers and spread seeds over great distances throughout the tropical rainforest. These seeds often grow into healthy new plants. We were left wondering what would happen if something changed with other populations in the systems we are investigating.

This Lesson

Putting Pieces Together

2 DAYS



We wonder how the rainforest system changes if the fruit populations change. We use an updated system model to make predictions and test ideas with different kinds of disruptions to fruit tree populations. We test some of the same disruptions using our oil palm system model. We figure out that the rainforest system can withstand some disruptions due to all the interconnectedness, but the oil palm system cannot withstand disruptions. We apply these ideas to a new case about the southwestern willow flycatcher and complete a short individual assessment. We summarize what we know about monocrop oil palm farming to motivate us to design a better way to farm it.

Next Lesson

We will read about one of three ways to grow food and help populations in ecosystems: diversified farming, sustainable oil palm, and Customary Forests. We will discuss how these approaches help populations in ecosystems and wonder how people benefit.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

13.A Use a model to make predictions and test ideas about how disruptions, or changes, to one part of the system affect populations throughout the system.

13.B Construct an argument supported by empirical evidence that releasing the tamarisk beetle (change) affects the willow flycatcher population when there are fewer nesting tree types available.

What Students Will Figure Out

- There are more populations and more connections in the rainforest system compared to the oil palm system.
- Any change to the ecosystem, or disruption, will affect some populations. Some disruptions affect many populations.
- If an ecosystem has many connections between populations, the ecosystem has a better chance of being OK when a change happens.
- A disruption in a monocrop system will impact all the populations in the system.

Lesson 13 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION** Brainstorm ways ecosystems can experience disruptions and how the tropical rainforest would respond if a disruption affected the fruit trees in the system.	A-B	word wall, Rainforest System Model (from Lesson 11)
2	10 min	**MODEL DISRUPTION SCENARIOS IN THE TROPICAL RAINFOREST** Have students identify real-world scenarios that could disrupt the fruit tree populations in the tropical rainforest; then use their models to predict how the system would be impacted in each scenario.	C-D	*Updated Rainforest System Model*, paper squares (prepared in advance)
3	8 min	**MAKE SENSE OF DISRUPTIONS IN THE TROPICAL RAINFOREST** Discuss how each scenario impacts the system.	W	enlarged or projected *Updated Rainforest System Model*, sticky note with an "X" or alternative
4	14 min	**DISCUSS AND COMPARE DISRUPTIONS IN THE OIL PALM FARM** Have students turn and talk about disruptions to oil palms. Then facilitate a Building Understandings Discussion to compare disruptions in oil palm farms to the tropical rainforest.	E-J	word wall
5	3 min	**ASSIGN HOME LEARNING** Have your students pay attention to the plants in their communities and whether they see more biodiverse plants around them or more similar to monocrop plants.	K	
				End of day 1
6	5 min	**SHARE HOME LEARNING** Have your students share examples from the home learning assignment in partners and then as a class.	L	
7	5 min	**CREATE A SUMMARY CHART OF KEY TAKEAWAYS** Have students transition from sharing home learning to document key takeaways comparing biodiverse plant communities to single plant communities. Use Cause and Effect to guide the summary ideas.	M	Summary chart (prepared in advance), markers
8	18 min	**APPLY TO A NEW CASE: THE WILLOW FLYCATCHER** Work together as a class to apply the ideas from the summary chart to a new case about the southwestern willow flycatcher. Use this whole class setup to prepare students for a short individual assessment opportunity.	N-S	*Southwestern Willow Flycatcher System Model*, paper squares (prepared in advance)

Part	Duration	Summary	Slide	Materials
9	12 min	**INDIVIDUAL ASSESSMENT: THE WILLOW FLYCATCHER** Have students individually complete an assessment to demonstrate their learning about disruptions to systems.	T-U	*Southwestern Willow Flycatcher, Scoring Guidance: Southwestern Willow Flycatcher*
10	5 min	**NAVIGATION: MONOCROP OIL PALM** Summarize what we know about monocrop palm farms, so we know what we are trying to improve upon in our designs.	V	chart paper, markers

End of day 2

Lesson 13 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• *Southwestern Willow Flycatcher*	• *Updated Rainforest System Model* • paper squares (prepared in advance) • *Southwestern Willow Flycatcher System Model*	• word wall • Rainforest System Model (from Lesson 11) • enlarged or projected *Updated Rainforest System Model* • sticky note with an "X" or alternative • Summary chart (prepared in advance) • markers • *Scoring Guidance: Southwestern Willow Flycatcher* • chart paper

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.

The timing for this lesson is tight. Make the following modifications to fit your situation:

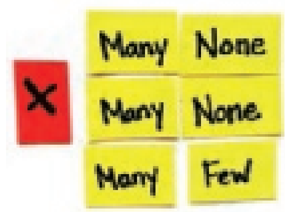
- If your students will need more time on the individual assessment, then delay the sharing of home learning until the start of Lesson 14. This will add 5 minutes for the individual assessment.
- If you have class periods longer than 45 minutes, move the Summary Chart to day 1, saving all of day 2 to share home learning and complete the transfer task and assessment.
- If you have class periods shorter than 45 minutes, spend more time sharing home learning on day 2 and completing the Summary chart. Add a 3rd day to this lesson focused on the transfer task and assessment only.

Online Resources

Prepare a "Summary Chart" with cause-and-effect sentence stems written on it. Write the "if" part of the sentence stem. This will allow your students to focus on completing the "then" conclusion as a class. This should make the summary chart proceed quickly on day 2. Alternatively, if you are expanding this lesson to 3 days, complete the full summary chart together as a class.

Be prepared to add "disruption," "biodiversity," and "monocrop" to the class word wall.

Prepare paper squares: The paper squares need to be approximately the size of a penny or nickel.



- For day 1: Prepare a snack size bag for each partner group that contains 8 paper squares with "X" on them. Alternative options include chips, beads, or other penny-sized items.
- For day 2: Prepare a snack size bag for each partner group that contains 2 paper squares with "none" written on the square, 1 paper square with "few," and 3 paper squares with "many." Add 1 paper square with an "X."

Lesson 13 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students explore what happens to ecosystems when plant populations, particularly ones that serve as key resources, experience a disruption. For the first time in this unit, students explicitly consider disruptions to ecosystems and how they impact populations within the ecosystem. They use models to predict and test different physical disruptions (e.g., drought) and biological disruptions (e.g., disease). Economic disruptions are backgrounded in this lesson, but may come up for students. They predict how these disruptions will lead to shifts in all of the populations within the rainforest ecosystem, and then test the same disruptions in an oil palm system. 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 are related to the system's biodiversity and that the oil palm system is a monocrop with little biodiversity. By the end of this lesson, students should solidify their understanding about the following:

- "Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations."
- "Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health."

Students apply these ideas to a transfer case to explain how changes to one component of an ecosystem (e.g., introducing a tamarisk beetle to kill tamarisk trees) affects other populations (e.g., the willow flycatcher population) in the system. On the assessment, students are building toward Performance Expectation MS-LS2-4: *Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

Students will engage with the crosscutting concepts of Cause and Effect and Stability and Change throughout the lesson. In this context, the two crosscutting concepts are intertwined. Students are using cause and effect relationships to describe consequences from disruptions (e.g., the summary chart on day 2) and to make predictions (e.g., using system models to test scenarios). During the discussion, support students in thinking about disruptions and their impacts in terms of time and space. For example, prompt students to consider the sudden or gradual nature of the disruption, how short-lived or long-term the impacts may be, and how widespread or focused the impacts are within the system.

Engaging in Arguments from Evidence is a practice your students have worked with in several previous units. The individual assessment on day 2 will require students to construct an argument to support one of two claims. The assessment assumes that students are proficient at writing an argument using evidence and scientific reasoning. If students need more support, (1) review the class anchor chart from the *Bath Bombs Unit*, or (2) develop an anchor chart together reviewing the components of a good argument.

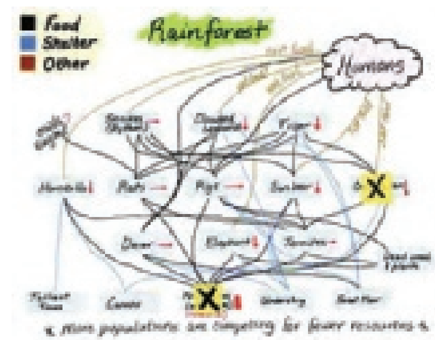
Where We Are NOT Going

Students do not consider economic disruptions that impact farm systems, such as a change in the market price for a crop or the demand for it. These ideas may emerge for students in Lesson 15 as they hear more from farmers.

1. Navigation

10MIN

Materials: word wall, Rainforest System Model (from Lesson 11)



Take stock of what we figured out in the previous class. Display the *Rainforest System Model* with a sticky note with an X over Fruit Trees. Display **slide A.** Say, *One big change happening in Indonesia is that people there are cutting down tropical rainforests to grow oil palm. We already figured out that this practice was causing changes in populations like orangutans and tigers. But in the last class, we also wondered what would happen if orangutans went extinct, which could affect the tropical rainforest, and fruit tree populations specifically, in other ways.*

Suggested prompts	Sample student responses
What did we figure out about the connection between the orangutan and fruit tree populations?	*Orangutans get food and trees get their seeds spread around the rainforest.* *They help each other.* *It's a two-way relationship.*
How did we think losing the orangutan could impact the fruit trees?	*Seeds may not get spread in the rainforest.* *New fruit trees may not grow.* *Fruit tree populations may decrease.* *Everything depends on the fruit trees, and they may not have food.*
If fruit trees are affected by the loss of the orangutan, what do we predict could happen to the whole rainforest system?	*Everything would die without the fruits as food.* *It wouldn't matter because there are lots of different kinds of fruit so if it's only a few kinds, everything will be OK.* *somewhere in between* *Really not certain, because it's so complex.*

Say, *Some of these sound like they could be big changes to the tropical rainforest, and others seem like smaller changes that might not matter that much. Let's consider whether these different scenarios are possible.*

Broaden to related experiences that we know about. Display **slide B.** Give students time to turn and talk about related experiences, cases, and stories they know about where a plant in an ecosystem experienced a big change, like dying off. Have students think about whether this had a big or small impact on the ecosystem.

Bring students back together as a whole class to share briefly. Listen for students to share examples like:

- Cutting down forests
- Crop disease

- Trees killed by beetles or other insects
- American chestnut
- Plants died because of drought
- Grass in backyards
- Cutting down the Amazon rainforest

Introduce and define the term "disruption." Say, *What you are describing with these changes to ecosystems are called* disruptions. *Disruptions are things that happen that change the ecosystem.*

Work with the class to co-construct a definition for disruption and add it to the class Word Wall. An example definition might be: *A disruption is a change (sudden or slow) to an ecosystem.*

If time permits, have your students go back to the examples they shared to name the disruption that occurred and whether the disruption was big or small, or sudden or slow.

2. Model disruption scenarios in the tropical rainforest. 10 MIN

Materials: *Updated Rainforest System Model,* paper squares (prepared in advance)

Brainstorm scenarios where these kinds of disruptions could affect the fruit trees in the tropical rainforest. Display **slide C**. *We're going to figure out what kinds of disruptions would have to happen to have both big and small impacts on the system. Let's name some scenarios together that we want to test.*

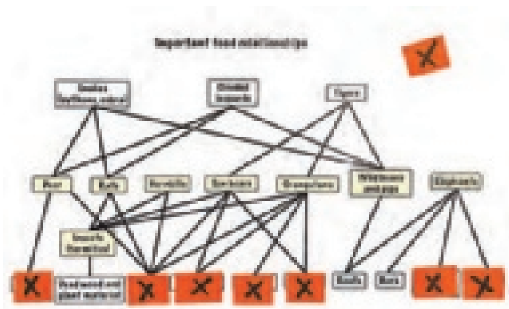
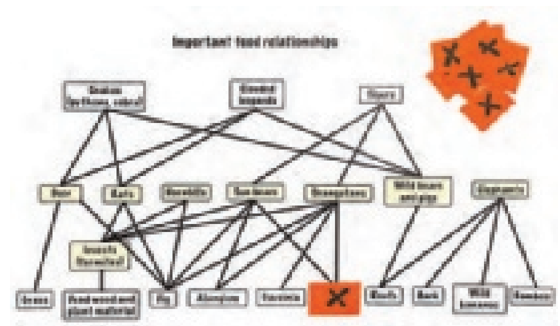
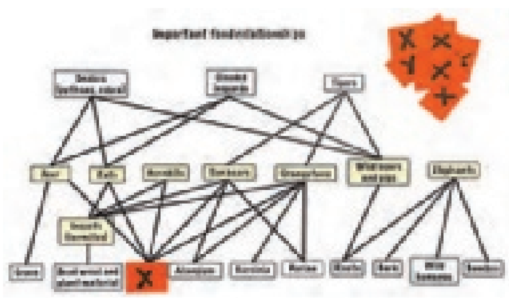
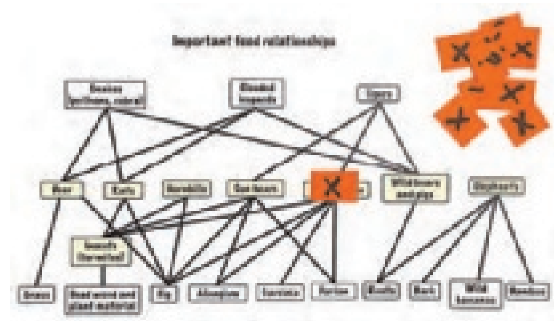
Suggested prompts	Sample student responses
Some of you thought there could be major impacts on the system if fruit populations were disrupted. What could cause a big change to the fruit tree populations, where a lot of them are impacted?	*cutting the rainforest down* *fire* *drought*
Others thought there might only be small impacts. What could cause a small change to the fruit trees, where only a few of them are impacted?	*People harvesting one kind of fruit.* *Seeds from one kind of fruit don't get spread around.* *Disease that kills one kind of fruit.*

Work with your students to select 3-4 scenarios above. It is recommended to choose something like drought for an example of a large, widespread disruption and something like a disease for an example of a focused disruption. The rest of this lesson will use four example scenarios, but modify these scenarios if your students are interested in testing other disruptions (e.g., fire).

Preview how to use the model to predict impacts to the system. Arrange students into partners. Pass out 1 copy of the *Updated Rainforest System Model* to each pair of students and 8 paper squares with an "X" on them (or chips, beads, coins, or other alternative). First, review with students the changes made to the model compared to the class Rainforest System Model that they have been using. Say, *Some of these animals and plants are familiar to us already, but* *some things are new. What do you notice is new or different from our system model?* Listen for students to identify new components, such as:

- Roots
- Bark
- Wild bananas
- Bamboo
- Alangium, garcinia, durian, and fig may be familiar from previous lessons, but new to our model.
- Dead wood and plant material and grass may not have been in the original model either.

Explain the new colors to students: green are plants, yellow are plant and/or insect eaters, purple are the predators. Clarify that this model is oversimplified because the number of boxes and lines to draw in the real system would be very complex and challenging to use. **Have students work in groups using a model to test their ideas.** Once the class is oriented to the new model, display **slide D**. Preview instructions with students. Have students work in partners to model the scenarios by covering the different kinds of fruit trees with paper squares, based on the scenario context. Focus the partners on discussing who they predict would be most impacted and how, as well as whether the change could be considered big or small to the system as a whole.

Scenario #1: Long-term drought	Scenario #2: Durian disease
	
Scenario #3: Fig disease	**Scenario #4: Loss of seed disperser (orangutans)**
	

3. Make sense of disruptions in the tropical rainforest.

8 MIN

Materials: Enlarged or projected *Updated Rainforest System Model*, sticky note with an "X" or alternative

Model each scenario together. Bring students back together. Project a copy of the *Updated Rainforest System Model* or **slide W**. Ask partners to share how they modeled the scenarios and their prediction for impacts on the system as a whole.* As the class discusses each scenario, use sticky notes, paper squares, or chips to cover up the population that is affected.

Suggested prompts	Sample student responses
What did we predict would happen if there was a disease affecting durian fruit?	*The durian would die, and the orangutans would not have durian fruit. But orangutans eat other things.*
What if this disease was with figs?	*If figs get a disease, more things would be affected because more things eat figs, but most of the things eat other fruits too.*
What did we predict would happen if there was a long drought in the area?	*We thought that a lot of plants could die or get harmed, which would affect everything else in the system. Everything relies on fruits, so if there isn't fruit, then the animals would die or have to fight for very little food.*
How would the tropical rainforest be affected if a seed disperser like the orangutan went extinct?	*There are some important fruits that would not get dispersed, maybe, like Garcinia. But other things may spread the seeds. We aren't really sure.*
What can we conclude about these kinds of disruptions to the system as a whole?	*The fewer fruit or plants affected, the less impact on the system.* *The more fruit populations affected, the bigger the impacts on the system as a whole.*
Let's think about this in terms of the connections to other things. What can we summarize about the likely outcomes of a disruption if the thing most disrupted is only connected to a few other parts of the system? To a lot of parts of the system?	*If there are only a few connections, then the outcomes may not be as bad. Animals may eat other fruits, so if they lose 1 food source, it's going to be OK. If the thing that is disrupted has a lot of connections, then a lot of populations are going to be affected if that part of the system has a problem.*

Motivate students to look at oil palm farms too. Say, *We just figured out that different things could cause both big and small disruptions in the tropical rainforest. We looked at how drought and disease would affect rainforest plants and then the system as a whole. Oil palm is growing right next to the tropical rainforest. How would disruptions like these affect the oil palm?*

***Supporting Students in Developing and Using Stability and Change**

During this discussion, guide students to use Stability and Change to make sense of both small and widespread impacts, as well as sudden and gradual change. Consider adding the following kinds of prompts:

- How might the system be impacted in the short term?
- How might the system be impacted in the long term?
- What scenario is a long-term gradual disruption, and which are sudden events? Does that affect how the system responds?
- Do we predict that the disruption will have a widespread impact on the system? Why or why not?

4. Discuss and compare disruptions in the oil palm farm. 14 MIN

Materials: word wall

Brainstorm disruptions that could occur in the oil palm system. Display **slide E**. Give students time to individually think about disruptions that could occur that would affect the oil palm. After a minute, ask students to share.* Listen for examples like:

- *Crop disease*
- *Drought*
- *Fire*
- *People quit buying it*

Have students turn and talk about predicted impacts from disruptions to the oil palm. Display **slide F**, which shows a model for the oil palm farm. Arrange students as partners for a Turn and Talk. Have students discuss how the same kinds of disruptions they brainstormed for the tropical rainforest could affect the oil palm system, and other related cases they know about. Then, bring students back together to share their ideas.

Suggested prompts	Sample student responses	Follow-up questions
What do you predict would happen if this system experienced a drought or crop disease?	*Everything would die because they all depend on the oil palm.* *The rats, snakes, and pigs would move back to the rainforest to find food.*	*Does this seem like a big or small disruption? Why?*
What other examples do you know about where a crop was impacted by a disruption?	*when crops get flooded near us* *when bugs eat all the crops* *if there is a big storm that crushes the crops*	*What happens to farmers when there is a big disruption to their only crop?*
If the farm had more kinds of crops, would that help if there was a disruption?	*Maybe if it's a disease on one crop, others would survive.* *Not really, if it's a fire or drought.*	*What about a disruption caused by social factors, like people quit buying a certain crop or the market price changes for it?*

Make comparisons between the two systems in a Building Understandings Discussion. Display **slide G**, then **slide H**, then **slide I**. For each slide, allow students to make noticings to compare the two systems.

***Attending to Equity**
If farming is central to students' communities, extend this opportunity to draw out real-world disruptions that they and their community have experienced. This will create more realistic disruption scenarios that farmers experience.

Key Ideas

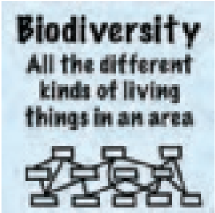
Purpose of the discussion: (1) To explicitly name that the tropical rainforest has a biodiverse plant compared to the oil palm system, (2) agree that more biodiverse systems may be able to better handle small disruptions, and (3) agree that less biodiverse systems are more at risk of disruptions.

Listen for students to suggest the following:

- There are more *total* plants and *kinds* of plants in the rainforest system than the oil palm system.
- There are more overall populations and connections in the rainforest system than the oil palm system.
- When a disruption occurs, the rainforest system as a whole can be mostly OK because there are other resources that populations can eat and use.
- When there is a disruption that affects the oil palm crop directly (disease, drought) in the monocrop farm, all of the populations in the system are affected because they all rely on oil palm.

Suggested prompt	Sample student responses
What did you notice when you compared these two systems?	*The rainforest is a lot more complex.* *The rainforest has a lot more kinds of plants than the oil palm farm.* *There are more living things in the rainforest and only a few in the oil palm.* *If something happens to oil palm, it's the only resource in the system for other populations. In the rainforest, there are other resources.*

Define biodiversity and monocrop. Say, *We are noticing that the rainforest system has a lot more populations and connections between them compared to the oil palm system. The oil palm system is mostly just 1 kind of plant that we grow for food. We have two words that may be useful to us in describing the kinds of systems:* biodiversity *and* monocrop. Work with your class to co-construct a definition of *biodiversity* in the context of the tropical rainforest (i.e., a biodiverse system) and the oil palm farm (i.e., a system that lacks biodiversity). Post these new terms to the class Word Wall, and support your students in using them throughout the remainder of this lesson and the unit.



Summarize important science ideas. When you are ready to summarize important takeaways, transition to **slide J**.

Suggested prompt	Sample student responses
Why can the rainforest systems tolerate some disruptions that affect plants while the oil palm system cannot?	*If a disruption happens, the more connections there are, the less likely it is to have big problems.* *If there are more connections, that means there are other food sources that animals can use if one food source goes away.* *If there are not many populations or not many interactions, then the whole system is affected when there's a disruption.*

Suggested prompt	Sample student responses
What were some differences we noticed between the tropical rainforest and oil palm farm that may be important if we want to design better ways to farm?	*We should plant more than one kind of plant.* *We should farm more than one kind of crop.* *We should make our system more like the rainforest, so if there's a problem, not everything dies.*

Assessment Opportunity

Building towards: **13.A** Use a model to make predictions and test ideas about how disruptions, or changes, to one part of the system affect populations throughout the system.

What to look/listen for: See the Key Ideas above.

What to do: If students are struggling to make predictions about what will happen to populations, have them use a highlighter to draw attention to the first population that is affected (e.g., oil palm) and then trace any interaction lines to other populations that would be affected. This will help students see the ripple effects in the tropical rainforest and how those effects are more consequential in the monocrop oil palm farm. If students are struggling to use Stability and Change in this context, ask them to generate ideas for the kinds of data they would want to see to decide (1) if the disruption resulted from a gradual or sudden event, (2) if the impacts from it were short-lived or long-term, and (3) how focused or widespread the disruption was for the system.

5. Assign home learning.

3 MIN

Materials: None

Assign students to notice some examples of biodiverse plant communities and plant communities that are more like monocrops in their lives (at home or school). Display **slide K**. Assign students to be more aware of and notice the plants in their lives. Ask them to identify examples of where they see biodiverse plants or plants that are more like monocrops. They can photo document these examples to share with the class.

If your students need help getting started, you may want to brainstorm a few ideas as a class. Ask students, *Where do we have plants around our school, home, and communities?* Listen for examples like:

- *Lawns and landscaping at home or school*
- *Plants in front of buildings*
- *Trees planted along a street*
- *No trees at all—just concrete or pavement*
- *Gardens*
- *A schoolyard*
- *Parks*

- *River trails*
- *Fields near our school*

End of day 1

6. Share home learning.

5 MIN

Materials: None

Have students turn and talk about their home learning. Display **slide L**. Allow students 1-2 minutes to share what they noticed in their communities, responding to the first two prompts on the slide.

- Where did you observe biodiverse plants?
- Where did you observe plants like a monocrop (or single plants of the same kind)?

Bring students back together to share and discuss, transitioning to the third prompt on the slide.

Suggested prompt	Sample student responses
Why do you think humans prefer monocrop/single plant types in some places instead of more diverse plants?	*They are easier to take care of.* *They might look good.* *People may like that one kind of plant.* *People want the plants to look a certain way and not too messy.*

7. Create a summary chart of key takeaways.

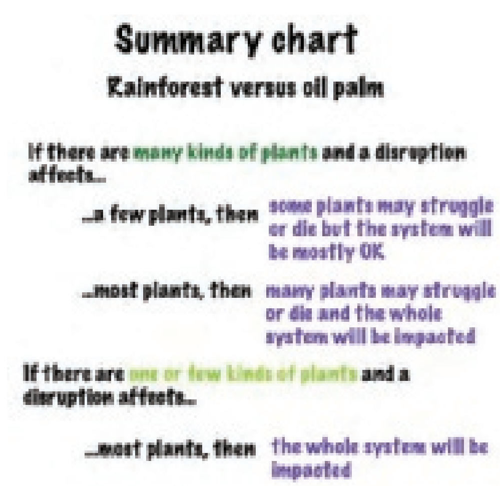
5 MIN

Materials: Summary chart (prepared in advance), markers

Say, *So we're noticing that people tend to like single plants because of the look or ease of caring for them, but what did we learn yesterday about the potential problems this could have for biodiversity?* Display **slide M**.

Summarize key ideas using cause-and-effect sentence structures. On a class chart or whiteboard space, record important summary ideas as a class. Focus on ideas about how the diversity of plants in a system makes the system "healthier" or more resilient to some disruptions.

Say, *These seem like useful ideas for designing farms, but also for thinking about the plants we have around our own community. We're making some general statements here. We should test these ideas on a different case to see if they are useful for explaining more than what we are observing with tropical rainforests and oil palm.*



8. Apply to a new case: the willow flycatcher.

18 MIN

Materials: *Southwestern Willow Flycatcher System Model*, paper squares (prepared in advance)

Introduce the southwestern willow flycatcher case. Say, *This new case comes from North America. This is a real case, with a real debate happening among scientists and community members. We're going to work on this case together to understand what is happening in this new place; then you'll have a chance to apply these ideas on your own.*

Display **slide N**. Read the background information about the southwestern willow flycatcher. Then display **slide O** and read about the trees it uses for nests. Pause to share what students notice from the two system models.

Suggested prompt	Sample student responses
What changed for the flycatcher when tamarisks were introduced?	*It has more places for shelter or to build nests.* *Some people claimed that it prevented the other trees, like willows, from growing, so the flycatcher might not be able to build homes there anymore.*

Introduce the tamarisk beetle to the system model. Display **slide P**. Read about the use of the tamarisk beetle to control the tamarisk.

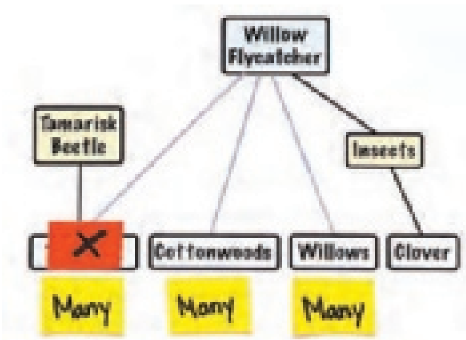
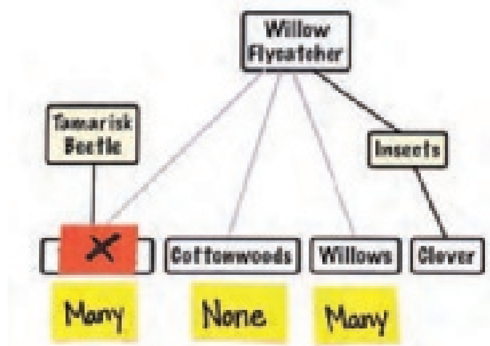
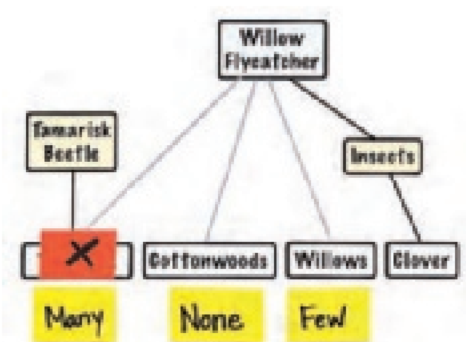
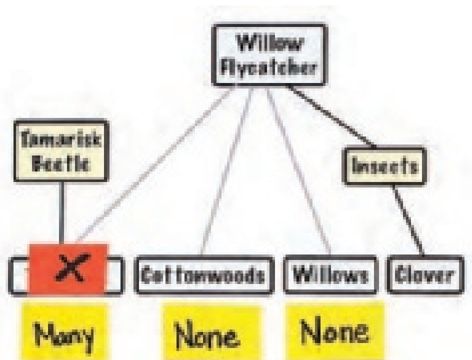
Suggested prompt	Sample student responses
What do you predict will happen to the system with this new beetle?	*It will kill the tamarisk.* *It will take away a place for the flycatcher to build their nests.* *If the willows and cottonwoods don't come back quickly, there might be a problem.*

Slide Q can be used to show students what happens to the tamarisk once beetles are introduced.

Analogy map the new system model to the rainforest system model. Display **slide R**. Engage students in noticing what is similar or different between the two system models. Listen for ideas such as:

Similar	Different
The Flycatcher needs a lot of plants. There are plants on the bottom of the model. Then there are plant eaters on the next level up. There are predators on the top of the model. They are the same colors we were using with the rainforest. The model shows food interactions. The model shows shelter interactions. The up and down arrows show how populations are changing.	The Flycatcher has a lot of plants for shelter. The Flycatcher has only 1 food source. We're adding something instead of taking something away. We're trying to kill a plant.

Arrange students in small groups to predict impacts. Display **slide S**. Arrange students in partners. Pass out 1 copy of the *Southwestern Willow Flycatcher System Model* handout to each pair of students. Give each set of partners paper squares with the labels “many,” “few,” “none,” and “X.” Have students use the squares of paper with labels to set up the four scenarios. Remind them to discuss what they predict would happen to the flycatcher population in each scenario. If needed, complete one scenario as a whole group before partners break to work through the other three scenarios.

Scenario #1: Mix of tamarisks, willows, cottonwoods	Scenario #2: Mix of tamarisks, willows, no cottonwoods
	
Scenario #3: Mostly tamarisks, few willows, no cottonwoods	**Scenario #4: Tamarisk only**
	

Bring small groups back together to discuss the scenarios.

Suggested prompts	Sample student responses
What did we figure out in each scenario?	*The flycatcher will probably do OK in places where there are willows and cottonwoods because there are other places to build homes when tamarisks die.* *Where there is mostly tamarisk or only tamarisk, we think the flycatcher population will go down or they'll have to move somewhere else.* *We weren't certain about the location with only tamarisks and willows because we think the flycatcher can build nests in willows, but we were not sure there would be enough willows.*
In this case, there were two disruptions—one gradual with the tamarisk growing over time, one sudden with the release of the beetle. What new or different ideas can we add to our summary chart?	*If it's gradual, there may be time for populations to get used to the new change.* *If it's sudden, there may not be enough time to get used to the change.*

9. Individual Assessment: The Willow Flycatcher

12 MIN

Materials: *Southwestern Willow Flycatcher, Scoring Guidance: Southwestern Willow Flycatcher*

Introduce the two data sites. Display **slide T**. Introduce the two sites where scientists have collected data on the southwestern willow flycatcher. St. George is a site with mixed tamarisks and willows (similar to scenario 2), and Mormon Mesa is a site with mostly tamarisks and a few willows (similar to scenario 3). Have students identify the corresponding scenario before proceeding.

Introduce the individual assessment. Display **slide U.** Pass out 1 copy of *Southwestern Willow Flycatcher* to each student. Allow students to keep *Southwestern Willow Flycatcher System Model* as a resource for the assessment. You may need to pass out another copy to each partner or display the model on a slide for the class to reference.

Say, *There are data on the willow flycatcher population from each of these sites. Think about the predictions you made with your group, and compare those predictions to the actual data. First, you'll spend time making observations from the data. Then you'll use the data to write an argument to support a claim.*

Encourage students to use pictures and words, or other modalities, to communicate their understanding as they complete the assessment.*

***Attending to Equity**
This assessment encourages students to demonstrate their understanding of key skills and concepts from the unit so far through multiple modalities, including analyzing and annotating data and writing arguments to support claims. Some students may benefit from using multiple modalities to share their thinking for any or all of the questions in this assessment. In each case, encouraging students to use multiple modalities to share their thinking creates a clear, accessible, equitable pathway for all students to demonstrate proficiency. Sharing orally may be particularly beneficial for some students.

10. Navigation: Monocrop Oil Palm

5 MIN

Materials: chart paper, markers

Record what we know about monocrop oil palm. Display **slide V.** Say, *We're going to start designing new kinds of farms soon, and we want our designs to work for both orangutans and farmers. We just figured out that the oil palm farms could be risky for farmers and other living things if there is a disruption, so we probably want to consider other kinds of farm designs. But to have a comparison, let's summarize what we know about these monocrop oil palm farms.*

As students share, record a list of what they describe. Listen for:

- Large-scale farms
- Clearing large areas of land
- Only growing one kind of crop—oil palm
- Bringing money to the farmers there, even though some people aren't paid well
- Using workers and technology to make, grow, or harvest crops

If students don't mention the above, you may need to remind them of the different artifacts they've seen during the unit, such as the palm oil reading in Lesson 1, palm oil video in Lesson 2, interviews with farmers in Lesson 4, and so on.

Additional Guidance

If not made explicit prior to this moment, now is the time to record what students know about large-scale, industrial oil palm farms. Students will need a clear understanding of monocrop oil palm farming so they can compare it to the alternative farming and food-growing approaches they will investigate in the next lesson.

Say, We have this one kind of farming that's already happening, but we know this isn't working well. We've been wondering if we can do this better. Let's pick up there in the next class to see what we can do to make farms healthier places for people and other living things.

ADDITIONAL LESSON 13 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.

Students work with partners and as a whole group to collaboratively discuss and develop their thinking about disruptions, biodiversity, and monocrop systems. These discussions require students to share their ideas, reflect on others' ideas, and modify their own views when warranted to come to a consensus.

LESSON 14

Are there ways people can grow food without harming the tropical rainforest?

Previous Lesson

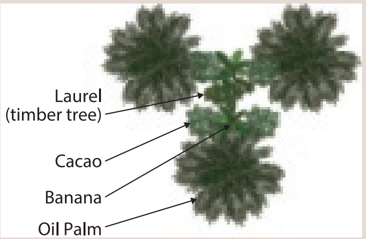
We wondered how the rainforest system changes if the fruit populations change. We made predictions and tested ideas using our rainforest and oil palm system models. We figured out that the rainforest system can withstand some disruptions, but the oil palm system cannot. We applied these ideas to a new case and completed a short individual assessment. We summarized what we know about monocrop oil palm farming to motivate us to design a better way to farm it.

This Lesson

Investigation

1 DAY

From above



We review our ideas about how to grow food in ways that don't harm living things and wonder if people actually use any of these approaches. In groups of three, we read about one of the following approaches: (1) diversified farming, where farmers grow multiple crops together; (2) sustainable oil palm, where farmers don't clear forested areas and include wildlife habitat on the farm; and (3) Customary Forests, where people cultivate and harvest plants from forests. We discuss in our groups how these approaches help populations in ecosystems and prepare to share what we learned with our peers. We wonder if and how people benefit from these approaches.

Next Lesson

We will hear from some people that they use approaches to growing food that differ from large-scale monocrop farming because of the benefits they receive from ecosystems. We will also learn that some people choose these strategies to support biodiversity and ecosystem health. We will wonder which approach might work best for people, plants, and animals, and why.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

14. A Critically read scientific texts to obtain information about how different ways to grow food (cause) can have a positive impact on populations in ecosystems (effect).

What Students Will Figure Out

- There are multiple ways communities grow food while also helping populations in ecosystems.
- Diversified farming involves growing multiple crops together.
- Sustainable oil palm farms do not clear forested areas and incorporate wildlife habitat on their farms.
- Villages with Customary Forest permits cultivate and harvest food, medicine, and craft plants from within the forest that they can use and sell.

Lesson 14 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**NAVIGATION** Review students' ideas about ways to grow food that won't harm living things. Motivate a need to learn more about approaches that people actually use in the real world.	A-B	
2	25 min	**OBTAIN INFORMATION ABOUT DIFFERENT WAYS TO GROW FOOD** Have students individually read about one way to grow food that supports populations in ecosystems. Then have students discuss this approach together in small groups.	C-E	*Two-Column Notes*, *Summarizing ways to grow food*, *Reading: Diversified Farming in Costa*, *Reading: Sustainable Palm Oil in Indonesia*, *Reading: Customary Forests in Indonesia*
3	7 min	**UPDATE INDIVIDUAL PROGRESS TRACKERS** Have students answer the lesson question for the approach to growing food that they researched in their small groups.	F	
4	5 min	**NAVIGATION** Have a few students share their thoughts on the approach they read about, along with their ideas about who might use these approaches. This will motivate an investigation into if and how people benefit.	G	

End of day 1

Lesson 14 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide  Student Work Pages 	• *Two-Column Notes* • *Summarizing ways to grow food* • *Reading: Diversified Farming in Costa Rica* • *Reading: Sustainable Palm Oil in Indonesia* • *Reading: Customary Forests in Indonesia*		

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.

Online Resources

Lesson 14 • Where We Are Going and NOT Going

Where We Are Going

This lesson begins a three-day jigsaw over Lessons 14, 15, and 16. In Lessons 14 and 15, students work in small groups to obtain information about one way to grow food and how it supports populations in ecosystems (Lesson 14), along with how people benefit from this approach (Lesson 15). They then communicate and synthesize information about each approach across jigsaw groups in Lesson 16.

The content of this lesson should expand students' understanding of agricultural practices designed to support biodiverse ecosystems. Up to this point in the unit, students have only encountered large-scale monocrop farming systems. This lesson will help students better understand alternative farming strategies, which they may want to apply to their palm farm designs in Lesson 17.

This lesson also engages students in considering how humans design systems with positive impacts on populations in ecosystems. This focus can balance some of their concerns that humans only negatively impact ecosystems when we make changes to the biosphere. To do this, students use the lens of Cause and Effect. Students will identify cause-and-effect relationships between different ways to grow food and how they positively impact populations in ecosystems. Because students are not using these relationships to make predictions, this lesson is an opportunity to reinforce a fifth-grade Cause and Effect element: *Cause-and-effect relationships are routinely identified, tested, and used to explain change*. The scaffold provided to students supports them in critically reading text to identify central ideas and supporting details.

Where We Are NOT Going

Students will share briefly at the end of the lesson about their approach to growing food and who it may or may not work for and why. This motivates the question "How would people benefit from these different approaches?," which students will answer in Lesson 15. Students do not share in mixed jigsaw groups in depth until Lesson 16. This is also when they will complete the remaining rows on their *Summarizing ways to grow food* handout (providing information on other ways to grow food).

1. Navigation

8 MIN

Materials: None

Brainstorm about some ways to grow food that support plant and animal populations.* Display **slide A**. Say, *We want to be able to grow oil palm in ways that support plant and animal populations. If tropical rainforests are better systems for living things and more resilient to disruptions than large-scale monocrop oil palm farms, how can we make our farms more like them?*

Suggested prompt	Sample student responses
How can we grow food in ways that might help plants and animals?	*Plant more crops together.* *Stop cutting down the forest for farms.*

Review some student ideas for how to improve ways of growing oil palm for plant and animal populations. Have a few students share the ideas they discussed at the end of the previous session. Then, consider how to investigate approaches to growing food that support populations in ecosystems. Display **slide B** and have students discuss in pairs and then as a class.

Suggested prompts	Sample student responses
Are our ideas for what to do realistic?	*Maybe—we're not sure.*
How could we investigate real ways that people grow food that don't harm orangutans or other populations in ecosystems?	*Research it.* *Read about it.*

***Attending to Equity**
This is an opportunity to leverage students' prior knowledge and experiences with different approaches to growing food. Prompt students for different kinds of farming approaches they are familiar with, as well as any smaller-scale gardening approaches that might apply to larger farming operations.

2. Obtain information about different ways to grow food.

25 MIN

Materials: *Two-Column Notes, Summarizing ways to grow food, Reading: Diversified Farming in Costa, Reading: Sustainable Palm Oil in Indonesia, Reading: Customary Forests in Indonesia*

Revisit and share questions from the DQB related to growing food without harming animals. Say, *Some of you were curious about what we can do about the problem. We know we need to grow food, but we want to protect animals and the forest at the same time.*

***Attending to Equity**
Universal Design for Learning: While the scientific information in each of these readings is equally rigorous, they are written at different reading levels to support differentiation. Group students strategically so that students who need more support with scientific

Suggested prompt	Sample student responses
What questions from our DQB relate to this problem?	*Are there ways people can grow food without harming the tropical rainforest?* *Are there ways to grow the oil palm without cutting down all the trees/destroying the forests?* *Can we grow oil palm and protect forests at the same time?* *How can people grow food and protect forest plants and animals at the same time?*

Co-create the lesson question and set a purpose for reading: Discuss a lesson question similar to: *Are there ways people can grow food without harming the tropical rainforest?* Set answering this question as a purpose for reading. Students will each explore one approach that will help them answer this question.

Introduce the jigsaw and the purpose for reading. Display **slide C** and **slide D**. Divide students into groups of three. Assign all of the students in each group the same approach to read about.*

Individually read about different ways to grow food that support animal populations. Distribute *Two-Column Notes**, *Reading: Diversified Farming in Costa*, *Reading: Sustainable Palm Oil in Indonesia*, and *Reading: Customary Forests in Indonesia** (printed for students so they can mark up the text) to each student. Alternately direct students to the corresponding reading in their Student Edition book. Give students 15 minutes to read, marking up their copy and filling out the *Two-Column Notes*.

Identify central ideas about one approach to growing food in small groups. Display **slide E.** Distribute *Summarizing ways to grow food*. Give students 10 minutes to share and identify the important ideas about the approach to growing food that they all read about. Have students take notes on *Summarizing ways to grow food*. Have students add ideas from their group that all read the same material so they are prepared to communicate when they get into mixed groups in Lesson 16.

Additional Guidance

There are two copies of the reading. One copy is the color copy located in the back of the Student Edition behind the reading section. The other copy is a handout to download and print. If you want students to mark the text, they can use the handout version. Otherwise, students can read the text using their Student Editions.

Assessment Opportunity

***Building towards:* 14.A** Critically read scientific texts to obtain information about how different ways to grow food (cause) can have a positive impact on populations in ecosystems (effect).

What to look/listen for:

- Students describing the approach to growing food that they read about and how it differs from large-scale monocrop farming.

texts are distributed among mixed-expertise groups assigned readings of grade-level complexity, while students who are looking for a challenge are in groups assigned readings at a higher level.

- *Reading: Diversified Farming in Costa*, Flesch-Kincaid Grade Level 6.1
- *Reading: Sustainable Palm Oil in Indonesia*, Flesch-Kincaid Grade Level 7.4
- *Reading: Customary Forests in Indonesia*, Flesch-Kincaid Grade Level 8.7

***Supporting Students in Three-Dimensional Learning**

Students critically read one text and, with their group, identify central ideas and supporting details about how human-designed systems impact populations in ecosystems. Students identify cause-and-effect relationships between how one way to grow food positively impacts populations. *Two-Column Notes* helps students identify central ideas, and *Summarizing ways to grow food* supports students in drawing causal links between ways of growing food and their respective impacts in ecosystems.

***Attending to Equity**

Customary Forests are one approach to cultivating food that students explore in this lesson.

- Students explaining how their approach to growing food supports populations in ecosystems, either orangutans specifically or other insects, birds, and mammals.
- Students summarizing from the text the main farming approaches in each case: (1) planting multiple crops, (2) setting aside and protecting intact forested areas, and (3) cultivating food from the forest.
- Students linking each approach to growing food to an effect on a forest population.

What to do: (1) If students struggle to obtain information from their reading, have them do paired reading. Have both students read one paragraph of text silently. Next, have one student summarize the main ideas. The partner must then agree or disagree and say why. Once students agree, each partner takes a turn identifying details that support the main idea. Then they read the next section quietly. (2) If members of a group struggle to identify their approach to growing food, pair them with another group who read about the same approach and have them compare notes. Prompt them for evidence from the text to support their summaries.

This involves intentionally tending plants and animals in the forest for food, medicine, and crafts. It is a way of life for Indigenous peoples around the world. Tending the wild requires deep ecological knowledge and wisdom that is distinct from western science. It continues to be practiced today, especially in places where Indigenous communities have land rights and tribal sovereignty. If some (or all) of your students are from Indigenous communities, give them an opportunity to share their cultural and ecological knowledge. If not, this is an opportunity to highlight Indigenous peoples in our communities and learn about their ways of life. Learn more about traditional ecological knowledge:

- PBS Tending the Wild Series:
- Science Magazine, "Forest Gardens": (See the **Online Resources Guide** for links to these items. **www.coreknowledge.org/cksci-online-resources**)

3. Update individual Progress Trackers. 7 MIN

Materials: None

Update individual Progress Trackers for reflection. Explain to students that we want to take some time to capture what we have figured out from the reading that helps us answer our question: "How can we grow food in ways that might help plants and animals?"

Have students turn to the Progress Tracker section in their science notebooks. Use **slide F** to guide students in drawing a line after the last entry from Lesson 14 and to complete the 2 columns, filling in the lesson question and their responses.

Give students 3-5 minutes to quietly update their Progress Trackers individually for the case they explored, using words and drawings to show what they have figured out. Prompt students to use evidence from their readings to answer the lesson question.

After students update their Progress Trackers individually, give them 3-5 minutes to discuss the lesson question with their group and to add to their Progress Trackers as needed. Ask students to draw a line underneath their responses when they are done discussing the lesson question with their groups.

4. Navigation

5 MIN

Materials: None

Have one student from each reading share briefly about the way to grow food they read about.

Display **slide G.**

Problematize if and how these approaches work for the people and discuss them as a class. Encourage students to consider that while these approaches seem better for animals, they may or may not be in the best interests of people growing food. Consider if people could make a similar living if they have less land to grow oil palm on or are growing fewer oil palm plants.

Suggested prompts	Sample student responses
Describe the way of growing food that you investigated.	*Sustainable oil palm farming involves not clearing forests and growing wildlife habitat.* *Diversified farms plant several different kinds of crops.* *Customary Forests grow and harvest food and other plants from the forest to eat and sell.*
Why might someone want to use this approach?	*Maybe it helps their crops somehow.* *Maybe they can get more money for sustainable oil palm.* *Maybe protecting the forest is more important to them than making money.*
What might not work for them?	*They might not make as much money with less land.* *It might be hard to harvest the crops.*
Which kinds of farmers or people might this approach work best for? Why?	*Customary Forests only work for small villages.* *Diversified farming can work for large or small farms.* *Sustainable oil palm seems like mainly bigger companies.*

ADDITIONAL LESSON 14 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-Literacy.RI.7.2: Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.

In this lesson, students must provide a summary for the text and call out the central ideas in the text to build their understanding of different ways to grow food that support populations in ecosystems.

LESSON 15

How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?

Previous Lesson

We read about one of the following ways to grow food: (1) diversified farming, where farmers grow multiple crops together; (2) sustainable oil palm, where farmers don't clear forest and include wildlife habitat on farms; and (3) Customary Forests, where people cultivate and harvest plants from forests. We discussed how these approaches help populations in ecosystems and wondered how people benefit from them.

This Lesson

Investigation

1 DAY

Orangutan conservation

We examine three StoryMaps that present various perspectives on the approaches to growing food explored in Lesson 14. We notice that people using approaches that differ from large-scale monocrop farming receive benefits from ecosystems, including protection from disruptions such as disease and pests. They may earn more money, too. We also learn that some people choose these strategies to support biodiversity and ecosystem health. We wonder which approach might work best for people, plants, and animals, and why.

Next Lesson

We will jigsaw to synthesize information about different approaches to growing food, and compare and contrast those approaches in terms of how well they work for people and natural systems. We will rank the approaches on how well they support plants and animals and people. We will discuss the trade-offs between each approach and clarify claims about which approach we think will work best. We will brainstorm how to test claims in a simulation.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

15.A Critically read text and listen to interviews to obtain information about how people receive ecosystem services from farming practices that also maintain and promote stability in natural systems.

What Students Will Figure Out

- Diversified farming like intercropping helps farmers have stable incomes if diseases, pests, or storms hurt one crop, but not the other(s).

- Sustainable oil palm farms maintain healthy soils that help improve harvests, which means more income for farmers.
- Customary forests provide people with stable food, water, and materials, and protection from landslides.

Lesson 15 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review three approaches to growing food that differ from monocropping. Identify the need to figure out how people benefit from these approaches.	A-C	
2	30 min	**HEAR FROM PEOPLE USING DIFFERENT WAYS TO GROW FOOD** In groups, explore one of three StoryMaps that include text and video interviews with people who explain how they benefit from growing food in ways that differ from monocropping.	D	Different Approaches to Growing Food StoryMap, *Two-Column Notes*, *Summarizing ways to grow food*, internet-connected device for groups of 2-3 students, computer and projector
3	10 min	**NAVIGATION AND PROBLEMATIZE** Share what we learned from the interviews. Discuss which approaches are best for people to motivate a discussion into which approach is best for everyone (people, animals, and plants).	E	

End of day 1

Lesson 15 • Materials List

	per student	per group	per class
Lesson materials Student Procedure Guide Student Work Pages	• science notebook • Different Approaches to Growing Food StoryMap • *Two-Column Notes* • *Summarizing ways to grow food*	• internet-connected device for groups of 2-3 students	• computer and projector

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.

Online Resources

If you have access to computers or tablets for students in groups of 2-3, practice opening the *Different Approaches to Growing Food.* (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) There are three tabs:

- *Diversified Farming*
- *Sustainable Palm Oil and Prairie Strips*
- *Customary Forest*

Review the StoryMaps so that you know how to help students navigate them and the embedded videos, texts, and maps.

If you do not have access to computers or tablets, consider the following options or a combination of them:

1. Have students use their personal devices to view their assigned StoryMap.
2. Use the print-based alternatives: *Diversified Farming Cases*, *Sustainable Palm and Prairie Strip Cases*, and *Customary Forests*. If you choose to use these materials, you may need to allow more time for reading. These materials are located in the Reference section of the *Student Edition* and can be printed as handouts for students to annotate and attach to their science notebooks.

If you live in a farming community, consider extending student learning of prairie strips. This is particularly relevant to students in the upper Midwest. The following resources can be used to provide you background knowledge:

- STRIPS at Iowa State University. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

For more information on Customary Forests use the following resources (See the **Online Resources Guide** for links to these items. **www.coreknowledge.org/cksci-online-resources**):

- Gunung Palung Orangutan Conservation Program:
- Tropenbos International
- Tropenbos Indonesia

Lesson 15 • Where We Are Going and NOT Going

Where We Are Going

Lesson 15 is day 2 of a three-day jigsaw that occurs over Lessons 14, 15, and 16. In Lesson 14, students read about three approaches to growing food and figured out that using diversified farming strategies, not cutting down forests, including native habitat in and around farms, and tending the wild with customary forest permits seem to work really well for the plants and animals in nearby ecosystems. In this lesson, students will investigate the same approaches but with a new lens. They will examine StoryMaps that provide the perspectives of various people and the reasons why they choose to grow food in ways that differ from large-scale monocropping systems.

Through critically reading and listening to interviews (SEP: Obtaining, Evaluating, and Communicating Information) and summarizing central ideas from text and videos, students will figure out these things:

- Diversified farming like intercropping helps farmers have stable incomes if diseases, pests, or storms hurt one crop, but not the other(s).

- Sustainable oil palm farms maintain healthy soils that help improve harvests, which means more income for farmers.
- Customary forests provide people with stable food, water, and materials, and protection from landslides.

These important ideas will build toward understanding of the following DCIs that will be further solidified in Lesson 16:

- LS2.C: Ecosystem Dynamics, Functioning, and Resilience: Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- LS4.D: Biodiversity and Humans: Changes in biodiversity can influence humans' resources, such as food, energy, and medicines; changes in biodiversity can influence ecosystem services that humans rely on—for example, water purification and recycling.

Additionally, this lesson will build toward understanding of the crosscutting concept of Stability and Change and connect that to the idea of disruptions (continued from Lessons 12 and 13). As students learn about reasons why farmers switched from monocropping approaches, they will deepen their understanding that the stability of a farming system can be disturbed by either sudden or long-term events. Sudden events like landslides, crop diseases, storms, or market price changes can impact what is available to harvest, which affects people's income. Gradual cumulative changes like poor soil health from nutrient depletion or soil erosion can impact how crops grow, which also affects income. Therefore, for both designed systems (e.g., farms) and natural systems (e.g., customary forests within tropical rainforests), conditions that affect stability can change the amount of resources available for animals, plants, and humans.

Toward the end of the lesson, students will have a discussion and pose questions focused on the extent to which people using the approaches the class has studied could continue to earn an income if faced with a disease or pest problem. They will also consider what benefits are the most important and for whom. This discussion will motivate students to wonder about which of the benefits really matter.

Lesson 16 will engage students in considering tradeoffs, and whether and how each approach benefits everyone: plants, animals, and humans. This will set students up for Lesson 17, when they will name their criteria for their final farm designs and start designing better farming systems.

Where We Are NOT Going

By the end of the lesson, students will understand ways that both animals and people can benefit from approaches to growing food that differ from large-scale monocropping systems. But at that point, students will only briefly share what they learned about the ways people benefit and what benefits are the most important and for whom. Similar to what students learned in Lesson 4, it is important to consider people's needs and their available resources because many people's well-being is integrally tied to, for example, the tropical rainforests in Indonesia. Maintaining biodiversity is important for humans, as well as for plants and animals; however, we will not explicitly support students in making these connections until after they share in mixed jigsaw groups on day 1 of Lesson 16.

This lesson builds toward student understanding of ecosystem services, which we will solidify in Lesson 16. Although we focus on the conceptual understanding of the varied resources and functions that humans get from ecosystems, we do not explicitly call out the vocabulary term "ecosystem services." If you would like to add this term to the Word Wall, be sure to wait to do so until after they have developed this conceptual understanding.

1. Navigation

5 MIN

Materials: None

Review ways to grow food and who benefits. Project **slide A**. Remind students that during the last class, we wondered what approaches to farming help populations in ecosystems. For each of the three approaches we read about, ask a student to remind the class of the approach and who benefited.

Project **slide B**. Say, *It sounds like animals and plants benefit from the approaches that we read about, but are there any benefits to people? We thought maybe so, but we weren't quite sure.* Ask students to share ideas about why people would use these approaches to grow food to benefit plants and animals.

Suggested prompts	Sample student responses
Why do you think people would grow food in ways that differ from monocropping if only the animals benefit?	*It makes them feel better.* *They care about the animals and plants.* *They want to save the environment.*
Why would someone want to use these approaches other than to benefit animals?	*Maybe it helps their crops somehow.* *Maybe they can get more money for sustainable palm oil.* *Maybe they want to protect the forest more than make money.*

Brainstorm ways to investigate our predictions. Project **slide C**. Ask students to briefly turn and talk with a partner to discuss how the class can figure out why people would choose these approaches if they only benefit plants and animals. Then ask a few students to share their ideas.

Suggested prompt	Sample student responses
How could we figure out why people use these approaches?	*We could listen to interviews with farmers describing their reasons for intercropping.* *We could talk to community members who live in Indonesia and ask them why they decided to create a customary forest.*

Come to an agreement as a class that we need to hear from people who grow food and learn what their reasons are for choosing an approach that is different from large-scale monocrop farming, and to figure out whether or how people benefit.

2. Hear from people using different ways to grow food.

30 MIN

Materials: science notebook, Different Approaches to Growing Food StoryMap, *Two-Column Notes*, *Summarizing ways to grow food*, internet-connected device for groups of 2-3 students, computer and projector

Introduce the StoryMaps. Project **slide D** and remind students that the question we are trying to answer is "How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?" Have students reconvene in their Lesson 14 groups. Assign each group the StoryMap tab that matches the approach they read about in Lesson 14 (diversified farming, sustainable palm oil, or customary forests).

Alternate Activity

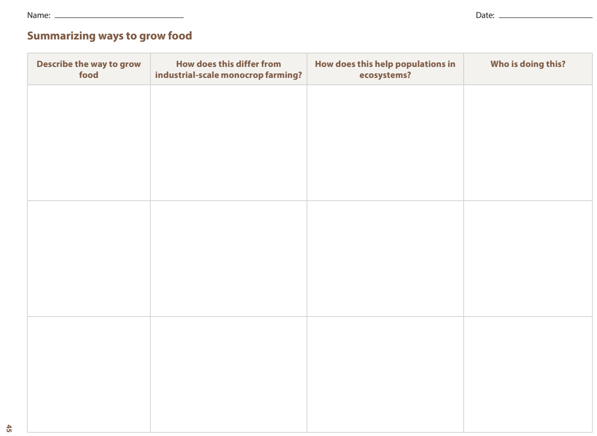
If you do not have enough computers or devices for students to work in groups, there are two alternative ways to facilitate this activity: (1) have students use their personal phones or other internet-connected devices to view their StoryMap, or (2) use the text-based versions of the materials. See the preparation section of this lesson for more information.

View StoryMaps in groups. Distribute *Two-Column Notes* to each student.* Give students the *Different Approaches to Growing Food StoryMap*. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Give groups 15 minutes to read the text and listen to the videos in their StoryMaps.

As students work, circulate among groups to check on their progress. Use prompts like the following to help students focus on what the people are getting from the farming systems. In particular, prompts focused on stability and change could be useful:

- *What kind of event happened to this farmer or community that caused them to want a change? Was the event sudden? Was it something that was gradual over time?*
- *What are the people naming as something important they get by farming this way?*
- *Are people getting something from the ecosystem that is not related to money?*
- *What are people concerned about protecting themselves from in the future?*

Share and synthesize benefits people receive from each approach to growing food.* After 15 minutes, have students add a column on the right-hand side of the table they used in Lesson 14, *Summarizing ways to grow food*, and label the column "Benefits people receive". Give students 10 minutes to synthesize the important ideas about benefits people receive that they learned from their StoryMap and take notes on this in the new column. Have them also add ideas from their group that they want to share when they gather in mixed groups in Lesson 16.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Summarizing ways to grow food

Describe the way to grow food	How does this differ from industrial-scale monocrop farming?	How does this help populations in ecosystems?	Who is doing this?

***Attending to Equity**

Supporting Universal Design for Learning: There are three StoryMaps, and each group of 2-3 students will explore one. Students first used StoryMaps in Lesson 7 to figure out how many orangutans typically live in intact tropical rainforests. The StoryMaps in this lesson combine several representations (maps, text, audio, and videos) to help students further explore the same approaches to growing food that they read about in Lesson 14.

Some of the videos in the StoryMaps are subtitled. We have embedded one strategy to help students follow the text: we remind them that they can pause the video at any moment to read. As they view these videos, consider walking around and reminding them that they can pause and that there is also an option to slow the video: click on the gear icon in the lower right side of the screen, then click on "playback speed" and choose a speed that is 0.75 or less. To return to regular speed, click on "normal."

Supporting Universal Design for Learning: The scientific information in each StoryMap is equally rigorous, but the printed text is written at different reading levels to support differentiation.

- Diversified Farming - 810-1000 L
- Sustainable Palm Oil - 975-1025 L
- Customary Forests -1010-1200 L

Assessment Opportunity

Building towards: **15.A** Critically read and listen to text to obtain information about how farmers receive ecosystem services from farming practices that also maintain and promote stability in natural systems.

What to look/listen for:

- descriptions of why people grow foods or save forests in ways that benefit their families and communities
- descriptions of why people benefit more from these strategies than those who large-scale monocrop

What to do: If members of a group struggle to synthesize how people benefit from their approach to growing food, pair them with another group who viewed the same StoryMap and have them compare notes. Prompt them to identify evidence from the StoryMap to support their summaries.

*Supporting Students in Three-Dimensional Learning

Students are working toward understanding what ecosystem services are (DCI) and what kinds of disruptions (DCI) might impact stability of a designed or natural system (CCC7) by critically reading and listening to text (SEP8) and viewing video from the perspective of people who use different approaches to growing food. From the interviews with farmers, students will begin to draw the connection between disruptions and ecosystem services: that people can receive services from designed and natural systems, but disruptions can impact the availability of those resources. As student groups explore the StoryMaps and determine the central ideas (SEP8), they should begin to recognize the similarities and differences between large-scale monocropping systems and the other approaches that they are learning about. For example, in intercropped systems, farmers plant more than one crop in a given area so in the event of a disruption, they have another crop they could sell; or, one crop may be more resistant to pests and can therefore make other plants less susceptible to those same pests, allowing both crops to flourish (DCI). Learning about these strategies will be important for helping students to solidify their understandings in Lesson 16 and to develop new criteria for their designed farms in Lesson 17.

3. Navigation and Problematize

10 MIN

Materials: None

Briefly share what we learned from the StoryMaps. Project **slide E**. For each StoryMap, have one student share about the ways people benefitted from the featured approach to growing food.

Problematize which approaches are best for people. Have students discuss, either as a class or through small group or partner talk, what would happen in each of these cases if there were a disruption, such as a disease that kills their plants or a pest that eats their crops. Have them consider whether people would continue to earn an income and whether this is the benefit that really matters.

Suggested prompts	Sample student responses
How did people benefit from the approach to growing food that you investigated?	*The farmer who intercrops did not have to worry about storms destroying his crops. We read that planting some crops also helps the soil and protects from pests.*
Would people continue to earn an income if there were a disease or pest problem?	*Intercropping would help because farmers would have more than one crop to sell if another crop got a disease.* *Customary forests might be okay if there were a pest or disease because there are many plants to use.*
What benefits are the most important and for whom?	*Income is important for people, but also getting food and water is important too.* *Saving habitat is important for animals, but this seems to be important for farmers too, because it protects against floods and other problems.*

Say, *It sounds like these approaches can work for both people and for designed and natural ecosystems, but we may need to make some trade-offs. In the next class, let's share what each group has been finding out and how we can use these approaches to growing food to help us design a better palm farm.*

ADDITIONAL LESSON 15 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

In this lesson, students determine a theme or central idea of a text in order to summarize the benefits of using alternative strategies to farming that are different from monocrop farming. Students must compare text in the StoryMap to information from videos of interviews with farmers. They must also compare and combine information they learn in one context (e.g., oil palm farming) with another context (e.g., prairie strips).

LESSON 16

What approach to growing food works for everyone and why?

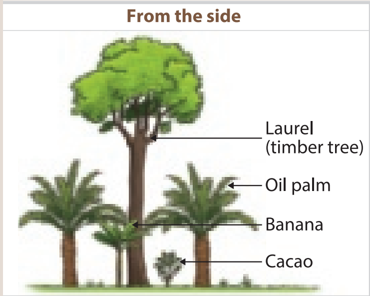
Previous Lesson

We examined three StoryMaps that presented various perspectives on the approaches to growing food explored in Lesson 14. We noticed that people use approaches that differ from large-scale monocrop farming because of the benefits they receive from ecosystems. We also learned that some people choose these strategies to support biodiversity and ecosystem health. We wondered which approach might work best for people, plants, and animals, and why.

This Lesson

Putting Pieces Together

2 DAYS



We summarize what we know about monocropped farms. We jigsaw to synthesize information about different approaches to growing food. This helps solidify the connections between disruptions and the stability of designed and natural ecosystems. We rank how the approaches work for plants, animals, and people. We discuss the trade-offs between each approach and clarify claims about which approach we think will work best. We brainstorm about how to test our claims in a simulation.

Next Lesson

Students will use a computer simulation to redesign the way land is used in Indonesia to support orangutans and people at the same time. Students will evaluate design solutions created by other groups and then optimize their own design solutions. In an assessment, students will evaluate competing design solutions for maintaining or increasing orangutan population sizes and people's income on oil palm farms in Indonesia.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

16.A. Integrate qualitative information obtained from written text and media to clarify claims about farming practices that reduce risk to disruptions and that maintain and promote stability of populations in natural systems.

What Students Will Figure Out

- There are trade-offs in how we approach growing our food: some approaches work better for humans than for animals and plants in the natural ecosystem.
- Some approaches to growing food work for some people and farmers, but not all people.
- We can grow food in ways that minimize the effects of disruptions on natural and designed systems.

Lesson 16 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review that we need to figure out which approaches work well for plants, animals, and humans.	A	
2	10 min	**ADD MONOCROP FARM TO THE TABLE** As a class, add monocrop farms to the summary tables as a comparison to other approaches to growing food.	B-C	*Summarizing ways to grow food*
3	25 min	**JIGSAW TO SHARE APPROACHES WITH A NEW GROUP** Jigsaw what was learned in Lessons 14 and 15 to compare and contrast the different approaches to growing food.	D	*Summarizing ways to grow food*, *Reading: Diversified Farming in Costa*, *Reading: Sustainable Palm Oil in Indonesia*, *Reading: Customary Forests in Indonesia*, *Different Approaches to Growing Food* StoryMap (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**), device with internet access
4	5 min	**NAVIGATION** Students share what they learned and make initial claims about which approach they think is best and why.	E	
				End of day 1
5	30 min	**FACILITATE A CONSENSUS DISCUSSION ABOUT APPROACHES TO GROWING FOOD** Convene a Scientists Circle for a Consensus Discussion to answer the lesson question.	F-H	*Summarizing ways to grow food*, *Best Approaches to Growing Food for Animals, Plants, and People*, six sticky notes with 2 of the same color (example: 2 blue/2 pink/2 yellow), markers, Driving Question Board
6	5 min	**ADD TO THE INDIVIDUAL PROGRESS TRACKERS** Add new ideas to individual Progress Trackers.	I	
7	10 min	**NAVIGATION/PROBLEMATIZE** Introduce simulation and surface claims to test in final farm designs.	J	*Summarizing ways to grow food*, *Best Approaches to Growing Food for Animals, Plants, and People*
				End of day 2
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 16, students are ready to read Student Reader Collection 5 and then respond to the writing exercise.		Student Reader Collection 5: *Valuing Ecosystems*

Lesson 16 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• *Summarizing ways to grow food* • *Reading: Diversified Farming in Costa* • *Reading: Sustainable Palm Oil in Indonesia* • *Reading: Customary Forests in Indonesia* • *Best Approaches to Growing Food for Animals, Plants, and People* • six sticky notes with 2 of the same color (example: 2 blue/2 pink/2 yellow) • markers • science notebook	• *Different Approaches to Growing Food* StoryMap (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • device with internet access	• Driving Question Board

Online Resources

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.

Students may need access to resources from Lessons 14 and 15 as they jigsaw on day 1. Make sure each group has an internet-connected device and access to the *Different Approaches to Growing Food* StoryMap. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) There are three tabs:

- *Diversified Farming*
- *Sustainable Palm Oil and Prairie Strips*
- *Customary Forest*

It will also be helpful for students to refer back to *Reading: Diversified Farming in Costa*, *Reading: Sustainable Palm Oil in Indonesia*, and *Reading: Customary Forests in Indonesia*.

Prepare a large chart or space on the whiteboard for the Consensus Discussion on day 2. Students will rank the approaches using sticky notes. Each student will need 6 sticky notes, 2 each of 3 different colors. Designate 1 color to represent 1's, another color to represent 2's, and the third color to represent 3's. Have markers available for students to write 1, 2, and 3 on their stickies before posting to the class chart.

Lesson 16 • Where We Are Going and NOT Going

Where We Are Going

This lesson is the end of a three-day jigsaw that started in Lesson 14. In that lesson, students worked in expert groups to figure out that people can use approaches to growing food that seem to work better for animals compared to monocrop farming (e.g., diversified farming, sustainable practices for harvesting oil palm, tending the wild in a customary forest). This motivated students to wonder if people can also benefit from those same approaches. In Lesson 15, students remained in their expert groups to see how the approaches they researched in Lesson 14 benefited people. Students recognized that people can benefit financially, and they can also receive other ecosystem services like access to water, materials, and protection from sudden and gradual disruptions. In this lesson, students will jigsaw on day 1 to share with their peers the different approaches they learned about. Day 2 culminates in a Consensus Discussion.

This lesson is a two-day lesson that will lead students to consider the complexity of designing a farming system that will support both orangutans and people. On day 1, as students jigsaw in groups, they will work to integrate qualitative information (SEP: Obtaining, Evaluating, and Communicating Information) about the different approaches to growing food. As they work to integrate information, emphasis should be placed on supporting them in using the language of Stability and Change. A goal of this first part of the jigsaw conversation is to support them in solidifying the connection between disruptions and the availability of ecosystem services in both designed and natural systems.

On day 2, students will rank approaches to growing food for animals and plants, and then do so again for humans, by using sticky notes that represent the "best approach" to the "third best approach." As students discuss why they ranked the approaches as they did, they will use evidence obtained in the jigsaw to support their claims (SEP: Obtaining, Evaluating, and Communicating Information). When they examine patterns in their rankings, they will recognize that there is no one way to grow food that works best for everyone. This will motivate a deeper discussion of the trade-offs involved with the various approaches to growing food. Then, when students are introduced to their final farm design simulation, they will brainstorm what they need to test the claims they made in the Consensus Discussion in their designs.

By the end of this lesson, students should solidify their understanding about the following:

- Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines. (MS-LS2-5)
- Changes in biodiversity can influence ecosystem services that humans rely on—for example, water purification and recycling. (MS-LS2-5)

Where We Are NOT Going

This lesson focuses on motivating students to consider trade-offs with respect to which approaches to growing food might work best for everyone including humans, animals, and plants in natural ecosystems. The design simulation is introduced at the end of the lesson, but students will not design their farms until Lesson 17.

Students will also consider ideas related to the crosscutting concept of Scale with respect to small family farms versus large-scale companies that run large oil palm plantations. The focus of this lesson is on Stability and Change, but supporting students in using Scale is an option that may prove beneficial.

1. Navigation

5 MIN

Materials: None

Recall how these new approaches to growing food benefit people.* Project **slide A**. Ask students to share what they figured out in the last lesson about the question "How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?"

Listen for students to share:

- *Planting more than one crop can help farmers have a stable income if there are diseases, pests, or storms that hurt one crop.*
- *Making sure soil stays healthy can improve harvests, which means more income for farmers.*
- *Establishing customary forests can provide food, water, and materials for people, along with protection from landslides. People can also benefit from tourism.*

Come to an agreement that each of the approaches benefits people in different ways. Say, *We figured out that these approaches to growing food not only benefit plants and animals, but there are also benefits to people too.*

***Supporting Students in Developing and Using Stability and Change**

Support students to use the language of Stability and Change. You might rephrase students' responses to include "sudden changes" or "gradual changes." For example, if a student says *"Customary forests protect people from landslides,"* you might rephrase that to "*It sounds like you are saying that customary forests help protect people from sudden changes to an ecosystem, like landslides."* You might also follow up and ask how sudden or gradual disruptions could influence the availability of resources people receive from ecosystems. Continue to encourage students to discuss the approaches to growing food in terms of disruptions and ecosystem stability throughout the rest of the lesson.

2. Add monocrop farm to the table.

10 MIN

Materials: *Summarizing ways to grow food*

Frame the activity for synthesizing information. Project **slide B**. Tell students that they are now going to share what they learned with other groups to make claims about which approach to growing food they think will work for everyone and to use evidence from the readings and their StoryMaps to explain why. But first, they will do some synthesizing as a class.

Have students add a monocropped farm to their handout. Have students take out their notes from Lessons 14 and 15, which are on the handout *Summarizing ways to grow food*. Tell them to add another row at the bottom and that as a class you will fill out a row about monocropped farms. Ask students to share how they would describe monocropped farms. As a class, reach consensus and have students write the description in the last row under "Describe the way to grow food." An example is provided in the table: *Monocropped farms grow only one kind of plant* (see image below).

Describe the way to grow food	How does this differ from industrial-scale monocrop farming?	How does this help populations in ecosystems?	Who is doing this?	*Benefits People Receive*
Diversified Farming & Intercropping means growing more than one kind of plant together				
Sustainable oil palm plantations cannot clear forests and maintain habitat for plants and animals in near by ecosystems. Prairie steps also maintain habitat for plants and animals				
Customary Forests protect the rainforest from deforestation				
Monocropped farms grow only one kind of plant				

Additional Guidance

Students will already have one row filled out on their handout because they are using the same one they used in Lessons 14 and 15. Following the completion of the "monocropped farms" row as a class, students will work in groups to synthesize the information they learned to complete their handout.

Discuss if and how monocropped farms work for animals, plants, and people. Project **slide C.** Have students turn and talk about the prompts on the slide (also on their handout), and then share out with the whole class. Listen for and draw out ideas that monocropped farming (1) does not work well for many plants and animals, (2) is an approach used by both large-scale and small family farmers, and (3) really only benefits large-scale farmers who have a lot of land to farm for financial gain and ease of harvesting. Reach consensus on responses and have students complete the row.

Describe the way to grow food	How does this differ from industrial-scale monocrop farming?	How does this help populations in ecosystems?	Who is doing this?	Benefits People Receive
Diversified Farming & Intercropping means growing more than one kind of plant together				
Sustainable oil palm plantations cannot clear forests and maintain habitat for plants and animals in near by ecosystems. Prairie steps also maintain habitat for plants and animals				
Customary Forests protect the rainforest from deforestation				
Monocropped farms grow only one kind of plant	________________	It does not help plant and animal populations in the ecosystem because of deforestation	Mostly industrial scale farmers but small family farmers too	Only benifits industrial-scale farmers because if something happens in one area of their land, they have a lot more land that can be harvested

Suggested prompts	Sample student responses	Follow-up questions
How does monocropped farming help populations in ecosystems?	*It hurts animals and plants.* *Trees are cut down to grow oil palm.*	*How does monocropped farming harm animals?* *How does monocropped farming harm plants?*
Who is using a food growing approach like monocropping?	*Large-scale companies that own oil palm plantations only grow oil palm trees.* *Small farmers may only grow one kind of plant.*	*Why do large-scale companies typically monocrop?* *Why would a small family farmer choose to monocrop?*
How does monocropping benefit people?	*Small family farmers may lose their crops to disease.* *Large-scale farms might benefit from money, and it may make it easier to farm and harvest just one crop.*	*What would happen if there was a sudden or gradual disruption? How would that affect large-scale companies? Small family farmers?*

Additional Guidance

Small family farmers may monocrop, despite the risk for disruptions. If this comes up, connect it to Lesson 4 and the farmers and farmworkers who work on large-scale oil palm plantations. Monocropping may be the only approach possible because it is a way to make money, even if it is risky. Also, farm equipment is expensive, and monocropping may be easier because less machinery is required to grow and harvest a single crop. It may be easier because the farmer only has to worry about one kind of crop, and can use the same pest control and fertilizers year after year.

3. Jigsaw to share approaches with a new group. 25 MIN

Materials: *Summarizing ways to grow food*, *Reading: Diversified Farming in Costa*, *Reading: Sustainable Palm Oil in Indonesia*, *Reading: Customary Forests in Indonesia*, Different Approaches to Growing Food StoryMap, device with internet access

Regroup in expert groups to prepare for jigsaw. Give students five minutes to work with their groups from Lessons 14 and 15 to review their notes and prepare to share what they learned about their approach to growing food with other groups. It may be helpful for students to have access to the readings from Lesson 14 (*Reading: Diversified Farming in Costa*, *Reading: Sustainable Palm Oil in Indonesia*, and *Reading: Customary Forests in Indonesia*) and the *Different Approaches to Growing Food* StoryMap. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Display **slide D**. Preview instructions for the jigsaw. Remind students that when they share with their new group members, they need to be specific and cite evidence from their case studies to help their new group members understand the approach. They should also be prepared to answer any clarifying questions.

Jigsaw and share with others what was learned.* Rearrange students into new groups. Groups should include at least one student who read about diversified farming, sustainable palm oil and prairie strips, and customary forests. Students will share their case study with new group members and should record the new information to complete their tables.

Tell students they should be prepared to discuss what they learned with the class when they are done. Give students 20 minutes. An example of a completed jigsaw is available to review, *Jigsaw Notes Example*.

* Supporting Students in Three-Dimensional Learning

In Lesson 15, students were working toward understanding ecosystem services (DCI) and what kinds of disruptions (DCI) might impact the stability of a designed or natural system (CCC7). In this lesson, students are continuing to solidify those connections by discussing the benefits or ecosystem services people can receive from designed (e.g., farms) and natural systems (e.g., customary forests). Importantly, students are integrating qualitative information during their jigsaw activity (SEP8) and should begin to recognize that there are differences in each approach to growing food and the extent to which they benefit people, animals, and plants. This noticing will be further explored on day 2 as students discuss the trade-offs of each approach.

Additional Guidance

This is a good opportunity to remind students that scientists use both qualitative and quantitative information to help them understand a phenomenon or problem. For this activity, they are integrating qualitative information found in text and media to help them better understand the varied approaches to growing food, who they work for, and why.

Assessment Opportunity

Building towards: **16.A.** Integrate qualitative information obtained from written text and media to clarify claims about farming practices that reduce risk to disruptions and that maintain and promote stability of populations in natural systems.

What to look/listen for:

- Students communicating to their peers about how approaches to growing food can support plants and animals in natural and designed systems. Listen for students to connect specific ecosystem services people receive (or not) through farming practices to sudden or gradual disruptions.

What to do: If members of a group are struggling, direct them to review the source information together. They can also check in with another group for information as needed. As groups work, you can circulate to each group to prompt them for evidence from notes and support them in using the language of Stability and Change, and in linking sudden and gradual changes to receiving ecosystem services.

4. Navigation

5 MIN

Materials: None

Share findings about different approaches to growing food. Project **slide E.** Say, *The question we're trying to figure out is, What approach to growing food works for everyone and why? If you had to make a claim right now to answer this question, what claim would you make?* Ask students to share what they think the best approach to growing food is and why. As students share, draw out uncertainty about the approaches as "good" or "bad" for animals, plants, or people.

Say, *It sounds like some approaches are better for people than plants and animals, and that humans tend to be OK with all approaches, unless they are small farmers. Is there an approach that you think works for everyone?* Accept all answers.

Tell students that in the next class, we're going to have a Consensus Discussion to come to agreement about which approach will work best for everyone and that we will answer our lesson question.

End of day 1

5. Facilitate a consensus discussion about approaches to growing food.

30 MIN

Materials: *Summarizing ways to grow food*, *Best Approaches to Growing Food for Animals, Plants, and People*, six sticky notes with 2 of the same color (example: 2 blue/2 pink/2 yellow), markers, Driving Question Board

Remind students of the lesson question. Say, *Throughout this unit, some of you were curious about whether we can do things better. A few of you posted questions to our Driving Question Board related to what we're trying to reach a consensus about now.* Example questions might include:

*** Supporting Students in Three-Dimensional Learning**
As students engage in conversation, they should clarify the claims they made (SEP8) about which farming practices

- *What can we do to save the tropical rainforest from being cut down?*
- *What could humans do to help the orangutan and still make food?*
- *What can we do to stop destroying the environment?*
- *What can we do to stop these things?*
- *What if the workers of the industry tried to farm in a way that wouldn't harm or destroy the forests?*
- *Can we farm food and not destroy the natural environment?*

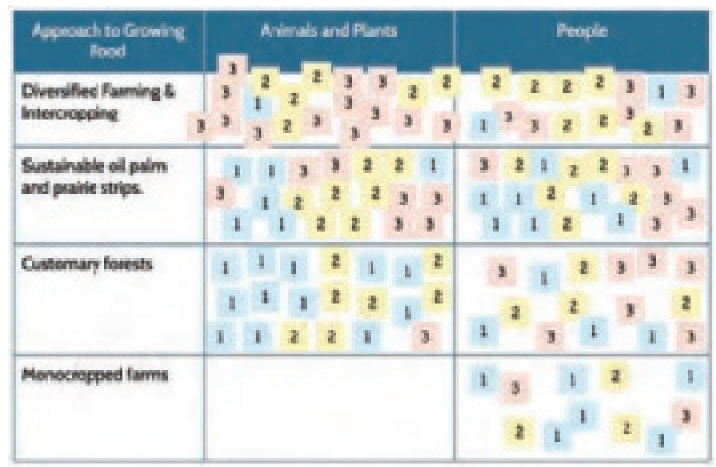
If time permits, ask the students who authored these questions to share what they were wondering about when they posed the questions.

Display **slide F**. Then say, *We've been trying to figure out a better way to grow oil palm to support both people and orangutans. Our question right now is, What approach to growing food works for everyone and why? Let's use the information we've gathered to start supporting claims to answer this question as best we can.*

maintain the stability of natural and designed systems (CCC7) and which protect people from disruptions (DCI) in receiving ecosystems services (DCI).

Additional Guidance

We recommend doing this next activity on chart paper or on a whiteboard because students will use sticky notes to rank approaches according to what they think works best for everyone. If you choose to do the activity digitally, an empty table can be found on **slide G**. An optional student version has been created, *Best Approaches to Growing Food for Animals, Plants, and People*, for students to complete at the end of the activity. Alternatively, you may choose to have them draw the table in their notebooks.



Convene a Scientists Circle. Project **slide G.** Tell students that you have created a new table that will help them draw conclusions about the information in their jigsaw handout to better help us answer our question.

Ask students to rank the approaches to growing food for animals and plants. Give students 1-2 minutes to review their jigsaw handout (*Summarizing ways to grow food*) and to decide which approach to growing food they think is best for animals and plants. Have them also consider which approach they think is second and third best. Choose which color sticky note you would like students to use for the "best" option, the second-best option, and the third-best. You may want students to mark these with a large "1", "2", and "3", using a dark marker.

When ready, invite students to place their sticky notes in the appropriate rows of the "animal and plants" column. Repeat this procedure for "people."

Key Ideas

Purpose of this Discussion: Categorize approaches to growing food as 1 (best), 2 (second-best), 3 (third-best) to motivate a conversation about trade-offs and help students determine if there is an approach that works best for everyone and why.

Look for patterns in stickies:

- Very few stickies on monocrop farms for plants and animals
- More stickies on monocrop farms for people, but spread across other farming strategies, like diversified farms and sustainable farms

Listen for these ideas:

- Customary forests work well for plants, animals, and people in natural ecosystems, but it is hard to obtain permits and really only works well for small communities and small family farms.
- Growing food sustainably by maintaining habitat patches and not cutting down forests can work well for small farmers and large-scale companies, but it is not as good for animals as customary forests are.
- Intercropping and diversified farming strategies also work well for people and can help animals and plants because we are not destroying their habitat.
- Monocropping approaches like those used on oil palm plantations only work well for large-scale farmers.

There will be some areas of disagreement because there is no clear answer to this question. The consensus is that some approaches to growing food benefit plants and animals more so than people, and vice versa. There is no single approach that works best for everyone and every context. Each approach has both monetary and environmental consequences. Importantly, the key ideas that arise should lead to a discussion about trade-offs. For example, students will most likely agree that customary forests appear to work well for everyone except large-scale farm companies, but permits can take years to obtain and may not be feasible for all communities.

Notice patterns in the table. Tell students to look at the sticky notes posted to the new table. Focus them on identifying patterns related to how they ranked the approaches for animals and plants and for people. Ask students to count up or estimate how many "1's", "2's," and "3's" appear for each approach.

Suggested prompt	Sample student responses
What patterns do you notice in our table?	*There are a lot of 1's in the customary forest column for plants and animals.* *There are not really any votes in the monocropping space for plants and animals.* *Customary forests have 1's in each category.* *There are no votes in the plants and animal column for monocropping, but some 1's for the people.* *There are a lot of 2's and 3's in the diversified farm and sustainable farm for plants and animals and people.*

Approach to Growing Food	Animals and Plants	People
Diversified Farming & Intercropping	*2*	*1 or 2 or 3 (Depending on who)*
Sustainable oil palm and prairie steps	*1 or 2*	*1 or 2 or 3 (Depending on who)*
Customary Forests	*3*	*1 or 3 (1 if communities are successful in getting a permit: 3 or no vote for large-scale farmers)*
Monocropped forms	*Few to no votes*	*1 or 3 (1 only for industrial-scale farmers, no votes for other kinds of farmers)*

Record the general patterns noticed. Have students create a table in their science notebook, or pass out 1 copy of *Best Approaches to Growing Food for Animals, Plants, and People* for each student and have them tape it into their notebooks. As the class seems to agree where certain approaches received the most "votes," have students record on the handout or in their notebook. It's OK if there is no clear "winner" to record for each approach.

Facilitate discussion about trade-offs.* Say, *It looks like some approaches were ranked differently for people than for animals and plants. Let's talk about why we ranked approaches the way that we did*. Display **slide H.** Call on students to clarify their claims about which way of growing food is best, using evidence from the jigsaw activity. Foster cross-talk between students, continuing to encourage students to cite evidence, and ask clarifying questions of their peers using the provided prompts in the "What to do" assessment guidance.

Assessment Opportunity

***Building towards:* 16.A.** Integrate qualitative information obtained from written text and media to clarify claims about farming practices that reduce risk to disruptions and that maintain and promote the stability of populations in natural systems.

What to look/listen for:

- Students making claims and supporting them with evidence from the jigsaw activity. As the class evaluates which approach works best for animals and plants and humans, listen for students naming specific reasons for why one approach may be better for humans than animals. For example, a student might say that a sustainable oil palm farm works well for farmers but does not do much for the animals in the nearby ecosystem because they only have to maintain small habitat patches.

What to do: If students are struggling to clarify claims by citing evidence, the following prompts may be helpful to support them:

- Why did you rank X as number one for people and not animals and plants?

- It looks like many of you chose X as the worst approach to growing food for people. Why?
- Why did some of you put 1 in the people column and 2 in the animals column for the same approach?
- Does monocropping work the same for all people? For large-size farmers or small farmers? Why or why not?
- Can all people get customary forest permits? Why or why not?

6. Add to the individual Progress Trackers. 5 MIN

Materials: science notebook

Update Individual Progress trackers for reflection. Explain to students that we want to take some individual time to capture what we have figured out in response to the question we were working on in this class period, *What approach to growing food works for everyone and why?*

Have students turn to the Progress Tracker section in their science notebooks. Use **slide I** to guide students in drawing a line after the last entry and to complete the 2 columns, filling in the lesson question and their responses. When students are finished, have them draw a line after their entry. If time permits, they can share their ideas with a partner.

7. Navigation/Problematize 10 MIN

Materials: *Summarizing ways to grow food, Best Approaches to Growing Food for Animals, Plants, and People*

Introduce the final farm simulation and redesign. Project **slide J.** Tell students that in the next lesson, they will have an opportunity to test their claims using a computer simulation. In the simulation, they will redesign an area of land in Indonesia that must support orangutans and humans at the same time. Probe students for what they would want to see in the simulation to allow them to test their ideas. Remind students that in Lesson 6 they developed a set of criteria for their farm designs that they can refer to.

Suggested prompts	Sample student responses	Follow-up questions
If you were going to test your claims about which approach to growing food works best for orangutans and humans, what would you want the simulation to look like?	*We would want to be able to change how the land is used.* *We want to include a tropical rainforest.*	*Why would being able to change how the land is used be important?* *Why is having a tropical rainforest important?*
What ways of growing food would you want to have?	*We should be able to choose plants for something like a prairie strip.* *We would want to include a customary forest.* *We would want to habitat on our farm.* *We should include fruit trees for orangutans.*	*Why would having options for different crops be important?* *Why is including a customary forest important?* *Why would maintaining areas of habitat be important?*

Suggested prompt	Sample student responses	Follow-up questions
How would we know if our design is successful? What outcomes would you want to measure?	*We would want to measure income.* *We want to count the number of orangutans.*	*What would income tell us about the success of our design?* *What would the number of orangutans tell us about the success of our design?*

Say, *In the next lesson, we'll talk more about what our farms can look like and what our rules will be for designing farms that work for orangutans and humans.*

ADDITIONAL LESSON 16 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-LITERACY.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

On day 1 of this lesson, students take the central ideas extracted from text and media and provide a summary of those central ideas to their peers in the form of a jigsaw.

CCSS.ELA-LITERACY.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

On day 2 of this lesson, students take the qualitative information they obtained in the jigsaw and participate in a consensus discussion that focuses on visually representing their claims.

SCIENCE LITERACY: READING COLLECTION 5

Valuing Ecosystems

1 **Bans, Boycotts, and Bargains**
2 **Stability through Diversity**
3 **Selectivity in Logging and Fishing**
4 **Tillman Marsh Town Hall**

Literacy Objectives

- ✓ Read to find out how people can protect threatened organisms.
- ✓ Consider pros and cons of monoculture.
- ✓ Compare ways of harvesting resources to determine which methods are least harmful to an ecosystem.
- ✓ Identify arguments based on scientific evidence.

Literacy Exercises

- Read varied text selections related to the topics explored in Lessons 13–16.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Write a history of agriculture in response to the reading.

Instructional Resources

Student Reader

Collection 5

Science Literacy Student Reader, Collection 5
"Valuing Ecosystems"

Exercise Page

EP 5

Science Literacy Exercise Page
EP 5

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 13: How does an ecosystem change when the plants change?
- Lesson 14: Are there ways people can grow food without harming the tropical rainforest?
- Lesson 15: How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?
- Lesson 16: What approach to growing food works for everyone and why?

Standards and Dimensions

NGSS Performance Expectation

LS2-1: (Building toward) Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

ESS3.C: Human Impacts on Earth Systems

Science and Engineering Practice: Analyzing and Interpreting Data

Crosscutting Concepts: Cause and Effect; Patterns

CCSS

English Language Arts

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.W.7.2

Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

bycatch

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

boycott **monocrop** **subsidy**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the in-class lesson investigations during this week.

Exercise Page

EP 5

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Ecosystem Dynamics unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
    - *In "Bans, Boycotts, and Bargains," you will find out how people have successfully organized together to pressure governments into protecting threatened species.*
    - *In the second selection, you'll learn more about why depending on just one source of food or employment can lead to problems.*
    - *In "Selectivity in Logging and Fishing," you'll compare methods to extract resources to identify which are most sustainable.*
    - *In the last selection, you'll revisit the Tillman Marsh debate and consider arguments for and against the development of the marsh.*

- Distribute Exercise Page 5. Preview the writing exercise. Share a summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
    - *For this assignment you will be expected to research and write a historical account of agriculture.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
    - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
    - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
    - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
    - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
    - *Revisit the reading selections to complete the writing exercise.*
    - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What would it take to get a state or national government to pass a new law to protect an ecosystem?	*First, you would have to identify a threat and study it. Next, you must get others to agree and work with you. Then you must ask government representatives to propose legislation. If there is no interest, you must take measures to draw attention to the danger and get more people on your side to increase pressure.*
What could happen to a species if it only ate one food, such as koalas that only eat eucalyptus?	*If the food source were reduced because of disease or human development, the species would starve or need to move.*
What are the advantages to finding ways to extract resources that are less harmful to the environment than others?	*The ecosystem is more stable, and plants and animals can survive and reproduce to provide continuous resources to extract.*
How can science help make decisions that affect ecosystems?	*Basing decisions on impartial, unemotional scientific studies of evidence can help make rational decisions that provide the best solutions for the most people.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
How can science help to find ways to grow food without harming an ecosystem?	*Conducting controlled fair tests of different farming methods would provide evidence to make decisions about which ones are the most effective for a sustainable ecosystem.*
What would happen if there were too many restrictions on farmers such that they could not grow crops as they always have?	*It could become too expensive or difficult to make a living as a farmer. Thus, they could stop farming, and certain crops or products would not be available.*
What could happen if there were no restrictions on farmers?	*Many would produce crops in the least expensive way so they could make the most money without worrying about the environment. The least expensive way is not always the "best" way.*

- Refer students to the Exercise Page 5. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The writing expectation for this assignment is to write a historical account of agriculture.*
    - *In the selections, you learn about the pros and cons of farmers relying on planting one crop and populations relying on only one food source.*
    - *Think about what you read as you think about the history of agriculture and how it has evolved from many small farmers to large farms that produce single crops.*
    - *Your historical account can be the story of one area or one crop or a general overview.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 5

4. Facilitate discussion.

(Friday)

Facilitate class discussion about the reading collection and writing exercise.

The four reading selections provide information and encourage thinking about sustainable farming and resource extraction.

Student Reader

Collection 5

Pages 46–47 Suggested prompts	Sample student responses
What is the general purpose of the first selection, "Bans, Boycotts, and Bargains"?	*It presents ways people have organized and pressured governments to protect threatened species.*
What is the difference between a boycott and a ban?	*A boycott is when consumers refuse to buy or use certain products or services as a protest or punishment.* *A ban is a legal or official prohibition.*

Pages 46–47 **Suggested prompts**	**Sample student responses**
What are some boycotts and bans that you know about?	*There are boycotts to stop using plastic straws, throwaway plastic water bottles, and plastic bags to protect the environment.* *There are bans on selling certain products to minors and bans on using cellphones in some places.*
Are boycotts and bans effective in protecting threatened species?	*yes, because they bring awareness and make people think about how what they are doing may be harmful*

Pages 48–49 **Suggested prompts**	**Sample student responses**
How does the second selection help you build knowledge on top of what you learned in the first selection?	*It provides a different view of ecosystem stability. The first selection outlined ways to help maintain the stability of marine life by using better fishing methods. The second selection focuses on maintaining stability in agriculture by considering farming methods that do not rely on one crop.*
What is a monocrop?	*It is the strategy of growing only one crop in a field or area instead of several crops or instead of rotating the growing of crops.*
What are benefits of monocropping?	*Farmers can specialize and develop growing and selling efficiencies. Large-scale tree and fruit crops like grapes, apples, bananas, and nuts must be established as monocrops so they produce year after year.*
What are problems with monocropping?	*If a disease is introduced, it could destroy the entire crop. If demand goes down, the farmers have no other resource to sell.*
Why do subsidies work?	*They give farmers incentives for growing and producing certain products so that food prices are affordable for all people. Otherwise, farmers might produce foods that most people could not afford to buy.*

Pages 50–53 **Suggested prompt**	**Sample student response**
What is the general purpose of the third article, "Selectivity in Logging and Fishing"?	*It shows that there are different ways to raise crops and extract resources, some of which are better for the ecosystem than others.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

SUPPORT—Have students watch a video about issues in monoculture farming. Discuss the pros and cons of monoculture methods of farming.

SUPPORT—Compare with students the terms *bycatch* and *incidental. Bycatch* specifically refers to unintentionally catching other fish when fishing for specific fish. This is incidental, which is anything that is an unintended consequence.

CHALLENGE—Challenge students to learn about the differences between farm-raised and wild-caught salmon practices and the advantages and disadvantages of each. Have them report their findings to the class.

Pages 50–53 Suggested prompts	Sample student responses
What are the differences among the three different ways of logging?	*Clear-cutting, the least expensive method, is most harmful to the ecosystem. Shelterwood logging and selective cutting are better for the ecosystem stability but are more expensive.*
What is the relationship between money and farming?	*People farm to produce food and products to sell to earn a living. Farms support many other industries that have interest in farming, like equipment manufacturers, food distributors, and grocery stores. To be most profitable, a farm must have low operating costs and produce profitable products.*

SUPPORT—Have students watch a video about fish farming. Discuss the advantages and disadvantages of fish farming.

Pages 54–55 Suggested prompts	Sample student responses
How does the last selection relate to the other selections in this collection?	*It revisits the issue posed in the Preface to consider the marsh preservation after the scientific and financial issues from the selections we read.*
Which are the arguments for developing a piece of the marsh?	*The entire marsh ecosystem will not be destroyed.* *Natural forces will erode part of the marsh anyway.* *There are laws and regulations that would protect the construction of the developed area from harming the ecosystem.* *Development will provide economic diversity.*
What are the arguments for conserving the entire marsh area?	*The marsh is valuable in its natural state and is a fragile ecosystem. Development may harm it in unintended ways.*
Would you vote for preservation of the marsh or partial development if you had a say?	*I would vote to preserve it and look for other ways to sustain the economy.* *I would vote to carefully develop a part of it so the town would have another source of income.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 5, students should research and write a historical account of agriculture.

Use the rubric provided on the Exercise Page to supply feedback to each student.

LESSON 17

How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?

Previous Lesson

We jigsawed to synthesize information about different approaches to growing food, and compared and contrasted those approaches in terms of how well they work for people and natural systems. We then ranked the approaches on how well they support plants and animals and people. We discussed the trade-offs between each approach and clarified claims about which approach we think will work best. We brainstormed how to test claims in a simulation.

This Lesson

Investigation

3 DAYS

Working in groups of three, students use a computer simulation to redesign the way land is used in Indonesia to support orangutans and people at the same time. Students evaluate design solutions created by other groups and then optimize their own design solutions. In an assessment, students evaluate competing design solutions for maintaining or increasing orangutan population sizes and people's income on oil palm farms in Indonesia.

Next Lesson

We will present our best designs to our peers and evaluate the designs based on agreed-upon criteria and constraints. We will argue for which designs work best for people, orangutans, or both, and we will make claims about why they work well. We will end the unit by returning to the DQB and celebrating our learning on graffiti boards, or we will navigate to one of two extension opportunities: to communicate about the palm oil problem to community members, or to deepen our understanding of human impact in our own community.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

17.A Refine criteria and constraints for designing a way to use the land to increase precision and to take into account the potential impacts and the ways in which potential solutions are limited by the natural environment.

17.B Apply ideas about ways of growing food to design a better way to use the land to minimize human impact on orangutan populations.

What Students Will Figure Out

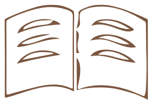
- Some potential design solutions work well for both people and orangutans but are not realistic due to land-use changes and time.
- Using a variety of different ways to grow food can maintain or increase orangutan populations and people's income.
- People can reasonably set aside a portion of their land to support orangutan populations without reducing their income.
- Neighboring farms can coordinate their approaches to increase space for orangutans.
- Rainforest corridors connecting intact areas of forest increase orangutan populations.

Lesson 17 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Lead a navigation discussion to brainstorm which ways of growing food might work best for redesigning the way land is used in Indonesia to support orangutans and people at the same time.	A	*Summarizing ways to grow food*
2	10 min	**NAVIGATE TO PADU BANJAR, INDONESIA** Using Google Earth or ArcGIS Earth, zoom in on and explore a region in Indonesia called Padu Banjar.	B-F	*Padu Banjar*, markers, computer and projector, Google Earth or ArcGIS Earth location for Padu Banjar (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Collaborative Oil Palm Model, *Labeled Guide of Padu Banjar*
3	5 min	**ORIENT TO THE SIMULATION** View the updates and features in the *Collaborative Oil Palm Model* simulation.	G	computer and projector, Collaborative Oil Palm Model
4	10 min	**REVIEW THE REDESIGN CHALLENGE (PARTS A AND B)** Review and revise the redesign goal, criteria, and constraints to more specifically define the design task.	H	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, *Palm Farm Designs* (from Lesson 6), chart paper, markers, chart of criteria and constraints from Lesson 6
5	8 min	**GATHER BASELINE DATA (PART C)** Gather baseline data to determine the maximum number of orangutans that could live in the area, the maximum income people could earn, and the default orangutan population size and income for people.	I	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, computer and projector, Collaborative Oil Palm Model

Part	Duration	Summary	Slide	Materials
6	7 min	**PLAN WAYS TO REDESIGN THE LAND (PART D)** Individually plan a redesign for the assigned area of the land.	J	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, *Summarizing ways to grow food*, computer and projector, Collaborative Oil Palm Model *End of day 1*
7	25 min	**TEST THE REDESIGN (PART E)** Test and optimize the redesign in small groups. Reflect on the key features of the redesign.	K-M	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, access to a word processing or PDF reader to save code, device with internet access, Collaborative Oil Palm Model
8	20 min	**EVALUATE DRAFT SOLUTIONS (PART F)** Evaluate draft solutions from at least two other groups. Consider how the features supported people and/or orangutans, what is working well about the design, and how the design could be improved.	N	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, sticky notes, device with internet access, Collaborative Oil Palm Model *End of day 2*
9	20 min	**OPTIMIZE REDESIGN SOLUTIONS (PART G)** Review feedback given by other groups and optimize the redesign solution. Reflect on the key adjustments in the redesign and how the adjustments helped orangutans and people.	O	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, device with internet access, Collaborative Oil Palm Model
10	20 min	**CONSTRUCT AN EXPLANATION TO SUPPORT A REDESIGN (PART H)** Write an individual explanation describing the best redesign and how it supports both people and orangutans.	P	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*
11	5 min	**NAVIGATION** Navigate to the next lesson by thinking about weaknesses other groups may find in our design solutions when we present and evaluate our design solutions.	Q	 *End of day 3*

Lesson 17 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Summarizing ways to grow food* • *Padu Banjar* • markers • science notebook • *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* • *Palm Farm Designs* (from Lesson 6) • access to a word processing or PDF reader to save code • sticky notes	• device with internet access • Collaborative Oil Palm Model	• computer and projector • Google Earth or ArcGIS Earth location for Padu Banjar (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Collaborative Oil Palm Model • *Labeled Guide of Padu Banjar* • chart paper • markers • chart of criteria and constraints from Lesson 6

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.

Make sure you can access the *Collaborative Oil Palm Model* simulation and that students' devices can access this URL too. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Review the *Collaborative Oil Palm Model*. Spend some time familiarizing yourself with the simulation and the controls. Run the "Forest Only" and "Income Only" setups to observe the baseline models. Run a few trial set-ups to get a sense of how students will interact with the simulation. For saving and loading simulation codes, watch the Collaborative Oil Palm Model: Saving Design Codes video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Navigate to Padu Banjar, Indonesia, on Google Earth or ArcGIS Earth. The Google Earth location. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Using *Labeled Guide of Padu Banjar* as a guide, zoom in and out to view the key features listed on *Labeled Guide of Padu Banjar* and the handout, *Padu Banjar*. Get ready to navigate to these features while projecting Google Earth or ArcGIS Earth for the class.

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

Arrange students in groups of three. Each group should include one representative from each of the expert groups in Lessons 14-16. Students will work in these groups over the course of this lesson and Lesson 18 to redesign the way land is used in Indonesia to support orangutans and people at the same time. If possible, you may wish to reconfigure your classroom space to maximize group work.

Online Resources

Lesson 17 • Where We Are Going and NOT Going

Where We Are Going

In the previous lessons, students learned that systems with a larger variety of plant types support biodiversity and create more resilient systems to handle disruptions. Diversified farms are one type of these systems. This lesson provides an opportunity for students to apply what they have learned throughout the unit to design a diversified farm system that supports orangutans and farmers.

A new key takeaway from this lesson is the idea that individual farmers can amplify their impacts by coordinating with neighboring farms to utilize forest setbacks to the benefit of wildlife.

Students should demonstrate their use of several important science concepts as they engage in this design task:

- Diversified systems are resilient to disruptions.
- Diversified farm systems can support farmers by reducing their financial risk in a disruption event.
- Diversified systems can support biodiversity.
- Farms can set aside a portion of their land and still maintain productivity levels.

This lesson builds on 3rd and 5th grade DCIs: “Populations live in a variety of habitats, and change in those habitats affects the organisms living there” (grade 3) and “A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life” (grade 5). Students extend their understanding to realize that human-managed systems, like farms, are ecosystems, and these ecosystems can be designed to better support organisms that lived in the ecosystem before the farm was developed.

In this lesson, students make significant progress on MS-ESS3-3. Students work in teams to design a method for minimizing human impact on the environment in Indonesia. Specifically, students work to design ways to use the land that work for both people and orangutans. Students apply science concepts developed throughout the unit to inform their designs. Specifically, students think about multiple ways of growing food and how each approach impacts food resource availability for orangutans and thus orangutan population sizes.

Students also make significant progress on MS-ETS1-1. In previous lessons (e.g., Lesson 1 and Lesson 6), students developed a list of criteria and constraints for their design solutions. In this lesson, students refine their criteria and constraints so that their list has enough precision to ensure a successful solution. Specifically, students identify the target orangutan population size of a successful design solution in a computer simulation.

This lesson also sets students up to make significant progress in MS-LS2-5 in the next lesson (Lesson 18). In this lesson, students set up their designs and do an initial pass at evaluating the designs of other groups. In the following lesson, students will formally evaluate competing design solutions.

Where We Are NOT Going

In this lesson, students focus on the science and engineering practice of developing explanations and designing solutions. In the following lesson (Lesson 18), students argue from evidence about competing design solutions. While this lesson sets students up to argue from evidence, students don’t actually engage in argumentation in this lesson.

LEARNING PLAN FOR LESSON 17

1. Navigation

5 MIN

Materials: *Summarizing ways to grow food*

Frame a navigation discussion. Project **slide A** and remind students that during the last class, they discussed the trade-offs of different ways to grow food. Explain that in this lesson, students will work in groups of three to try to redesign the way land is used in Indonesia to support orangutans and people at the same time.

Assign students to groups of three.

Additional Guidance

Consider having group assignments posted in the classroom at the beginning of Lesson 17 so that students can sit with their group from the beginning of the lesson. If your class does not divide evenly, consider creating a few groups of four. In a group of four, two students can be assigned to work together in the same role.

Lead a navigation discussion. Use this discussion to help students brainstorm which ways of growing food might work best to redesign the way land is used in Indonesia to support orangutans and people at the same time. Explain that each student will take on the role of a person living in a community in Indonesia. The roles are (1) large-scale oil palm company, (2) small-scale oil palm farmer, and (3) village elder. Prompt students to assign each group member a role and then discuss which ways they would approach growing food and why. You may wish to refer students to *Summarizing ways to grow food* to review the different approaches to growing food.

Suggested prompts	Sample student responses
Large-Scale Oil Palm Farmer—*Which way of growing food would you try? Why?*	*I might try a combination of planting oil palm trees on land where the forest has already been cut down, and planting or maintaining native habitat plants on the farm. Maintaining the native habitat plants would help the orangutans, and planting oil palm trees on land already cleared means no new forests are cut down, and this can maintain my income.*
Small-Scale Oil Palm Farmer—*Which way of growing food would you try? Why?*	*I could try planting different types of crops to increase my income. I could also plant more oil palm trees on land that was already cleared of forest so no new forest is cut down.*
Villager Farmer—*Which way of growing food would you try? Why?*	*I could try harvesting food from the forest (customary forest) and planting a combination of oil palm trees and other crops.*

2. Navigate to Padu Banjar, Indonesia.

10 MIN

Materials: *Padu Banjar*, markers, computer and projector, Google Earth or ArcGIS Earth location for Padu Banjar, Collaborative Oil Palm Model, *Labeled Guide of Padu Banjar*

Navigate to Padu Banjar, Indonesia. Explain that we are going to use a computer simulation to help us answer the question: *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* Share that the simulation was designed to represent a location in Indonesia called Padu Banjar. Use the images on **slides B, C, and D** to help orient Padu Banjar's location.

Make observations of Padu Banjar. Present **slide E** and pass out 1 copy of the *Padu Banjar* handout to each student. Explain that we are going to make some initial observations of Padu Banjar using the satellite imagery. Several key features of Padu Banjar are listed on the handout. Share that we are going to try to locate each of the key features by zooming in and out of the region using a satellite imagery software (Google Earth or ArcGIS Earth). Prompt students to label each of the key features on the *Padu Banjar* handout as we find them.

Project the satellite image of Padu Banjar. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Using *Labeled Guide of Padu Banjar*, navigate around the area. You may wish to have students direct your navigation. Be sure to zoom in on all of the key features so that students can see a close-up image of what each feature looks like.

Point out the trees along the river and explain that there is an Indonesian law requiring that 100 meters on either side of the river be protected in rural areas. As a result, most rivers are surrounded by a small area of protected rainforest.

Additional Guidance

Consider allowing students to load the Google Earth link on their own devices or a comparable satellite map software like ArcGIS Earth. This would allow students to navigate around the area and explore on their own. It is important to note that many people live in Padu Banjar. While it is useful to use Google Earth or ArcGIS Earth to get a feel for the landscape, take care to avoid singling out a specific home or farm out of respect for the people who live and work there.

Lead a discussion about where people and orangutans likely spend their time in Padu Banjar. Using the prompts on the slide, ask students to consider where people and orangutans likely spend most of their time.

Suggested prompts	Sample student responses
Where do you think orangutans may spend most of their time in this area?	*Orangutans likely spend lots of time in the protected and customary forest because that is where they can find food. They may also spend time near the river because of the protected rainforest near the river.*
Where do you think people may spend most of their time in this area?	*People likely spend most of their time in or near the villages or farming the fields. They might travel into the rainforest occasionally.*

Compare Padu Banjar to the computer simulation layout. Present **slide F** and explain that the layout of the computer simulation we will be using is based on Padu Banjar. Using the second image on the *Padu Banjar* handout, prompt students to try to identify and label some of the important features in Padu Banjar. You may wish to use *Labeled Guide of Padu Banjar* as a reference for yourself to help guide their work. You may also wish to show students what the different symbols in the simulation mean (e.g., rainforest, fruit, palm, etc.).

Discuss the benefits and limitations of the computer simulation layout. Using the prompts on the slide, prompt students to consider how the simulation layout is a good representation of Padu Banjar and how it is a limited representation.

Suggested prompts	Sample student responses
How is the simulation a good representation of Padu Banjar?	*The simulation includes all of the key features that we noticed using satellite imagery.*
How is the simulation a limited representation of Padu Banjar?	*The simulation is not an exact replica of Padu Banjar. It is missing some of the specific locations we noticed.* *The river in the simulation is just a straight line. It does not curve like we noticed using the satellite images.* *The simulation is not representative of the entire ecosystem. It does not include animals other than orangutans and termites, and it only includes certain types of trees.*

Summarize by sharing that while the simulation has its limitations, it can be a useful tool for us as we consider ways to redesign how we use the land.

3. Orient to the simulation.

5 MIN

Materials: computer and projector, Collaborative Oil Palm Model

Orient to the updates and features in the computer simulation. Project **slide G** to show students the features of the *Collaborative Oil Palm Model* simulation. When comparing the simulation to Padu Banjar, students likely noticed that different symbols in the simulation indicated different types of trees growing in that area. It is important to point out that even though one square in the simulation may show one oil palm tree, it is actually representative of a group of oil palm trees growing in that area.

Be sure to point out the following design features:

- Different boxes in the layout represent different types of trees or farms growing in that area.
- The layout is separated into three areas outlined by solid and dotted white lines. Any area that is not enclosed by the white lines is a protected tropical rainforest and cannot be changed.

- Students can change the land use in the area by selecting the desired type of layout and then "painting" or dragging a box over the area they want to be a certain type of land use.
- The income monitor at the bottom of the screen monitors income as you make changes to the land.

Additional Guidance

The income monitor at the bottom of the screen monitors income by shading in 5 bills. The bills are not representative of a particular income, but are rather designed to show income earned in relation to each other and in relation to total possible income.

4. Review the redesign challenge (Parts A and B). 10 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, *Palm Farm Designs* (from Lesson 6), chart paper, markers, chart of criteria and constraints from Lesson 6

Articulate the redesign task. Pass out 1 copy of *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* to each student. This is a packet that will be used across the course of the entire redesign task. It will be used every day of this lesson and should be attached to students' notebooks now or at a future point in the lesson.

Read through the problem together. Ask students if there are any additions or edits to make. Then display **slide H**.*

Review and revise the redesign goal (Part A). Direct students to find *Palm Farm Designs* (from Lesson 6), already attached in their science notebooks. Students should read the original goal. Elicit from students ideas for how they want to revise the original goal now that they know more. Record the revised goal on chart paper for the class (or on the classroom whiteboard) as students record the new goal under Part 1 on their *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout.

Sample change:

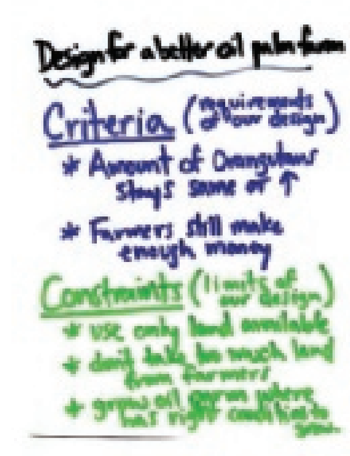
Original design goal	Revised design goals
An oil palm farm that meets a farmer's need for crops to sell and also maintains or increases orangutan populations (from Lesson 6).	A palm farm that meets a farmer's need for income, minimizes the risk of disruption, and supports orangutans and other populations (biodiversity). or A palm farm that supports biodiversity and is resilient to disruptions to benefit people and orangutans.

Review and revise the criteria and constraints for the design challenge (Part B). Keep **slide H** displayed. Direct students to read the original criteria they recorded in Lesson 6. Elicit from students ideas for how they want to revise the criteria now that they know more.

*** Supporting Students in Engaging in Constructing Explanations and Designing Solutions**
In this moment, students articulate a shared redesign goal and criteria and constraints they will use in the redesign task. Keep a class record of the design goal, criteria, and constraints, which should be visible to students and can be revisited or modified should the class agree to change something as the design task progresses.

*** Supporting Students in Three-Dimensional Learning**
By thinking about the desired outcomes (or effects) of their design solutions (CCC: Cause and Effect) for designing a better way to use the land to limit human impact on the environment (DCI), students are further refining their criteria with greater precision (SEP: Asking Questions and Defining Problems).

Revise the criteria about people. Facilitate a discussion about these criteria from Lesson 6 (e.g., people have the same amount of crop to sell or people still make money from their land). The purpose of this discussion is to help students articulate what they have learned about disruptions that affect people (disease, drought, fire, market prices) and solutions they learned about to minimize the disruption (diversifying farms).



Suggested prompts	Sample student responses	Follow-up questions
How can we ensure our farm makes us money?	*has enough crops to sell* *has different kinds of crops*	*Why do different kinds of crops help to support a farmer in making money?*
If we agree that our farms should have several different kinds of plants, how many?	*a lot* *at least 2 or more*	*Should we set a criterion that we all include at least 2 crops? How would that help us meet our design goal? (Answer: Minimize risk to people.)*
Are we interested in maximizing profits or having a stable income?	*Stable income, so we always make money each year.*	

Record the revised criteria on chart paper for the class (or on the classroom whiteboard) as students record the new criteria under Part 2 on their *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout.

Original criterion for people	Revised criteria for people
People have the same amount of crop to sell or people still make money from their land.	Farm with 2 or more crops to sell, Steady income from the crops, and Selection of crops that can survive different environmental conditions (drought, disease, heavy rain).

Revise the criteria about orangutans. Facilitate a discussion about this criterion from Lesson 6 (e.g., the amount of orangutans stays the same or goes up). This discussion should help students articulate what they have learned about resource availability and biodiversity supporting orangutan populations.

Suggested prompts	Sample student responses
What did we learn that orangutans need?	*Fruit trees mostly if they want to reproduce.* *canopy for shelter and protection*
What could we do to include some canopy and fruit options for them on our farms?	*add tall rainforest trees or rainforest fruit trees*

Original criterion for orangutans/ecosystem	Revised criteria for orangutan/ecosystems
The amount of orangutans stays the same or goes up.	Stable or increasing orangutan population Enough fruit trees to support the orangutan population Enough tall rainforest trees for orangutans to travel through the trees

Add a constraint about the scale of the redesign. Facilitate a discussion about how much we can change about the land and how long the changes take to have an effect. This discussion should help students realize that the design challenge is truly a REdesign challenge. The land is already being used, and it is neither realistic nor a productive strategy to completely clear cut and replant the entire space.

Suggested prompts	Sample student responses
It takes about 4 years for oil palm trees to produce fruit, and they live for about 25 years. It takes 20-50 years for most rainforest trees to grow. Even though you are "painting" the changes in the simulation, how long would the following changes actually take? • *Clearing the tropical rainforest and planting oil palm trees* • *Planting rainforest trees on land already cleared of forest* • *Planting farms*	*Clearing rainforest and planting oil palm trees would take 4-5 years.* *Planting rainforest trees on land could take 20-50 years to grow the forest.* *Planting farms may only take 1-2 years.*
Is it realistic to turn the entire tropical rainforest into a customary forest? Why or why not?	*Probably not. People need to be able to access the rainforest and would need to be able to find certain types of plants. While this could happen in lots of places, especially near villages, it might require too much effort to go deep into the rainforest on a regular basis.*
Is it realistic for the entire tropical rainforest to be composed of rainforest fruit trees? Why or why not?	*Probably not. Many different kinds of plants grow in the rainforest. If it were all rainforest fruit trees, the rainforest would lose biodiversity in different ways.*

Original criterion for orangutans/ecosystem	Revised criterion for orangutan/ecosystems
	Make realistic changes to the land that minimize different kinds of effects.

Additional Guidance

As the class revises the criteria and constraints, use this opportunity to specifically emphasize engineering DCI ETS1.A: Defining and Delimiting Engineering Problems: "The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions."

Summarize the key revisions to the criteria and constraints. Verbalize the key changes that the class made to the criteria and constraints. Observe, out loud, that we only added one new constraint. Otherwise, we made our original drafts of criteria and constraints more precise to help us solve the design problem.*

Assessment Opportunity

***Building towards:* 17.A** Refine criteria and constraints for designing a better way to use the land to increase precision and to take into account the potential impacts and the ways in which potential solutions are limited by the natural environment.

What to look/listen for:

- Revised criteria about people that address disruptions that affect people (disease, drought, fire, market prices) and solutions they learned about to minimize the disruption (diversifying farms).
- Revised criteria about orangutans that include ideas about resource availability and biodiversity supporting orangutan populations.
- Some potential design solutions work well for the people and the orangutans but are not realistic due to land-use changes and time.

What to do: If students struggle to see what kinds of changes may be realistic for the land, use a local example to think about the changes that might be possible. Ask students to think about a park, forest, or farm near your school or in your community. Ask, *What would it take to change the [park, forest, or farm] into a [park, forest, or farm].* Help students think about the kinds of trees that would need to be cut down, the trees or crops that would need to be planted, and the amount of time and money the process would take. Then apply the thinking to the land in Indonesia.

5. Gather baseline data (Part C). 8 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, computer and projector, Collaborative Oil Palm Model

Gather baseline data (Part C). Explain that in order to further define criteria and constraints; it would be helpful to know the maximum orangutan population and the maximum income in the computer simulation. Use the prompts to help students think about how they might figure out the maximum orangutan population and the maximum income.

Suggested prompts	Sample student responses	Follow-up questions
In the computer simulation, how could we figure out the maximum orangutan population size?	*If we made the entire area rainforest trees with as many fruit trees as possible, it would be like a natural habitat for the orangutans. That could help us figure out the maximum orangutan population size.*	*Could the entire tropical rainforest be composed of rainforest fruit trees? (Answer: No, that is not realistic for the rainforest. In our previous simulation, the default was 25 percent fruit trees.)*
In the computer simulation, how could we figure out the maximum income?	*If we made the entire area oil palm trees, we could figure out the maximum income?*	*Could we plant oil palm trees in the protected rainforest and the area by the river? (Answer: No, there are laws in Indonesia that prevent us from cutting down the rainforest trees.)*

Run the "Forest Only" model. After students have articulated that running the simulation with only tropical rainforest and rainforest fruit trees would help us identify the maximum orangutan population size supported by the area, run the "Forest Only" model. Use the instructions on **slide I** and in the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout to guide the work. Navigate to the computer simulation and select the "Forest Only" layout. Run the simulation and view the results with the class. Discuss the results using the prompts below. Have students record the average number of orangutans.

Suggested prompts	Sample student responses
What was the average number of orangutans in the population?	*approximately 25 orangutans*
Was the population stable, increasing, or decreasing?	*The population increased from about 15 orangutans to about 50 orangutans, but there were some fluctuations in the population size.*
How many orangutans can this area support?	*Between 40 and 50. There was an average of 32 orangutans and a maximum of 50 orangutans.*

At the end of the discussion, summarize by saying, *It sounds like if this entire area were rainforest trees with the normal amount of rainforest fruit trees, it could support 40-50 orangutans. Let's add that number to our criteria.* On your list of criteria, next to "amount of orangutans stays the same or goes up," add *~40-50 orangutans in the simulation*.

Run the "Income Only" model. After students have articulated that running the simulation with only oil palm trees would help us identify the maximum income supported by the area, run the "Income Only" model. Use the instructions on **slide I** and in the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout to guide the work. Navigate to the computer simulation and select the "Income Only" layout. Run the simulation and view the results with the students. Discuss the results using the prompts below. Have students record the incomes.

Suggested prompts	Sample student responses
What was the maximum income in each area?	*Area 1: all 5 dollars* *Area 2: a little less than all 5 dollars* *Area 3: all 5 dollars*
What was the average number of orangutans in the population when we maximized income?	*approximately 8 orangutans*
Was the population stable, increasing, or decreasing?	*The population decreased from about 15 orangutans to 0 orangutans.*

At the end of the discussion, summarize by saying, *It sounds like if this entire area were oil palm trees, the people could make a very large income, but the orangutan population would disappear.*

Run the "Default Design" model. Reflect that while the "Forest Only" and "Income Only" models are extremes on different ends of the spectrum, Padu Banjar isn't completely tropical rainforest, nor is it completely oil palm. Say, *Let's run the default model, with the layout of Padu Banjar, to see what the default orangutan population size is and what the default incomes are so that we know our starting point.*

Run the "Default" model. Use the instructions on **slide I** and in the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout to guide the work. Navigate to the computer simulation and select the "Default Design" layout. Run the simulation and view the results with the students. Discuss the results using the prompts below. Have students record the average number of orangutans and the people's incomes.

Suggested prompts	Sample student responses	Follow-up questions
What was the default average orangutan population size?	*around 15 orangutans*	*Our goal is to increase this as much as possible.*
What were the defaults for people's incomes?	*Area 1: about 2.5 bills* *Area 2: about 1.5 bills* *Area 3: a little more than 1 bill*	*Our goal is to increase this amount while also making sure that it stays stable if there are any disruptions.*

Transition to the next activity by saying, *Now that we have a sense of our baseline data, let's think about ways that we can redesign the land so that it can help both people and orangutans.*

6. Plan ways to redesign the land (Part D).

7 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, *Summarizing ways to grow food*, computer and projector, Collaborative Oil Palm Model

Plan ways to redesign an area of the land (Part D). Explain that in the next class session, students will get into groups to work collaboratively on a redesign of the land using the computer simulation. Remind students that each student has been assigned a particular role. Show students that each role is associated with a different area in the computer simulation:

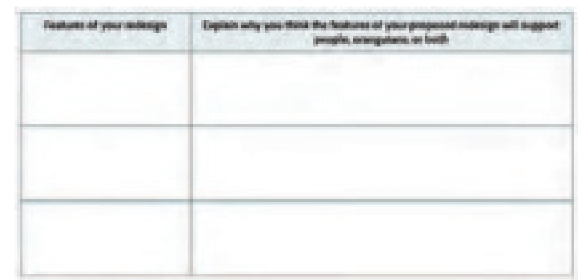
1. Area A: Large-scale oil palm company
2. Area B: Small-scale oil palm farmer
3. Area C: Village elder

Project **slide J** and have students circle their assigned area and role on the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout. Have students work individually to plan ways to redesign your area of the land. Students should use the space on the handout to sketch and describe a redesign plan for their assigned area. As students plan, you may wish to have them revisit the Goal from Part 1 and the Criteria and Constraints from Part 2. Students may also wish to revisit their copy of *Summarizing ways to grow food* as a reference for the approaches they might take.

Additional Guidance

As students plan ways to redesign an area of the land, they will use paper and pencil to plan rather than the computer simulation. This is to encourage students to think carefully about their redesign and be intentional about their decisions before they begin tinkering with the simulation design.

After developing a redesign plan, have students identify the features of their redesign and explain why they think the features they proposed will support people, orangutans, or both. Students should record their ideas on the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout.



End of day 1

7. Test the redesign (Part E). 25 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, access to a word processing or PDF reader to save code, device with internet access, Collaborative Oil Palm Model

Test the redesign (Part E). Display **slide K** with instructions. Explain to students that they will work with their group, to test a redesign.

Remind students that their goals are to:

- Design a better way to use the land (see Part A: Revise or Add to Our Goal)
    - Support the largest orangutan population possible (see Part C: Gather Baseline Data, "Forest Only")
    - Support adequate income for the people (see Part C: Gather Baseline Data, "Income Only")
- Meet the Criteria and Constraints (see Part B: Revise or Add to Our Criteria and Constraints)

Have students use their plans on Part E of the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout to guide their work. Students may redesign and run tests as many times as they would like, in order to optimize their design. Encourage students to optimize their design at least 3-5 times. They should work to find a solution that they are prepared to share with their peers for feedback.

As students work, circulate the room to provide feedback using *Teacher Feedback on Land Redesign Projects* for guidance.

Additional Guidance

Encourage students to share the controls for the simulation. One strategy is to have each student manipulate only their area, so that the students take turns adjusting the layout before running the simulation.

Save and load work. Using **slide L**, show students how to save and load their work if they need to close their browser window and reload at a different point in time. You may wish to show Collaborative Oil Palm Model: Saving Design Codes or watch the video yourself before demonstrating to students how they can save and reload their work. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Consider using the example *Design Solutions Slide Deck* as a place where students can save their work. An example slide is provided. Groups can include a screenshot of their design, the income levels, and the population graph. The design code should be pasted in the notes section.

Reflect on the redesign. Once students have created a redesign that they would like to share with their peers for feedback, have students reflect on their redesign. Have students individually reflect on their redesign using the prompts on **slide M** and in Part E of the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout.

8. Evaluate draft solutions (Part F). 20 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, sticky notes, device with internet access, Collaborative Oil Palm Model

Evaluate draft solutions (Part F). Display **slide N** with the instructions. Explain that students are going to have the opportunity to evaluate the solutions proposed by at least two other groups. The purpose of this activity is to check the proposed solutions against the criteria and constraints, to provide constructive feedback to peers, and to get ideas and learn from one another's solutions. Students will view the solutions designed by at least two other groups and evaluate the solutions using the prompts on **slide N** and in Part F of their *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout. Students should work individually to reflect on the design and then convene with their group to determine some feedback to give to the group that they are reviewing. Students should record their feedback on a sticky note.

Additional Guidance

Students can view the designs created by other groups in a variety of ways:

1. Students can physically travel to the device used by another group and look at the design on the group's device.
2. Groups can save the code from their design and send it to the reviewing group by email or through a shared Google doc.
3. Groups can save the code from their design and send it to the teacher. The teacher can share the code with the reviewing group.
4. Students can print their design and share a hard copy with the reviewing group.
5. Students can save their design as a PDF and share it with the reviewing group.
6. A *Design Solution Slide Deck* is also provided. Students can share a slide with the screenshot of their design, the income levels, and the population graph. The design code could be pasted in the notes section.
7. Sharing the design code via any Google app (docs, slides, etc.) should work, though the code can also be copied and pasted to Microsoft Word or printed as a PDF and shared.

Give students about 10 minutes to review the design before moving on to the next design.

End of day 2

9. Optimize redesign solutions (Part G). 20 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*, device with internet access, Collaborative Oil Palm Model

Optimize the redesign solution (Part G). Display **slide O** with the instructions. Students should begin the process by reviewing the feedback they received and recording their key takeaways on Part G of their *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout. Next, students should discuss their redesign with their group. Finally, students should work with their group to optimize the design.

Once students have optimized their design, prompt them to reflect on the process using the prompt on the slide and in the handout: *Review your experiment and trial history. What were some key adjustments you made in your optimized redesign? How did the adjustments help the orangutans, the people, or both?*

10. Construct an explanation to support a redesign (Part H). 20 MIN

Materials: science notebook, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*

Construct an explanation to support a palm farm design. Have students return to their seats. Display **slide P** and direct students to Part H of their *How can we redesign the way land is used in Indonesia to support*

*** Supporting Students in Three-Dimensional Learning**
Throughout the redesign, students work with science ideas that

orangutans and people at the same time? handout. Read through the explanation prompt together. Then give students time to individually develop an explanation supporting their ideas for a betterdesigned palm farm that works for both people and orangutans.*

Assessment Opportunity

Building towards: **17.B** Apply ideas about ways of growing food to design a better way to use the land to minimize human impact on orangutan populations.

What to look/listen for:

- Using a variety of different ways to grow food can maintain or increase orangutan populations and people's income.
- People can reasonably set aside a portion of their land to support orangutan populations without reducing their income.
- Neighboring farms can coordinate their approaches to increase space for orangutans.
- Rainforest corridors connecting intact areas of forest increase orangutan populations.

Students should identify 2 features of a diversified palm farm that support people and biodiversity, along with how each of these features works. Example features include:

Feature	How it works
Many crops	Protects people in case of a disruption and can give them steady income. Creates multiple layers, which act more like a forest for animals, insects, and birds.
Forest set aside or corridor	People can get the same amount of crop with less land. Protecting part of the land for forest creates corridors for animals to travel through.

Students should explain that together these features create a way to use the land that better supports a farmer because it minimizes the farmer's risk in case of a disruption. These features better support biodiversity by having more types of plants in the farm area, which support more kinds of consumers. The corridors combined with more diverse crops provide animals with more space and habitat in which to live.

What to do: Look ahead at the rubrics provided in Lesson 18. *Rubric Option 1: Redesign the Land* or *Rubric Option 2: Redesign the Land* are offered as ways to score group and individual design work and provide feedback. If students struggle to generate ideas for the design of the land, consider projecting an existing solution and evaluating the trade-offs of the solution. The code for one possible design solution is located in the Design Solution Slide Deck, slide 1, notes section. Copy this code into the simulation and run the simulation. Prompt students to identify design features in the design (e.g., corridor, areas of customary forest grouped together, using land already cleared of forest to plant oil palm). Then prompt students to consider how and why the different features work. Once students have had the opportunity to see and think about a potential design, have students work on their own and in their groups to create a new design.

Complete the teamwork self-assessment. In addition to writing an explanation, students should complete the *Teamwork Self-Assessment*. Use this as an opportunity to help students reflect on their own work and to provide feedback on their teamwork.

they developed throughout the unit (DCI) to minimize human impact on the environment (CCC: Stability and Change). In this final piece of writing, students develop an explanation (SEP: Constructing Explanations) that draws together evidence gathered from the computer simulation and science ideas that they developed throughout the unit to explain how and why their design solution improves outcomes for both the orangutans and the farmers.

11. Navigation

5 MIN

Materials: None

Turn and talk about potential weaknesses in the design solution. Share that in the next class, students will present and evaluate their design solutions. The class will argue for the top design solutions. Have students turn and talk about potential weaknesses in their solutions using the prompts on the **slide Q**.

ADDITIONAL LESSON 17 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.WHST.6-8.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

In Part H of the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout, students construct an explanation to support a redesign for ways to use the land. They should provide a how or why account of the design features they used that are based in science ideas. In constructing the explanation, students prepare to write and present an argument in Lesson 18.

LESSON 18

How do our designs work for orangutans and people in Indonesia?

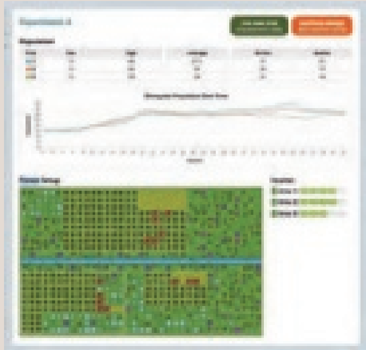
Previous Lesson

Students used a computer simulation to redesign the way land is used in Indonesia to support orangutans and people at the same time. Students evaluated design solutions created by other groups and then optimized their own design solutions. In an assessment, students evaluated competing design solutions for maintaining or increasing orangutan population sizes and people's income on oil palm farms in Indonesia.

This Lesson

Putting Pieces Together

3 DAYS



We present our best designs to our peers and evaluate each other's designs based on the agreed-upon criteria and constraints. We consider how well each design would work in the real world, along with trade-offs made in the design process. We argue for which designs work best for people, orangutans, or both, and make claims about why they work well. We end the unit by returning to the DQB and celebrating our learning on graffiti boards, or we navigate to one of two extension opportunities: to communicate about the palm oil problem to community members, or to deepen our understanding of human impact in our own community.

Next Lesson

We will see some examples of public service announcements (PSAs) and consider what we would want to communicate to others in our school and community about the palm oil problem. Then, we will create our own PSAs to educate others and encourage them to take action.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

18.A Evaluate competing design solutions for supporting and/or increasing a stable orangutan population and meeting people's income needs.

18.B Construct an argument grounded in evidence and scientific reasoning to recommend a design solution that will support a stable orangutan population and protect the needs of people (effect).

18.C Ask questions about and define problems that arise when humans design land-use systems that have positive and negative effects on biodiversity and ecosystem services.

What Students Will Figure Out

- Design solutions that retained tropical rainforests and customary forests supported the largest orangutan populations.
- Customary forests provided income for people but were not realistic for large-scale farms.
- Design solutions with more palm farms and crops provided income but did not increase orangutan populations.
- Mixed land-use designs overall seemed best for people and orangutans.
- Science learning is about asking questions and gathering evidence to answer those questions.
- Science can help solve complex problems, but it's not the only thing to consider.

Lesson 18 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**PREPARE TO EVALUATE OUR DESIGN SOLUTIONS** Agree on what everyone will pay attention to in order to evaluate the designs. Modify the evaluation sheet as needed.	A-B	Design packet (from Lesson 17), *Solutions to Redesign the Land: Evaluations*
2	30 min	**PRESENT AND EVALUATE DESIGN SOLUTIONS** Have each group present their design and answer clarifying questions.	Design slides	Design packet (from Lesson 17), *Solutions to Redesign the Land: Evaluations*, Design Solutions Slide Deck, computer and projector, Collaborative Oil Palm Model, *Rubric Option 1: Redesign the Land* or *Rubric Option 2: Redesign the Land*
3	5 min	**ADD TO OUR PROGRESS TRACKERS** Allow students individual processing time to reflect on what they learned or figured out from group presentations.	C	
				End of day 1
4	20 min	**CONSENSUS DISCUSSION ABOUT WHAT WORKED AND TRADE-OFFS MADE** Students make claims about what they observed worked well, the trade-offs made in the designs, and how these designs would work in the real world.	D-F	Design packet (from Lesson 17), *Solutions to Redesign the Land: Evaluations*, Design Solutions Slide Deck, computer and projector, Collaborative Oil Palm Model
5	20 min	**CONSTRUCT A CONVINCING RECOMMENDATION FOR LAND USE IN INDONESIA** Students make a recommendation for land use (claim) that they support with evidence and scientific reasoning.	G-I	*Argument for the Best Redesign of Land*, *Rubric: Engaging in an Argument from Evidence for a Land Redesign*

Part	Duration	Summary	Slide	Materials
6	5 min	**NAVIGATION TO DAY 3 OR EXTENSION LESSONS 19 OR 20** Navigate to day 3 to end the unit or to Lessons 19 or 20 to continue applying ideas to relevant action.	J-L	
				End of day 2
7	5 min	**NAVIGATION: CONVINCING ARGUMENTS** Have students share what made arguments more or less convincing.	M	
8	20 min	**REVISIT THE DRIVING QUESTION BOARD (DQB)** Revisit the DQB with the whole class and take stock of all of the questions we've now answered.	N-O	sticky dots, sticky notes, Driving Question Board, Consensus Models
9	20 min	**CELEBRATE LEARNING** Celebrate learning on graffiti boards.	P-Q	markers, 3 graffiti boards
				End of day 3

Lesson 18 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• Design packet (from Lesson 17) • *Solutions to Redesign the Land: Evaluations* • science notebook • *Argument for the Best Redesign of Land* • sticky dots • sticky notes • markers		• Design Solutions Slide Deck • computer and projector • Collaborative Oil Palm Model • *Rubric Option 1: Redesign the Land* or *Rubric Option 2: Redesign the Land* • *Rubric: Engaging in an Argument from Evidence for a Land Redesign* • Driving Question Board • Consensus Models • 3 graffiti boards

Materials preparation (30-45 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.

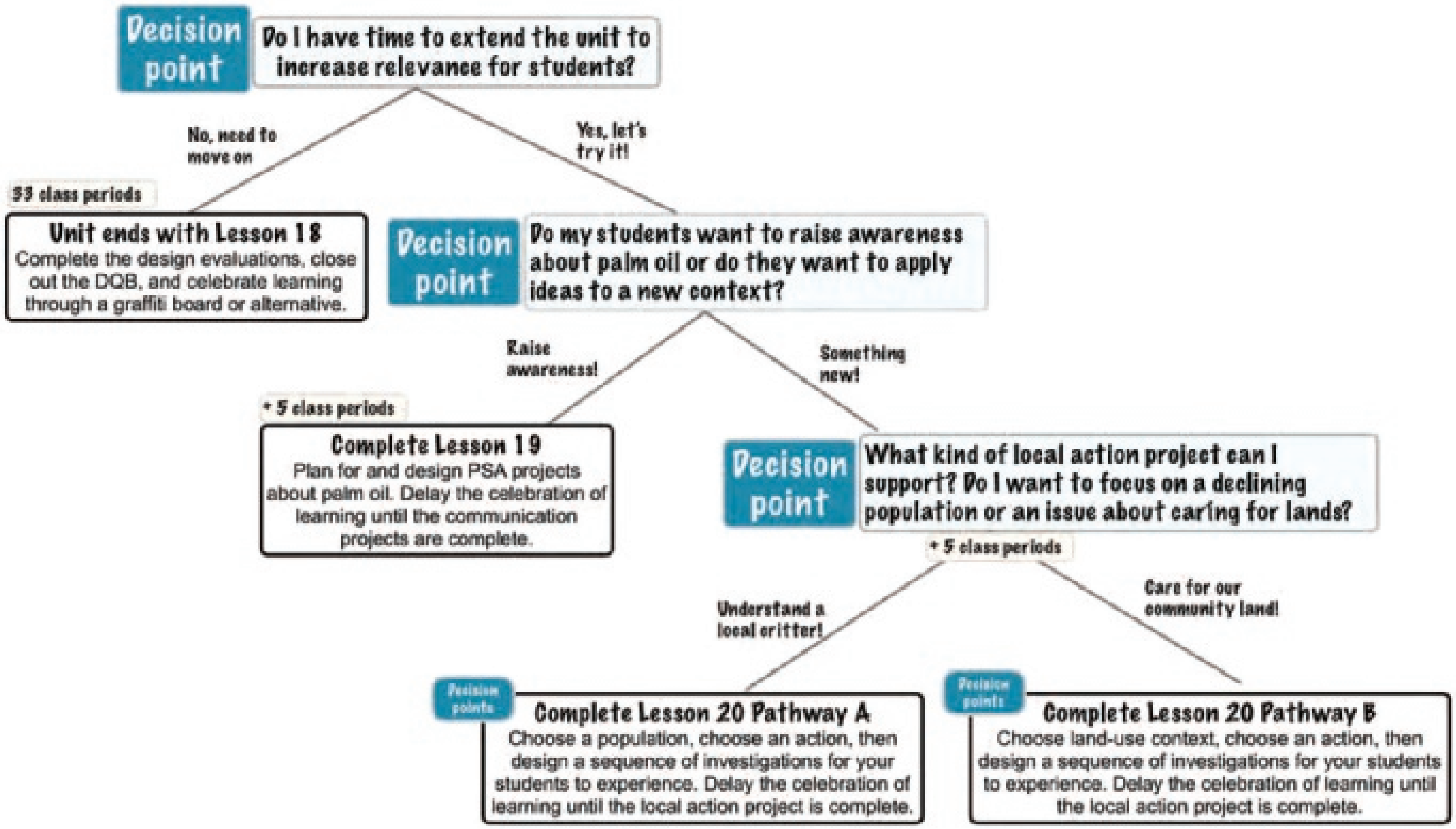
Prepare the *Design Solutions Slide Deck* ahead of time. Students can do this at the end of Lesson 17. A set of Google slides are provided. Students need to share a screengrab of the results from their best design, including a picture of the design, orangutan population over time, and area income levels. Students should copy the design code into the slide notes or a shared Google doc so that you or others can test the design.

Online Resources

There are several opportunities for assessment in this lesson. You do not need to complete all of them. You may want to assess students' group projects and individual explanations that are in *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*. If so, there are two rubric choices provided, with similar content but different format options. Alternatively, you may want to assess students' individual arguments on day 2. If this option is selected, there is a different rubric provided.

Make certain to have all previous classroom consensus models and the DQB prominently displayed for the Scientists Circle on day 3.

If you plan to complete Lesson 19 or Lesson 20, delay completing day 3 until the end of the unit. After day 2, navigate to the extension project. Then return to the DQB and graffiti boards at the very end of the unit.



Lesson 18 • Where We Are Going and NOT Going

In this lesson, students engage in evaluation of the design solutions to support people and orangutans. They also construct an argument for which solutions worked best for people and for orangutans—the two criteria that the designs needed to meet. The lesson builds closely toward:

- MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

As groups share their designs, they will evaluate each other's work based on the class's agreed-upon criteria. They will also consider the trade-offs made in the design in terms of how stakeholders might respond to those trade-offs and whether the designs are realistic. To participate in this evaluative work, students will engage in arguments from evidence, first through a Consensus Discussion grounded in evidence from their designs, then through an individual moment to construct an argument. To engage students in these practices at the Grade 6-8 level, focus them on using empirical evidence and scientific reasoning that goes beyond just the results from the design trials centered on criteria and constraints. Make sure they ground their thinking in the evidence and science ideas they have encountered throughout the unit, which they can bring up and use as they argue for features of designs they think work best.

This lesson also provides an opportunity for students to evaluate the Driving Question Board (DQB) to identify the questions they are now able to answer, questions they can partially answer, and those they still have not been able to answer. Through this evaluation of the DQB, students can identify questions they want to explore for future learning outside the classroom or in future science classes.

Stability and Change and Cause and Effect are two useful lenses to support during this lesson. Students may choose to use either, crosscutting concepts as they engage in their evaluation of designs and arguments from the evidence. Because of the focus on stable orangutan populations over time, students may lean toward that focus during the evaluation process. However, when writing arguments, it may be more natural for them to make cause-and-effect claims that they want to support. Encourage students to choose which lens they want to apply in their work.

LEARNING PLAN FOR LESSON 18

1. Prepare to evaluate our design solutions. 10 MIN

Materials: Design packet (from Lesson 17), *Solutions to Redesign the Land: Evaluations*

Prepare for evaluating designs. Gather students in a Scientists Circle around a space where you can project students' designs. Say, *We are going to present our best designs to the class. Our goal is to evaluate our design solutions for redesigning the way land is used in Indonesia. This involves comparing and critiquing our designs. We want to see if we notice any designs that seem particularly strong, or if we notice any features across the designs that seem to work well.* Review classroom norms to prepare students to critique designs and accept feedback during this process.

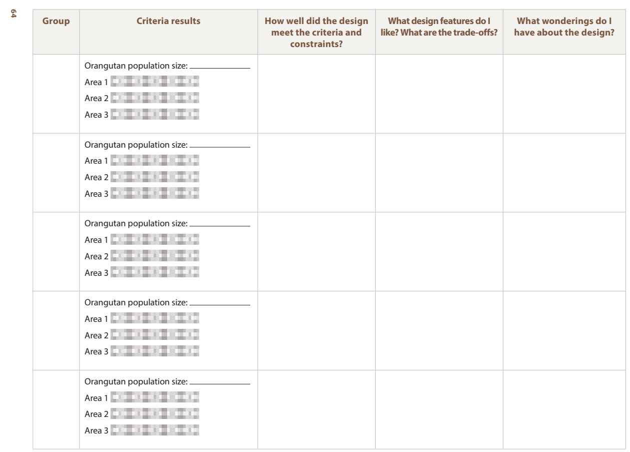
Additional Guidance

During critique-based interactions, it is important to emphasize that the goal is to "make our ideas stronger," not "show we have the best ideas." You can encourage students to take a "coaching" stance, where their role is to ask questions that support others' ideas. You can also encourage them to speak up when something needs to be repeated or clarified.

Elicit ideas for how to compare designs. Display **slide A**. Say, *Given our design task, what do we need to pay attention to in order to evaluate the designs fairly?* Listen for students to suggest ideas related to criteria and constraints, such as:*

- *The orangutan population size*
- *Whether the orangutan population size increased and/or stayed stable*
- *The income level for each area*
- *Where the income level for each area was equal or "fair"*

Direct students' attention to Part B on their *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout if they need additional clarity on what to pay attention to as they evaluate designs.



Group	Criteria results	How well did the design meet the criteria and constraints?	What design features do I like? What are the trade-offs?	What wonderings do I have about the design?
	Orangutan population size: ___ Area 1 Area 2 Area 3			
	Orangutan population size: ___ Area 1 Area 2 Area 3			
	Orangutan population size: ___ Area 1 Area 2 Area 3			
	Orangutan population size: ___ Area 1 Area 2 Area 3			
	Orangutan population size: ___ Area 1 Area 2 Area 3			

Prepare the evaluation sheet to match the class's agreed-upon plan. Pass out 1 copy of *Solutions to Redesign the Land: Evaluations* to each student. Give students 1 minute to read the headings on the handout. Elicit from students any changes they want to make or anything else they should pay attention to as groups present. If students suggest changes to the handout, make the edits now. Also, ask students to pose clarifying questions if they aren't certain what they should track in each column.

*** Supporting Students in Three-Dimensional Learning**
As you elicit ideas from students about how to evaluate designs, listen for students to suggest ideas related to criteria and constraints, population size, stability, and income. This will give you a sense of what students are paying attention to. If you notice a gap, for example, that no one mentions "stability," prompt students to consider it now (e.g., How would we know if the design is supporting a stable orangutan population? What could we look for when they present their design?). You may also want to review with students how to provide and receive critique through a peer evaluation process.

Group	Criteria results	How well did the design meet the criteria and constraints?	What design features do I like? What are the trade-offs?	What wonderings do I have about the design?
	Orangutan population size: ____ Area 1 Area 2 Area 3			

Preview presentation timing. Display **slide B**. Preview that each group will have up to 3-4 minutes to share their designs and answer clarifying questions from their peers. Depending on the number of groups, this timing may need to be modified.

2. Present and evaluate design solutions.

30 MIN

Materials: Design packet (from Lesson 17), *Solutions to Redesign the Land: Evaluations*, Design Solutions Slide Deck, computer and projector, Collaborative Oil Palm Model, *Rubric Option 1: Redesign the Land* or *Rubric Option 2: Redesign the Land*

Have groups present their designs using the design solutions slide deck. Give each group the allotted time to share and monitor that other groups are asking clarifying questions. If students are not certain how to ask clarifying questions, model a few examples for them:

- General clarifying questions
  - Can you say more about that?
  - What do you mean when you say the word "______"?
- Design-specific questions
  - Did putting ______ feature in Area ___ help the orangutan population?
  - Did planting palm oil in Area ___ lower the orangutan population?
  - What is one thing you did to optimize your design?

As groups present, their peers should be recording notes using their *Solutions to Redesign the Land: Evaluations* handout, which will be useful to them later in the Consensus Discussion and for writing their arguments on day 2. You can record feedback for groups on the rubrics that are provided. If time permits, give the students at least 1-2 minutes to process each design and record additional notes even after the group has completed their presentation.

If you want to press students on Stability and Change, consider the additional prompts to the right.*

*** Supporting Students in Developing and Using Stability and Change**

Stability and Change could be a useful tool for students to evaluate the designs in terms of their resilience to disruptions. Consider adding the following prompts to support students in thinking about how the designs would respond to the different disruptions they learned about:

- In what ways is the design solution stable?
- What might cause this solution to become unstable or imbalanced? How do we think the design would respond to a disruption?

3. Add to our Progress Trackers. 5 MIN

Materials: science notebook

Update Individual Progress trackers for reflection. Explain to students that we want to take some individual time to reflect on our current understanding after the group presentations.

Have students turn to the Progress Tracker section in their notebooks. Use **slide C** to guide students in drawing a line after the last entry and to complete the 2 columns, filling in the lesson question and their responses.

Give students 3-4 minutes to quietly update their Progress Trackers. If time permits, allow students to share their ideas with a partner.

End of day 1

4. Consensus Discussion About What Worked and Trade-Offs Made 20 MIN

Materials: Design packet (from Lesson 17), *Solutions to Redesign the Land: Evaluations*, Design Solutions Slide Deck, computer and projector, Collaborative Oil Palm Model

Convene in a Scientists Circle for a Consensus Discussion. Display **slide D** and begin the discussion by naming the question our designs are trying to answer: How do our designs work for orangutans and people in Indonesia?

Give students a few minutes to talk with their design group about the claims they want to make in response to this question.

Then convene the whole class to begin the Consensus Discussion. Encourage students to first make claims and support them with evidence about how the designs worked for people, for orangutans, or both. After 5 minutes, transition to a discussion of trade-offs (**slide E**) and close out the discussion by considering these designs in the real world (**slide F**).*

Key Ideas

Purpose of the discussion: There are three important moves in this discussion: (1) to come to consensus on some design features we agree work well for people and orangutans, but identify areas we may disagree on for different reasons; (2) consider the trade-offs made in optimizing designs and whether these are tolerable; and (3) think about how realistic these designs are for the real world.

What to look/listen for:

Areas of agreement:

- Design solutions that retained tropical rainforests and customary forests supported the largest orangutan populations.
- Customary forests provided income for people but were not realistic for large-scale farms.

*** Strategies for This Consensus Discussion**

A Consensus Discussion is different from other kinds of discussions because the purpose of the discussion is to converge on ideas that the whole class agrees upon. In this discussion, your classroom community is pressing toward ideas to support design solutions. Your role is to help students see where they agree and where they still disagree. Prompts that are helpful in these kinds of discussions include:

- What ideas are we in agreement about?
- Would anyone have put this point a different way?
- Who feels like their idea is not quite represented here?
- Are there still places where we disagree? Can we clarify these?

- Design solutions with more palm farms and crops provided income, but did not increase orangutan populations.
- Mixed land-use designs overall seemed best for people and orangutans.

Areas of disagreement:

- How much of an income drop people are willing to accept.
- How realistic different designs may be in the "real world."
- Whether the trade-offs of designs are minimal or significant.

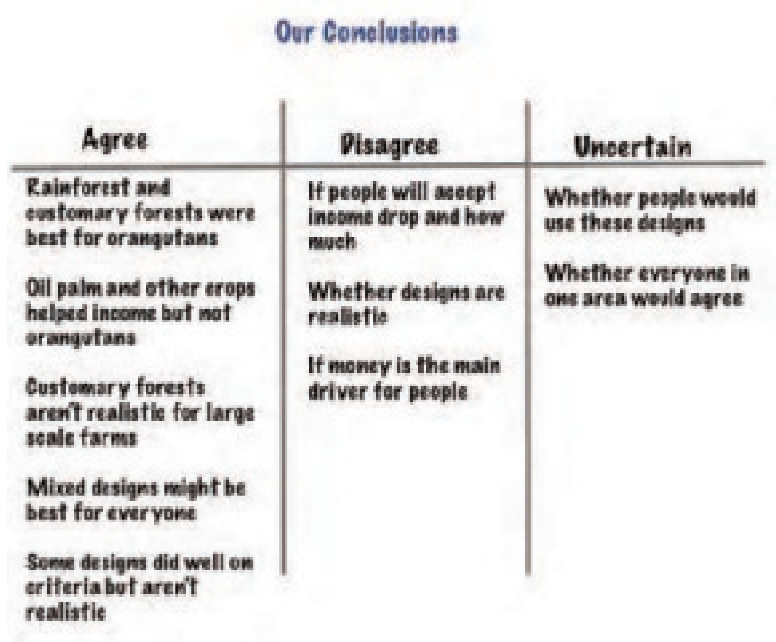
Suggested prompts	Sample student responses	Follow-up questions
What claims can we make about how the designs work for people, orangutans, or both?	*Designs with customary forests worked really well for orangutans and weren't too bad for people.* *Designs with too much palm or other crops kept income high, but orangutans couldn't live in those areas.*	*Did you observe this in one design or several designs?* *What is your evidence that it works?* *How did the design solution fit the criteria we identified?*
What claims can we make across all the designs?	*There are different ways to solve this problem.* *Everyone mixed things up in different ways, but many still met the criteria.* *There is no one way to meet the criteria.*	*How did [select two very different designs] manage to achieve the criteria while being so different?* *How did you arrive at that conclusion?* *What evidence supports your claim?*
What did you notice about the trade-offs that different groups made in their designs?	*Group _____ design didn't want any oil palm so they tried to put customary forest everywhere, but we learned that doesn't work for large-scale farmers.* *Group __ design kept the income pretty high, but their orangutan population only increased a little.*	*What information or evidence did we have to support that?* *Do others agree or disagree with this statement?*
Do we think we have designs that all the stakeholders in Indonesia—the large companies, villagers, small-scale farmers, people protecting orangutans—would support? Why or why not?	*We have designs that meet our criteria, but I'm not sure everyone would agree to them.* *We have designs that increased orangutan populations and only reduced the income by a little, so people may be OK with doing those designs.*	*What evidence could we share with these stakeholders to make these designs more convincing?*

Suggested prompt	Sample student responses	Follow-up questions
Let's think about how these designs will work in the real world. What claims can we make about which designs are most realistic?	*The designs with the highest income are most realistic because money always motivates people to do things.* *Some designs have people planting forests, but that would take a long time to grow. If you put palm on degraded land, it might grow in 5 or 10 years, but would a whole tropical rainforest take a lot longer?*	*Do we all agree with this statement? Why or why not?*

It may be useful to record a class representation of what is agreed upon and what still remains uncertain.

Conclude the discussion with an appreciation for your students' creative design solutions, collaborative teamwork, and thoughtful critique of each other's work. Preview that in the next class they will get to make recommendations on how land should best be used to meet the criteria and constraints, given real-world considerations. Ask them to ponder what they want to recommend most based on their investigations and the evidence they observed from different designs.

If time permits, share feedback with students on what you noticed across the designs and what you noticed about the way they supported their claims during the discussion.



Assessment Opportunity

***Building towards:* 18.A** Evaluate competing design solutions for supporting and/or increasing a stable orangutan population and meeting people's income needs.

What to look/listen for: Two rubrics are provided for guidance on what to look for in students' work: *Rubric Option 1: Redesign the Land* and *Rubric Option 2: Redesign the Land*. The rubrics can be applied to students' work on the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout and group presentations. Note that most of this work was completed as a group, except for Part H, which is an opportunity for individual assessment.

What to do: It is OK if students do not come to complete agreement on the design solutions. This is a complicated problem and there are many ways to solve it, and the preferred design solutions are often rooted in values we hold outside of science. As students share their claims, push them to support the claims with evidence from the simulations or other investigations. For example, if a student claims that people are money-driven, push them to support that claim with evidence. If students cannot identify evidence to support their claims, ask them to brainstorm what kinds of evidence they'd want to collect to support or refute the claim.

On students design packets, look for students to raise ideas about the specified criteria and constraints, as well as other ideas (particularly from Lessons 14-16), in their explanations for Part H. Provide written feedback to students on their explanation to encourage them to make sure their explanations include scientific reasoning to explain how or why the design solution works.

5. Construct a convincing recommendation for land use in Indonesia.

20 MIN

Materials: *Argument for the Best Redesign of Land, Rubric: Engaging in an Argument from Evidence for a Land Redesign*

Preview the argumentation task. Display **slide G**. Say, *We've been designing a part of the world that is really far away from us. We've been making suggestions for how people in Indonesia should redesign their land. We're going to make some recommendations for what we think is the best approach, but first we need to think about how to communicate our recommendations. Let's consider what it might be like to hear someone far away tell us what to do with our land. If we were Indonesian people hearing American students make recommendations, what would make us more receptive to the information? What would make us want to pay attention or engage in a conversation about it?*

Give students a minute to turn and talk. Then elicit ideas from the class. Listen for suggestions:

- Make a convincing argument that these approaches will help their families.
- Make a convincing argument using data.
- Since the orangutan is a special animal to Indonesians, we could think about how our recommendations protect the orangutan.
- We could focus on what is realistic for Indonesians and not just what we think they should do.

Complete the individual argumentation task. Display **slide H.** Modify the task to match the modality choices you plan to offer to students. Give students up to 10 minutes to write their individual argument.*

*** Attending to Equity**

Universal Design for Learning: The default argumentation task is designed as a written task, but should be considered an opportunity for your students to choose the modality by which they want to communicate what they have figured out. Here are several options you may want to offer to your students:

- Oral argument presented to you live (e.g., 1 minute "elevator speech")

Peer feedback on arguments. Display **slide I**. Arrange students in peers. Allow each student 1 minute to share their argument with their peer and 1 minute for feedback from their peer, then switch and repeat. Feedback should focus on:

- Did they make a claim?
- Did they support the claim with evidence?
- Did they support the claim with science ideas?
- Did they use a tone that could be convincing to a stakeholder? Who? Who might not be convinced?

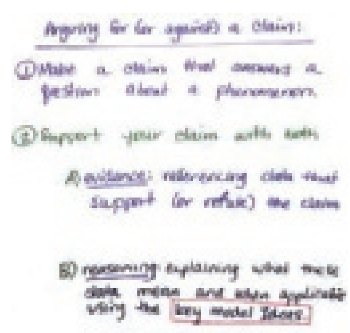
Allow students up to 5 minutes of individual time to add to or improve their argument based on peer feedback. Home learning to work on arguments could be assigned if needed.

- Oral argument presented to you via a video or audio recording
- Visual representation that uses a model to support the being claim made
- Visual representation that communicates an argument through a poster design or other visual layout of information

Assessment Opportunity

Building towards: **18.B** Construct an argument grounded in evidence and scientific reasoning to recommend a design solution that will support a stable orangutan population and protect the needs of people.

What to look/listen for: A rubric is provided to guide you through scoring students' individual arguments. See *Rubric: Engaging in an Argument from Evidence for a Land Redesign*.



What to do: This lesson assumes that students are proficient at writing arguments from their previous learning in 7th grade (e.g., their experiences in the *Bath Bombs Unit* and the *Homemade Heater Unit*). If students need additional support to engage in this practice, first co-construct a class anchor chart that names the parts of a good argument (see the example to the right). If time permits, first work together on a Gotta-Have-It checklist of science ideas that may be useful in the argument. With the argumentation anchor chart and Gotta-Have-It checklist as scaffolds, assign the individual task at that time.

6. Navigation to Day 3 or Extension Lessons 19 or 20

5 MIN

Materials: science notebook

If you are navigating to end the unit after Lesson 18, set students up for closing out the DQB. Display **slide J.** Say, *In the next class, we're going to revisit all the questions we asked on our Driving Question Board to see what we can now answer. I want you to take a moment to relook at the questions you added at the start of the unit, or later on, and think about how you might answer the question now.*

Have students pick 1 question they had early on in the unit and journal about how they would answer it now.

If you are navigating to Lesson 19, engage students in a Quickwrite. Display **slide K.** Say, *We've figured out a lot about this problem that most of us were not aware of just weeks ago. I'm wondering how we can share what we've learned with people in our community.*

Have students reflect on what they want to communicate most about their learning during the unit to their families, friends, or others in their community. Have students respond to the two prompts in their science notebook:

- What should people understand about this problem?
- Why might raising awareness about this problem be important?
- How could we raise awareness about the palm oil problem?

If you are navigating to Lesson 20, engage students in reflecting on local change. Display **slide L.** Say, *We've come so far in exploring this problem about palm oil in Indonesia and how we are connected to it. But we also realized that there are a lot of changes happening in the world—even some right here in our community.*

Have your students reflect on the local population or land-use change you want to engage with in Lesson 20. Have them record in their science notebooks the initial questions they have and ideas for data and information they would need.

End of day 2

7. Navigation: Convincing Arguments

5 MIN

Materials: None

Reflect on convincing arguments. Arrange students in a Scientists Circle. Display **slide M**. Give students time to openly reflect on what made their argument or a peer's argument more or less convincing and to whom?

Suggested prompts	Sample student responses
What made an argument more convincing?	*When they used evidence to show how much better the orangutan population did.* *When they used science ideas to show that farming strategies are about more than getting money.*
Do you think our arguments would be more convincing to some than others?	*It's going to be hard to convince the large oil palm companies to protect the orangutans.*
What could make it convincing to them?	*If we show how they benefit from better farming techniques, that might be more convincing than protecting the orangutan population.*
What made arguments less convincing?	*If they were too focused on one criteria more than others.* *If they didn't use enough evidence or science ideas.*

Say, *We've come a long way since we started. Back in Lesson 1, we weren't even certain why the orangutan population was having a problem and now we've been able to craft strong arguments to show that we clearly understand the problem and all its complexities, and we can still offer up solutions to be considered.*

Transition to reflection on progress on the DQB.

8. Revisit the Driving Question Board (DQB). 20 MIN

Materials: science notebook, sticky dots, sticky notes, Driving Question Board, Consensus Models

Display the Driving Questions Board, which includes a section of "Questions We Answered" from Lesson 6. Since Lesson 6 we've answered more clusters of questions, but we have not explicitly named all the new questions we've answered. Now is the time to do that. Make sure consensus models from the unit are visible to all, too.

Review and share the questions that students think we have answered. Present **slide N** and have students mark on the class DQB with sticky dots the questions that they think we have made progress on.*

Look for patterns using the sticky dots. Focus on the questions that have the most number of sticky dots.

Discuss as a class the questions that the class can now answer. Present **slide O**. Have the class discuss the answers to those questions. If you have space, you might make a "Takeaways" board that has a record of the answers with which the class comes up.*

Assessment Opportunity

***Building towards:* 18.C** Ask questions about and define problems that arise when humans design land-use systems that have positive and negative effects on biodiversity and ecosystem services.

What to look/listen for:

- Students can clearly answer some of the questions using ideas learned in the unit.
- Students can partially answer some of the questions with ideas learned in the unit, but they require more information/evidence.
- Students recognize that the problem they've been investigating goes beyond the scope of science alone. Science can help solve complex problems, but it's not the only thing to consider.

What to do: If students struggle to answer questions from the DQB, place them in small groups with one question or cluster of similar questions assigned to the group. Have them (1) locate where the questions most closely relate to the different investigations conducted, and (2) examine their science notebooks and other documents to search for evidence that could answer or partially answer the question. Ask the group to coconstruct, in writing or orally, an explanation to the question(s) using evidence from their previous work. Remind students what makes a good explanation is a how or why causal account supported with evidence.

*** Attending to Equity**
Revisiting the DQB is important, so students can feel as though their questions are valued and recognized. While not all questions will have been addressed (it's more likely that 50-75 percent will be at least partially answered), this helps students see that they have done this hard work to answer many of their own questions.

*** Supporting Students in Engaging in Asking Questions and Defining Problems**
Students were tasked with asking questions "that required sufficient and appropriate evidence to answer." They were also tasked with defining a design problem that could "be solved through the development of a system where scientific knowledge may limit possible solutions." Through the unit investigations and individual and whole-group sensemaking, they can now answer many of the questions they had throughout the unit, and develop a deeper understanding of defining complex socioscientific problems.

9. Celebrate learning. 20 MIN

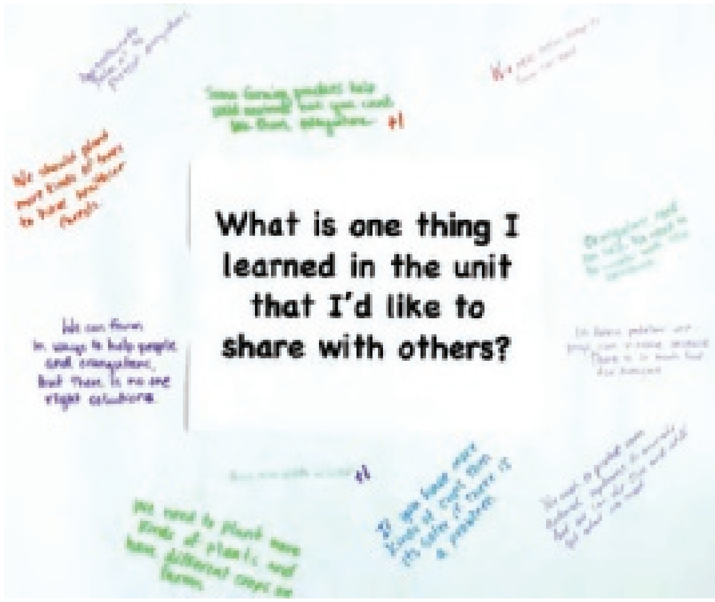
Materials: science notebook, markers, 3 graffiti boards

Celebrate learning using graffiti boards. Display **slide P**. Post 3 graffiti boards around the classroom with the following prompts placed in the center of each board. Alternatively, you can make one large graffiti wall and space out the three prompts along the wall:

- How does changing an ecosystem affect what lives there? (unit question)

- What is one action I want to take to have a positive impact on natural systems?
- What is one thing I learned in the unit that I'd like to share with others?

Give each student 1 marker. Allow students to move around the classroom to visit at least 2 of the 3 prompts to add their thoughts. They can choose to sign their name to the idea or leave it as anonymous. They can also read other ideas that inspire them and add onto those ideas. There is no need for these ideas to be organized. Students can write anywhere on the chart paper.



Discuss and celebrate as a class the ideas shared on the graffiti boards. As time permits, ask students to share some of the interesting ideas they saw as they added to the boards using **slide Q**.

Additional Guidance

The purpose of this graffiti board strategy website is to help students see and reflect one another's ideas. It also helps students who may not be comfortable sharing ideas in a whole-group discussion engage in the conversation. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

ADDITIONAL LESSON 18 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.7.4: Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

Students will present their best designs to their peers and make claims about what works well in the designs given the criteria and constraints.

CCSS.ELA-Literacy.SL.7.3: Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.

During the Consensus Discussion and during peer feedback, students will need to listen to arguments made by their classmates to determine the claims made and whether there is sufficient evidence and sound reasoning to support the claims.

CCSS.ELA-LITERACY.W.7.1: Write arguments to support claims with clear reasons and relevant evidence.

In this lesson, students write an argument based on evidence and supported by scientific reasoning. At this point in their development, this written argument is not overly scaffolded, but you can choose to support students with more scaffolding per suggestions in the Where We're Going section and the assessment guidance.

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.

CCSS.ELA-LITERACY.SL.7.1: Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

This lesson includes partner, small-group, and whole-group discussion and reflection. It represents a culmination of learning in which students should be able to engage with a range of ideas as they present to each other, make arguments, and gather and respond to feedback.

LESSON 19

How can we inform others in our community about the palm oil problem and convince them to take action?

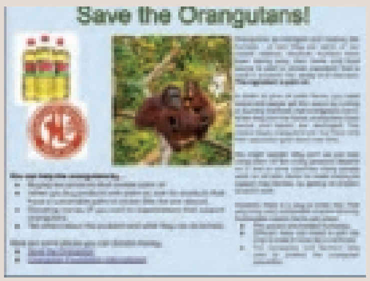
Previous Lesson

We presented our best designs to our peers and evaluated the designs based on agreed-upon criteria and constraints. We argued for which designs work best for people, orangutans, or both, and made claims about why they work well. We ended the unit by returning to the DQB and celebrating our learning on graffiti boards, or we navigated to one of two extension opportunities: to communicate about the palm oil problem to community members, or to deepen our understanding of human impact in our own community.

This Lesson

Putting Pieces Together

5 DAYS



We watch a few examples of public service announcements (PSAs) and discuss what makes good PSAs effective. We brainstorm what messages we want to convey to others in our school and community who do not yet know about what's happening with orangutans. Then, we create PSAs that define the problem, educate others about how the problem is affecting orangutans, and encourage others to take action to be part of the solution.

Next Lesson

We will investigate a local phenomenon, either a declining local population (Pathway A) or a way our community is currently caring for the land (Pathway B), through readings, videos, and/or learning with community members. We will take action in our community in service of addressing a challenge with this local phenomenon.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

19.A Communicate information in writing, drawing, and oral presentation about how even small changes in people's habits or behaviors, like buying different brands of products at the store, can have large impacts on the preservation of natural systems, like the tropical rainforests where orangutans live, over time.

What Students Will Figure Out

- People and communities can take small and large actions that aid the preservation of natural systems like the tropical rainforest.

- Small actions, like changes in people's habits and behaviors, when combined with others' actions or extended over time, can have a large impact on the preservation of natural systems.
- Some actions are more feasible for people or communities to implement, while others are more challenging.

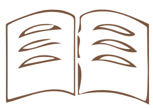
Lesson 19 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	15 min	**INTRODUCE PUBLIC SERVICE ANNOUNCEMENTS (PSAs)** Introduce the idea of a public service announcement (PSA) as a way to communicate to people about a problem.	A-D	*Distracted Driving PSA*
2	10 min	**ANALYZE EXAMPLE PSAs** View some example PSAs and discuss how they are effective.	E-F	*Sample Print PSAs*
3	20 min	**MAKE A PSA CHECKLIST** Students brainstorm ideas that their PSAs should include; then come together with classmates to build a checklist for their PSAs.	G-H	*End of day 1*
4	15 min	**BRAINSTORM ACTION IDEAS FOR PSAs** Students review the criteria they developed last time and discuss what actions they should recommend to people in their PSAs.	I-J	
5	20 min	**GET GROUPS STARTED ON PSAs** Students consider the audience for their PSAs and get started with their group's project.	K	*PSA Communication Plan, Project Options*
6	10 min	**GROUP WORK TIME** Give groups time to work on developing their project.	L	*Self-Assessment: Giving and Receiving Feedback, Obtaining and Communicating Information about the Palm Oil Problem* *End of day 2*
7	45 min	**GROUP WORK TIME** Give groups time to work on developing their project.	L	*Self-Assessment: Giving and Receiving Feedback, Obtaining and Communicating Information about the Palm Oil Problem* *End of day 3*
8	45 min	**PRESENT FINAL PSAs** Groups present final products to one another or a stakeholder group.		*Obtaining and Communicating Information about the Palm Oil Problem* *End of day 4*

Part	Duration	Summary	Slide	Materials
9	35 min	**PRESENT FINAL PSAs** Groups present final products to one another or a stakeholder group.		*Obtaining and Communicating Information about the Palm Oil Problem*
10	10 min	**DECIDE HOW TO SHARE PSAs AND NAVIGATION** Consider what audiences the class wants to reach with their PSAs and how they might share their PSAs with those audiences.	M-N	Driving Question Board

End of day 5

Lesson 19 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Distracted Driving PSA* • *Self-Assessment: Giving and Receiving Feedback* • *Obtaining and Communicating Information about the Palm Oil Problem* • science notebook	• *Sample Print PSAs* • *PSA Communication Plan* • *Project Options*	• *Obtaining and Communicating Information about the Palm Oil Problem* • Driving Question Board

Materials preparation (30 minutes)

Online Resources

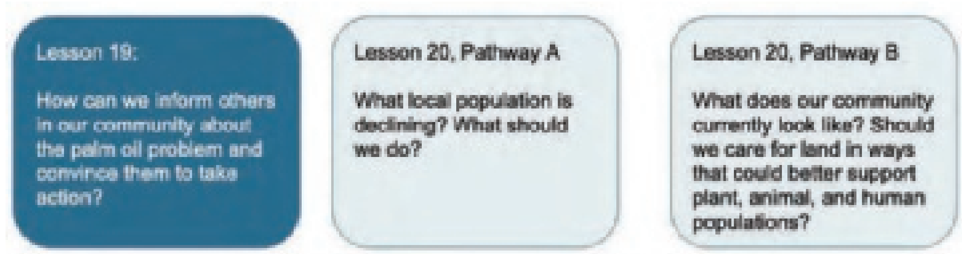
Review teacher guide, slides, and teacher references or keys (if applicable).

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

The purpose of this local project is for students to create public service announcements (PSAs) to raise awareness about the palm oil problem and encourage people in their school or community to take action to address the problem.

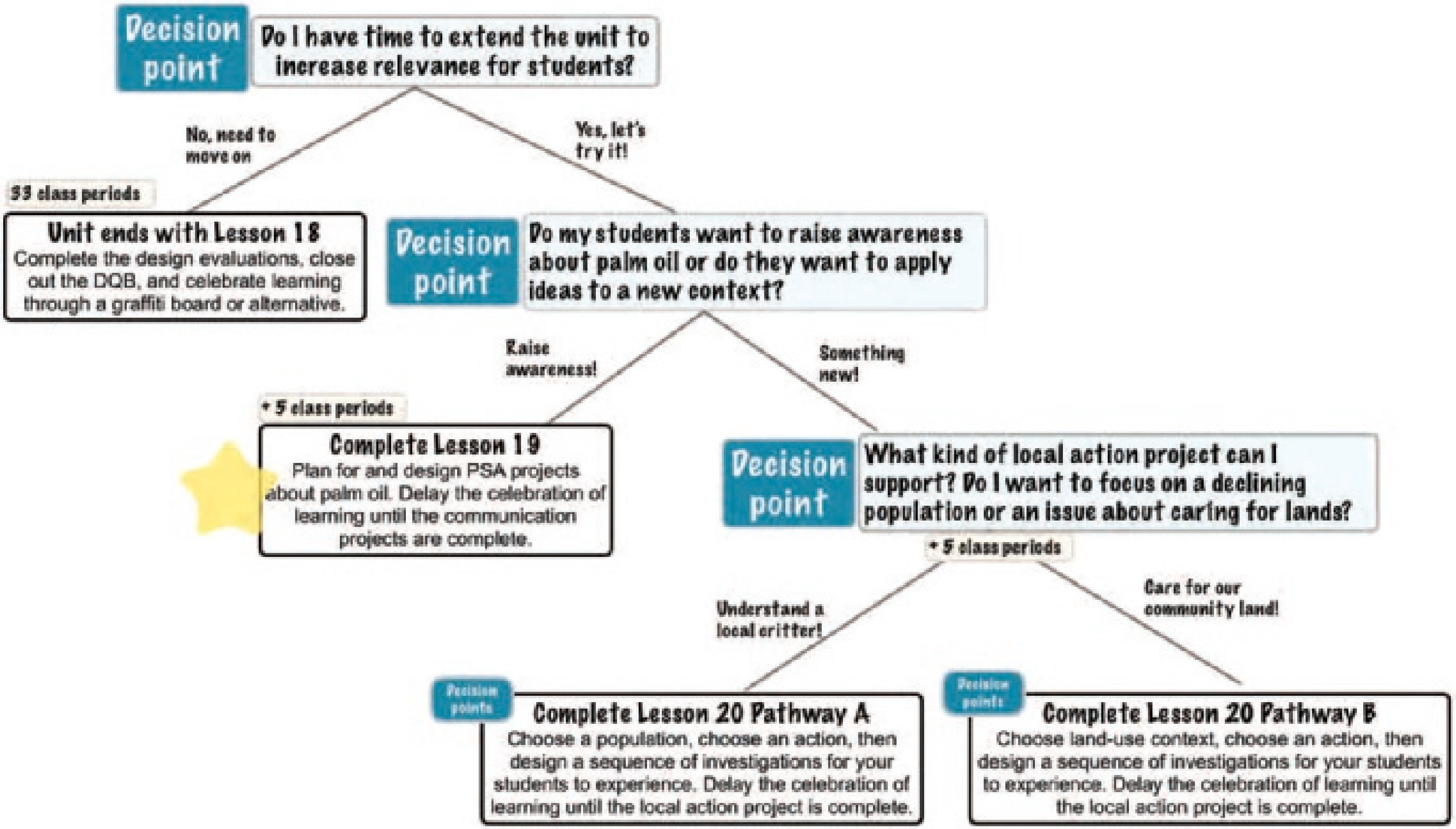
Other options for a local community action project include community action in service of orangutans focusing on one specific local population decline (Lesson 20 Pathway A), or surveying their local schoolyard or neighborhood landscape to see how land is being used (Lesson 20 Pathway B).

Review and edit the options for final products on *Project Options*. Use *PSA Project Choice and Platform Information* to learn more about digital tool options and modify the handout according to any acceptable use policy or classroom limitations. Use *Potential Accompanying Standards* to identify possible accompanying project standards.



Gather any materials that students will need (chart paper, markers, pencils, etc.) and ensure the groups have computer access for the duration of this lesson if they pursue a digital choice.

Identify and alert community and/or school administration that your students might be communicating or sharing their projects with them.


Decision point
Do I have time to extend the unit to increase relevance for students?
No, need to move on
Yes, let's try it!
33 class periods
Unit ends with Lesson 18
Complete the design evaluations, close out the DQB, and celebrate learning through a graffiti board or alternative.
Decision point
Do my students want to raise awareness about palm oil or do they want to apply ideas to a new context?
Raise awareness!
Something new!
+ 5 class periods
Complete Lesson 19
Plan for and design PSA projects about palm oil. Delay the celebration of learning until the communication projects are complete.
Decision point
What kind of local action project can I support? Do I want to focus on a declining population or an issue about caring for lands?
+ 5 class periods
Understand a local critter!
Care for our community land!
Decision points
Complete Lesson 20 Pathway A
Choose a population, choose an action, then design a sequence of investigations for your students to experience. Delay the celebration of learning until the local action project is complete.
Decision points
Complete Lesson 20 Pathway B
Choose land-use context, choose an action, then design a sequence of investigations for your students to experience. Delay the celebration of learning until the local action project is complete.

Lesson 19 • Where We Are Going and NOT Going

Where We Are Going

This lesson gives students a platform for communicating about the problems facing orangutans and other animals that they've encountered throughout this unit. The lesson is intended to be a meaningful experience about understanding human behavior and how crafting key messages can change decision-making in their school and community. Further, this lesson ties those changes in behavior to large-scale changes in the preservation of natural systems like tropical rainforests.

Consider working with your school's social studies teacher(s) to plan and implement these projects. Much of the work in this project is about integrating science ideas with social and civic action.

Where We Are NOT Going

Possible solutions and action ideas can range from small, personal choices to larger systemic changes. Carefully consider your school and community context so that you can guide students in selecting and communicating about solutions that are reasonable and helpful for their audiences. Focus students on the science that supports their solutions and communication plan.

LEARNING PLAN FOR LESSON 19

1. Introduce public service announcements (PSAs).

15 MIN

Materials: *Distracted Driving PSA*

Introduce the idea of a public service announcement (PSA). Show **slide A.** Say, *Last time, we said we wanted to raise awareness about palm oil and the problems that orangutans and other rainforest creatures are facing.*

Suggested prompts	Sample student responses
Why did we say that we wanted to raise awareness about palm oil?	*We thought a lot of people probably hadn't heard about it before, like some of us didn't before we talked about it in class.* *Since we don't live in Indonesia and we can't do other things to help, this was a way we could help from where we live.*
How does it help with the problems facing orangutans?	*If people know about the problem, they could buy less palm oil or only buy sustainable palm oil.* *When more people know about a problem, more people can do stuff to help.* *Maybe if enough people know, bigger changes can happen that could help the orangutans.*

Show **slide B.** Ask students, *What are some ways we could raise awareness about this problem?* Listen for student responses like:

- *Talking to our friends and families*
- *Making announcements to our classmates and our school*
- *Putting up flyers or posters around school*
- *Spreading the word on social media*

Accept students' ideas and come to agreement that there are many different ways to raise awareness that could reach different amounts of people. Point out that different ways of raising awareness might also reach different groups of people—for example, putting up flyers in school might only reach people who are in the school building.

Introduce public service announcements (PSAs). Show **slide C.** Say, *Many people and organizations who want to raise awareness about issues make public service announcements to inform people and encourage them to take action. Public service announcements are often called PSAs, for short. A PSA might be an effective tool for us to communicate with others about palm oil, but first we need to learn more about how they work.*

Tell students that PSAs are meant to get messages out to large numbers of people about a problem and what people can do to help address the problem. Point out that PSAs can take many different forms: visuals (like posters or infographics), audio, video, or in writing.

Point to the image on the right side of the slide. Say, *This is a public service announcement about distracted driving. It was published by the National Institutes of Health (NIH) to help people avoid getting into car accidents.*

Give students time to skim *Distracted Driving PSA*. Show **slide D**. Then, have students share what they notice in this PSA.

Suggested prompts	Sample student responses
What do you notice on this PSA?	*At the beginning, they tell you what distracted driving is and why it's bad.* *They tell you some things that distract you while you're driving, like eating or texting.* *There's some ways that parents can keep their teens from distracted driving.* *There's bullet points and little pictures of things like phones or food.* *There's bigger drawings of people driving.* *At the bottom, there are sources and also icons for different social media.*
What do you think the authors were trying to tell people with this PSA?	*That they shouldn't be distracted while they're driving.* *That they shouldn't do stuff like text or eat while they're driving.*
Who do you think was the audience for this PSA? Who was it meant for?	*I think it was for people who are old enough to drive.* *for teens and their parents*
How do you think this PSA could help this audience?	*It could help remind them not to be distracted while they drive.* *It could tell them the different things to avoid, like texting.* *It gave some tips for how parents could help teens be better drivers.*

Building upon students' responses, point out to the class that this public service announcement defined the problem it was addressing (distracted driving), explained some of the causes of the problem, and gave suggestions for actions people could take to address the problem.

2. Analyze example PSAs. 10 MIN

Materials: *Sample Print PSAs*

Show students some example PSAs. Say, *We're going to check out a few other examples of public service announcements. As we watch, let's look for how each PSA does what the distracted driving PSA did: inform people about a problem, explain what's causing the problem, and convince people to take action to address the problem.*

Additional Guidance

Often, PSAs are published in multiple forms depending on the audience the authors are attempting to reach. For example, CDC announcements are published in multiple languages or sometimes with different voice actors as a means to make PSAs more relatable and trustworthy across different communities.

Consider finding examples of public service announcements (PSAs) relevant to your students and community. Look for topics or presentations that students in your class can relate to. As you consider which PSAs to share as examples, look for the key components that students will include in their PSAs:

- Defining the problem and getting people to care about the problem
- Educating people about what's causing the problem
- Directing people to take action and telling them what actions they could take

Display **slide E.** Ask students to set up a table to record what they notice in their notebooks.

Then, show students each PSA. There are some examples listed on the slide. Additionally, the written PSA examples (e.g., infographic, social media post, and brochure) can be shared through *Sample Print PSAs* and the audio and video examples can be found here (See the **Online Resources Guide** for links to these items. **www.coreknowledge.org/cksci-online-resources**):

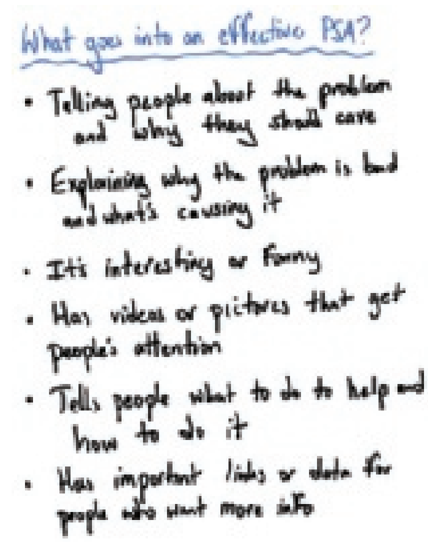
- Audio-Flu: A Serious Disease (CDC)
- Video-Protecting Children from Sunburn (American Academy of Pediatrics)
- Video-Love It or Lose It: The Cycle (World Wildlife Fund).

After giving students time to view or listen to each PSA, ask, *What problem is this PSA raising awareness about? What do the authors do to help people take action to address the problem?* Ask students to turn and discuss with a partner what was similar and different across the different PSAs. Then, have them share what they discussed with the class.

Suggested prompt	Sample student responses	Follow-up question
What were some differences you noticed between the different PSAs?	*They were in different formats, like one was audio and others were video or drawings or writing.* *They were on different subjects and had different information in each one.* *Some were more like a story or more entertaining, and others were more serious.* *Some were longer and took more time, and some were shorter.*	*Why do you think authors might choose to make a certain kind of PSA, like a video or an audio recording or a poster?*

Suggested prompts	Sample student responses	Follow-up questions
What were some similarities you saw?	*All of them were trying to get people to care about a problem.*	*What were some ways that the authors were trying to get people to care?*
What did the different PSAs have in common?	*They all had information about the problem and about why people should care.* *They also told you what you were supposed to do to help. Some of them had different ways to help.*	*What did they do in their PSAs to educate people about the problem and how to help?*

Come to agreement as a class that a PSA like the ones we've seen could be a good way to raise awareness of the palm oil problem.



Define criteria for an effective PSA. Show **slide F.** Title a piece of chart paper "What goes into an effective PSA?". Say, *Now that we've seen some examples of PSAs, we need to decide what makes a PSA effective if we're going to try and make one ourselves.*

Building on the patterns students identified across the different PSAs, add key components to the poster. Say, *One thing that we said all of these PSAs had in common was that they introduced people to a problem they were trying to solve. Let's add "Defines the problem they're trying to solve" to our list of what makes a PSA effective.*

As you build a list with your class, come to agreement on at least the following three components:

- Defining the problem and getting people to care about the problem
- Educating people about what's causing the problem
- Directing people to take action and telling them what actions they could take

Students might also add criteria that emphasizes how engaging or convincing a PSA is. They might point out, for example, that PSAs that have images, video, or music are more engaging than those without. Further, they might point out elements of the script of a PSA like humor, compelling data, or quotes as being effective at convincing an audience.

3. Make a PSA checklist.

20 MIN

Materials: None

Consider the audience for the class's PSAs about the palm oil problem. Recall with students that the class agreed that a PSA would be a good way to inform people about the palm oil problem and what they can do to help address the problem. Say, *Our class is going to create PSAs for the palm oil problem we've been investigating throughout this unit. One first step that might be helpful is to consider the audience for our PSAs.* Listen for student ideas like:

- *Our families*
- *People in our school or in our community*

- *People who could see our PSAs in other places, online or in public*
- *The people or the companies that make palm oil*

Come to agreement that our audiences will likely include people who have never heard of the palm oil problem, just like many of us before beginning this unit. On the other hand, some of our messages may be aimed at people involved in palm oil production, like farmers or corporation leaders. Remind students to keep these different audiences in mind as they plan and create their PSAs.

Define the problem students are addressing in their PSAs. Show students the PSA checklist on **slide G**. Tell students that as we're planning and making our PSAs, we can keep track of what we want and need to include using this checklist tool.

Additional Guidance

On slide G, there is a digital version of the PSA checklist that you can update along with your class. Or, make this checklist on an electronic document or chart paper with markers. The class will add to this checklist during the lesson, so be sure to leave space to add rows and to add ideas to the right column of the table. Also, students will need to be able to access this checklist as they work on their PSAs. Consider creating this checklist in a way where you can make copies of the checklist to give to students later in the lesson.

Say, *We said that one thing that makes a PSA effective is that it tells people about a problem and gets them to care about that problem.* Come to agreement as a class that a good first step for creating PSAs to inform people about palm oil would be to define the problem for people who haven't heard about it before. Add this idea to the first row of the PSA checklist in the left column.

Ask students, *What's the problem that we're trying to raise awareness about?* Come to consensus that we're trying to tell people about how people are cutting down tropical rainforests to produce palm oil. Add this problem to the class's PSA checklist in the first row, like in the example below:

What an effective PSA does	What our PSA should include
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil.

Then, ask students to add other ideas that they think people need to know about the problem and why they should care. Listen for ideas like:

- *Orangutans and other animal populations are going down because their habitat is being destroyed.*
- *The problem is getting worse, and soon many animals could go extinct.*
- *People in the United States and other places, including many of us, are a big part of the problem since we use so much palm oil.*

As the students come to consensus on ideas they think are important to include, add those ideas to the first row of the PSA checklist. Here is an example from a middle-school classroom:

What an effective PSA does	What our PSA should include
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil. • Palm oil is an ingredient in a lot of things we use, like candy, soap, and cleaning products. • Orangutan and other animal populations are decreasing as more palm oil gets produced.

Then, introduce the second row of the checklist. Say, *Besides just defining the problem, we also said that effective PSAs educate people about what's causing the problem*. Emphasize to students that they have learned many new science ideas throughout this unit, and that some (but not all) of these ideas might be important to share with others to help them understand what's happening with palm oil. Add a new row to the class's PSA checklist to represent this component:

What an effective PSA does	What our PSA should include:
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil. • Palm oil is an ingredient in a lot of things we use, like candy, soap, and cleaning products. • Orangutan and other animal populations are decreasing as more palm oil gets produced.
Teaches people about what's causing the problem	

Ask students to make a heading in their notebook, like that shown on **slide H**. Then, direct students to take five minutes to turn and talk with a partner to brainstorm what information and science ideas they think should go on the class's PSA checklist for this second row.

As students are discussing with their partners, direct them to look back through their notebook to find important ideas and findings from different lessons that might help someone better understand what's causing the problems that orangutans and other rainforest animals are facing due to palm oil. After students have had time to brainstorm, ask them to share their ideas with the class.

Suggested prompt	Sample student response	Follow-up questions
What science ideas do you think we should include in our PSAs?	*Palm oil is especially good for a lot of products that we use, and it's hard to replace with other kinds of oils.*	*What evidence do we have for this idea? Where can we find this idea in one of our investigations?*

Suggested prompt	Sample student responses	Follow-up questions
What findings from our investigations should we include?	• *Palm oil comes from oil palm trees, which can only be grown in places with the right sunlight and rainfall.* • *Companies are cutting down rainforests in places like Indonesia because these are good places to grow oil palm trees.* • *When companies cut down rainforests, they remove trees that orangutans use for food, shelter, and travel.* • *Without these trees, orangutans can't survive and so the number (population) of orangutans decreases.* • *Some companies and farms are growing oil palm trees sustainably, but it's expensive and most companies aren't doing this yet.*	*Why is this idea important to include? Why do people need to know this to understand the problem?*

Come to consensus on important ideas to include in the PSAs. Add them to the PSA checklist in the second row, as shown below:

What an effective PSA does	What our PSA should include
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil. • Palm oil is an ingredient in a lot of things we use, like candy, soap, and cleaning products. • Orangutan and other animal populations are decreasing as more palm oil gets produced.
Teaches people about what's causing the problem	• *Palm oil is especially good for a lot of products that we use, and it's hard to replace with other kinds of oils.* • *Palm oil comes from oil palm trees, which can only be grown in places with the right sunlight and rainfall.* • *Companies are cutting down tropical rainforests, where orangutans and other animals live, in places like Indonesia because these are good places to grow oil palm trees.* • *When companies cut down tropical rainforests, they remove trees that orangutans use for food, shelter, and travel.* • *Without these trees, orangutans can't survive and so the number (population) of orangutans decreases.* • *Some companies and farms are growing oil palm trees sustainably, but it's expensive and most companies aren't doing this yet.*

Point out to students that the class now has a checklist for what should go into their PSAs, which they will start creating the next time the class meets. Say, *There are still some decisions your group will need to make, like how to present this information in a way that people will find convincing.* Ask students to think about how they think their group should present their PSA ahead of your next class together.

End of day 1

4. Brainstorm action ideas for PSAs. 15 MIN

Materials: None

Recall the criteria the class brainstormed about last time. Remind students that last time, the class was discussing what makes a public service announcement (PSA) effective and brainstorming what they should include for a PSA about the palm oil problem.

First, point students to the "What makes a PSA effective?" poster the class created last time. Say, *Last time, we checked out some PSAs and we noticed some components that PSAs had that made them effective.*

Then, direct students' attention to the PSA checklist the class developed last time. Point out that the class already decided what they need to include in their PSAs to (1) define the palm oil problem and (2) explain what's causing the problem using science ideas from this unit.

Add a third row to the PSA checklist from last time. Say, *One other component that we said needed to be included in an effective PSA is to direct people to actions they can take to help solve the problem.*

Fill in the third row to the PSA checklist with this component. Here's an example of what this could look like:

What an effective PSA does	What our PSA should include
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil. • Palm oil is an ingredient in a lot of things we use, like candy, soap, and cleaning products. • Orangutan and other animal populations are decreasing as more palm oil gets produced.
Teaches people about what's causing the problem	• *Palm oil is especially good for a lot of products that we use, and it's hard to replace with other kinds of oils.* • *Palm oil comes from oil palm trees, which can only be grown in places with the right sunlight and rainfall.* • *Companies are cutting down tropical rainforests, where orangutans and other animals live, in places like Indonesia because these are good places to grow oil palm trees.* • *When companies cut down tropical rainforests, they remove trees that orangutans use for food, shelter, and travel.*

What an effective PSA does	What our PSA should include
	• *Without these trees, orangutans can't survive and so the number (population) of orangutans decreases.* • *Some companies and farms are growing oil palm trees sustainably, but it's expensive and most companies aren't doing this yet.*
Directing people how to take actions to help solve the problem	

Point out to students that if they are going to direct people how to take action, they will need some ideas for how people can act to help address the palm oil problem.

Begin by students what action ideas were suggested in the PSAs they watched last time. Listen for ideas like:

- *Donating money or time to charities*
- *Changing behaviors, like how they drive or what they do in their everyday life*
- *Telling other people in their family or community about the problem*

Brainstorm ideas for actions to help address the palm oil problem. Show **slide I**. Ask students to turn and talk with a partner to brainstorm what actions people could take. Have students jot these ideas down in their notebook and be ready to share with the class.

Once students have had some time to think with a partner, ask them to share with the class.

Suggested prompt	Sample student responses	Follow-up questions
What actions do you think we could suggest to people to help address the palm oil problem?	*They could stop buying palm oil.* *They could buy different products that have no palm oil, less palm oil, or only sustainable palm oil.* *They could donate money to people or charities who are helping preserve the forest.* *They could go and plant trees in the rainforest where they've been cut down.* *They could protest or write to the companies that are cutting down trees and tell them to stop.* *They could tell other people in their families or communities about the problem, too.*	*How do you think this action would help address the palm oil problem?* *Who can do this action? Can everyone do it?*

As students share, add the ideas the class reaches consensus on to the third row of the PSA checklist:

What an effective PSA does	What our PSA should include
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil. • Palm oil is an ingredient in a lot of things we use, like candy, soap, and cleaning products. • Orangutan and other animal populations are going down as more palm oil gets produced.
Teaches people about what's causing the problem	• *Palm oil is especially good for a lot of products that we use, and it's hard to replace with other kinds of oils.* • *Palm oil comes from oil palm trees, which can only be grown in places with the right sunlight and rainfall.* • *Companies are cutting down tropical rainforests, where orangutans and other animals live, in places like Indonesia because these are good places to grow oil palm trees.* • *When companies cut down tropical rainforests, they remove trees that orangutans use for food, shelter, and travel.* • *Without these trees, orangutans can't survive and so the number (population) of orangutans decreases.* • *Some companies and farms are growing oil palm trees sustainably, but it's expensive and most companies aren't doing this yet.*
Directing people how to take actions to help solve the problem	• Suggest actions people could take like: ◦ Buy products with no palm oil, less palm oil, or only sustainable palm oil. ◦ Donate money to people or organizations that work to preserve the tropical rainforest. ◦ Plant trees in the tropical rainforest to replace the trees that have been cut down. ◦ Protest the companies that are cutting down trees to tell them to stop. ◦ Tell other people they know to take these actions, too, so they can also help.

After students have brainstormed ideas to add to the checklist, ask them to reflect on the actions they've suggested. Show **slide J.** Say, *Let's look at the actions that we said we might suggest to people. Can everyone do these actions? Who can and who can't? Would we take these actions?*

Facilitate a discussion with students about the action ideas they suggested.

Suggested prompts	Sample student responses
Can everyone do all the actions that we brainstormed?	*Everyone could tell others about the problem or write letters.*
Who can and who can't?	*Some people probably couldn't donate if they didn't know where to donate or if they didn't have money to give.* *Only people who live near the rainforest or who could travel there could plant trees there.* *Some people may not be able to buy different products if they're more expensive or not available where they shop.*
Would you take all of these actions yourself?	*I would do some of them, but not all of them.* *I can't plant more trees, because I don't live near the rainforest.* *Some of us can't buy different products because we don't do the shopping for our families. Maybe we could tell our families what not to buy?*
Can we ask people to take actions that we're not willing to ourselves?	*No—that wouldn't be fair.* *Maybe—if there were some actions that people could take that we couldn't take, like planting trees or donating money.*

Ask students if there are any other criteria they want to add to the PSA checklist after this discussion. Listen for ideas like:

- *We should include multiple different actions that different people can take in different situations.*
- *We should tell people what they could do if they can't do the other actions we suggested.*
- *We could direct them to places to learn more.*

Add any further criteria that students brainstorm to the class's PSA checklist.

What an effective PSA does	What our PSA should include
Tells people about a problem and gets them to care about that problem	• People are cutting down tropical rainforests to produce palm oil. • Palm oil is an ingredient in a lot of things we use, like candy, soap, and cleaning products. • Orangutan and other animal populations are decreasing as more palm oil gets produced.

What an effective PSA does	What our PSA should include
Teaches people about what's causing the problem	• *Palm oil is especially good for a lot of products that we use, and it's hard to replace with other kinds of oils.* • *Palm oil comes from oil palm trees, which can only be grown in places with the right sunlight and rainfall.* • *Companies are cutting down tropical rainforests, where orangutans and other animals live, in places like Indonesia because these are good places to grow oil palm trees.* • *When companies cut down tropical rainforests, they remove trees that orangutans use for food, shelter, and travel.* • *Without these trees, orangutans can't survive and so the number (population) of orangutans decreases.* • *Some companies and farms are growing oil palm trees sustainably, but it's expensive and most companies aren't doing this yet.*
Directing people how to take actions to help solve the problem	• Suggest actions people could take like: ◦ Buying products with no palm oil, less palm oil, or only sustainable palm oil. ◦ Donate money to people or organizations that work to preserve the tropical rainforest. ◦ Plant trees in the tropical rainforest to replace the trees that have been cut down. ◦ Protest the companies that are cutting down trees to tell them to stop. ◦ Tell other people they know to take these actions, too, so they can also help. • Give people more than one way to help. • Include different actions that different people can take in different situations.

5. Get groups started on PSAs.

20 MIN

Materials: *PSA Communication Plan, Project Options*

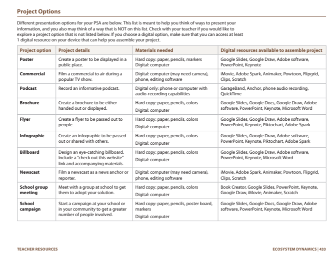
Gather students in their PSA project groups. Show **slide K.** Say, *Now, we have a checklist for what all should be included in our PSAs about the palm oil problem.*

Tell students that their groups are going to begin working on their PSAs. Project the class PSA checklist. Review the criteria for groups' work on their PSAs. Emphasize that students should use the PSA checklist that the class created along with the "What makes a PSA effective?" poster to make sure they've included every important component to make their PSAs effective. Give time for students to ask any clarifying questions about expectations.

Additional Guidance

The PSA Checklist the class created is a key resource for groups to make sure they include all the important components, ideas, and actions that the class decided must be in an effective PSA. Consider creating copies of this checklist for students to use as they work in groups to create their PSAs. They can check off ideas and components as they work. This strategy could help support students in meeting the expectations for the project laid out in the project's rubric.

To each group, pass out *PSA Communication Plan*. Direct students to work with their group to begin their work on their PSA by deciding on a communication strategy and platform. *Project Options* could be used by students to help identify which communication platform or method would best help them communicate their message based on their group strengths and classroom limitations.* This reference can also be used to gain general information about different popular project platforms that may be used during this project by any student. In these discussions, students should consider who the audience is for their PSA and what they need to know before choosing a communication strategy and platform.


Project Options

Different presentation options for your PSA are below. This list is meant to help you think of ways to present your information, and you also may think of a way that is NOT on this list. Check with your teacher if you would like to explore a project option that is not listed below. If you choose a digital option, make sure that you can access at least 1 digital resource on your device that can help you assemble your project.

Project option	Project details	Materials needed	Digital resources available to assemble project
Poster	Create a poster to be displayed in a public place.	Hard copy: paper, pencils, markers Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote
Commercial	Film a commercial to air during a popular TV show.	Digital: computer (may need camera), phone, editing software	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch
Podcast	Record an informative podcast.	Digital only: phone or computer with audio-recording capabilities	GarageBand, Anchor, phone audio recording, QuickTime
Brochure	Create a brochure to be either handed out or displayed.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Flyer	Create a flyer to be passed out to people.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark
Infographic	Create an infographic to be passed out or shared with others.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark
Billboard	Design an eye-catching billboard. Include a "check out this website" link and accompanying materials.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Newscast	Film a newscast as a news anchor or reporter.	Digital: computer (may need camera), phone, editing software	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch
School group meeting	Meet with a group at school to get them to adopt your solution.	Hard copy: paper, pencils, colors Digital: computer	Book Creator, Google Slides, PowerPoint, Keynote, Google Draw, iMovie, Animaker, Scratch
School campaign	Start a campaign at your school or in your community to get a greater number of people involved.	Hard copy: paper, pencils, poster board, markers Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word

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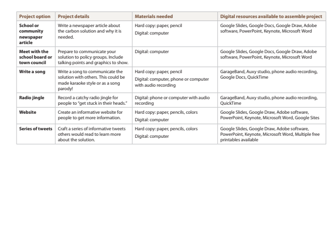
Project option	Project details	Materials needed	Digital resources available to assemble project
School or community newspaper article	Write a newspaper article about the carbon solution and why it is needed.	Hard copy: paper, pencil Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Meet with the school board or town council	Prepare to communicate your solution to policy groups. Include talking points and graphics to show.	Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Write a song	Write a song to communicate the solution with others. This could be made karaoke style or as a song parody!	Hard copy: paper, pencil Digital: computer, phone or computer with audio recording	GarageBand, Auxy studio, phone audio recording, Google Docs, QuickTime
Radio jingle	Record a catchy radio jingle for people to "get stuck in their heads."	Digital: phone or computer with audio recording	GarageBand, Auxy studio, phone audio recording, QuickTime
Website	Create an informative website for people to get more information.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word, Google Sites
Series of tweets	Craft a series of informative tweets others would read to learn more about the solution.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word, Multiple free printables available

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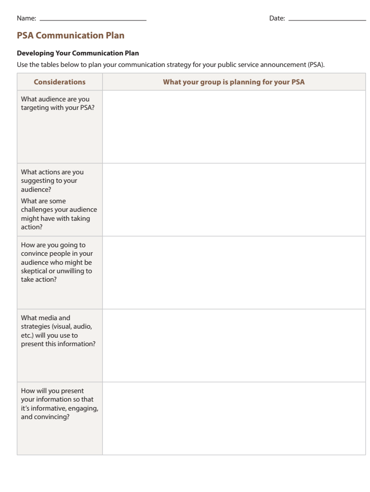
Approve an appropriate project format. Once students are finished with *PSA Communication Plan*, have students bring the handout and their thoughts on a project option to you. Review the handout with students and ask clarifying questions about any areas that seem to be lacking information or are incomplete.* Some example prompts include:

- What audience(s) are you targeting with your PSA?
- What solutions are you suggesting to them? Can they implement these solutions? Do they need help? If so, who can help them?
- What are some potential issues that you think your audience might have?
- How are you going to convince people who might be skeptical or unwilling to take action?
- What media and strategies (audio, visual, etc.) will you use to present this information?
- How will you present your information so that it's informative, engaging, and convincing?


Name: ______________ Date: ______________

PSA Communication Plan

Developing Your Communication Plan

Use the tables below to plan your communication strategy for your public service announcement (PSA).

Considerations	What your group is planning for your PSA
What audience are you targeting with your PSA?	
What actions are you suggesting to your audience? What are some challenges your audience might have with taking action?	
How are you going to convince people in your audience who might be skeptical or unwilling to take action?	
What media and strategies (visual, audio, etc.) will you use to present this information?	
How will you present your information so that it's informative, engaging, and convincing?	

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*** Attending to Equity**

Supporting Emerging Multilingual Students: This could be an opportunity to highlight the benefits of multilingual communication in our global world because expressing ideas across many languages can help reach larger and broader audiences. This would also be particularly beneficial if the stakeholder group(s) speak a primary language other than English. Consider encouraging your emerging multilingual students—who feel comfortable doing so—to develop a communication project that includes key messaging about the orangutan and palm oil problem in multiple languages.

*** Supporting Students in Engaging in Obtaining, Evaluating, and Communicating Information**

At this point in this lesson, students are integrating information from a variety of sources (visual and written) and deciding how to communicate it with others in a relevant, effective, and/or engaging way. To support this practice, use questions like: *What are the main ideas that people need to know?* Or, *What are the three most critical pieces of information to communicate to people? How can we best communicate that information in our PSA?*

6. Group Work Time

10 MIN

Materials: *Self-Assessment: Giving and Receiving Feedback*, *Obtaining and Communicating Information about the Palm Oil Problem*

Decide on how long students have to work on the project. Projects should be approved late in day 2. Give students the remaining time on day 2 to work and up to two additional class periods to develop their project.

End of day 2

7. Group Work Time

45 MIN

Materials: *Self-Assessment: Giving and Receiving Feedback*, *Obtaining and Communicating Information about the Palm Oil Problem*

Provide students time to work on PSA Projects.

As students work through the development of the project, provide four key points in the development process to assess their work:

Four Assessment Points	Resources to Use	Purpose of the Assessment
Initial requirements discussion	**Slide K** *Obtaining and Communicating Information about the Palm Oil Problem*	Provides students with clear directions on the scope of the project. Provides students an opportunity to ask clarifying questions about expectations.
Self-assessment	**Slide L** *Self-Assessment: Giving and Receiving Feedback* *Obtaining and Communicating Information about the Palm Oil Problem*	Use the exit ticket early during students' project work to have students reflect on their groups' work up to that point, which will also give you additional information about whether students feel they need more support. Provide students with specific criteria and level of expectation for their projects.
Peer feedback	For students: *Self-Assessment: Giving and Receiving Feedback* Sticky notes, markers For teacher: *Reference: Peer Feedback Guidelines*	Can be done as a gallery walk. Gives students an opportunity to review others' projects and provide feedback. Gives students an opportunity to incorporate ideas from others into their projects. Read through *Reference: Peer Feedback Guidelines* for more information.

Four Assessment Points	Resources to Use	Purpose of the Assessment
Teacher and peer assessment	*Obtaining and Communicating Information about the Palm Oil Problem*	As students present their projects, teachers, classroom guests, and peers can use the rubric to assess how well the project met the expectations.

If extending this to a multi day project, provide students with a timeline of when these assessment opportunities will occur. For example:

- Provide initial requirements on day 2 of the lesson.
- Conduct a self-assessment early on day 3 of the lesson. This self-assessment can be found on **slide L**.
- Ask peers to provide feedback at the end of day 3.
- Conduct a final assessment of group work on day 4 or 5 when the groups present their projects.

End of day 3

8. Present final PSAs.

45 MIN

Materials: *Obtaining and Communicating Information about the Palm Oil Problem*

Provide any additional time needed to complete group work before beginning presentations.

Present final PSAs. Students should present their final projects anywhere between days 3-5 of this lesson.* Use *Obtaining and Communicating Information about the Palm Oil Problem* to assess each group's product. This is also another opportunity for self- and peerassessment using *Obtaining and Communicating Information about the Palm Oil Problem*.

Additional Guidance

Students may point out that their peers and their science teacher already know about the problem and may want to present to an audience more like the one they were planning for in their PSAs. Consider inviting other community members or students from other grades to be an audience for students' presentations. These audience members could provide useful feedback to groups about how to best communicate to people who may be unaware of the problems facing orangutans and other rainforest animals.

Assessment Opportunity

Building towards: **19.A** Communicate information in writing, drawing, and oral presentation about how even small changes in people's habits or behaviors, like buying different brands of products at the store, can have large impacts on the preservation of natural systems, like the tropical rainforests where orangutans live, over time.

*** Supporting Students in Three-Dimensional Learning**
As outlined in the project rubric, these PSAs should clearly integrate and communicate science ideas about changes in ecosystems while also addressing small or large changes in human behavior having larger impacts on habitat preservation. The three dimensions chosen for this lesson were done to help students use their science ideas to communicate with others and begin to make small, cumulative changes in their school and community.

What to look for/listen for: Use *Obtaining and Communicating Information about the Palm Oil Problem* for specific criteria and expectation levels. General ideas include:

- Ideas about actions, both large and small, that people can take that are available and accessible to the targeted audience.
- Ideas connecting these actions to the preservation of natural systems like tropical rainforests by preventing further deforestation and habitat destruction.
- Ideas that account for why it might not work for all stakeholders and that offer options for different actions that could work across different situations.

What to do: Use the Four Points of Assessment table above to provide feedback during the development process. If these strategies are used, it will help students stay on track and focus on the purpose of the project. Provide opportunities throughout development for students to ask clarifying questions. Challenge students' work with questions focused on *PSA Communication Plan* or using the criteria in *Obtaining and Communicating Information about the Palm Oil Problem*.

End of day 4

9. Present final PSAs. 35 MIN

Materials: *Obtaining and Communicating Information about the Palm Oil Problem*

Provide time to finish presentations and give and receive feedback.

10. Decide how to share PSAs and navigation. 10 MIN

Materials: science notebook, Driving Question Board

Celebrate the class's accomplishments on their PSAs. Display **slide M**. Say, *We've learned a lot about the palm oil problem and how humans can cause changes to ecosystems, even ones across the world from where we live. And, importantly, we figured out and communicated ideas for how to address this problem. We have done some great work taking our science ideas and crafting key messages to inform others.*

Ask students, *Who do you think our PSAs need to be shared with?* Listen for ideas like:

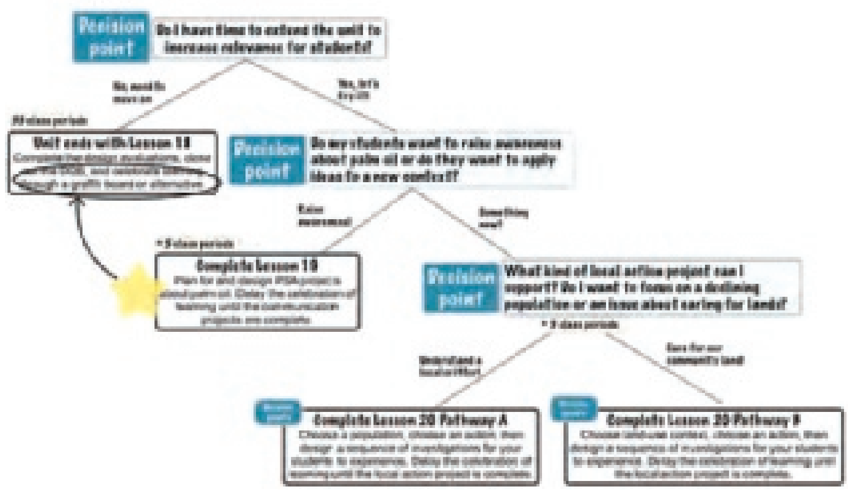
- *Our families and neighbors*
- *Others in our school, like students or teachers in other grades*
- *People in our communities*
- *Everyone!*

Work with students to decide how best to share their PSAs with their intended audiences. This could be within the school through a hallway gallery walk or sharing copies of students' work electronically. Students could also send their work to trusted community stakeholders, or the school could find other ways to publicly display their projects.

Navigate to the next lesson. Say, *In the next class, we're going to revisit all the questions we asked on our Driving Question Board to see what we can now answer. I want you to take a moment to look back at the questions you added at the start of the unit, or later on, and think about how you might answer those questions now.*

Display **slide N**. Have students pick 1 question they had early on in the unit and journal about how they would answer it now.

In the next class, complete Lesson 18, day 3, by revisiting the Driving Question Board and celebrating your learning using Graffiti Boards.



ADDITIONAL LESSON 19 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

See *Potential Accompanying Standards* for a complete list of connections to ELA standards.

Supporting Students in Making Connections in Math

See *Potential Accompanying Standards* for a complete list of connections to Mathematics and Technology standards.

LESSON 20

What should we do to take care of our local land, plants, and animals?

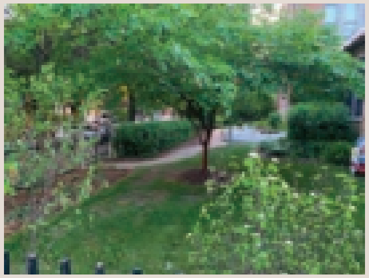
Previous Lesson

We watched some public service announcements (PSAs) and brainstormed what made them effective. We defined what we would want to include in a PSA to inform people about the palm oil problem. Then, we created PSAs to share with others in our school and community.

This Lesson

Investigation

5 DAYS



We are introduced to a local phenomenon, either a declining local population (Pathway A) or a way our community is currently caring for the land (Pathway B). We investigate this phenomenon through readings, videos, and/or learning with community members. We are introduced to one action we can take or multiple actions we could consider taking. We take action in our community in service of addressing a challenge with this local phenomenon, such as habitat restoration, monitoring biodiversity, or communicating with stakeholders about the issues.

Next Lesson

There is no next lesson.

Building Toward NGSS

MS-LS2-1, MS-LS2-2, MS-LS2-4, MS-LS2-5, MS-ESS3-3, MS-ETS1-1

What Students Will Do

20.A Ask questions about a local phenomenon, based on careful observations and patterns from graphs, charts, or images.

20.B Obtain information from texts, videos, or speakers about why the local population (Pathway A) or the way our community has cared for the land (Pathway B) has changed over time.

20.C Apply scientific ideas to take small actions that will positively impact organisms in our local communities.

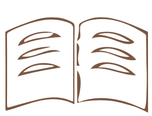
What Students Will Figure Out

- We apply many ideas that we figured out with the palm oil problem and orangutans to populations and lands in our local communities.

Lesson 20 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	45 min	**DAY 1: INTRODUCE A LOCAL PHENOMENON** Introduce students to the local phenomenon: A local population is declining (Pathway A) or we notice interesting patterns about the way our community is currently caring for the land (Pathway B).	A-B	Video/images/data/text to notice and wonder about *End of day 1*
2	45 min	**DAY 2: INVESTIGATE** Investigate questions about the local phenomenon.	C-I	*Obtaining Information Tools*, *Analyzing and Interpreting Data Tools*, *Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional) *End of day 2*
3	45 min	**DAY 3: INVESTIGATE FURTHER AND FRAME WHAT WE CAN DO** Investigate questions about the local phenomenon. Frame an action we could take.	G-I	*Obtaining Information Tools*, *Analyzing and Interpreting Data Tools*, *Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional) *End of day 3*
4	45 min	**DAY 4: ACT IN YOUR COMMUNITY** Take action in your local community by participating in habitat restoration, communicating with an authentic audience, or monitoring a species or biodiversity.	G-I	*Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional) *End of day 4*
5	45 min	**DAY 5: ACT IN YOUR COMMUNITY** Take action in your local community by participating in habitat restoration, communicating with an authentic audience, or monitoring a species or biodiversity.	J	*Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional) *End of day 5*

Lesson 20 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Obtaining Information Tools* • *Analyzing and Interpreting Data Tools* • *Self-Assessment: Giving and Receiving Feedback* (optional)		• Video/images/data/text to notice and wonder about • *Reference: Peer Feedback Guidelines* (optional)

Materials preparation (varied amount of minutes)

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

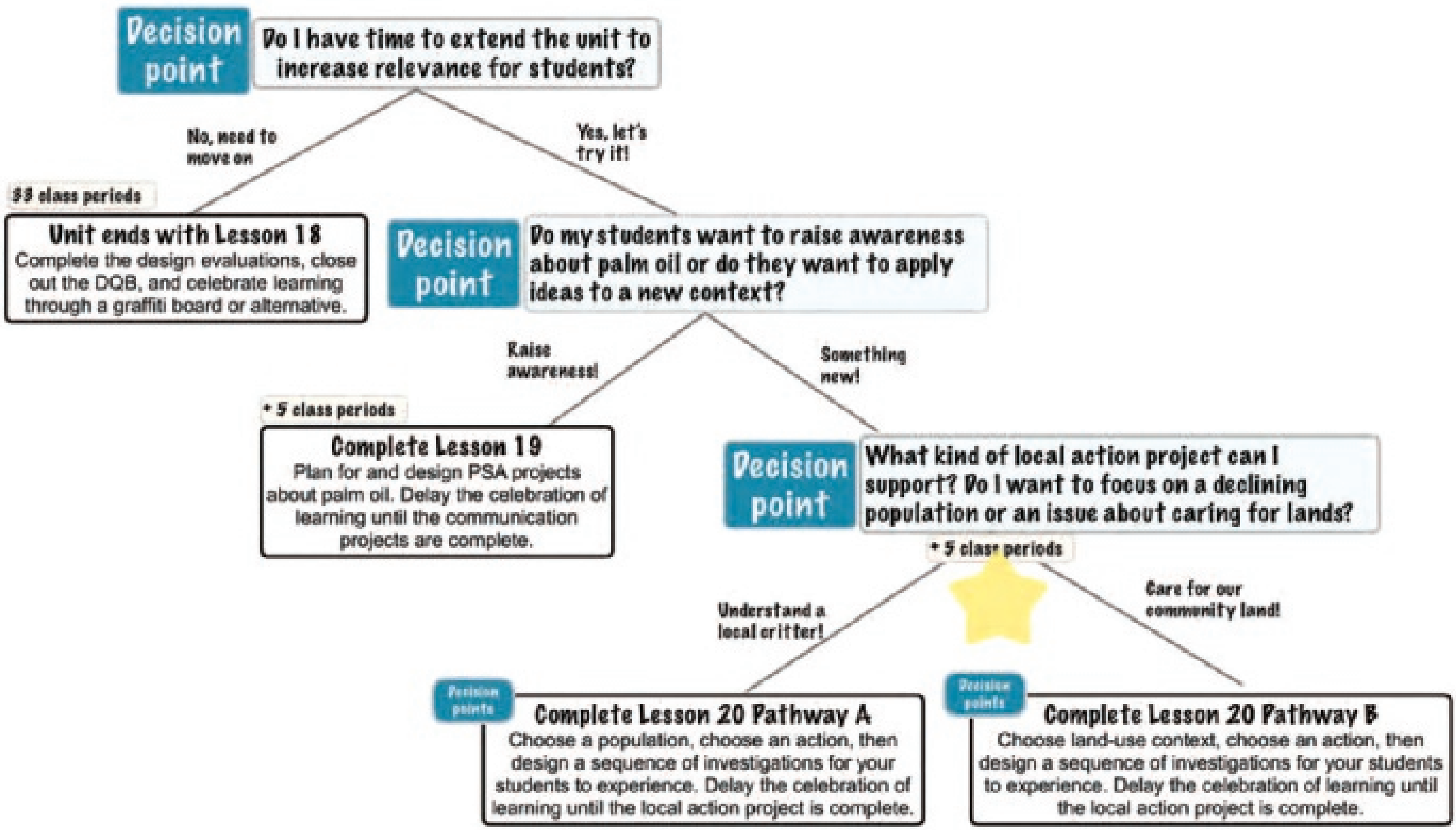
Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

The lesson question has two possible pathways: Pathway A: What local population is declining? What should we do?

Pathway B: How is our community currently caring for the land? Should we care for the land in ways that could better support plant, animal, and human populations?

See *Pathway A: Local Project Planning Guide* or *Pathway B: Local Project Planning Guide* for advance preparation needs.

Online Resources



Lesson 20 • Where We Are Going and NOT Going

In this 5-day lesson, you can select one of two pathways that help students engage in a community action project designed primarily by you and your students, depending on how much you want to involve them in the design. In Pathway A, students observe a declining local population and investigate what is causing the decline and ways to consider taking community action. In Pathway B, students observe the way their community is currently caring for the land and consider if and how they could contribute to stewarding the land in a different way. As you plan, consider related phenomena students have brought up throughout the unit that you may want to incorporate into this local project.

In both pathways, students apply ideas they figured out from Lessons 1-18 about how to support biodiversity and populations in ecosystems. This lesson is intentionally designed for you to position students to make meaningful and real contributions to their communities. The lesson is written so you as a teacher make most of the decisions. However, involving students in co-constructing the direction of their learning will support students' voices, choices, and agency. Consider places where you can involve students in decision-making about this learning as you balance your needs around planning for instruction.

1. Day 1: Introduce a local phenomenon.

45 MIN

Materials: Video/images/data/text to notice and wonder about

Navigation from Lesson 18. Display **slide A**. Say, *Last time we started to wonder about ______. We made some reflections in our notebooks about initial questions we might have and ideas for data we may need. Today we're going to dig into this new problem a little deeper.*

Suggested prompt	Sample student response
How do we think this new problem in our community could be similar to or different from the palm oil and orangutan problem?	*Answers will vary.*

Say, *Let's explore this new problem further to see what science ideas we can bring forward from our previous learning.*

Set up a notice and wonder chart. Display **slide B** and have students start a new notice and wonder chart in their science notebooks.

Introduce a local phenomenon and generate observations and wonderings about the local phenomenon. Display **slide C** and add additional slides as needed. See *Pathway A: Local Project Planning Guide* or *Pathway B: Local Project Planning Guide* for guidance on what kinds of resources to have students make observations and wonderings about.

Pathway A	Pathway B
A local population is declining	How your schoolyard, neighborhood, or community is caring for the land

Have students share their noticings. Display **slide D** and facilitate a sharing of observations.

Generate and share questions about the phenomenon.* Display **slide E**. Ask students to use their wonderings to pose questions for the DQB. Then, display **slide F** to guide building a new section on the DQB for the new problem. Post student questions to the DQB. This should set the stage for much of what students will investigate over the rest of Lesson 20.

*** Supporting Students in Developing and Using Patterns**
Support students in identifying patterns in data. For Pathway A, consider using graphs or charts to help students identify population declines. For Pathway B, consider using images, such as Google Earth or images that students take, to identify patterns in the way your community is currently caring for the land.

Assessment Opportunity

***Building towards:* 20.A** Ask questions about a local phenomenon, based on careful observations and patterns from graphs, charts, or images.

What to look/listen for:

- Connecting observation of patterns from graphs, charts, or images to questions that emerge about a local phenomenon.

What to do: Prompt students to share an observation about patterns in the graphs, charts, or images first, and then a question that arose directly from their observations. Have students work in pairs or small groups before sharing with the whole class.

End of day 1

2. Day 2: Investigate. 45 MIN

Materials: *Obtaining Information Tools*, *Analyzing and Interpreting Data Tools*, *Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional)

Obtain information to answer questions about the phenomenon. Consider using *Obtaining Information Tools* for reading text, watching videos, listening to audio, or listening to an in-person guest. Also, consider additional focus questions to help students synthesize important information.

Slides G-I are provided as templates. Duplicate as needed.

Pathway A	Pathway B
• Why is the local population declining? • What does this population need to survive? • What are people doing to help?	• Who lives here now? • What did land look like in the past? • Who lived here in the past? Why are they not here anymore? • Who might benefit or be harmed by the way land is currently being cared for? • What do community members think should happen?

Discuss important ideas we figured out as a class. Have students share important ideas they figured out about the local phenomenon.

Student self-assessment is one option for assessment. See *Self-Assessment: Giving and Receiving Feedback*. Where appropriate, consider also including an opportunity for peer feedback. See *Reference: Peer Feedback Guidelines*.

Assessment Opportunity

Building towards: **20.B** Critically obtain information from texts, videos, or speakers about why the local population (Pathway A) or the way our community has cared for the land (Pathway B) has changed over time.

What to look/listen for:

- Ideas from the readings, videos, or community members about why local populations are declining and solutions to consider for how to address this (Pathway A) or how lands are currently being cared for and other ways to consider that might benefit populations in ecosystems (Pathway B).

What to do: (1) If students struggle to obtain information from their reading, video, or community speaker, have students do work in pairs to summarize important information. Prompt students to support their conclusions with evidence from the text, video resources, or their conversations with community members.

End of day 2

3. Day 3: Investigate further and frame what we can do. 45 MIN

Materials: *Obtaining Information Tools*, *Analyzing and Interpreting Data Tools*, *Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional)

Continue obtaining information to answer questions about the phenomenon. Consider using *Obtaining Information Tools* for reading text, watching videos, listening to audio, or listening to an in-person guest. Alternatively, consider using *Analyzing and Interpreting Data Tools* for analyzing and interpreting data. Also, consider additional focus questions to help students synthesize important information.

Slides G-I are provided as templates. Duplicate as needed.

Share one action we can take and discuss how it would help. If you are presenting one action students will have an opportunity to take, discuss how this action would help.

Suggested prompt	Sample student responses
How would this action help?	*Habitat restoration—Gives plants and animals back the habitat they need to survive.* *Monitoring biodiversity—Helps us know which populations might need help.* *Science communication—Helps us influence people who have more power to act.*

Additional Guidance

If you are able to involve students in decisions about what we should do, this is a powerful move that supports students' voices, choices, and agency. Some ways you can do this include:

- Brainstorm possible actions to take.
- Discuss and evaluate trade-offs for different kinds of action.
- Consider what we value and whose perspectives we're thinking about for each solution.
- Consider who would each action help and who it would harm. Consider doing nothing.
- Decide what to do.

Additional resources for ethical decision-making in complex socio-ecological systems are available from Learning in Places.

Assessment Opportunity

***Building towards:* 20.C** Apply scientific ideas to take small actions that will positively impact organisms in our local communities

What to look/listen for:

- Ideas about what populations the proposed action would make a difference for and why, drawing on science ideas from Lessons 1-18 about resource availability, competition, and biodiversity.

What to do: (1) If students struggle to apply science ideas to the new problem, consider completing an analogy map between the palm oil and orangutan case and the new problem students are working on. See *Mapping the ______ to the* _______ for a tool for the mapping activity.

End of day 3

4. Day 4: Act in your community.

45 MIN

Materials: *Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional)

Engage students in a community action. See *Pathway A: Local Project Planning Guide* or *Pathway B: Local Project Planning Guide* for **Additional Guidance**. Suggested actions include:

Slides G-I are provided as templates. Duplicate as needed.

Pathway A	Pathway B
• Habitat restoration for the specific population and/or invasive species removal. • Communicate with an authentic audience about the population and what they can do. • Monitor this population or a population it depends upon.	• Habitat restoration. • Communication to authentic audiences about what should happen in this place. • Monitor biodiversity in this place.

End of day 4

5. Day 5: Act in your community.

45 MIN

Materials: *Self-Assessment: Giving and Receiving Feedback* (optional), *Reference: Peer Feedback Guidelines* (optional)

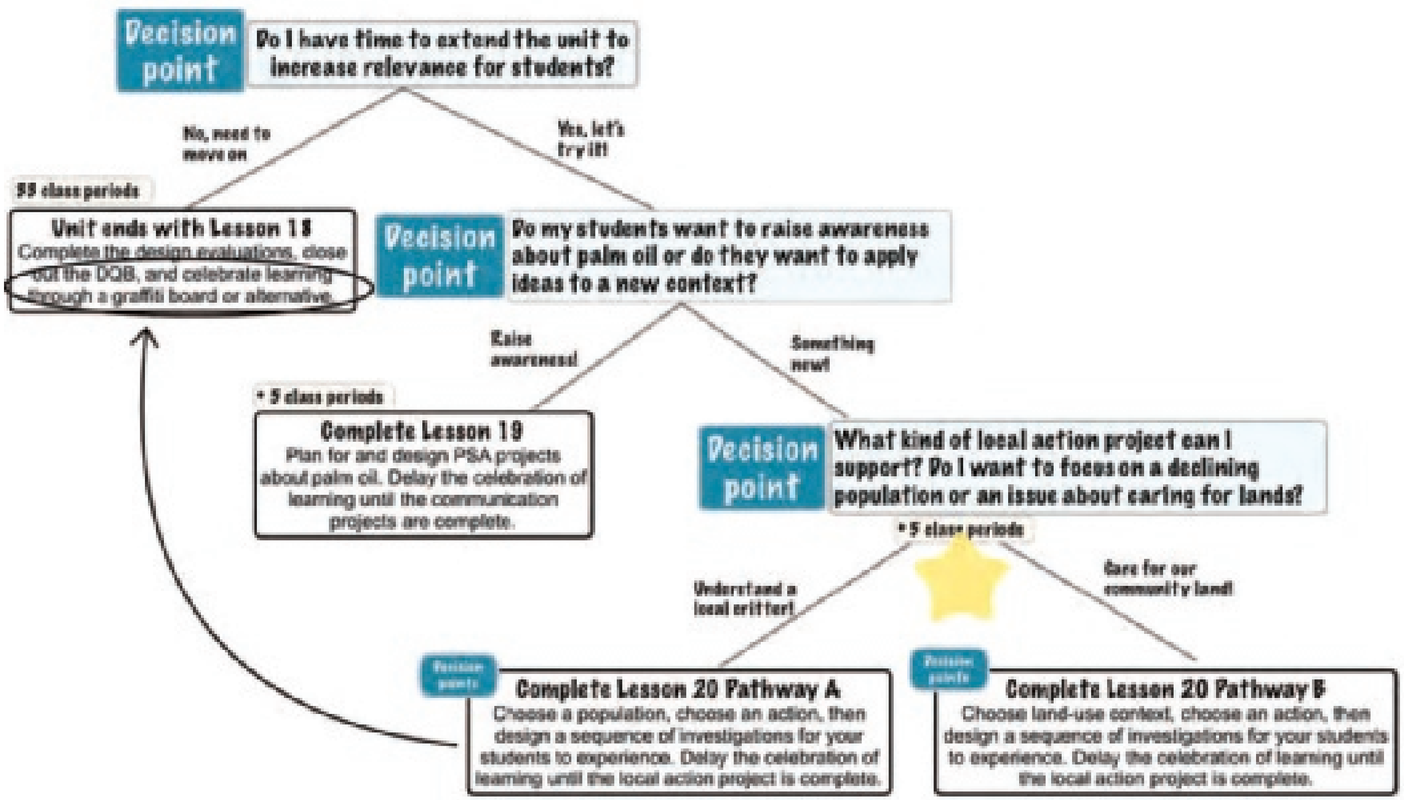
Engage students in a community action. See *Pathway A: Local Project Planning Guide* or *Pathway B: Local Project Planning Guide* for Additional Guidance.

Celebrate the class's accomplishments in their community projects. Discuss with students how to share communication projects or fieldwork focused on habitat restoration or biodiversity monitoring.

Navigate to the next lesson. Say, *In the next class, we're going to revisit all the questions we asked on our Driving Question Board to see what we can now answer. I want you to take a moment to relook at the questions you added at the start of the unit, or later on, and think about how you might answer the question now.*

Display **slide J**. Have students pick 1 question they had early on in the unit and journal how they would answer it now.

In the next class, complete Lesson 18, day 3, by revisiting the Driving Question Board and celebrating learning using Graffiti Boards.



Teacher Resources

Table of Contents

Assessment System Overview

Each unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons, including pre-assessment, formative assessment, summative assessment, and student self assessment. Formative assessments are embedded and called out directly in the lesson plans. Please look for the "Assessment Icon" in the teacher support boxes to identify places for assessments. In addition, the table below outlines where each type of assessment can be found in the unit.

Overall Unit Assessment

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 1	*Develop an Initial Model: Candy and Orangutans* Initial Class Consensus Model Driving Question Board	**Pre-Assessment** The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas that your students bring to this unit. Revealing these ideas early can help you be more strategic in how to build from and leverage student ideas across the unit. The initial models developed in the lesson are an opportunity to pre-assess student understanding of systems in the context of ecosystem changes. The two most important times to do this include: (1) on day 2, after students have developed their initial system model, and (2) during the Consensus Discussion on day 3, when the class develops an initial model together. For the initial palm system model, look and listen for: • inclusion of the living components of the system (such as the oil palm trees, orangutans, rats, snakes, tigers, and pigs) in the system model • inclusion of at least some of the needs that these livings components have in the system model, such as needs for food, water, air, habitat, or shelter • initial ideas about what causes population sizes of living things to increase in number (e.g., a lot of food or water, a lot of mates, not very many predators) and decrease in number (e.g., very little food or water, can't reproduce, many predators) • uncertainty about interactions between the living things within the system and the specific cause-and-effect relationships in the system mode • uncertainty about which components of the system model are causing increases or decreases in the different population sizes The Driving Question Board is another opportunity for pre-assessment. Emphasize that students should generate open-ended questions, such as how and why questions, to post to the DQB, but celebrate any questions that students share even if they are close-ended questions. Make note of the parts of the ecosystem that have raised many questions and the parts that have raised few or no questions. If there are few or no questions about a part of the system, prompt students to generate more questions in this space so each part of the system has a set of questions with which to guide investigations. As you move into the discussion of ideas for future investigations and data we need, have students focus on categorizing their

When	Assessment and Scoring Guidance	Purpose of Assessment
		questions and then identifying the kinds of data and additional information that would help answer a category of questions.
Lesson 6	*Palm Farm Designs*	**Formative** Lesson 6 is a critical moment to re-anchor the unit. After students have spent Lessons 2 through 5 digging deeper into the problem, the students are ready to re-articulate the problem, define a design goal, and take a second pass at the DQB. This lesson offers several opportunities for formative assessment, including (1) when the class articulates the problem during a Consensus Discussion and (2) when the students articulate a design goal and criteria for a successful palm farm. When defining the problem, students should identify the multiple aspects of the problem that make it complex to solve (e.g., oil palm uses less land than alternatives, it grows in the same place as tropical rainforests, and it provides income to farmers). Students should set a goal for the design that functions for farmers, orangutans, and other living things. Students should also suggest criteria that are in line with this goal, such as (1) the newly designed palm farm supports animal populations, like orangutans and tigers, and (2) the newly designed palm farm supports the farmers' income. Students may struggle to suggest constraints, and that is OK at this point. Students may suggest constraints, such as not taking land away from farmers, not cutting down new forests, and so forth.
Lesson 10	*Monarch Butterflies on the Shortgrass Prairie* *Scoring Guidance: Monarch Butterflies on the Shortgrass Prairie*	**Formative + Summative** There is a formative and summative assessment at the end of Lesson Set 2. The lesson-level performance expectation is: **Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short- and long-term.** This assessment is building towards **MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** At this point, students should be able to explain that resource availability affects individual organisms' survival and reproduction, which ultimately affects population size. Land use change by farming has decreased resource availability. Students demonstrate their new understanding using a related phenomenon of monarch butterfly populations that depend on the prairie, which has largely been converted for agricultural use. Prior to engaging in the individual assessment, spend 10-15 minutes setting up the new context of monarch butterflies on the prairie and mapping the new case to the orangutan case. There is room to use this assessment formatively with respect to competition for resources because students will expand on the idea of competition within a population (Lessons 8 and 9) to competition between populations (Lesson 11). Therefore, you have the opportunity to use this assessment to adjust how you approach resource availability and competition in the next lesson. The assessment can also serve

When	Assessment and Scoring Guidance	Purpose of Assessment
		as a summative assessment for students' understanding of resource availability for organism growth and reproduction, as these ideas will not be revisited later in the unit.
Lesson 13	*Southwestern Willow Flycatcher* *Scoring Guidance: Southwestern Willow Flycatcher*	**Summative** There is a formative and summative assessment at the end of Lesson Set 3. The lesson-level performance expectation is: Construct an argument supported by empirical evidence that releasing the tamarisk beetle (change) affects the willow flycatcher population when there are fewer nesting tree types available. This assessment is building towards **MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** This is a summative assessment focused on students' understanding of ecosystem interactions and disruptions that can change systems over time. The context of the assessment is a real-world debate in the southwestern United States. The case focuses on the southwestern willow flycatcher population, which has been impacted by invasive tamarisks and tamarisk (leaf) beetles. The assessment is an opportunity to engage your students in authentic argumentation based on a small subset of data. To prepare your students for this transfer task, you will spend at least 20 minutes orienting students to the new case by mapping the new case model to the orangutan model. Students will also make predictions about the outcome of different disruption scenarios in the new context before they engage in individual argumentation on the assessment.
Lesson 17 and Lesson 18	*How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* with two rubric options: • *Rubric Option 1: Redesign the Land* • *Rubric Option 2: Redesign the Land* *Argument for the Best Redesign of Land* with rubric: • *Rubric: Engaging in an Argument from Evidence for a Land Redesign*	**Instructionally-Embedded Design Task** The 5-day design task and its corresponding moments of assessment build towards: • **MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.** • **MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.** • **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.** Lesson 17 and 18 include instructionally-embedded tasks within the context of students redesigning oil palm farms in Indonesia to support orangutan populations, while also supporting farmers and local villagers. As students work in groups you can circulate among groups to provide feedback on their design content and process, using *Teacher Feedback on Land Redesign Projects*. Have your students complete Part H individually to explain how features of the design, and their design as a whole, work to support people and orangutans. In Lesson 18, groups will present their optimized designs. Two rubrics are provided as options

When	Assessment and Scoring Guidance	Purpose of Assessment
		to score and provide feedback on the group and individual portions of the design task (see *Rubric Option 1: Redesign the Land* or *Rubric Option 2: Redesign the Land*). Students will then construct an argument around the recommendation (claim) they want to make for redesigning the land. They receive and give peer feedback on these arguments. A rubric is also provided: *Rubric: Engaging in an Argument from Evidence for a Land Redesign*.
After each lesson	Lesson Performance Expectations Assessment Guidance	**Formative Assessment** Use this document to see which parts of lessons or student activity sheets can be used as embedded formative assessments.
Occurs in most lessons	Progress Tracker	**Formative and Student Self-Assessment** The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and to figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest that it is not collected for a summative "grade" other than for completion.
Anytime after a discussion	Lesson 11: *Self-Assessment for Classroom Discussions* Lesson 17: *Teamwork Self-Assessment* Lesson 19 Self-Assessment option Lesson 20 Self-Assessment option	**Student Self-Assessment** Lessons 11 and 17 include opportunities for self-assessment of students' participation in small-group and whole-group discussion. Lessons 19 and 20 also include this as an optional opportunity. The student self-assessment discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week. Initially, you might give students ideas for what they can try next time to improve, such as using sentence starters for discussions. As students gain practice and proficiency with discussions, ask for their ideas about how the classroom and small-group discussions can be more productive.
After students complete substantial, meaningful work	Lesson 17: *Teacher Feedback on Land Redesign Projects* Lesson 18 Peer Feedback on Designs Lessons 19 Peer and Teacher Feedback on PSA Lesson 20 Peer Feedback is an option depending on the project.	**Peer and Teacher Feedback** Lesson 17 and 18 include opportunities for peer feedback and teacher feedback on students' oil palm farm designs and arguments for recommended land use. Lessons 19 and 20 also include peer peer feedback as an option. There will be times in your classroom when facilitating student-student feedback will be very valuable for their three-dimensional learning. This will also allow students to learn to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback, along with self-assessment rubrics on which students can reflect on their experience with the process.

When	Assessment and Scoring Guidance	Purpose of Assessment
	Peer Feedback Facilitation: A Guide	Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work; rather, peer feedback will be more valuable to students if they have time to revise after receiving peer feedback. This should be a formative, not summative, type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities so they can use these experiences as evidence for their feedback.

For more information about the approach to assessment and general program rubrics, visit the Teacher Handbook.

Lesson-by-Lesson Assessment Opportunities

Every lesson includes one or more lesson-level performance expectations (LLPEs). The structure of every LLPE is designed to be a three-dimensional learning, combining elements of science and engineering practices, disciplinary core ideas and cross cutting concepts. The font used in the LLPE indicates the source/alignment of each piece of the text used in the statement as it relates to the NGSS dimensions: alignment to Science and Engineering Practice(s), alignment to Cross-Cutting Concept(s), and alignment to the Disciplinary Core Ideas.

The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 1	**1.A** Develop an initial system model to describe a phenomenon in which changes to one living component of an ecosystem (cause) affect the other living parts of the ecosystem (effect). **1.B** Ask questions that arise from initial observations of populations in an ecosystem to help seek additional information about the parts of the ecosystem and how they interact.	**1.A Developing and Using Models; Systems and System Models, Cause and Effect** **When to check for understanding:** After students develop their initial models on day 2, it may be helpful for them to leave their notebooks in the classroom for you to examine their work. **What to look/listen for:** • Inclusion of the living components of the system (such as the oil palm trees, orangutans, rats, snakes, tigers, and pigs) in the systems model • Inclusion of at least some of the needs that these livings components have in the system model, such as needs for food, water, air, habitat, or shelter • Initial ideas about what causes population sizes of living things to increase in number (e.g., a lot of food or water, a lot of mates, not very many predators) and decrease in number (e.g., very little food or water, can't reproduce, many predators)

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		• Uncertainty about interactions between the living things within the system and the specific cause-and-effect relationships in the system mode • Uncertainty about which components of the system model are causing increases or decreases in the different population sizes **1.B Asking Questions and Defining Problems; Systems and System Models** **When to check for understanding:** On day 3, students are directed to develop open-ended questions for the Driving Question Board (DQB) using *how* and *why* prompts. **What to look/listen for:** • Make note of any closed-ended questions and use navigation time throughout the unit to turn closed-ended questions into open-ended ones that necessitate a need to examine additional evidence. As you move into the discussion of ideas for future investigations and data we need, have students focus on categorizing their questions and then identifying the kinds of data and additional information that would help answer a category of questions.
Lesson 2	**2.A** Define a pattern of design problems for systems that provide food resources that humans need (cause) but transform the land and the biosphere once occupied by native plants and animals (effect).	**Asking Questions and Defining Problems, Patterns** **When to check for understanding:** During the Building Understandings Discussion toward the end of the lesson. **What to look/listen for**: Students share ideas, such as • all three of these crops are grown for use in food or products • all crops need land to grow • to farm, we need to clear land, which means cutting down native forests or grasslands • palm oil uses less land and produces more oil, so it is more efficient. Listen for students to connect patterns with causal reasoning (e.g., people clearing native habitats for farming in different places is causing the decline of local populations).
Lesson 3	**3.A** Define a problem in which oil palm is dependent upon the same environmental interactions with nonliving factors as other tropical rainforest plants (pattern).	**3.A Asking Questions and Defining Problems, Patterns** **When to check for understanding:** During the Building Understandings Discussion toward the end of the lesson and Progress Tracker entry. **What to look/listen for:** Students share ideas, such as (1) rainforest and oil palm areas overlap, (2) rainforests are mostly found in warm areas of the world that receive a lot of sunlight and rain, (3) there is a pattern in that a lot of plants or forests tend to grow near the equator for the same reasons, (4) planting oil palm farms requires the space that rainforests need, and (5) oil palm plants compete for this space (and other nonliving conditions) and "win" with the help of farmers.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 4	**4.A** Define a new criterion for a solution to more sustainably grow oil palm in ways that protect the tropical rainforest ecosystem but that also recognize the needs of local farmers, who are part of the palm oil production system.	**4.A Asking Questions and Defining Problems, Systems and System Models** **When to check for understanding**: During the Consensus Discussion toward the end of the lesson, as well as when students are adding to their Progress Trackers. **What to look/listen for**: Students share or record ideas, such as (1) many people in countries like Indonesia rely on cutting down tropical rainforests to harvest resources for money; (2) farming oil palms provides many people with a stable income; (3) in many places in which oil palms are grown, people do not have a lot of opportunities for making money to support their families; and (4) any solution to the palm oil problem will also have to account for the people who support themselves by growing and harvesting oil palms.
Lesson 5	**5.A** Ask questions to clarify and/or refine a model for explaining how (patterns in) human activities have altered the biosphere and changed habitats locally and in Indonesia.	**5.A Asking Questions and Defining Problems, Patterns** **When to check for understanding:** During the Consensus Discussion on day 2. **What to look/listen for:** • Articulate a change in the local ecosystem that is similar to the palm oil case and represent it in the model. • Articulate how the change in the local ecosystem may be different from that of the oil palm farms. • Recognize that the problem is bigger than changes resulting from agriculture. • Ask new questions about changes in the local ecosystem that may map to the questions students originally asked about palm oil (e.g., questions about the decline of a local species that may map to questions about orangutans). • Ask questions about a pattern of change that relates to both the tropical rainforest ecosystem (in the case of oil palm farms) and students' local ecosystem.
Lesson 6	**6.A** Define a problem that can be solved through designing a palm farm that will maintain the stability of orangutan populations and support farmers who depend on the farms for their livelihoods (criteria).	**6.A Asking Questions and Defining Problems, Stability and Change** **When to check for understanding**: During the discussion in Part 3 when we set a design goal and identify criteria and constraints. **What to look/listen for**: When defining the problem, students should identify the multiple aspects of the problem that make it complex to solve (e.g., oil palm uses less land than alternatives, it grows in the same place as tropical rainforests, and it provides income to farmers). Students should set a goal for the design that functions for farmers, orangutans, and other living things. Students should also suggest criteria that are in line with this goal, such as (1) the newly designed palm farm supports animal populations like orangutans and tigers, and (2) the newly designed palm farm supports the farmers' income. Students may struggle to suggest constraints, and that is OK at this point. Students may suggest constraints, such as not taking land away from farmers, not cutting down new forests, and so forth.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 7	**7.A.** Apply mathematical concepts (ratio) to find patterns in numerical relationships about the number of orangutans that can live in a 1 km^2 or 100 hectare area.	**7.A Using Mathematical Reasoning and Computational Thinking, Patterns** **When to check for understanding**: During the Building Understandings Discussion, toward the end of day 2. **What to look/listen for**: Students share ideas about patterns they are noticing, including that (1) most of the parks have a ratio of slightly above or below 1 orangutan per 1 km^2 or 100 hectares, which means only one orangutan lives in that area; (2) the larger parks do not necessarily have more orangutans per area; and (3) the ratio of orangutans to land area does not go above 3 orangutans per 1 km^2 or 100 hectares.
Lesson 8	**8.A** Carry out a series of investigations using a simplified computer simulation (system model) to produce data about how individual orangutans compete with each other for food resources in three different environmental conditions to answer a question about forest space. **8.B** Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to three different environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population.	**8.A Planning and Carrying Out Investigations, Systems and System Models** **When to check for understanding:** During the Building Understandings Discussion at the end of the lesson and in student Progress Trackers. **What to look/listen for:** • Students cite data from the trials the class ran together in order to answer the lesson question. • Students explain why multiple trials are necessary to feel confident that the data helps them answer the lesson question. • Students use data from the simulation to explain that orangutans need large areas of tropical rainforest because they compete with each other for food. • Students explain that if too many orangutans are in a small forest space with too little food, then many will struggle to survive. **8.B Analyzing and Interpreting Data, Using Mathematics and Computational Thinking, Stability and Change** **When to check for understanding:** In the *Make Sense* section of *Why Do Orangutans Need So Much Forest Space?*, following each experiment. **What to look/listen for:** • Students cite the averages and ranges of energy points for the orangutan population to support their claims. • Students reference their individual orangutan's energy points in relation to the averages and ranges of energy points for the orangutan population (e.g., orangutans with lower-than-average energy were not successful at competing for food, orangutans with higher-than-average energy were more successful at competing for food). • It seems typical to have a range of energy points among the orangutan population in all environmental conditions, meaning that some orangutans are more or less successful at competing for food, which could vary depending on whether there is a lot of food or little food available. • Students conclude that small changes in environmental conditions can have large impacts on their individual orangutan and on the orangutan population as a whole.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 9	**9.A** Collect data from an investigation to draw conclusions about how stable populations of orangutans fluctuate over time based on resource availability. **9.B** Use mathematical representations to draw conclusions about trends in orangutan population sizes over time, depending upon resource availability.	**9.A Planning and Carrying Out Investigations, Stability and Change** **When to check for understanding:** In the "Make sense" section for *Experiment 1* on the *Would planting more rainforest fruit trees help the orangutan population increase?* handout, the Make Sense of Experiment 1 class discussion, and in the Progress Tracker. **What to look/listen for:** • Students reference the line graph, ranges, and averages from *Experiment 1*, showing that populations can increase and decrease in size, but generally hover around an average size. • Students observe that the fluctuations in population size are due to increased births or deaths based on the short-term availability of food resources. • Students claim that a population that hovers around the average is a stable population, even though there may be fluctuations in the size of the population. • Students observe that running multiple trials on an experiment can provide more data to get more certainty about the conclusions being drawn from the data. **9.B Using Mathematics and Computational Thinking, Stability and Change** **When to check for understanding:** In the "Make sense" section following *Experiments 2* and *3* on the *Would planting more rainforest fruit trees help the orangutan population increase?* handout, the Make Sense of Experiment 1 class discussion, and in the Progress Tracker. **What to look/listen for:** • Students reference the line graph, ranges, and averages from *Experiments 2* and *3* to support the claim that major changes in ecosystems (e.g., more or fewer fruit trees) can increase or decrease the population size of orangutans. • Students observe that in some cases, a small change to the food resources in an ecosystem can lead to drastic outcomes for orangutans, as the ecosystem can no longer support the population.
Lesson 10	**10.A** Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short and long term.	**10.A Analyzing and Interpreting Data, Cause and Effect, Stability and Change** **When to check for understanding**: • On day 1 when students analyze the population cases. • On day 2 on the individual assessments. **What to look/listen for**: (1) Students using the structure of different data representations (graphs, tables, maps) to identify patterns of stability and change in population and resource availability.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		(2) Students connecting these patterns of change to textual evidence as a means of establishing a cause-and-effect relationship between resource availability and population size using mechanisms they have discussed in prior lessons for how changes to ecosystem factors cause changes to the amount of organisms an ecosystem can sustain. For the individual assessment, see *Scoring Guidance: Monarch Butterflies on the Shortgrass Prairie*
Lesson 11	**11.A** Develop a system model for a palm farm to explain why both snake (predator) and rat (prey) populations are increasing at the same time. **11.B** Develop a system model to explain how populations in a complex rainforest ecosystem interact to keep populations stable, compared to interactions in an agricultural system where some of the same populations are increasing.	**11.A Developing and Using Models, Systems and System Models** **When to check for understanding**: During the Building Understandings Discussion on day 1. **What to look/listen for**: • Students explaining that resources are unlimited in the oil palm farms, which causes both predators and prey to increase at the same time • Students noticing that there are very few populations in the oil palm system, and that the oil palm has only benefited a few populations • Students using their system models not to simply represent a food web but rather to answer questions about other populations, like rats and snakes **11.B Developing and Using Models, Systems and System Models** **When to check for understanding**: During the Consensus Discussion on day 2 (and optional Progress Tracker). **What to look/listen for**: • To explain rats, students should identify that there are many predators of rats in the tropical rainforest and that rats are competing for food with other populations. • To explain snakes, students should identify that there are not many predators of snakes, but snakes are competing with other predators for food sources. • When there is competition between populations for the same resource, like in the tropical rainforest, it keeps numbers from increasing too much. • A tropical rainforest is a lot more complex than a palm farm, with a lot more plants and animals interacting with each other. • There is only one kind of plant in the oil palm, but there are many kinds of plants in the tropical rainforest. • Populations interact for more than resources (like shelter and safety). • If one population (like orangutans) were to go extinct, then it could cause changes to other populations because everything is connected.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 12	**12.A** Gather information from text, images, and data tables to clarify claims that a change in the orangutan population could affect fruit trees because there is a mutually beneficial relationship between the two.	**12.A Obtaining, Evaluating, and Communicating Information; Stability and Change** **When to check for understanding:** During the Building Understandings Discussion **What to look/listen for:** • Orangutans disperse, or spread, seeds throughout the tropical rainforest, away from the parent plants. • Digested and defecated seeds seem to grow better than control seeds. • There is a two-way relationship between orangutans and fruit trees: orangutans get food, and fruit trees get their seeds spread throughout the tropical rainforest. • If orangutans go extinct, some fruit tree populations may struggle to spread their seeds, which grow into new plants.
Lesson 13	**13.A** Use a model to make predictions and test ideas about how disruptions, or changes, to one part of the system affect populations throughout the system. **13.B** Construct an argument supported by empirical evidence that releasing the tamarisk beetle (change) affects the willow flycatcher population when there are fewer nesting tree types available.	**13.A Developing and Using Model, Cause and Effect, Stability and Change** **When to check for understanding:** When students compare disruptions in the tropical rainforest to the oil palm farm on day 1, and at the start of day 2, when the class creates a summary chart. **What to look/listen for:** • The fewer fruit or plants affected, the less impact on the system. • The more fruit populations affected, the bigger the impacts on the system as a whole. • There are more *total* plants in the rainforest system and fewer total plants in the oil palm system. • There are more different *kinds* of plants in the rainforest system and fewer *kinds* of plants in the oil palm system. • There are more overall populations and connections in the rainforest system compared to the oil palm system. • When a disruption occurs, the rainforest system as a whole can be mostly OK because there are other resources that populations can eat and use. • When there is a disruption that affects the oil palm crop directly (e.g., disease, drought) in the monocrop farm, all of the populations in the system are affected because they all rely on oil palm. **13.B Engaging in Arguments from Evidence, Cause and Effect, Stability and Change** **When to check for understanding:** The individual assessment on day 2 using *Southwestern Willow Flycatcher.* **What to look/listen for:** See *Scoring Guidance: Southwestern Willow Flycatcher* for scoring guidance.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 14	**14.A** Critically read scientific texts to obtain information about how different ways to grow food (cause) can have a positive impact on populations in ecosystems (effect).	**14.A Obtaining, Evaluating and Communicating Information; Cause and Effect** **When to check for understanding:** On *Two-Column Notes* as students read their text individually and while students discuss and synthesize information in small groups on *Summarizing ways to grow food*. **What to look/listen for:** • Students describing the approach to growing food that they read about and how it differs from large-scale monocrop oil palm farming. • Students explaining how their approach to growing food supports populations in ecosystems, either orangutans specifically or other insects, birds, and mammals. • Students summarizing from the text the main farming approaches in each case: (1) planting multiple crops, (2) setting aside and protecting intact forest, (3) cultivating food from the forest. • Students linking each approach to growing food to an effect on a forest population.
Lesson 15	**15.A** Critically read text and listen to interviews to obtain information about how people receive ecosystem services from farming practices that also maintain and promote stability in natural systems.	**15.A Obtaining, Evaluating, and Communicating Information; Stability and Change** **When to check for understanding:** On *Two-Column Notes* as students read their text and watch their videos in groups, and while students discuss and synthesize information in small groups on *Summarizing ways to grow food*. **What to look/listen for:** • Descriptions of why people grow food or save forests in ways that benefit their families and communities. Identification of specific ecosystem services that people get from these approaches, such as food, water, protection from landslides in Indonesia, and income from non-timber products. • Descriptions of why people benefit more from these strategies than those who large-scale monocrop. Identification of specific ecosystem services such as improved soil health (which decreases erosion due to flooding and decreases the amount of fertilizer needed) and fewer effects of disruptions such as crop diseases or pests.
Lesson 16	**16.A.** Integrate qualitative information obtained from written text and media to clarify claims about farming practices that reduce risk to disruptions and that maintain and promote stability of populations in natural systems.	**16.A. Obtaining, Evaluating, and Communicating Information; Stability and Change** **When to check for understanding:** • On day 1, as students jigsaw what they learned about approaches to growing food and make initial claims. • On day 2, as students engage in a Consensus Discussion. **What to look/listen for:** • Students communicating to their peers how approaches to growing food can support plants and animals in natural and designed systems.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		• Students communicating that some approaches to growing food give people ecosystem services that might be important but do not have a monetary value. Listen for students to connect specific ecosystem services people receive (or not) to sudden or gradual disruptions. • Students making claims and supporting them with evidence from the jigsaw activity. As students evaluate which approach works best for animals and plants and humans, listen for them to name specific reasons for why one approach may be better for humans than animals. For example, a student might say that a sustainable oil palm farm works well for farmers but does not do much for the animals in the nearby ecosystem because the animals only have access to small habitat patches.
Lesson 17	**17.A** Refine criteria and constraints for designing a way to use the land to increase precision and to take into account the potential impacts and the ways in which potential solutions are limited by the natural environment. **17.B** Apply ideas about ways of growing food to design a better way to use the land to minimize human impact on orangutan populations.	**17.A Asking Questions and Defining Problems, Cause and Effect** **When to check for understanding:** On Day 1, Part B of the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout, when students revise and add to the criteria and constraints list. **What to look/listen for:** • Revised criteria about people that address disruptions that affect people (disease, drought, fire, market prices) and solutions they learned about to minimize the disruption (diversifying farms). • Revised criteria about orangutans that include ideas about resource availability and biodiversity supporting orangutan populations. • Some potential design solutions work well for the people and the orangutans but are not realistic due to land-use changes and time. **17.B Constructing Explanations and Designing Solutions, Stability and Change** **When to check for understanding:** On Day 3, Part H of the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout, when the students construct an explanation to support a redesign solution. **What to look/listen for:** • Using a variety of different ways to grow food can maintain or increase orangutan populations and people's income. • People can reasonably set aside a portion of their land to support orangutan populations without reducing their income. • Neighboring farms can coordinate their approaches to increase space for orangutans. • Rainforest corridors connecting intact areas of forest increase orangutan populations.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 18	**18.A** Evaluate competing design solutions for supporting and/or increasing a stable orangutan population and meeting people's income needs. **18.B** Construct an argument grounded in evidence and scientific reasoning to recommend a design solution that will support a stable orangutan population and protect the needs of people (effect). **18.C** Ask questions about and define problems that arise when humans design land-use systems that have positive and negative effects on biodiversity and ecosystem services.	**18.A Arguments from Evidence, Stability and Change** **When to check for understanding:** During the group presentations on day 1, the Progress Tracker entries, and the Consensus Discussion on day 2. **What to look/listen for:** Two rubrics are provided to guide what to look for in students' work: *Rubric Option 1: Redesign the Land* and *Rubric Option 2: Redesign the Land*. The two rubrics are similar in content but offer different formats for providing feedback. Option 1 includes "missing," "developing," and "demonstrated" columns to record feedback, while Option 2 includes only "developing" and "demonstrated" columns, with space for open feedback. The rubrics can be applied to students' work on the *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* handout and group presentations. Add feedback during the group presentations and Consensus Discussion on day 2. **18.B Arguments from Evidence, Stability and Change** **When to check for understanding:** On the individually constructed argument on day 2. **What to look/listen for:** A rubric is provided to guide you through scoring students' individual arguments. See *Rubric: Engaging in an Argument from Evidence for a Land Redesign*. Students will also receive peer feedback on arguments and have space to note what they would add or change about their argument based on feedback. **18.C Asking Questions and Defining Problems, Cause and Effect** **When to check for understanding:** While revisiting the DQB and celebrating learning on day 3. **What to look/listen for:** • Students can clearly answer some of the questions using ideas learned in the unit. • Students can partially answer some of the questions with ideas learned in the unit, but they require more information/evidence. • Students recognize that the problem they've been investigating goes beyond the scope of science alone. Science can help solve complex problems, but it's not the only thing to consider. • Science learning is about asking questions and gathering evidence to answer those questions.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 19	**19.A** Communicate information in writing, drawing, and oral presentation about how even small changes in people's habits or behaviors, like buying different brands of products at the store, can have large impacts on the preservation of natural systems, like the tropical rainforests where orangutans live, over time.	**19.A Obtaining, Evaluating, and Communicating Information; Stability and Change** **When to check for understanding:** When students develop and communicate their message **What to look/listen for:** • Ideas about actions, both large and small, that people can take that are available and accessible to the targeted audience. • Ideas connecting these actions to the preservation of natural systems like tropical rainforests by preventing further deforestation and habitat destruction. • Ideas that account for why it might not work for all stakeholders and that offer options for different actions that could work across different situations.
Lesson 20	**20A.** Ask questions about a local phenomenon, based on careful observations and patterns from graphs, charts, or images. **20B.** Obtain information from texts, videos, or speakers about why the local population (Pathway A) or the way our community has cared for the land (Pathway B) has changed over time. **20C.** Apply scientific ideas to take small actions that will positively impact organisms in our local communities.	**20.A Asking Questions and Defining Problems, Patterns** **When to check for understanding:** When students ask questions about the phenomenon on day 1. **What to look/listen for:** • Connecting observation of patterns from graphs, charts, or images to questions that emerge about a local phenomenon. **20.B Obtaining, Evaluating, and Communicating Information; Stability and Change** **When to check for understanding:** During the whole class discussion after students obtain information from readings, videos, or community members on days 2 and/or 3. **What to look/listen for:** • Ideas from the readings, videos, or community members about why local populations are declining and solutions to consider for how to address this (Pathway A) or how lands are currently being cared for and other ways to consider that might benefit populations in ecosystems (Pathway B). **20.C Constructing Explanations, Stability and Change** **When to check for understanding:** On day 3, when students discuss why the proposed action would help. **What to look/listen for:** • Ideas about what populations the proposed action would make a difference for and why, drawing on science ideas from Lessons 1-18 about resource availability, competition, and biodiversity. Student self-assessment is available for use on days 2-4 (*Self-Assessment: Giving and Receiving Feedback*)

Extension Opportunity: Comparing Plantations and Farms

About This Extension Opportunity

This extension is designed to explore the characteristics of plantations and farms more fully, allowing students to connect to prior knowledge and experiences, developing a deeper understanding of historical and modern-day perspectives of agricultural practices. It is designed to point out the similarities and differences among historical and modern-day plantations and farms. The extension also explores the negative and controversial land and labor practices associated with these places. It is important to acknowledge that these practices exist in some places and help students understand that when we choose to discuss these agricultural systems of plantations and farms, we also acknowledge how the land is being used and who the workers are in these places, both past and present.

For this extension opportunity, you will need the following:

- Copies of the three readings provided with the document, so each student has their own copy of one of the readings (Flesch-Kincaid readability: 6.8; Lexile 810L-1000L)
- Extension slides—either show separately or integrate them into the Lesson 1 slides, starting at **slide M**

Introduce Oil Palm Plantations (5 minutes)

Have students do a Turn and Talk about the word “plantation.” Display **slide M.1**, which shows different images of oil palm plantations. Give students a moment to study the images, and then display **slide M.2.** Ask students to turn to a partner and share what they think of when they hear the word “plantation” and see the images.*

*** Attending to Equity**
Plantation is a term used to describe where oil palms are farmed. This term is commonly used today for oil palm agriculture globally and is also widespread in other commodity crop industries, like bananas and rubber. The word *plantation* has historically been used in tropical and subtropical regions of the world, where commodity crops have been intensively grown and traded. In the United States, many students may associate the word *plantation* with exploited or enslaved laborers, particularly in the American South prior to the Civil War, where the commodity crops of cotton, tobacco, and sugar were intensively grown by enslaved people. The word may surface negative feelings and associations from students; it might also surface distant student attitudes about plantations as “something in the past” that they might not understand or feel connected to. We are using “farms” in this class to be sensitive to the history here in North America, but this does not mean “farms” is used in Indonesia or in the trade.

This extension is an opportunity for students to acknowledge and have a conversation about the use of the word, both in terms of its biological meaning and its historical and social use. These ideas will be more fully developed in this extension. This extension is also designed to allow the class to choose another word to use in place of *plantation*.

Ask the partners for any ideas they would like to share with the class. This is an opportunity for students to share what they think about when they hear the term "plantation." Allow a few partners to share their ideas. Here are some example responses:

- A big farm
- Where lots of plants are grown
- Where there are slaves, like the cotton plantations

Say, *I was surprised to see that the word "plantation" is still used today to describe where oil palm is grown. To me, it seemed like a word we don't use anymore because it's a word that represents a tragic time in North American history. I wonder why they call these places "plantations" instead of "farms," which is what I tend to call places that grow crops.*

Ask students to make some initial comparisons between plantations and farms by asking, *What ideas do you have about how a plantation and farm might be similar to or different from one another? Why might we use "plantation" for some places and "farm" for others?* Let students share some initial ideas. It's OK if students are uncertain about the similarities and differences.

Transition to exploring more about these agricultural places by saying, *Let's do a little more investigation about plantations and farms. This may help us understand what is going on in these places and how they are similar to or different from one another.*

Plantation and Farms Jigsaw Reading in Small Groups (15 minutes)

Additional Guidance

The purpose of this activity is to place plantations and farms in both historical contexts and modern-day contexts, while also pointing out that historically (and in some modern-day places) plantations and farms have exploited land or labor, or both. It is also important to highlight the hard work and perseverance within the agricultural community to provide the world with food, and that many farmers work diligently to protect both the land and the laborers on the land.

Preview the purpose of the activity. Arrange students into groups of 2–3 for the reading activity. Multiple groups will read the same text, as there are only 3 readings total. Display **slide M.3,** which includes directions for the activity and a set of guiding questions for students. The guiding questions include the following:

- Biological perspective: What do you notice about how the land is used on plantations and farms? What grows there?
- Historical and social perspective: What do you notice about who does the work on plantations and farms? How would you describe their work? How are they paid?

Give students about 5–7 minutes to read the text silently, on their own. Encourage students to write on the text and mark places where information might be helpful to answer these questions. With the remaining 8–10 minutes, prompt students to discuss the guiding questions on the slide with their group. Remind students to reference the text to support their answers.

Whole-Group Comparison and Discussion (15 minutes)

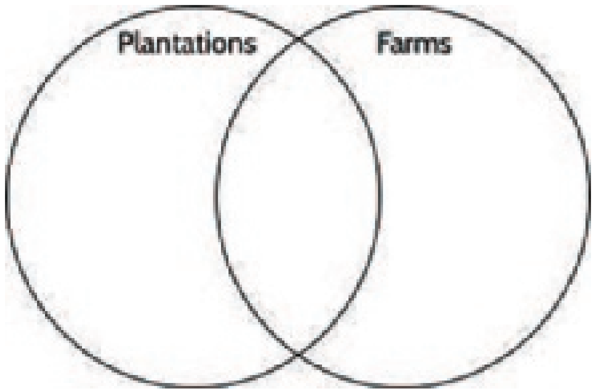
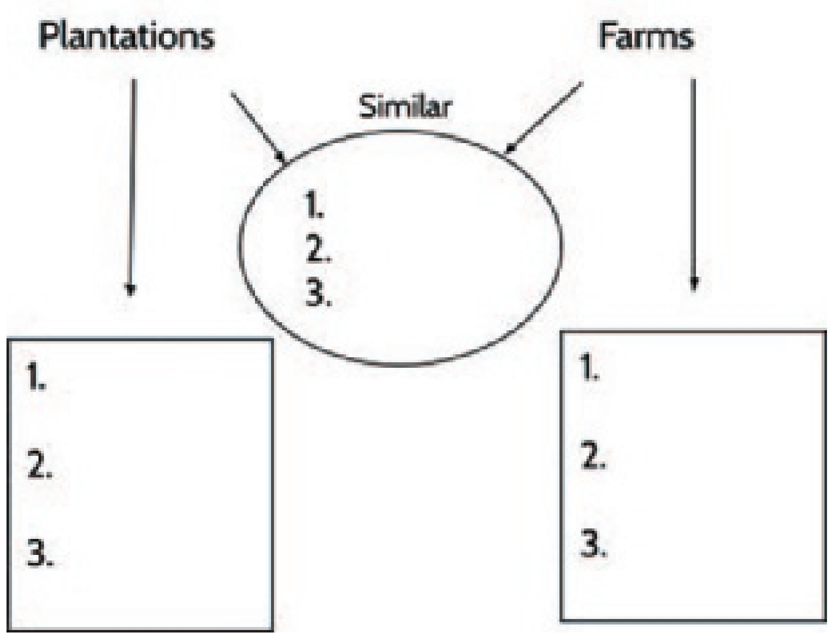
Discuss the plantation examples first. Continue to display **slide M.3**. Ask students, *From the readings about plantations, how would you describe plantations? Let's consider the questions on the slides. First, we will talk about the biological perspective—the land and what grows there. Then we will consider the historical or social perspective—the people and what the work is like.*

Suggested prompts	Sample student responses
What do you notice about how the land is used on plantations? What grows there?	*Usually there is only one crop on a big piece of land.*
What do you notice about who does the work on plantations?	*In the past, plantations used slave labor.* *Workers were mistreated. The Indigenous people died of disease, and the enslaved Africans were kidnapped and forced to work against their will.*
How would you describe their work?	*Even on modern-day palm oil plantations, some people have to work long hours without a fair wage.*

Transition to the farm readings. Say, *OK, let's discuss the farms.*

Suggested prompts	Sample student responses
What do you notice about how the land is used on farms? What grows there?	*Farms also produce a lot of the same thing, like cotton and strawberries.* *Farmers sometimes use machines to harvest crops.*
What do you notice about who does the work on farms?	*Modern-day farm workers are paid, but not very well. Some farmers make good money or enough to live on, but sometimes the farm workers don't make that much.*
How would you describe their work?	*Farming is hard work, especially if stuff has to be hand-picked. Sometimes on small, family-owned farms, family members need to work additional jobs to earn a living.*

Choose how to visually compare and contrast plantations versus farms. Two suggested options are a simple Venn diagram or a compare and contrast chart. Choose an option that might be more familiar or usable for your students. It's best to do this activity on a whiteboard so you can erase and move descriptions around. For example, students might decide that something they initially thought was a difference between the two places is really a similarity.

Venn diagram	Compare and contrast chart
	

Compare your information about plantations and farms. Introduce a new question: *How are plantations and farms similar to or different from one another?* Say, *Let's first start with similarities. What kinds of things did you notice about plantations and farms that make them similar?* Track these ideas on the diagram.

Then ask, *What things make them different from one another?* Track these ideas on the diagram.

Suggested prompts	Sample student responses
How are plantations and farms similar? • *Do they grow crops in similar ways?* • *Who does the work, and what is it like?*	*Most of them only grow one crop (monocrop).* *Most of them are really big—like, hundreds of acres.* *The people who work there have to work really long hours. It's hard work.*
How are they different?	*Plantations in the past used slaves and plantations today don't pay workers that well—just enough to get by.* *Farms seem to pay mostly living wages, but not always. Or the people still work very hard for very little pay—like on strawberry farms.*

Synthesize similarities and differences between "farm" and "plantation." Say, *From a biological perspective, the terms "plantation" and "farm" refer to land used in similar ways. They are both areas of land in which one or several crops, such as cotton, sugar, strawberries, corn, or oil palm, are grown. Historically, the term "plantation" referred to a larger area of land used to grow crops, and because the area was so large, they needed a lot of workers to care for and harvest the crops. To fulfill the need for so many workers, the landowners used enslaved people or exploited labor, which means they hired people who were desperate for work and willing to work in poor conditions for little pay. On the other hand, the term "farm" has referred to land used to grow crops while paying workers a wage, but some bad labor conditions still persist on certain farms too.*

Decide What to Call the Places Where They Grow Oil Palm (5–10 Minutes)

Decide what to call the places where they grow oil palm. Say, *To help us figure out what is happening to the tropical rainforests and orangutans, we're going to need to study the oil palm plantations more closely. Sometimes we may come across the word "plantation," and we know more about what these plantations actually are now that we've done some more investigation.*

Have students close their eyes and focus on the emotions that the words "plantation" and "farm" evoke when you say them aloud. Elicit from students a few examples of the emotions they felt when they heard the words. Students will likely share negative or indifferent emotions associated with "plantation" and positive or indifferent emotions associated with "farm."

Say, The people in Indonesia that work on oil palm plantations aren't necessarily enslaved people, but it is hard work and many do not get paid very much. Because of the negative history of plantations and enslaved farm labor, and the negative emotions that the word "plantation" invokes, I'm wondering if we could call these places a different word that doesn't have all the negative historical and social meanings we learned about.

Generate alternative words. Give students time to talk with a partner to brainstorm other words that could be used instead of *plantation*. Then ask students to come up with some alternative words, which could include *farm*, *orchard, grove*, and more.

Decide as a class to use an alternative word that does not have the same negative social and historical meanings as the word "plantation." Use this word throughout the remainder of the unit.

Additional Guidance

The development team decided to use the term "farm" for the remainder of the unit. We did not want to put students in an uncomfortable position, should the frequent use of the word "plantation" upset them. Using a word like "plantation" regularly can also normalize a very problematic issue. Most unit documents will use "palm farm" or "oil palm farm." It is your choice what word to use going forward, and ideally your class will agree on a word they prefer, which everyone is comfortable using. "Plantation" is the language of the trade, so your class may choose to adopt that language and continue to use it throughout. The tradeoff to our decision to refer to oil palm plantations using the term "farm" is that by calling them "farms," we background unfair labor practices on some plantations today. We decided that using a familiar word that is comfortable for most students and will avoid negative emotions when the word is used outweighed using the more accurate but socially laden term "plantation."

Reading 1: Historical Sugar Plantations and Modern-Day Cotton Farms

Historical Sugar Plantations

Sugar has been a favorite ingredient in foods for thousands of years. Sugar comes from the sugar cane plant, which grows well in tropical areas. Sugar cane juice is squeezed from the plant, cooked, and turned into crystals.

In the past, sugar was an expensive food. Only wealthy people could afford to buy it. Over time, the demand for sugar grew. Sugar plantations increased as new lands were colonized. The number of sugar plantations rose when the "New World" was colonized around 1500. The climate was ideal for sugar growing, and colonizers claimed the land and started planting sugar cane.

However, it was hard work making sugar. In the early days of the colonies, most of this work was first done by Indigenous people, who were enslaved by the Europeans when they arrived in the Americas. Europeans brought with them diseases that Indigenous peoples did not have immunity to. The diseases devastated the Indigenous population. Over time, sugar plantation owners bought, sold, and enslaved people from Africa to do the work. These workers were forced to work against their will.

An artist's painting of sugar plantations

Modern-Day Cotton Farms

Cotton is a valuable resource that is used to make many things in our everyday lives. We use cotton to make clothes, sheets, towels, and fabrics for furniture.

Modern-day cotton farming is done mostly on family-owned farms. This means that almost all the cotton in the United States is grown by farms that are under a family's control instead of being under the direct control of a business. Almost 80 percent of cotton farms cover more than 100 acres, with that land mostly used for growing cotton.

Cotton is farmed mostly by machinery and does not require much hired labor. The seeds are planted and the cotton is harvested using large machines.

Cotton farmers make a living wage, which means that the prices for harvesting cotton can support their families. The amount made by cotton farming does depend on the prices of cotton from year to year. The profits on cotton farming can go up or down each year.

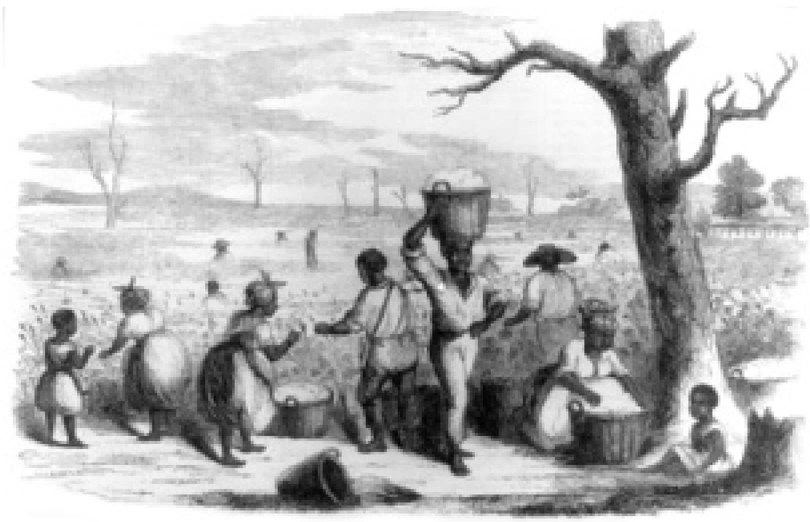
A large tractor harvests cotton.

Reading 2: Historical Cotton Plantations and Modern-Day Strawberry Farms

Historical Cotton Plantations

Cotton has been farmed for thousands of years. It is mainly used for cloth. When Europeans landed in the "New World" around 1500, cotton was already grown on the Caribbean Islands, but it wasn't grown in the United States until 1556. When Eli Whitney invented the cotton gin in 1793, cotton farming grew quickly in the United States. The cotton gin allowed two enslaved laborers to separate the seeds from 50 pounds of cotton fiber in one day. This had previously been done by hand, and a single enslaved laborer could only clean one pound of cotton in a day on average. This new technology helped make cotton the most popular cash crop of the United States in the South. By the 1830s, the United States was the biggest supplier of cotton in the world.

Growing cotton made cotton plantation owners very wealthy. A plantation was a large estate of land that grew one crop. The owner of the land was called the "planter." The difference between a planter and a farmer was that planters owned many enslaved people. Cotton was in high demand and a profitable cash crop. The reason cotton was so profitable is because these plantations used enslaved people to farm the cotton. These enslaved people, who mostly came from Africa, were kidnapped and brought to the Americas against their will to work on plantations.



Enslaved people return from the cotton fields in the 1860s.

Modern-Day Strawberry Farms

Strawberries are one of the most popular fruits eaten today, making up half of all berry sales in the United States. On average, each person in the United States eats 7–8 pounds each year. The United States is the top grower of strawberries in the world, with most grown in California. The climate there allows for strawberries to be grown year-round.

Many modern-day strawberry farms are large sections of land that grow only strawberries. But strawberries are the most labor-intensive fruit. They are hand-picked on a seasonal basis, mostly by migrant workers. A single field of strawberries might need to be hand-picked 40–50 times each season!

The workers are paid based on the number of strawberries they can pick each day. They often work 12–14 hours a day picking berries, and if they are slower than other workers, they are paid less. Most workers are able to pick fast enough to make minimum wage or slightly more. Migrant workers move around to new fields of strawberries, starting at southern farms and moving north as the fruit ripens.

Migrant workers pick strawberries. Alex Proimos CCBY-2.0 Alex Proimos, CC BY-2.0

Reading 3: Modern-Day Palm Oil Plantations and Modern-Day Small Farms

Historical and Modern-Day Palm Oil Plantations

The oil palm plant was originally from Africa. It grew naturally in African forests. Africans harvested the kernels to use as ingredients in food. It wasn't until 1870 that the Dutch brought oil palm plants to Indonesia to grow as a cash crop. This was the start of the palm oil industry in Indonesia. Indonesia and its neighboring country Malaysia now supply most of the world's palm oil.

The first palm oil plantation in Indonesia was started in 1911 by a Belgian person named Adrien Hallet. The plantations were owned by Europeans. These plantations were large areas of land where only one crop was grown. The land was taken or purchased cheaply from local Indonesian people.

Oil palm is sometimes harvested by hand and sometimes machines. This ensures jobs for local workers. When the Indonesian oil palm plantations were started in the early 1900s, the land was taken from local people. Without many job opportunities and very little land of their own, the local people had to work on the palm plantations to stay near their homes. Today, some plantations pay their workers a living wage, but many times the workers put in very long days for very little pay.

Palm oil workers in Indonesia

Modern-Day Small Farms

Small family farms are an important part of US culture, both historically and today. Small family farms make up 90 percent of all farms in the United States, but they only produce 20 percent of the crops. They are less than 180 acres in size. Some grow mostly one crop or livestock, and others might grow many things. Most of the chickens, eggs, and hay in the United States are produced by small family farms, along with many other crops.

Family farms often employ the labor of family members or a small number of farmworkers, using small machinery to harvest crops on the farm. Most small family farms make less than $50,000 per year, so often people work additional jobs off the farm to earn extra income. Family farms usually are passed down generationally to other family members.

However, small family farms have been gradually disappearing over the years, as families struggle to keep their farms productive. Many sell their land to larger, mechanized farming operations if they cannot afford to operate on their own.

A small family farm in Wisconsin

Example Student Ideas

The following is a list of student ideas compiled from piloting and field testing the unit. These examples can help you anticipate some of the ideas your students may share to build the list of related phenomena or ideas for future investigations, and can be included as initial questions on the Driving Question Board (DQB).

Related phenomena	Questions on the DQB	Data and information that could be helpful
• Plastic and other pollution in the ocean is killing animals. • Large animals, like elephants and white rhinos, are being poached. • Climate change is harming polar bears and melting glaciers. • The bees and other pollinators are disappearing. • The wolves in Yellowstone disappeared. • Pollution and/or oil spills affecting animals • Cutting down trees	**Why is palm oil in candy in the first place? Is there a substitute?** • Why isn't there a substitute for palm oil? • Why do we need palm oil in candy? • Is there something that can substitute palm oil so that orangutans don't go extinct?	Information about the characteristics of qualities of palm oil Information about why oil is in foods Information about other things we can use instead
	Where can oil palm trees grow? • Why don't they plant the trees somewhere else? • Why did they choose those two islands to plant the palm oil trees? • Can oil palm trees grow in other tropical places?	Climate for oil palm trees Ideal temperature for oil palm trees Ideal amount of water for oil palm trees What palm oil plants need in order to grow
	Why are people doing this? • Why do they keep cutting down trees? • Why are people killing orangutans by planting palm oil trees when they know it will affect the environment?	Interviews with farmers
	Where do orangutans live? • Can you take the orangutans and put them in a different habitat that is similar to their old one? • Do orangutans live in other places? • Why aren't there orangutan safe havens in Indonesia?	What orangutans need to live What the orangutans' habitat is like Information about safe places for orangutans Map of where orangutans live Climate for orangutans Shelter for orangutans

Related phenomena	Questions on the DQB	Data and information that could be helpful
	What do orangutans need to survive? • Why do orangutans only eat figs? • Are there other kinds of fruits that orangutans eat, other than figs? • If there are a lot of trees, why do orangutans need to stay in small groups?	Food sources for orangutans Social behavior of orangutans Information about why orangutans can't live in large groups
	How does cutting down rainforests affect orangutans? • Will the orangutans die out because of us? • What would happen if orangutans went extinct? • What would happen to the rainforest if the orangutans die out? • Why are Sumatran tigers and orangutans nearing extinction when the tropical rainforest still exists near oil palm plantations?	Current population size of orangutans Current population size of tigers Maps of the rainforest area and palm oil farms Simulations to predict what could happen to the orangutans
	Basic information on orangutans and tigers • How long do orangutans live? • How many orangutans are left? • How many orangutans die each year? • When did the orangutan first start going extinct? • What is the life-span of a Sumatran tiger? • Are orangutans a prey of the Sumatran tiger?	Data sheets about orangutans and tigers History of orangutan and tiger populations Different ways orangutans die and how many each year Food sources for tigers
	Solutions • What can we do to save the rainforest from being cut down? • Are there people currently taking action to prevent the extinction of the orangutan and Sumatran tiger? • What can we do to stop these things?	Data from similar examples Stories about similar cases Stories about people protecting the rainforests, orangutans, and tigers

Asking Question Tool—Open/Closed Questions

1. What question are you working on?

2. What is the purpose of your question? Circle one of the reasons below or write in your reason.

Here are some reasons why people ask questions in science:

- *We don't understand how a phenomenon (ora part of the phenomenon) works*
- *We have a disagreement (in our model or with someone's explanation or argument)*
- *We need to test an idea we have*
- *Other reason: ______________________*

Closed-ended and Open-ended Questions: Questions that can be answered with "Yes" or "No" or with a single word are closed-ended questions. Asking open-ended questions gives you space to figure out more things. Scientific questions are open-ended questions.

3. Is your question closed-ended or open-ended? Circle one.

- Closed-ended (complete step #4)
- Open-ended (skip to step #5)

4. Revise your question to make it an open-ended question. Think about what you want to explain about the phenomenon.

Try using:

- *How does...*
- *Why does...*
- *What happens when...*
- *What happens if...*
- *What is the difference between ________ and __________ ?*

Write your revised question:

5. What information or data do you need to answer your question?

6. How would this information or data help you achieve the purpose you circled in question #2?

Peer or Teacher Feedback

Name: ______________________________

Provide feedback to another student using the following table.

Criteria	Yes or no?	Feedback and/or suggested revision
Is the question open-ended?		
Does the information or data in question #5 help answer the question?		
Does the question help the student achieve their purpose for asking the question?		

LESSON 8: TEACHER REFERENCE 1

Orangutan Name Cards

Rose	Inji	Ken
Redd	Sam	Mia
Amy	Ava	Bob
Lucy	Mun	Kasa
Louie	Jax	Aponi

Key: Why Do Orangutans Need So Much Forest Space?

EXPERIMENT A: NORMAL FRUIT PRODUCTION

Before the Experiment

- My orangutan's name is: *Lucy*
- Record the independent variable (% of fruit trees in the forest): *25%*
- **Make a prediction:** Do you think your orangutan will do about the same, better, or worse than the other orangutans? Why? *I think my orangutan will do the same as the other orangutans because all of the orangutans have the same traits. They do not move faster or slower than other orangutans, and they all find food in the same way.*

Run the Experiment

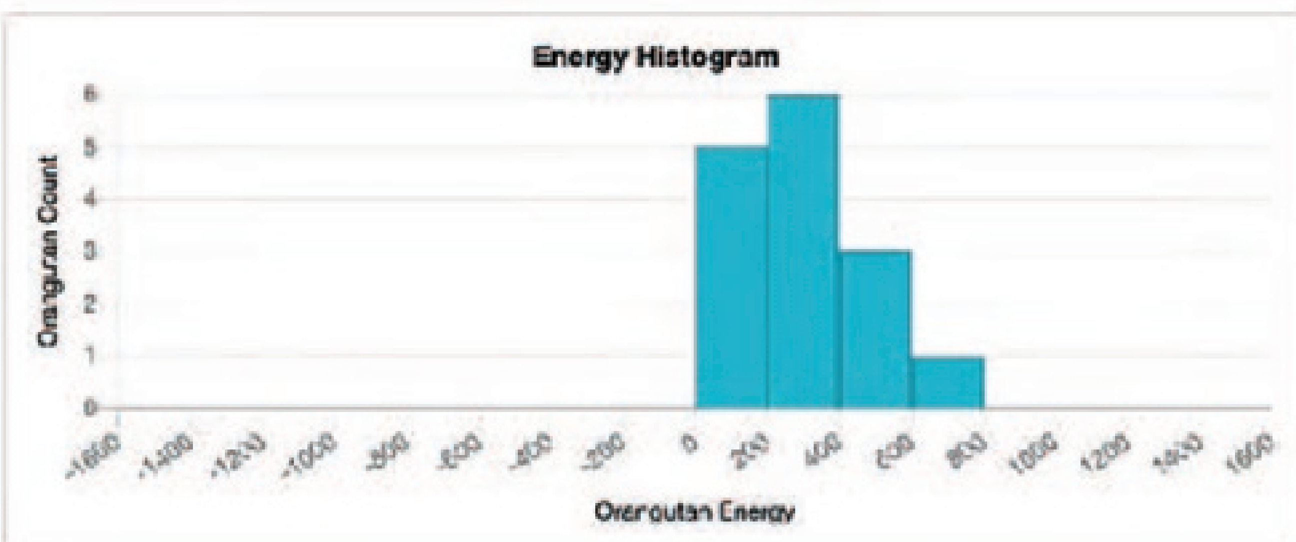
- **Observations.** Observe what makes it easier or harder for your orangutan to find food. Record notes and observations here.

Lucy moves around the lower part of the environment. When she found many fruit trees growing near each other, she traveled around in circles, eating from each fruit free before moving on. Sometimes if another orangutan started eating from the same fruit trees, Lucy traveled longer distances to find new fruit trees.

- **Record the energy results.**
- Individual (one orangutan)—Ending energy for your orangutan: *215*
- Population (all of the orangutans): Minimum, maximum, and average energy:

minimum energy	maximum energy	average energy
89	*678*	*294*

Population (all of the orangutans): Histogram of energy for the population



1. **Make sense—Individual (ONE orangutan):** Make a claim about your orangutan and support it with evidence and reasoning.

Circle the claim you agree with.

My orangutan was unsuccessful at finding food.	My orangutan was moderately successful at finding food.	My orangutan was very successful at finding food.

Data from the experiment that support my claim:

Lucy earned 215 energy points and the average was 294, which means Lucy was about average. She was in the same group as average on our graph.

Factors that contributed to the outcome for my orangutan:

Lucy started in an area of the environment that did not have many fruit trees but did have a lot of orangutans. While she was moving around, other orangutans kept reaching the fruit trees before she did. At one point, she lost a lot of energy traveling a long distance to reach a new fruit tree.

2. **Make sense—Population (ALL of the orangutans):** Make a claim about the orangutan population and support it with evidence and reasoning.

Circle the claim you agree with.

The orangutan population was unsuccessful at finding food.	The orangutan population was moderately successful at finding food.	The orangutan population was very successful at finding food.

Data from the experiment that support my claim:

The average energy points for the orangutans was 294 and the range was 89-678, which means that some orangutans were not able to find a lot of food while others were able to find lots, but on average, the oranguton population was able to find some food.

Factors that contributed to the outcome for the orangutan population:

There seemed to be enough fruit trees in the environment that all of the orangutans were able to find food, even if they had to compete with another orangutan for it or travel long distances to find a group of fruit trees to eat from.

EXPERIMENT B: FEWER FRUIT TREES

Before the Experiment

- My orangutan's name is: *Lucy*
- Record the Independent Variable (% of fruit trees in the forest): *20%*
- **Make a prediction**: Do you think your orangutan will do about the same, better, or worse than the other orangutans? Why? *I think my orangutan will do the same as the other orangutans because all of the orangutans have the same traits. Even though she didn't do very well last time, this is a new experiment and I think she has an equal chance of doing well.*

Run the Experiment

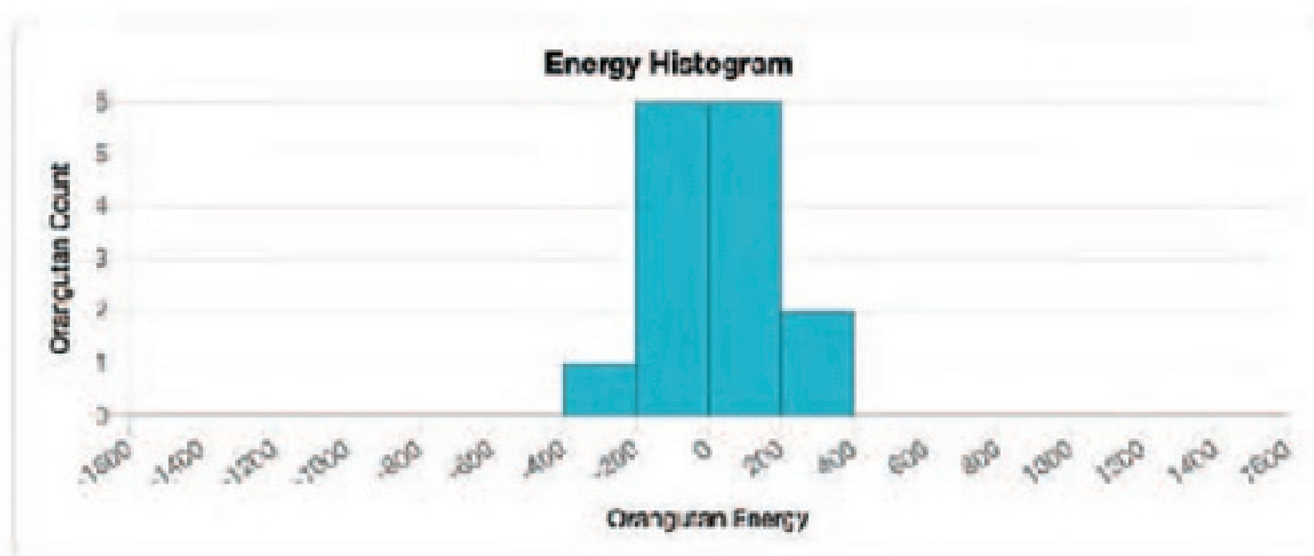
- **Observations.** Observe what makes it easier or harder for your orangutan to find food. Record notes and observations here.

Lucy moved around the lower-right-hand side of the environment. She moved in a slightly smaller space than in Experiment A. This was because there was a group of fruit trees in that area that she could circle around. There weren't many orangutans around her.

- **Record the energy results.**
  - Individual (one orangutan)—Ending energy for your orangutan: *201*
  - Population (all of the orangutans)—Minimum, maximum, and average energy:

minimum energy	maximum energy	average energy
-245	*370*	*24*

Population (all of the orangutans): Histogram of energy for the population



3. **Make sense—Individual (ONE orangutan):** Make a claim about your orangutan and support it with evidence and reasoning.

Circle the claim you agree with.

My orangutan was less successful at finding food compared to *Experiment A.*	My orangutan was equally as successful at finding food compared to *Experiment A.* (circled)	My orangutan was more successful at finding food compared to *Experiment A.*

Data from the experiment that support my claim:

Lucy earned 201 energy points in Experiment B and 215 energy points in Experiment A. There was only a difference of 14 energy points between the two experiments.

Factors that contributed to the outcome for my orangutan:

Lucy found a good group of fruit trees to eat from. There weren't many orangutans around her this time, so she was able to move in circles around the fruit trees.

4. **Make sense—Population (ALL of the orangutans):** Make a claim about the orangutan population and support it with evidence and reasoning.

Circle the claim you agree with.

The orangutan population was less successful at finding food compared to *Experiment A.* (circled)	The orangutan population was equally successful at finding food compared to *Experiment A.*	The orangutan population was more successful at finding food than in *Experiment A.*

Data from the experiment that support my claim:

The average energy points for the orangutans was 24 and the range was -245-370, which means that some orangutans had negative energy and should have actually died. On average, most of the orangutans had so few energy points that they should have almost died.

Factors that contributed to the outcome for the orangutan population:

There were fewer fruit trees but the same number of orangutans. That means that the orangutans had to compete for fewer resources. When that happens, the orangutans eat less fruit because other orangutans in the simulation seem to be stealing it away or it doesn't grow back quickly enough.

EXPERIMENT C: MORE FRUIT TREES

Before the Experiment

- My orangutan's name is: *Lucy*
- Record the Independent Variable (% of fruit trees in the forest): *30%*
- **Make a prediction**: Do you think your orangutan will do about the same, better, or worse than the other orangutans? Why? *I think my orangutan will do better than the other orangutans because there will be more fruit trees.*

Run the Experiment

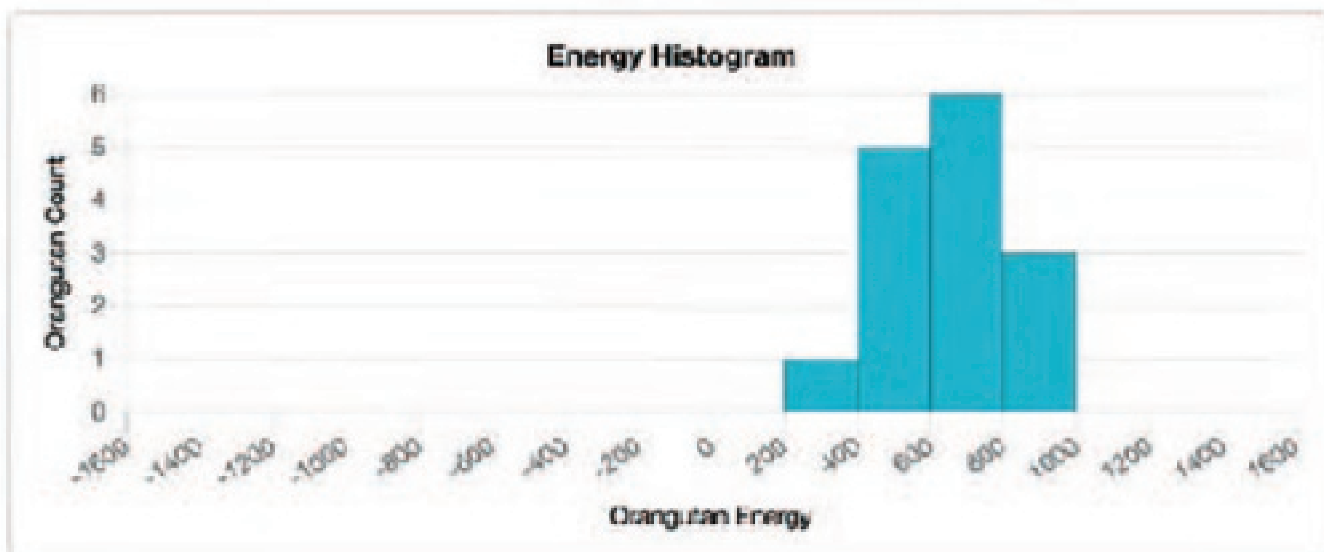
- **Observations.** Observe what makes it easier or harder for your orangutan to find food. Record notes and observations here.

Lucy moved around a lot and was able to find fruit trees with fruit wherever she went. While there were other orangutans around her, it didn't matter because there were enough fruit trees for everyone to eat.

- **Record the energy results.**
- Individual (one orangutan)—Ending energy for your orangutan: *862*
- Population (all of the orangutans)—Minimum, maximum, and average energy:

minimum energy	maximum energy	average energy
312	*862*	*636*

Population (all of the orangutans): Histogram of energy for the population



5. **Make sense—Individual (ONE orangutan):** Make a claim about your orangutan and support it with evidence and reasoning.

Circle the claim you agree with.		
My orangutan was less successful at finding food compared to *Experiment A*.	My orangutan was equally as successful at finding food compared to *Experiment A*.	My orangutan was more successful at finding food compared to *Experiment A*.

Data from the experiment that support my claim:

Lucy won! Lucy was the most successful orangutan at finding food. She had 862 energy points, the maximum number of energy points.

Factors that contributed to the outcome for my orangutan:

Lucy was in an area with lots of fruit, only one other orangutan, and she didn't ever have to travel far distances.

6. **Make sense—Population (ALL of the orangutans):** Make a claim about the orangutan population and support it with evidence and reasoning.

Circle the claim you agree with.		
The orangutan population was less successful at finding food compared to *Experiment A*.	The orangutan population was equally successful at finding food compared to *Experiment A*.	The orangutan population was more successful at finding food than in *Experiment A*.

Data from the experiment that support my claim:

The average energy points for the orangutans was 636 and the range was 312-862. This was an highest average and range out of all of the experiments.

Factors that contributed to the outcome for the orangutan population:

Even though this experiment had only 5-10% more fruit trees than the the other experiments, the orangutons were able to find trees with fruit on them much easier than the other experiments. They didn't really need to compete with each other for fruit.

Key: Would planting more rainforest fruit trees help the orangutan population increase?

EXPERIMENT 1: BIRTHS AND DEATHS WITH NORMAL FRUIT AVAILABILITY

Before the Experiment

1. Record the independent variable (% of fruit trees in the tropical rainforest): *25%*
2. **Make a prediction:** How do you predict the size of the orangutan population will change over time? Sketch your predictions as a line graph on the chart below.

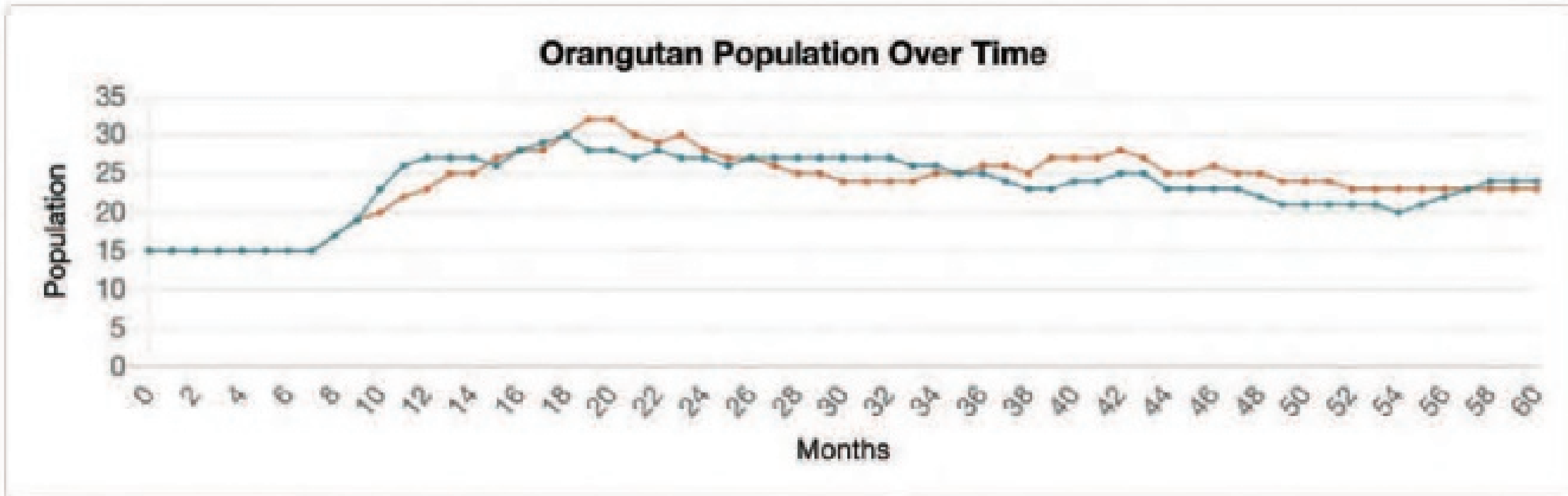
(accept all responses on the prediction graph)

Run the Experiment

3. **Record the population results**. For each trial, record the population low, high, average, total number of births, and total number of deaths. *(responses will vary)*

Trial	Low	High	Average	Births	Deaths
1	*15*	*30*	*22.5*	*27*	*18*
2	*15*	*32*	*23.5*	*26*	*17*

4. **Record the population size line graph.** Using a different color for each trial, sketch the orangutan population size versus time line graph. Label each trial color by placing a dot next to the trial in the chart above.



(responses will vary)

Make Sense

5. What claims can you make about the question, "What will happen to the orangutan population if we add births and deaths to our simulation with normal fruit availability?" *At first, there are many births, causing the population size to increase. Then, when the population size gets very large, the individual orangutans compete more for food resources. Some of the orangutans are not able to survive or reproduce, so the population size goes back down. The population size continues to go up and down (fluctuate) or levels off based on the availability of food resources.*

6. Why did the population size fluctuate? *The population size went up and down (fluctuated) based on how many orangutans were competing with each other for food resources. When more orangutans were competing for food resources, there was more competition, so some orangutans were not able to survive or reproduce, causing the population size to go down. When the population size went down, fewer orangutans were competing for food resources, so most were able to stay alive and reproduce, causing the population size to go up.*

7. Why was it important that we conduct two trials? *It was important to conduct two trials to give us more certainty in the observations we can make and the conclusions we can draw. The results of each trial were slightly different, so it was important for us to see that even though the results vary for each trial, the genera! trends were the same.*

EXPERIMENT 2: INCREASED RAINFOREST FRUIT TREES

Before the Experiment

8. **Determine an increased % of rainforest fruit trees.** Use a value above 25% to test the question, "Would planting more fruit trees help the orangutan population increase?" Record the Independent Variable (% of fruit trees in the tropical rainforest): *35% (responses will vary)*

9. **Make a prediction:** How do you predict the size of the orangutan population will change over time with the increased percentage of fruit trees? Sketch your predictions as a line graph on the chart below.

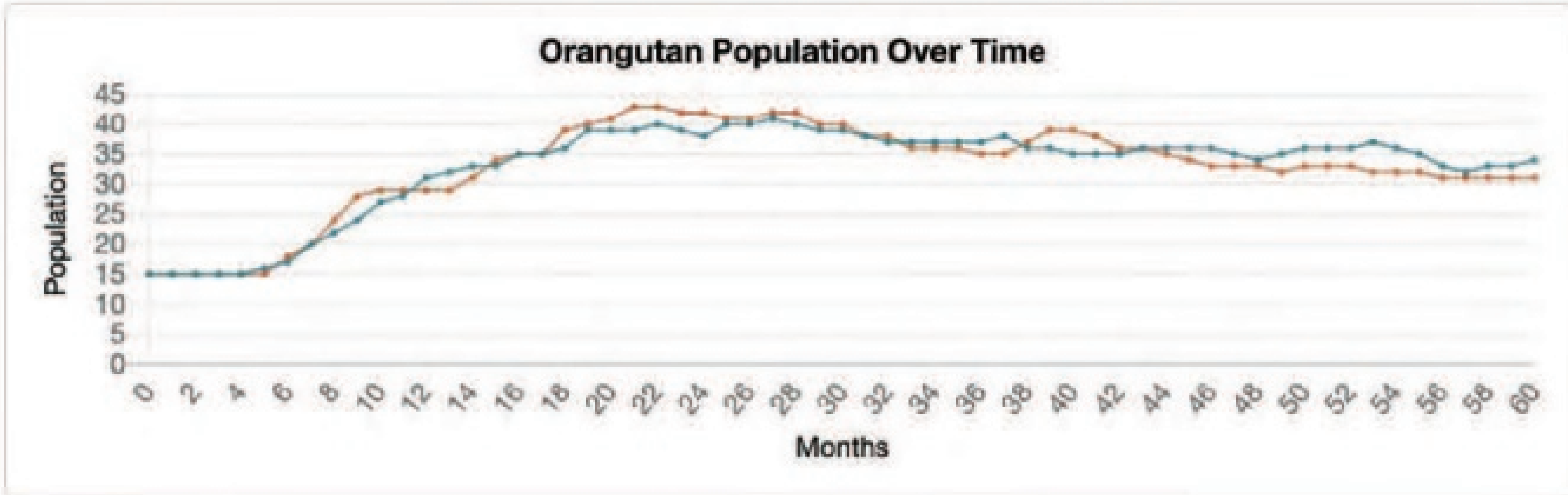
(accept all responses on the prediction graph)

Run the Experiment

10. **Record the population results.** For each trial, record the population low, high, average, total number of births, and total number of deaths. *(responses will vary)*

Trial	Low	High	Average	Births	Deaths
1	*15*	*45*	*30*	*39*	*19*
2	*15*	*42*	*28.5*	*39*	*21*

11. Record the population size line graph. Using a different color for each trial, sketch the orangutan population size versus time line graph. Label each trial color by placing a dot next to the trial in the chart above.



(responses will vary)

Make Sense

12. Record your class data table in the space below: *(responses will vary)*

% Rainforest Fruit Trees	Average Orangutan Population Size	Range of Orangutan Population Size
27%	*18.5*	*15-22*
30%	*22.5*	*15-30*
32%	*22.5*	*15-30*
35%	*25.5*	*15-36*
40%	*26*	*15-37*

13. What claims can you make about the question "Would planting more fruit trees help the orangutan population increase?" *Planting more trees causes the average orangutan population size to increase.*

14. Why can you make this claim? What is your evidence? *In the class data table, the average orangutan population size either stays the same or increases every time the percentage of rainforest fruit trees increases. In addition, the maximum number of orangutans in the population stays the same or increases every time the percentage of rainforest fruit trees increases.*

15. What questions do you have now? *(responses will vary) What is the smallest percentage of fruit trees that could still support an orangutan population?*

EXPERIMENT 3: SMALLEST PERCENTAGE OF FRUIT TREES TO SUPPORT AN ORANGUTAN POPULATION

Before the Experiment

16. Determine three different percentages of rainforest fruit trees to test. Record the three different values for the independent variable (% of fruit trees in the tropical rainforest):

(responses will vary)

Trial 1: *10%* Trial 2: *15%* Trial 3: *20%*

17. Make a prediction: How do you predict the size of the orangutan population will change over time with the increased percentage of fruit trees? Sketch your predictions as a line graph on the chart below. Use a different color for each trial. Label each trial color by placing a dot next to the trial in the chart above.

(accept all responses on the prediction graph)

Run the Experiment

18. Record the population results. For each trial, record the population low, high, average, total number of births, and total number of deaths. *(responses will vary)*

Trial	% Fruit Trees	Low	High	Average	Births	Deaths
1	*10%*	*5*	*15*	*10*	*1*	*10*
2	*15%*	*12*	*16*	*14*	*8*	*8*
3	*20%*	*15*	*23*	*19*	*15*	*12*

Make Sense

19. Record your class data table in the space below. If the entire orangutan population dies, indicate how many days it took for the orangutan population to die (e.g., 0 orangutans On day 440): *(responses will vary)*

% Rainforest Fruit Trees	Average Orangutan Population Size	Range of Orangutan Population Size
5%	*7.5 (0 on day 440)*	*0-15*
10%	*7.5 (0 on day 1182)*	*0-15*
12%	*10*	*5-15*
15%	*9.5*	*4-15*
20%	*13.5*	*11-16*

20. What claims can you make about the question "What is the smallest percentage of rainforest fruit trees that could still support an orangutan population?" *The smallest percentage of rainforest fruit trees that can still support an orangutan population is between 10% and 12%.*

21. Why can you make this claim? What is your evidence? *In the class data table, we see that the orangutan population generally dies after a certain number of days when there are 10% or fewer rainforest fruit trees. The orangutan population generally stays alive for the full 5 years when, there are 12% or more rainforest fruit trees. So, the smallest number of rainforest fruit trees that can still support an orangutan population is somewhere between 10% and 12%.*

22. How might our findings help US design a solution to the oil palm problem? *If we know a certain percentage of rainforest fruit trees that could keep the orangutan population alive, maybe we could plant enough rainforest fruit trees to keep the orangutan population alive.*

LESSON 10: TEACHER REFERENCE

Population Case Template

In this lesson, students will analyze other cases where populations changed due to a change in available resources. These cases help students generalize their model for population change to explain that population size (of any organism) depends on the availability of resources that organisms need to survive and reproduce.

There are a number of prepared cases of populations that include a range of geographic locations and types of organisms. Classes can select the cases of most interest to them. In addition, you may want to also include a case for a local population. This planning guide is intended to help you create a case for a local population.

To select a population, focus on choosing an example that includes:

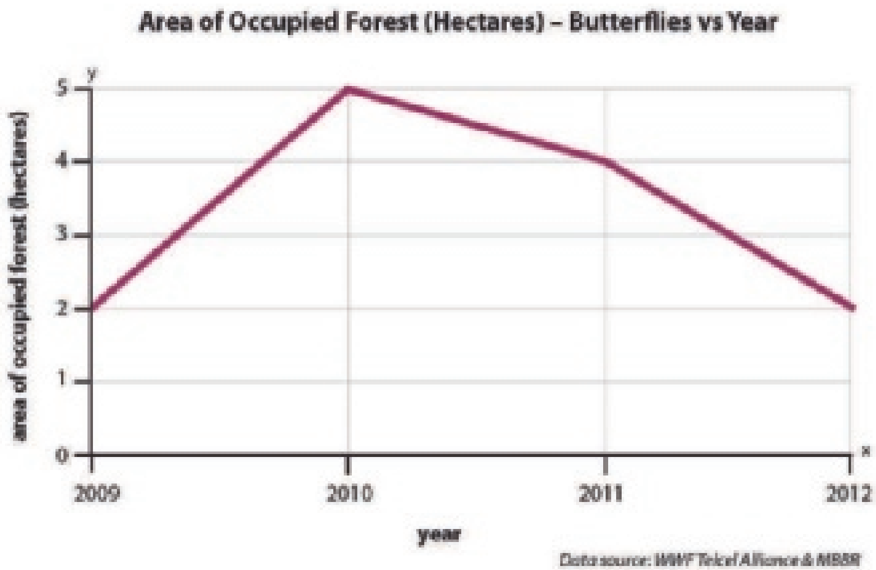
- A population that has changed due to a change in available resources.
- Data on the population that can be presented in graphical form for students to analyze.
- A population that is of interest to your students (e.g.,a local or regional population or another organism of interest).

[insert image of the organism]	A 75- to 90-word description of the organism highlighting interesting aspects. This could include: • Where it lives and its habitat • Unique characteristics • Food sources and other needs
A 75- to 90-word description of the resource that has changed. Could include: • Information about what they eat/rely on • What caused the resource change (e.g., habitat changed from x to y) • Dates when a particular change happened, to help connect to the graphs • Other threats to the population	[insert image of the resource or of maps of how the habitat or range has changed or data on how the resource changed]
[insert image of a line graph of the population of the organism over time]	A 50- to 75-word description related to the population change as needed. Could include: • Conservation status (and any changes over time) • Measures taken to manage the population • Where and how the data were collected

Name: ______________________ Date: ______________

Monarch Butterflies on the Shortgrass Prairie

The monarch butterfly population changes every year, and scientists are concerned about what might happen to the population over time. The graph below is the data collected between 2009 and 2012 for the populations of monarch butterflies. The area of occupied forest is a method scientists use to estimate the number of butterflies. In the graph below, the greater the area of occupied forest, the more butterflies.



1. Identify the trends in the butterfly population.

   a. Circle the sections of the graph that show a decreasing population over time in RED.

   b. Circle the sections of the graph that show an increasing population over time in BLUE.

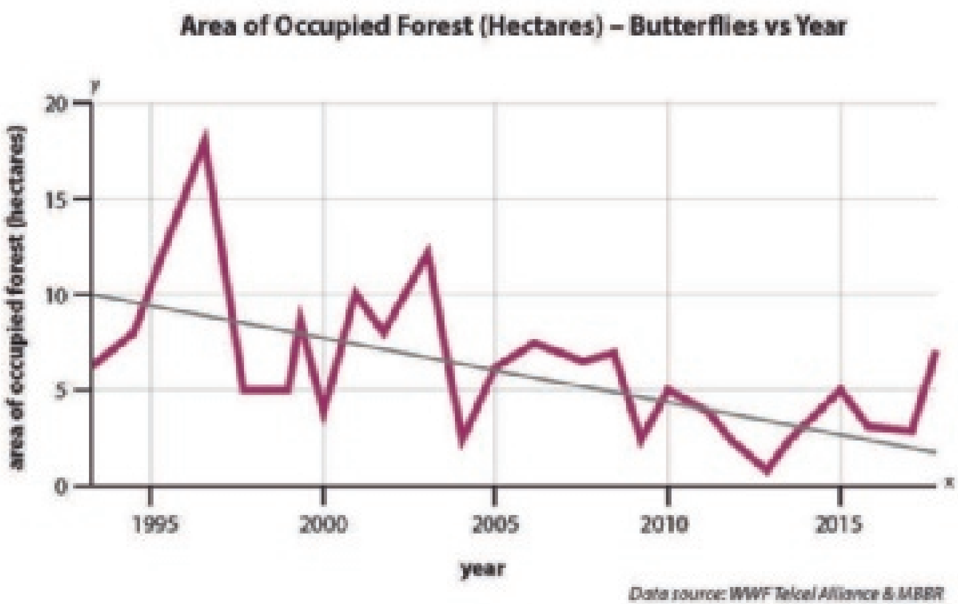
Milkweed is important to the survival of the butterflies. In years with lower than normal rainfall, there can be fewer milkweed plants. The table shows the number of milkweed plants per hectare from 2009 to 2012.

	Milkweed plants per hectare	Rainfall
2009	1,250	Low
2010	3,750	Normal
2011	3,000	Normal
2012	1,300	Low

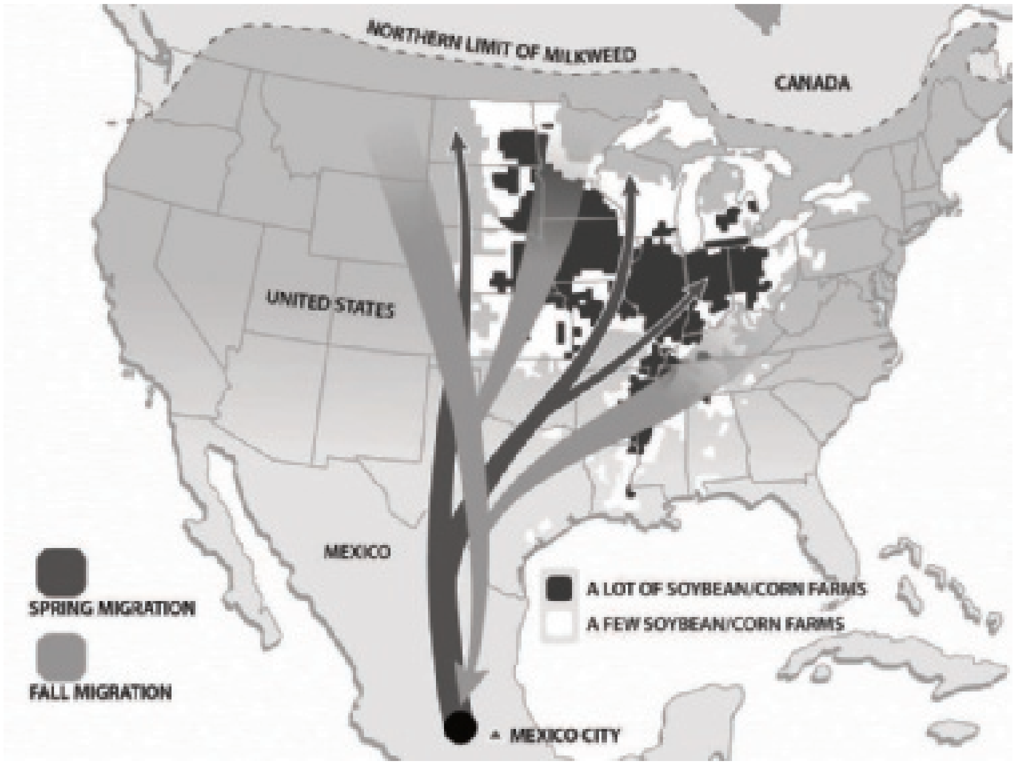
2. Annotate the butterfly population graph above (in Question 1) to show what is happening with the resource (milkweed) each year.

3. Explain how this change in the number of milkweed plants connects to how the population of monarch butterflies changed between 2009 and 2012.

The graph shows the eastern monarch butterfly population from 1993 to 2018. The gray line is a trend line which shows the overall pattern of change in the amount of land occupied by butterflies over time. Remember, the area of occupied forest is a method scientists use to estimate the number of butterflies. In the graph below, the greater the area of occupied forest, the more butterflies.

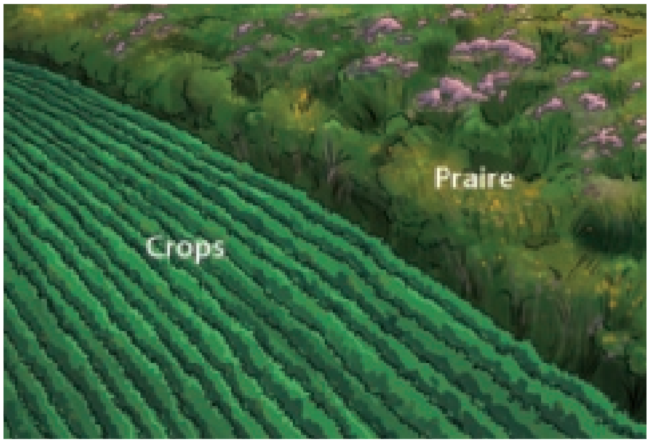
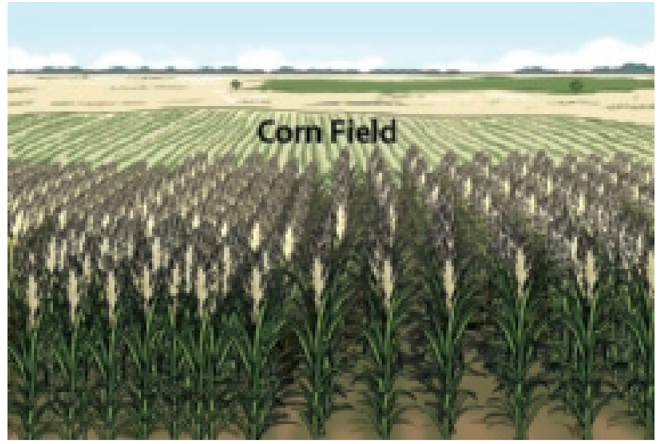


4. Is this graph showing a normal fluctuation or an unusual trend in population size? Explain your thinking and note specific evidence from the graph. You may want to label parts of the graph with words to support your explanation.



This map shows the eastern monarch butterfly migration route. The black shaded area shows where the prairies in the Midwestern United States used to be but is now mostly soybean and corn farms.

In the 1990s, farmers of corn and soybean changed their farming practices. Before 1990, there was space between plants for milkweed to grow. Now, farmers can grow corn and soybean from fence to fence leaving no space for milkweed.

Before 1990 (space for milkweed at edges of crops)	After 1990 (crop planted fence to fence)
	

Scientists estimate that there is only 1-2% of milkweed left in this area now compared to what was there before it was farmed.

5. Write an explanation to answer the question: Why did the change in the farming practices after 1990 affect the monarch butterfly population?

Scoring Guidance: Monarch Butterflies on the Shortgrass Prairie

This assessment can be used to assess student progress on the LLPE. This LLPE is an integration of elements from the three dimensions.

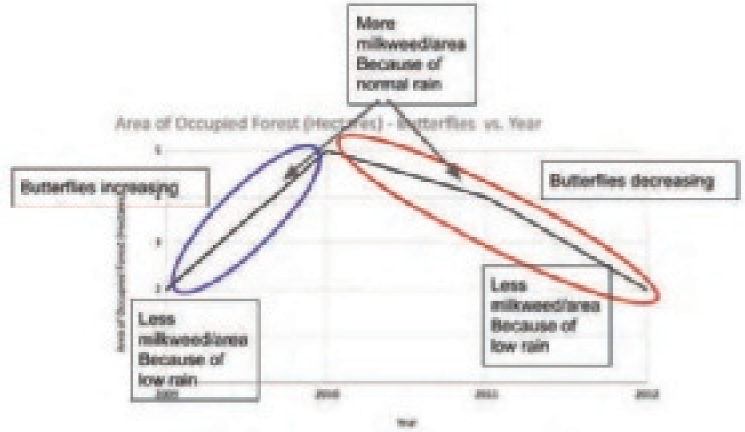
10A. Analyze and interpret data to draw conclusions about how changes in resource availability affect populations in the short and long term.		
SEPs	**DCIs**	**CCCs**
Analyze and Interpret Data Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships Students use graphs and tables to identify patterns of change in populations and amounts of resources to explain the relationships between the two. Students also use maps to visualize the change in available milkweed and connect this change to humans, converting existing prairie ecosystems to monoculture farmland. Patterns of change conveyed through maps, tables, and graphs support students in applying their developing model for resource and population change to this novel system, and in explaining what's causing the monarch butterfly population to decline over time. Look for (1) students using the structure of different data representations (graphs, tables, maps) to identify patterns of stability and change in population and resource availability; and (2) students connecting these patterns of change to textual evidence as a means to establish a cause-and-effect relationship between resource availability and population size.	**LS2.A Interdependent Relationships in Ecosystems** • 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). Students use their understanding to explain that the population size (of any organism) depends on the availability of resources that organisms need to survive and reproduce. This explains the change in monarch butterfly populations due to the change in milkweed.	**Stability and Change** Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Students use the lens of stability and change to explain changes to ecosystems, both gradual, like the loss of milkweed over decades of expansion, and sudden, like a seasonal change in rainfall. Look for students leveraging this understanding to explain how slow and fast changes to the availability of resources caused changes to the monarch butterfly population. **Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural or designed systems. Students use causal relationships developed in earlier lessons in a new context (monarch butterflies living in prairie ecosystems) to explain a decrease in population correlated with changes to ecosystem factors. Look for students to not only link these factors to changes in population size, but offer mechanistic explanations for why populations change that demonstrate a shift in understanding from a correlational to a causal relationship between ecosystem factors and population size. For example, students identify that there is a decline in butterfly populations following a decrease in milkweed, because without sufficient access to milkweed, butterflies can't eat or lay their eggs, both of which are needed for their population to grow or sustain itself.

The monarch butterfly population changes every year, and scientists are concerned about what might happen to the population over time. The graph below is the data collected between 2009 and 2012 for the populations of monarch butterflies. The area of occupied forest is a method scientists use to estimate the number of butterflies. In the graph below, the greater the area of occupied forest, the more butterflies there are.

1. Identify the trends in the butterfly population.
    a. Circle sections of the graph that show a decreasing population over time in RED.
    b. Circle sections of the graph that show an increasing population over time in BLUE.

+ Section of the graph from 2009 to 2010, circled in blue

+ Section of the graph from 2010 to 2012, circled in red



Milkweed is important to the survival of the butterflies. In years with lower than normal rainfall, there can be fewer milkweed plants. The table below shows the number of milkweed plants per hectare from 2009 to 2012.

	Milkweed plants per hectare	Rainfall
2009	1,250	Low
2010	3,750	Normal
2011	3,000	Normal
2012	1,300	Low

2. Annotate the butterfly population graph above (in Question 1) to show what is happening with the resource (milkweed) each year.

+ Graph is labeled with low milkweed in 2009 and 2012 and high milkweed in 2010 and 2011 (see the annotated example, above). Students may also annotate what was happening with rainfall.

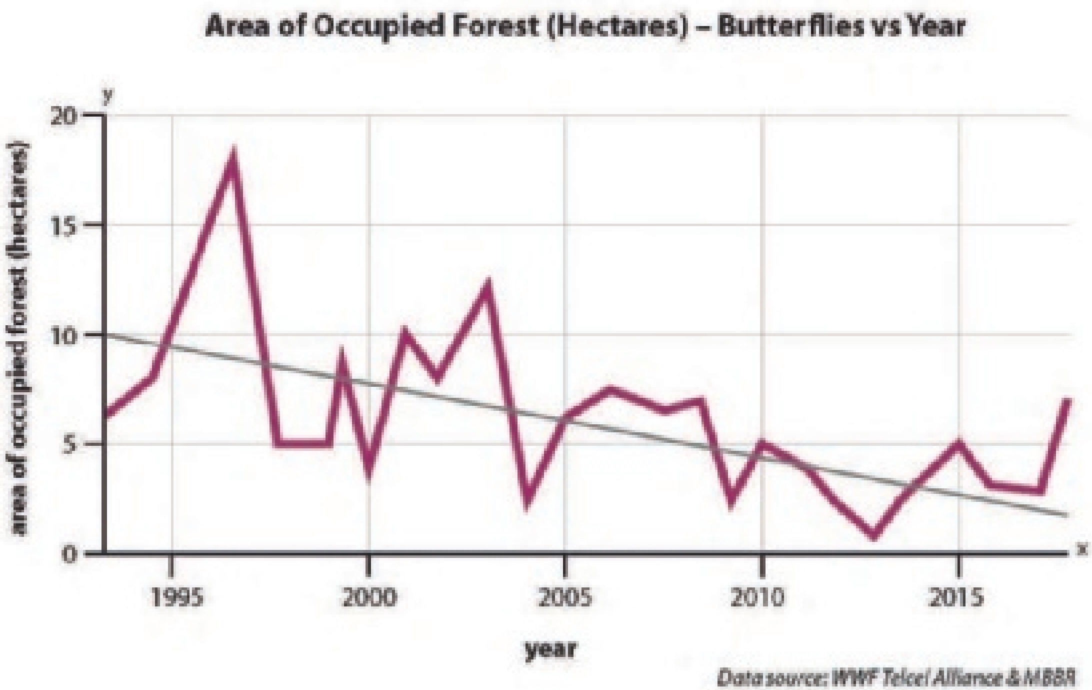
3. Explain how this change in the number of milkweed plants connects to how the population of monarch butterflies changed between 2009 and 2012.

+ Less rainfall meant fewer milkweed plants because plants need water to grow.

+ In 2009 and in 2012, the density of milkweed was lower so there were fewer resources available to butterflies per land area.

+ Therefore, in 2009 and in 2012, more butterflies died than were born, and the population was lower that year than in 2010 and 2011.

The graph shows the eastern monarch butterfly population from 1993 to 2018. The gray line is a trend line that shows the overall pattern of change in the amount of land occupied by butterflies over time. Remember, the area of occupied forest is a method scientists use to estimate the number of butterflies. In the graph below, the greater the area of occupied forest, the more butterflies there are.



4. Is this graph showing a normal fluctuation or an unusual trend in population size? Explain your thinking and note specific evidence from the graph. You may want to label parts of the graph with words to support your explanation.

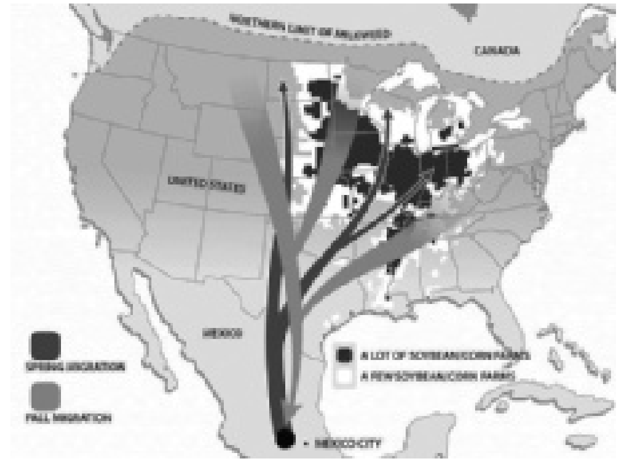
Students are expected to explain that the overall downward trend indicates that the number of butterflies is declining, which is not indicative of a stable population (or a normal population fluctuation). Students may link this back to resource and habitat availability. Students should also cite key values from the graph to support their explanation.

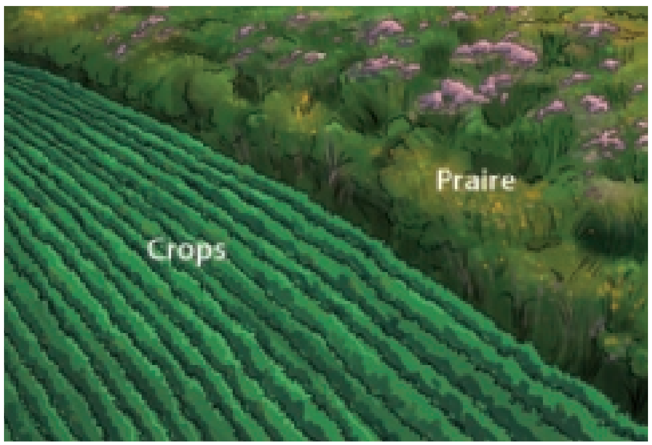
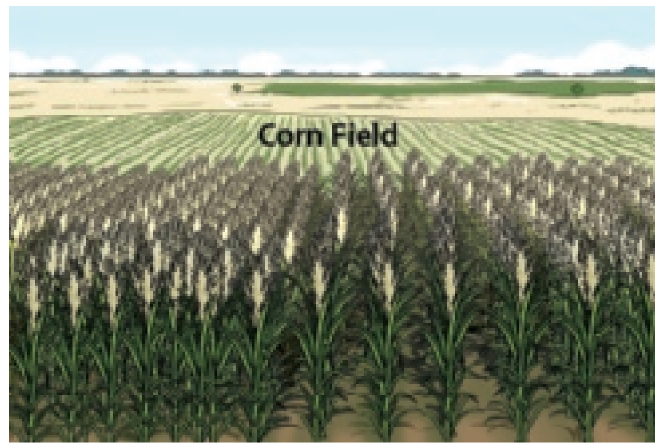
+ Over time, the butterfly population is going down, and it's lower in 2018 than in 1993.

+ Even though the population goes up and down from year to year, the population numbers are still going down overall, and you can see this in the trend line on the graph.

This map shows the eastern monarch butterfly migration route. The black shaded area shows where the prairies in the Midwestern United States used to be, but it is now mostly soybean and corn farms.

In the 1990s, farmers of corn and soybean changed their farming practices. Before 1990, there was space between plants for milkweed to grow. Now, farmers can grow corn and soybean from fence to fence, leaving no space for milkweed.



Before 1990 (space for milkweed at the edges of the crop)	After 1990 (crop planted fence to fence)
	

5. Write an explanation to answer the question: Why did the change in the farming practices after 1990 affect the monarch butterfly population?

+ Since the 1990s, in soybean and corn farming, there is less space for milkweed to grow between the crops.

+ Without milkweed, butterflies do not have access to resources—food, protection, and milkweed for laying eggs.

+ There’s less milkweed, so there is more competition between butterflies.

+ When there is more competition, fewer butterflies are able to meet their needs and survive.

+ When fewer butterflies are able to meet their needs and survive, the population numbers decrease. We see this happening in the downward trend of the graph.

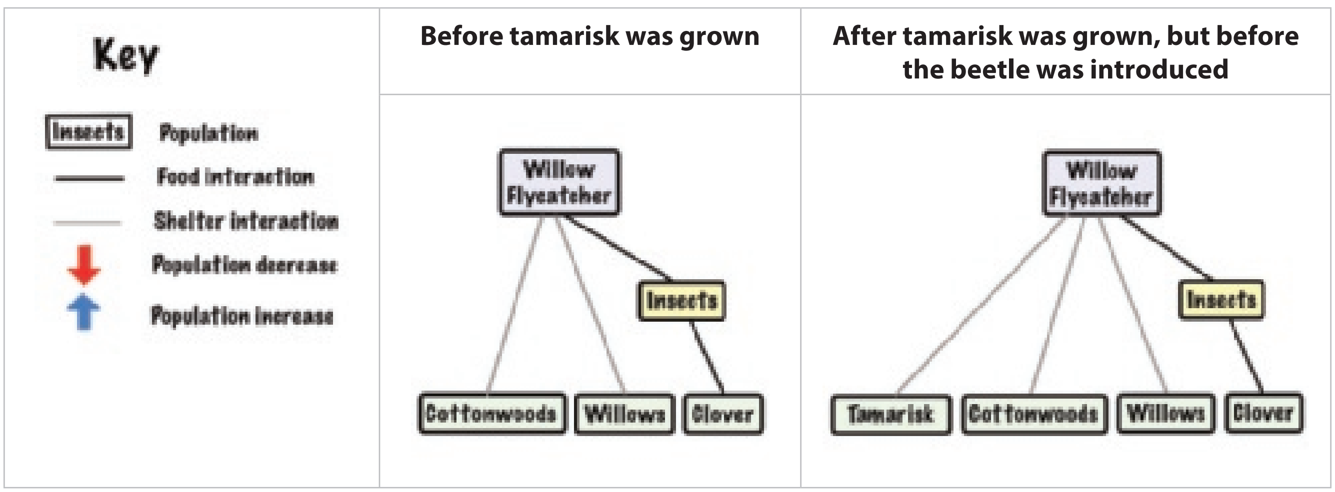
Name: ______________________ Date: ______________

Southwestern Willow Flycatcher

Background

Meet the southwestern willow flycatcher. In the spring and summer, this little bird migrates north from Mexico and Central America to Arizona, New Mexico, California, Utah, and Colorado. This is when the flycatcher has its babies. It builds nests along river habitats, where it also hunts insects. To build its nests, it chooses densely packed trees to keep the nest shaded from the sun and to hide its babies from predators.

For hundreds of years, the willow flycatcher built its nest in **willow** trees. That's how it got its name! However, over 100 years ago, humans planted a new plant along the rivers called **tamarisk**. The tamarisk was very successful at growing. Some people claim the tamarisk grew so well that it prevented new willow trees from growing. The willow flycatchers started to use tamarisks to build their nests instead of the willow trees.

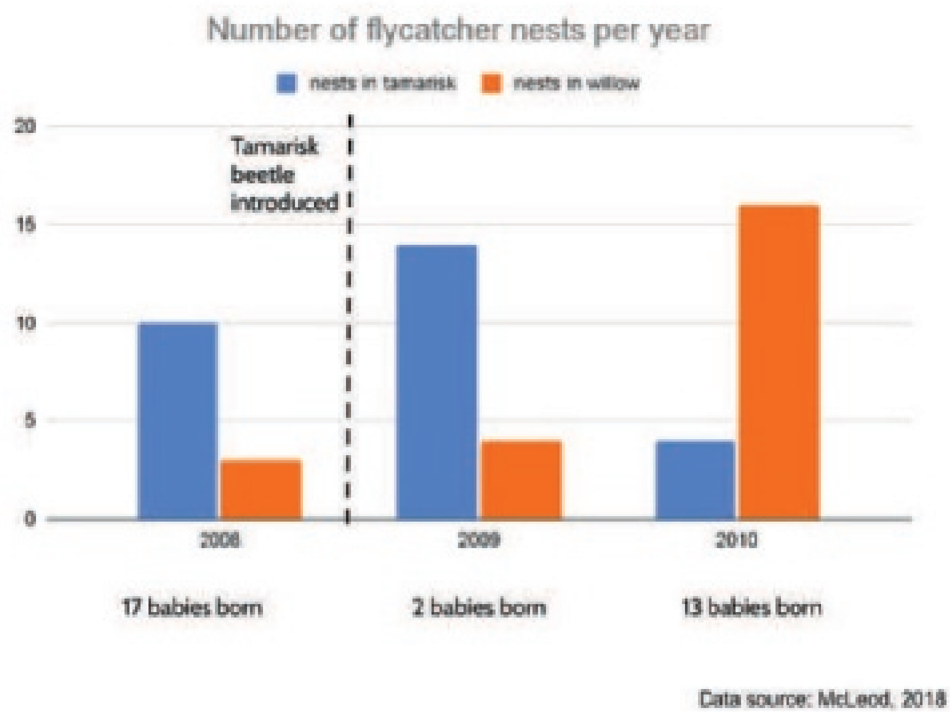


The tamarisk started to take over the river habitats. Scientists and community members grew concerned and wanted to control the tamarisk. To slow the spread of tamarisk, scientists released **tamarisk beetles**. The beetles only eat tamarisk. When they eat the plants, they kill them or slow down their growth. People hope that willows and cottonwoods will regrow, but it will not happen quickly.

Scientists have studied the southwestern willow flycatcher populations since the tamarisk beetle was released. Here are data from two study sites:

St. George, Utah

The habitat in this area is along a river. There are many willows and many tamarisk trees.

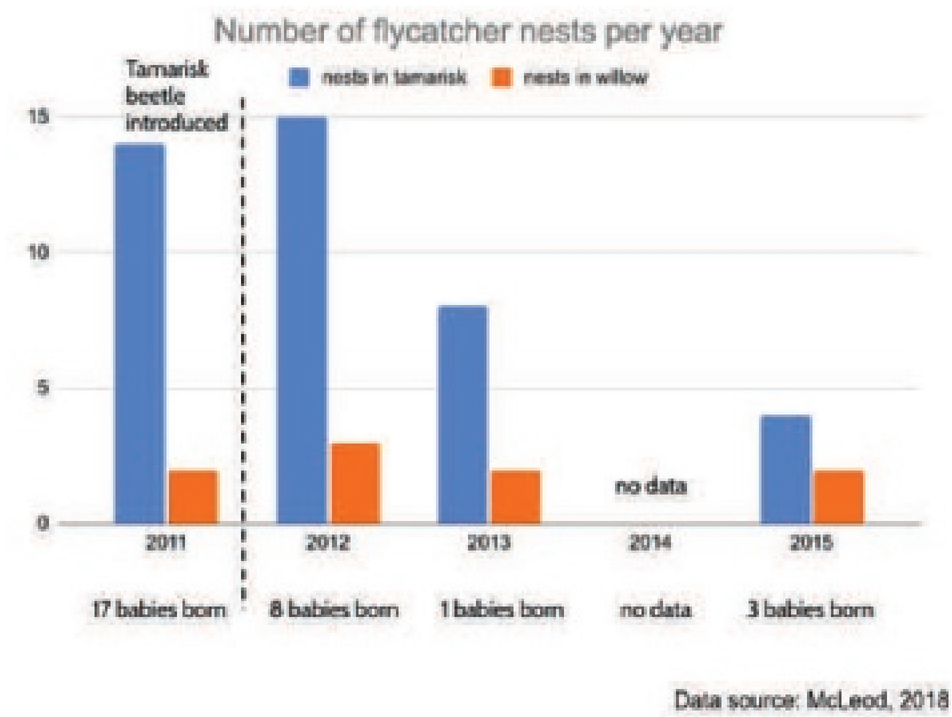


1. What observations and patterns do you notice in the types of trees the flycatcher used for nests?

2. What observations and patterns do you notice in the number of babies born?

Mormon Mesa, Nevada

The habitat in this area is along a river. There are few willows mixed with many tamarisk trees.



3. What observations and patterns do you notice in the types of trees the flycatcher used for the nests?

4. What observations and patterns do you notice in the number of babies born?

Scientists disagree about whether releasing the beetle was a good or bad thing. Below are three claims that people make about releasing the beetle in Mormon Mesa and St. George.

Claim A: Introducing the tamarisk beetle is bad for the willow flycatcher in both locations.

Claim B: Introducing the tamarisk beetle is bad for the willow flycatcher in Mormon Mesa, but good in St. George.

Claim C: Introducing the tamarisk beetle is bad in the short term for the flycatcher population but will be good in the long term.

5. Circle the claim you agree with most.

6. Write an argument to support the claim. Use data from the data tables and scientific reasoning to construct a convincing argument.

7. What additional data would you like to have to support your argument?

Scoring Guidance: Southwestern Willow Flycatcher

Allow students to annotate the graphs using words and symbols and/or write what they observe from the data in the space below the graph. Allow your students to choose the modality for communicating their arguments. They can construct their arguments in writing or orally. The guidance provided should be similar, regardless of the modality that students select.

This assessment can be used to assess student progress on the LLPE. This LLPE is an integration of elements from the three dimensions and builds toward Performance Expectation MS-LS2-4.

13.B Construct an argument supported by empirical evidence and scientific reasoning that releasing the tamarisk beetle affects the willow flycatcher population when there are fewer nesting tree types available (change to the system).

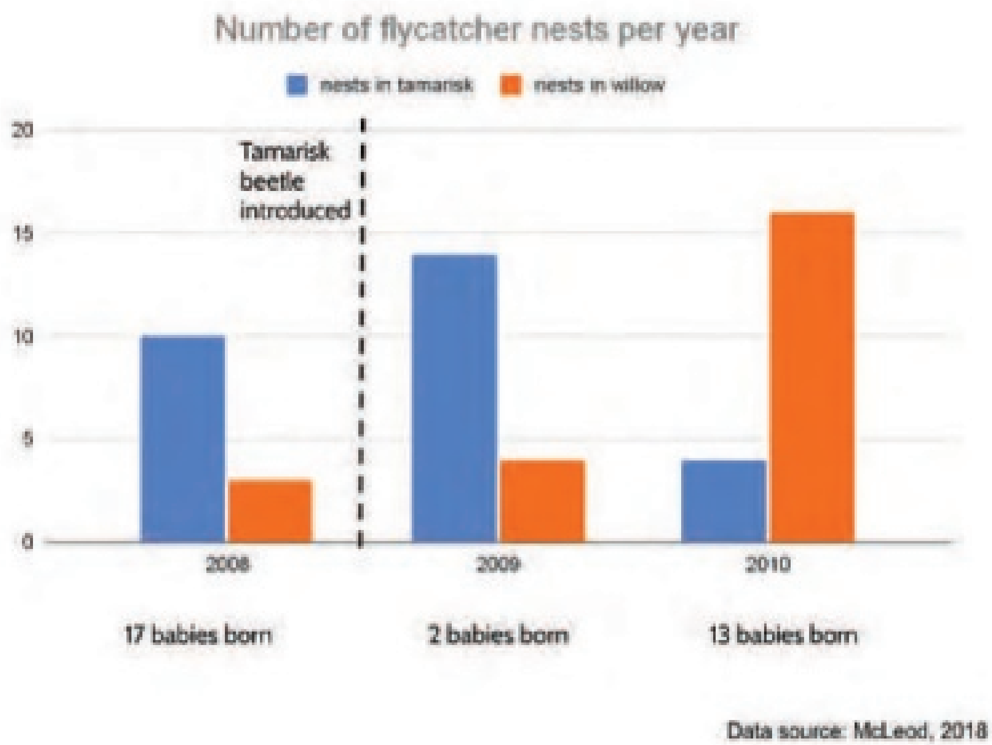
***Building towards:* MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**

SEPs	DCIs	CCCs
Construct, ~~use, and/or present~~ an oral and written argument supported by empirical evidence and scientific reasoning to support ~~or refute an~~ explanation ~~or a model~~ for a phenomenon ~~or a solution to a problem~~. In this assessment, students are given 3 plausible claims. Each claim can be supported by the data provided and are realistic claims made by scientists and community members about the problem. Some of the claims are better supported by the evidence than other claims, but ultimately you will be looking at how students use the short-term data and science ideas to reason about the claims. This will help you better understand how students are interpreting and using data to support their arguments (from a short-term versus long-term perspective and from two different locations), and it will allow you to see which science ideas they are emphasizing most (and least) to support their arguments.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) This transfer task is a disruption-focused scenario where students are using ideas about how populations in ecosystems with more or less biodiverse plant communities respond to disruptions. The focus is on disruption to a biological component of the system through the introduction of the tamarisk beetle (tamarisk leaf beetle) and the loss of the tamarisk, which is a habitat tree for the southwestern willow flycatcher. This assessment will allow you to assess students understanding of how disruptions to ecosystems can cause shifts in populations. Students may also bring ideas about biodiversity and competition, as well as resource availability, into their arguments.	Cause and Effect Cause and effect relationships may be used to predict phenomena in natural or designed systems. Stability and Change Small changes in one part of a system might cause large changes in another part. The focal crosscutting concept for this assessment is Cause and Effect. However, students may naturally use Stability and Change as they construct their arguments and describe additional data they would want to support their arguments. For Cause and Effect, look at how students reason about the relationships between populations (tamarisk beetle-tamarisk, tamarisk-flycatcher, tamarisk-willow, flycatcher-willow). If needed, encourage students to use "if-then" sentence frames to articulate how a change in one population may impact the other population. Students may use Stability and Change to describe how the loss of tamarisk in St. George was a small change, given the other habitat trees available, while the loss of tamarisk in Mormon Mesa was a big change, given its predominance in that location. Students may also point to needing more long-term data to understand how the flycatcher population is affected over the long term and whether the willows returned to either location.

Scientists have studied the southwestern willow flycatcher populations since the tamarisk beetle was released. Here are data from two study sites:

St. George, Utah

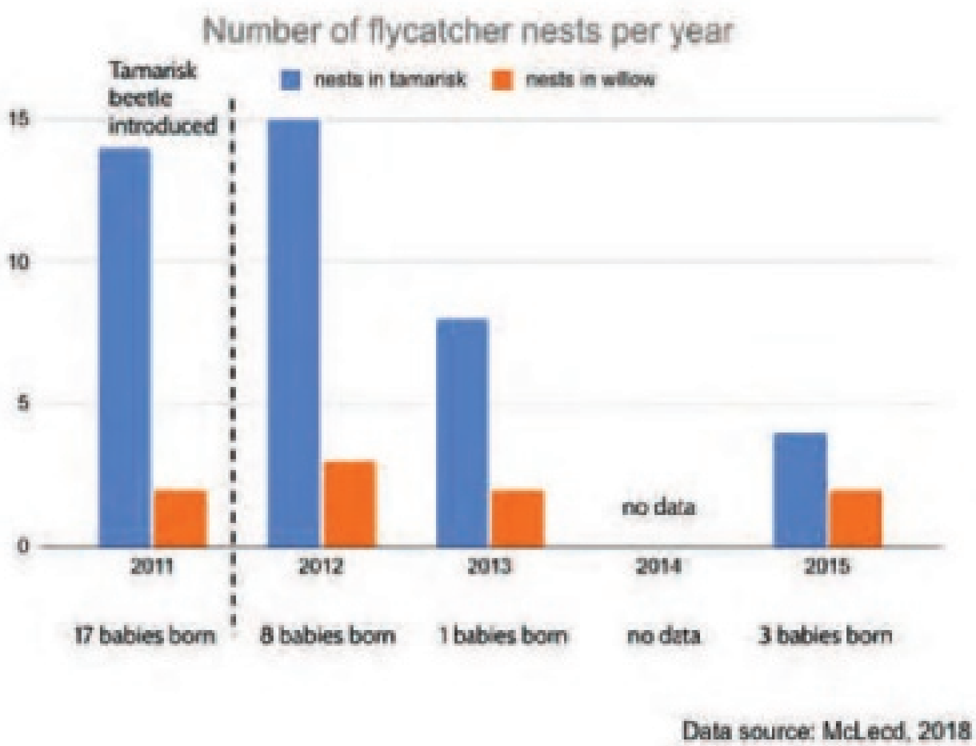
The habitat in this area is along a river. There are many willows and many tamarisk trees.



1. What observations or patterns do you notice in the types of trees the flycatcher used for nests?
    - In 2008 and 2009, they built nests mostly in tamarisk, and in 2010, they built nests mostly in willow.
    - After the beetle was introduced, they still built nests in tamarisk the first year after but switched later.
    - They built fewer nests before the beetle (about 13 total) and more nests after the beetle (18-19 total).
2. What observations or patterns do you notice in the number of babies born?
    - The year after the beetle was introduced, the number of babies dropped.
    - From 2008 to 2009, there was a big decrease, and from 2009 to 2010, there was a big increase.
    - 2010 was about back to the same number of babies as before the beetle was introduced.

Mormon Mesa, Nevada

The habitat in this area is along a river. There are few willows mixed with many tamarisk trees.



3. What observations or patterns do you notice in the types of trees the flycatcher used for the nests?
   - In all the years, they built nests mostly in tamarisk.
   - The number of nests in tamarisks decreases over time.
   - The number of nests in tamarisks was highest the year after the beetle, then dropped in 2013 and 2015.
   - The number of nests in willows stayed low across all the years.
   - The most nests were found the first year after the beetle.
4. What observations or patterns do you notice in the number of babies born?
   - The number of babies decreased, except for a small increase in 2015.

Scientists disagree about whether releasing the beetle was a good or bad thing. Below are three claims that people make about releasing the beetle in Mormon Mesa and St. George.

Claim A: Introducing the tamarisk beetle is bad for the willow flycatcher in both locations.

Claim B: Introducing the tamarisk beetle is bad for the willow flycatcher in Mormon Mesa, but good in St. George.

Claim C: Introducing the tamarisk beetle is bad in the short term for the flycatcher population but will be good in the long term.

5. Circle the claim you agree with most.

Students may select any claim.

6. Write an argument to support the claim. Use data from the data tables and scientific reasoning to construct a convincing argument.

For each claim, refer to the table below as a guide for what to look for in student responses.

7. What additional data would you like to have to support your argument?

For each claim, refer to the table below as a guide for what to look for in student responses.

	Claim A	**Claim B**	**Claim C**
Relevant Data	• The number of willow flycatcher babies born after the beetles were introduced decreased in both Morman Mesa and St. George.	• Two years after the beetles were introduced in St. George, the willow flycatchers were building more nests in willow trees. • In St. George, almost the same number of babies were born 2 years later compared to before the beetles were introduced. • In Mormon Mesa, two years after the beetles were introduced, the flycatchers built nests mostly in tamarisks, not in willows. • In Mormon Mesa, 2, 3, and 4 years after the beetles were introduced, the number of willow flycatcher babies born was low (under 5). • Comparing Mormon Mesa and St. George after the introduction of the beetles, the number of babies born in St. George was higher.	• The number of willow flycatchers born in each location after the beetles were introduced decreased in both Mormon Mesa and St. George. • In St. George, where there were more willows, the willow flycatcher births increased again in year 2. • In Mormon Mesa, the willow flycatcher births stayed low for 4 years after the beetles. There is very little long-term data to support this claim. Look at students' responses to question 7 to see if they wanted more long-term data to know for sure.

	Claim A	Claim B	Claim C
Scientific Reasoning (CCC: Cause & Effect of disruption and change)	Look for scientific reasoning that supports a cause-and-effect relationship between the disruption to the ecosystem and the willow flycatcher population, including: • The introduction of the tamarisk beetle resulted in fewer tamarisk plants. • This disruption means that fewer tamarisk plants are available as habitats for willow flycatchers to live and build nests. • With fewer nests, there are fewer willow flycatchers born in the next year after the beetle is introduced.	Look for scientific reasoning that supports a cause-and-effect relationship between the disruption to the ecosystem and the willow flycatcher population, including: • In St. George, the introduction of the beetle led to fewer tamarisk plants. • Tamarisks and willows compete for space and resources to grow. With fewer tamarisks, there are more resources for willows to grow. • In St. George, by year 2, the data shows that willow flycatchers were building most nests in willow trees. • In St. George, the mix of willows and tamarisks helped the ecosystem respond to the introduction of the beetles because the flycatchers could build their nests in the willows. • In contrast, Mormon Mesa has mostly tamarisks. When the tamarisks are killed by the beetles, the willow flycatchers lose their habitat. • Without many willows, the flycatchers do not have a place to live and build nests, and their birth numbers go down. • It takes time for the willows to return to an area, and they cannot grow back quickly.	Look for scientific reasoning that supports a cause-and-effect relationship between the disruption to the ecosystem and the willow flycatcher population, including: • In the short term, the beetles destroyed the tamarisk population, and this resulted in less habitat for the willow flycatcher in both locations. • Tamarisks and willows compete for space and resources to grow. With fewer tamarisks, there are more resources for willows to grow. • In St. George, where there were many willows, the willows may have been able to grow or expand by year 2, and willow flycatchers began to build nests in the willow trees. • In Mormon Mesa, where there were a few willows, we can expect the same thing to happen, but it will be slower because the willow population is smaller to start. Over the long term, with fewer tamarisks to compete with, the willow population will grow and willow flycatchers will have more habitat. • Because both locations have two types of trees, they can respond to the disruption and continue to support the willow flycatchers over time, but there will be a slower response to the disruption in Mormon Mesa.
Additional data that might support the claim (CCC: Cause & Effect of disruption and change)	• More data on the numbers of willow flycatchers born after 2010 in St George and 2015 in Mormon Mesa to support that births were lower for both locations over time.	• Long-term data on the birth of the willow flycatchers after the introduction of the beetles. • Data from each location on the number of tamarisk and willows in the area.	• Long-term data on the birth of the willow flycatchers after the introduction of the beetles. • Data from each location on the number of tamarisks and willows in the area. • Data from each location on the time it takes to regrow the willows after the tamarisks are killed.

	Claim A	Claim B	Claim C
*What a student might be missing if they selected this claim**	*Students selecting this claim might be missing that the mix and ratio of trees are likely to impact how the willow flycatcher population responds to the release of the beetles.* *St. George has a more balanced mix of willow trees and tamarisks, and the ecosystem is better able to handle the disruption to the tamarisks because of the mix of trees which can be seen in the data—the number of willow flycatchers born two years after the beetles were released in St. George rose back to pre-beetle levels. This student may not fully understand ideas about plant biodiversity, disruptions, and resilience from this lesson.* *They might also be missing that with fewer tamarisk plants, there is less competition for willow trees and the willow trees can come back and provide habitat for the willow flycatchers.*	*Students might be missing that the short-term data is unlikely to show the stability and change in the ecosystem over a long period of time after the beetle is introduced. They may be thinking that the pattern shown in the short-term data will continue over time—for example, that the flycatcher population in St. George is stable now that it returned to pre-beetle levels. However, we don't know what will happen without more long-term data.* *This student may understand how greater biodiversity allows a system to respond to a disruption, but may not fully understand the difference between normal fluctuations (year to year) and long-term trends (see Lessons 9 and 10). However, pay attention to the data requested on Question 7 to gain more insight about students' thinking. It may be that they realize they need long-term data to know for sure.*	*Students selecting this claim might be missing that the mix and ratio of trees is likely to impact how the willow flycatcher population responds to the release of the beetles. Some scientists argue that the beetle is OK to introduce to mixed vegetation areas, so there will be few short-term impacts on the flycatchers in these areas. Pay attention to whether the student supports the claim with ideas about biodiversity and mixtures of trees in each location.*

*Any claim can be supported by the evidence; this section is included to support you in making instructional decisions, depending on how students selected claims and constructed arguments.

Jigsaw Notes Example

Describe the way to grow food	How does this differ from large-scale monocrop farming?	How does this help populations in ecosystems?	Who is doing this?	*Benefits People Receive*
Diversified farming and intercropping means growing more than one kind of plant together.	More than one kind of plant is farmed, unlike monocrop farming.	There are more birds, bats, and beetles. There are fewer rodents, like rats.	Large-scale companies and small farms	If one crop fails because of disease or pests, then farmers have another crop they can sell. Farmers can get materials like timber.
Sustainable oil palm plantations cannot clear forests and maintain habitat for plants and animals in nearby ecosystems. Prairie strips also maintain habitat for plants and animals.	Monocrop farms destroy habitat for plants and animals.	Deforestation prevention helps animals that live in forests. Wildlife habitat prevents erosion, which keeps plants healthy. Wildlife habitat provides habitat for pollinators and birds. Wildlife habitats help orangutans travel through forests nearby farms.	Large-scale companies and small farms	People can make more money and can feel good about helping pollinators and orangutans.
Customary forests protect the tropical rainforest from deforestation.	Customary forest permits protect villages from losing forested areas to large-scale companies that own oil palm plantations.	The tropical rainforest stays intact. No deforestation can happen. Provides habitat for orangutans.	Villages in Indonesia	People can harvest food and materials. They can make money from tourism and selling fruits and materials.
Monocropped farms grow only one kind of plant.	---------------------------	It does not help plant and animal populations in the ecosystem, because of deforestation.	Mostly large-scale farmers but small-family farmers, too	Only benefits large-scale companies, because if something happens in one area of their land, they have a lot more land that can be harvested.

Labeled Guide of Padu Banjar

Navigate to Padu Banjar, Indonesia, Using Google Earth

Navigate to Padu Banjar, Indonesia, using Google Earth or another mapping software (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**).

Make observations of Padu Banjar by zooming in on important features. On the image below, label the following features:

❒ Village 1	❒ Large-scale oil palm farm	❒ Other crops	❒ Protected tropical rainforest
❒ Village 2	❒ Small-scale oil palm farm	❒ River	❒ Customary forest
			❒ Degraded land

Zoomed-in image of Village 1

Zoomed-in image of Village 2

Zoomed-in image of Degraded land

Zoomed-in image of Small-scale oil palm farm

Zoomed-in image of Other crops

Compare the Computer Simulation Layout to Padu Banjar, Indonesia

View the computer simulation layout. The layout design is based on Padu Banjar. Try to identify the same important features that you identified in the satellite image of Padu Banjar. On the image below, label the following features:

- ❐ Village 1
- ❐ Village 2
- ❐ Large-scale oil palm farm
- ❐ Small-scale oil palm farm
- ❐ Other crops
- ❐ River
- ❐ Protected tropical rainforest
- ❐ Customary forest
- ❐ Degraded land (already cut down)

Teacher Feedback on Land Redesign Projects

Strategies for providing feedback

Before providing feedback, view the work students are doing on the computer simulation and the current status of their design. Listen carefully to group conversations to get a sense of the trade-offs students are considering. When you feel ready to provide feedback, consider the following strategies:

- Provide verbal feedback.
- Use sticky notes to record feedback and leave the sticky note feedback with the group.
- Have students copy a screenshot of a design and the associated code into the *Design Solutions Slide Deck*. Leave feedback directly in the slide deck or send an electronic message to group members.

Sentence frames for providing feedback

The following sentence frames are intended as guides to help you frame your feedback. Each sentence frame begins with something that you notice about the design and concludes with something that you wonder about the design.

- I appreciate how you ______________. I wonder how ______________ might work.
- I see you are thinking about ______________. What do you think might happen if you try ______________?
- I hear some agreement/disagreement on ______________. How might you test your ideas?
- I hear you agreeing/disagreeing on ______________. What is your evidence for that?
- I noticed you added ______________. Can you explain what influenced your decision?

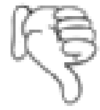
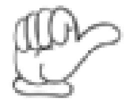
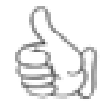
Examples of helpful feedback

The following examples are intended as guides for useful feedback.

- I appreciate how you are working to diversify your land use. I notice you doing it in Area A, where you added customary forests and other crops. I wonder how laying out the diversified forests differently might impact the orangutan population.
- I see that you are thinking about working together to create large areas of tropical rainforest and customary forest. What do you think might happen if you try moving that larger area of forest from the right side of the simulation to the left side of the simulation?
- I hear some disagreement about whether adding other crops might work the same, better, or worse than adding customary forest. How might you test your ideas?
- I hear you agreeing that creating some kind of a corridor, or path, for the orangutans to follow from one side of the simulation to the other might help the orangutan population. What is your evidence for that?
- I noticed that you added more oil palm farms in Area C. Can you explain what influenced your decision?

Name: ______________________ Date: ______________

Teamwork Self-Assessment

While working with my team ...		Not today 	Once or twice 	Several times 
I participated in the work.	I shared my thinking and contributed ideas to our design.			
	I used evidence to support my ideas, asked for evidence from others, and/or suggested ways to get additional evidence.			
	I used our time well and helped us stay on task.			
	I contributed to the work of drawing, writing, and building.			
I made sure that my teammates were included in the work.	I monitored my own time spent talking, drawing, writing, building, and/or leading so that others also had a chance to participate in the work.			
	I asked questions to help us understand everyone's ideas.			
	I encouraged others to share their ideas.			
	I provided support and genuine encouragement.			
I kept an attitude that was helpful for problem solving.	I came prepared to work toward a common goal.			
	I was open to changing my mind and challenged myself to think in new ways.			
	I may have critiqued the *ideas* we were working with, but I was careful not to critique the *people* I was working with.			
	When things did not go how we had planned or hoped, I stuck with it and learned from our failures.			

Something I did that I was really proud of during this work was . . . (because . . .)

____

____

The hardest part about this work was . . . (because . . .)

____

____

Rubric Option 1: Redesign the Land

Team name: ______________________________

Members: ____ Date: ________________

Category	Missing	Developing	Demonstrated
Developing a design solution **(group)**			Evidence from student artifact includes: • A model or design solution that supports orangutan populations and community income is **fully** developed, attending to **all** criteria and constraints. • The strategies, or features, for each area are identified, **including the reasoning for using certain strategies given different roles and land area.** • See evidence on *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* Part D.
Testing design solutions **(group)**			Student presents evidence to show: • The design solution was tested to see if it met **all** criteria and constraints. • See evidence on *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* Part E.
Evaluating design solutions **(group)**			Student presents evidence to show: • The design solution was evaluated by the team and two other groups on **all** criteria and constraints. • The characteristics of the design that performed the best in each test are identified **based on data**. • See evidence on *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* Part F and Part G, Question 15.
Optimizing design solutions **(group)**			Student presents evidence to show: • The design solution has been improved based on prior test results, and evidence of those decisions is clearly stated or shown using scientific reasoning. • The same tests have been repeated in order to compare designs and continue improving the proposed solution. • See evidence on *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* Part G, Question 16.

Category	Missing	Developing	Demonstrated

Explaining how the design works
 	
(individual)
			Student presents evidence to show:
			• The strategies, or features, for each area of the group's best design are identified, **including the reasoning for using certain strategies given different roles and land area.**
			  ◦ Includes how or why at least 2 strategies, or features, work together to support people, orangutans, or both.
			  ◦ Cites evidence from the design process to support conclusions.
			  ◦ Uses scientific reasoning to clarify how the strategies or features work.
			• See evidence on *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* Part H.

Rubric Option 2: Redesign the Land

Team name: ______________________

Members: ____ Date: ____________

Category	Developing	Demonstrated	Feedback
Developing a Design Solution (Part D) (group)	The design solution plan is **partially** developed and/or pays attention to **some** of the criteria and constraints. **Some** reasoning is provided to support the strategies, or features, in the design.	The design solution plan is **fully** developed and pays attention to **all** of the criteria and constraints. Some reasoning is provided to support the strategies, or features, in the design.	
Testing Design Solutions (Part E) (group)	There is evidence that the design solution was tested to see if it met **some** criteria and constraints.	There is evidence that the design solution was tested to see if it met **all** criteria and constraints.	
Evaluating Design Solutions (Part F) (group)	The design solution was evaluated on **some** criteria and constraints OR **non-specific** criteria and constraints. The characteristics of the design that performed the best in each test are identified **based on data**.	The design solution was evaluated on **all** criteria and constraints. The characteristics of the design that performed the best in each test are identified **based on data**	
Optimizing Design Solutions (Part G) (group)	The design solution has **not been improved based on prior test results**. Tests have **not** been repeated, **OR tests are not similar** to prior testing.	The design solution has been **improved based on prior test results,** and **evidence of those decisions is clearly stated** or shown using scientific reasoning. The same tests have been repeated in order to compare designs and continue improving the proposed solution.	
Explaining the Best Design Solution (Part H) (individual)	The strategies, or features, for each area of the group's best design are identified, **but limited reasoning is used to support them.** • **May not include how or why** the strategies work together to meet the criteria • May **not use** evidence or uses **limited** evidence to support conclusions • Uses **some** scientific reasoning	The strategies, or features, for each area of the group's best design are identified, **including the reasoning for using certain strategies given different roles and land area.** • Includes how or why at least 2 strategies work together to meet the criteria • Uses evidence to support conclusions • Uses scientific reasoning	

Rubric: Engaging in an Argument from Evidence for a Land Redesign

Claim	Category			Feedback
	Missing	Developing	Mastered	
• There is a claim that answers the question, *What are the shared features of the best designs to support people and orangutans?* • Claim includes diverse strategies beyond the profit-first model (monocrop oil palm farming) or orangutans-first model (forest farming).				
Justification Clearly represents or describes the following:	**Category**			**Feedback**
	Missing	Developing	Mastered	
• Evidence or empirical data that supports the claim is presented. ◦ Orangutan population numbers of the designed world in comparison to baseline data. ◦ Income for the three areas in comparison to baseline data.				
• Scientific principles or ideas that explain how each piece of evidence supports the claim (*reasoning*). ◦ Draws upon science ideas figured out during the unit (stable populations, competition, resource availability, biodiversity, disruptions, interactions between populations, positive impacts from biodiverse farming methods, ecosystem services, etc.). ◦ Draws upon trade-offs and social constraints that limit designs (which strategies work for which kinds of people and situations, realistic given the economic needs of people).				

Project Options

Different presentation options for your PSA are below. This list is meant to help you think of ways to present your information, and you also may think of a way that is NOT on this list. Check with your teacher if you would like to explore a project option that is not listed below. If you choose a digital option, make sure that you can access at least 1 digital resource on your device that can help you assemble your project.

Project option	Project details	Materials needed	Digital resources available to assemble project
Poster	Create a poster to be displayed in a public place.	Hard copy: paper, pencils, markers Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote
Commercial	Film a commercial to air during a popular TV show.	Digital: computer (may need camera), phone, editing software	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch
Podcast	Record an informative podcast.	Digital only: phone or computer with audio-recording capabilities	GarageBand, Anchor, phone audio recording, QuickTime
Brochure	Create a brochure to be either handed out or displayed.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Flyer	Create a flyer to be passed out to people.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark
Infographic	Create an infographic to be passed out or shared with others.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark
Billboard	Design an eye-catching billboard. Include a "check out this website" link and accompanying materials.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Newscast	Film a newscast as a news anchor or reporter.	Digital: computer (may need camera), phone, editing software	iMovie, Adobe Spark, Animaker, Powtoon, Flipgrid, Clips, Scratch
School group meeting	Meet with a group at school to get them to adopt your solution.	Hard copy: paper, pencils, colors Digital: computer	Book Creator, Google Slides, PowerPoint, Keynote, Google Draw, iMovie, Animaker, Scratch
School campaign	Start a campaign at your school or in your community to get a greater number of people involved.	Hard copy: paper, pencils, poster board, markers Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word

Project option	Project details	Materials needed	Digital resources available to assemble project
School or community newspaper article	Write a newspaper article about the carbon solution and why it is needed.	Hard copy: paper, pencil Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Meet with the school board or town council	Prepare to communicate your solution to policy groups. Include talking points and graphics to show.	Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Write a song	Write a song to communicate the solution with others. This could be made karaoke style or as a song parody!	Hard copy: paper, pencil Digital: computer, phone or computer with audio recording	GarageBand, Auxy studio, phone audio recording, Google Docs, QuickTime
Radio jingle	Record a catchy radio jingle for people to "get stuck in their heads."	Digital: phone or computer with audio recording	GarageBand, Auxy studio, phone audio recording, QuickTime
Website	Create an informative website for people to get more information.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word, Google Sites
Series of tweets	Craft a series of informative tweets others would read to learn more about the solution.	Hard copy: paper, pencils, colors Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word, Multiple free printables available


What You Should Know About Distracted Driving
Distracted driving, also called driver inattention, is a leading cause of car crashes.
The majority of drivers who were distracted at the time of a crash were teens.[1]
Distracting tasks—such as texting or dialing—take the driver's eyes off the forward roadway, making it harder for him or her to react to unexpected hazards.
It is more dangerous for new teenage drivers to engage in distracting tasks while driving than it is for experienced adult drivers.[2]
Tasks that take the driver's eyes off the forward roadway, including reaching for things, increase crash risk![3]
Sending or checking texts
Using a phone to make a call, check social media, take pictures, or play music
Looking at a map or GPS app
Eating or drinking
Talking to passengers, especially other teens
Adjusting seats, windows, mirrors, or a radio
NIH


How to Keep You and Your Teen Safe
Supervise your newly licensed teen more closely than you think you need to. Ride with him or her when you can.
Do not use your cell phone while driving. If you or your teen need to take a call, pull over to the side of the road.
Limit your teen's nighttime driving and driving with passengers, especially during his or her first 6 months of driving.
You and your teen can agree, in writing, to a series of monthly "checkpoints," easing restrictions as your teen's judgment and experience improve.[4]
Model good behavior for your teen when you are behind the wheel.
NICHD is committed to understanding driving risks and studying ways to help keep teen drivers safe.
Learn more about ways to reduce accidents from distracted driving at http://www.distraction.gov and https://www.nichd.nih.gov/DrivingRisk.
[1]National Highway Traffic Safety Administration. (2019). Distracted Driving in Fatal Crashes, 2017.
[2]Insurance Institute for Highway Safety. (2019). Teenagers.
[3]Eunice Kennedy Shriver National Institute of Child Health and Human Development. (2019). Release: Reaching for objects while driving may raise teen crash risk nearly sevenfold.
[4]University of Michigan Injury Prevention Center. (2019). Motor Vehicle Crash Prevention Resources.
NIH


SMOKEY
★6 Ways Only You Can★
Prevent Wildfires
BE SMART WHENEVER YOU GO OUTDOORS
USE CAUTION
Before lighting any fire
NEVER LEAVE A FIRE
Unattended for any reason
PROPERLY EXTINGUISH
All fires before moving on
BE CAREFUL
When using equipment
that creates sparks
DO NOT PARK ON GRASS
The hot undercarriage could
cause dry grass to catch fire
CALL 911
If you see a new wildfire
Take the Smokey Bear Pledge at
http://www.smokeybear.com/
More info on Wildfires at
http://go.usa.gov/kBSW
NOAA

National Park Service
June 13 at 2:37 PM

If a bear clacks its teeth, sticks out its lips, huffs, woofs, or slaps the ground with its paws, it is warning you that you are too close and are making it nervous. The bear's nervous? Heed this warning and slowly back away. What else should you do or not do if you come across a bear in Yellowstone?

Do not immediately drop to the ground and "play dead." Bears can sense overacting.

Do not run, shout, or make sudden movements.

Do not run up and push the bear and do not push a slower friend down...even if you feel the friendship has run its course.

Running may trigger a chase response in the bear and you can't outrun a bear. Bears in Yellowstone chase down elk calves all the time. You do not want to look like a slow elk calf. (Apologies to the elk calf.)

Slowly putting distance between yourself and the bear may defuse the situation.

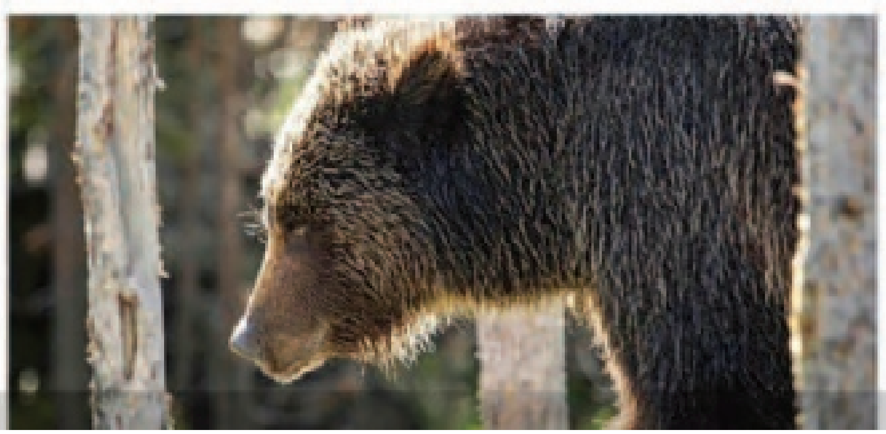
Draw your bear spray from the holster, remove the safety tab, and prepare to use it if the bear charges.

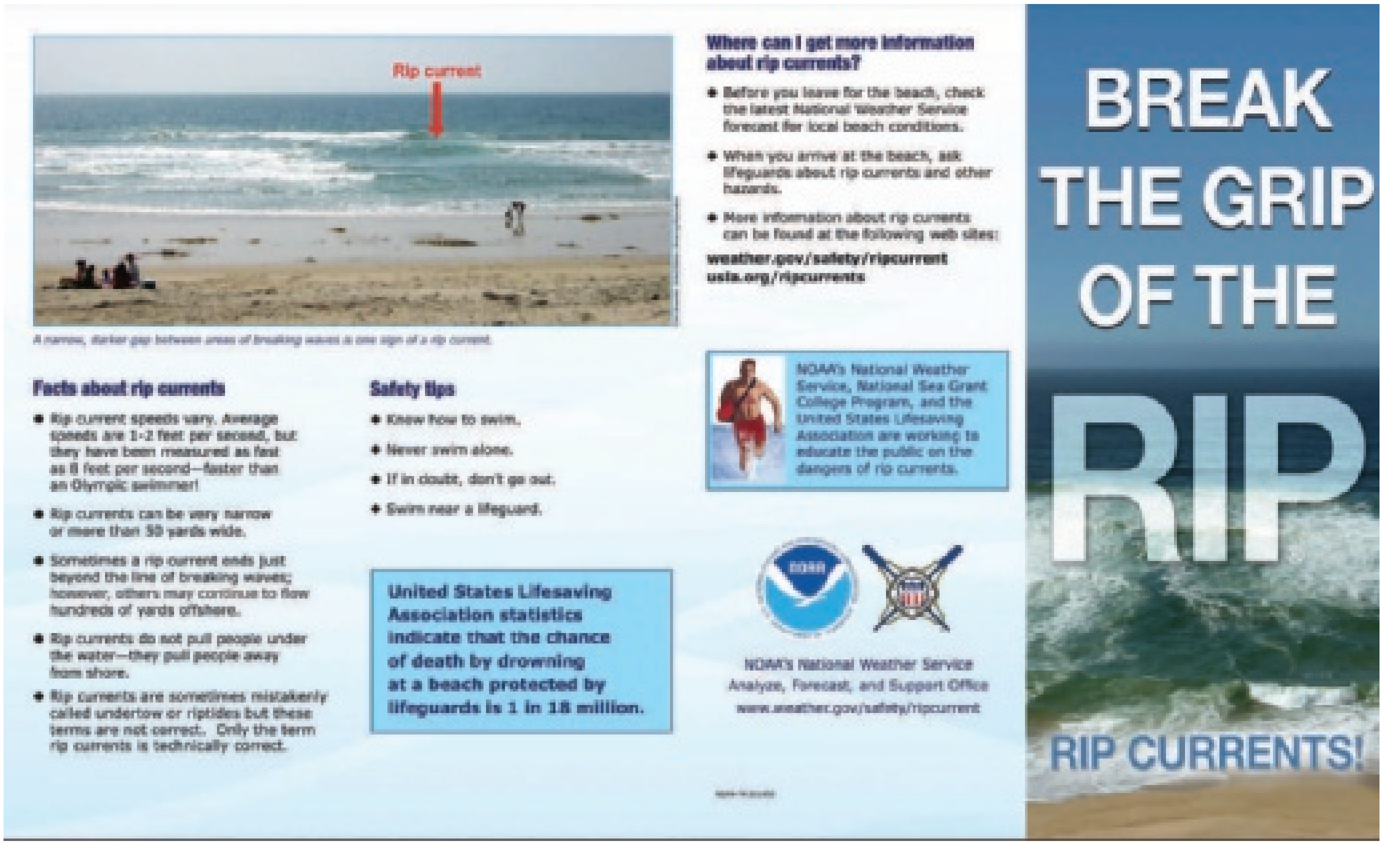
In most cases, climbing a tree is a poor decision. Bears can climb trees (especially if there is something up the tree that the bear wants). Also, when was the last time you climbed a tree?

Running to a tree or frantically climbing a tree may provoke a bear to chase you. If the friend you pushed down somehow made it up a tree and is now extending you a hand, there's a good chance you're not getting up that tree. Karma's a bear.

Learn more bear safety tips at
https://www.nps.gov/yell/learn/nature/bearreact.htm

Image: Close-up if Grizzly Bear near Swan Lake in Yellowstone National Park. NPS/Neal Herbert





A narrow, darker gap between areas of breaking waves is one sign of a rip current.

Facts about rip currents

- Rip current speeds vary. Average speeds are 1-2 feet per second, but they have been measured as fast as 8 feet per second—faster than an Olympic swimmer!
- Rip currents can be very narrow or more than 50 yards wide.
- Sometimes a rip current ends just beyond the line of breaking waves; however, others may continue to flow hundreds of yards offshore.
- Rip currents do not pull people under the water—they pull people away from shore.
- Rip currents are sometimes mistakenly called undertow or riptides but these terms are not correct. Only the term rip currents is technically correct.

Safety tips

- Know how to swim.
- Never swim alone.
- If in doubt, don't go out.
- Swim near a lifeguard.

United States Lifesaving Association statistics indicate that the chance of death by drowning at a beach protected by lifeguards is 1 in 18 million.

Where can I get more information about rip currents?

- Before you leave for the beach, check the latest National Weather Service forecast for local beach conditions.
- When you arrive at the beach, ask lifeguards about rip currents and other hazards.
- More information about rip currents can be found at the following web sites:

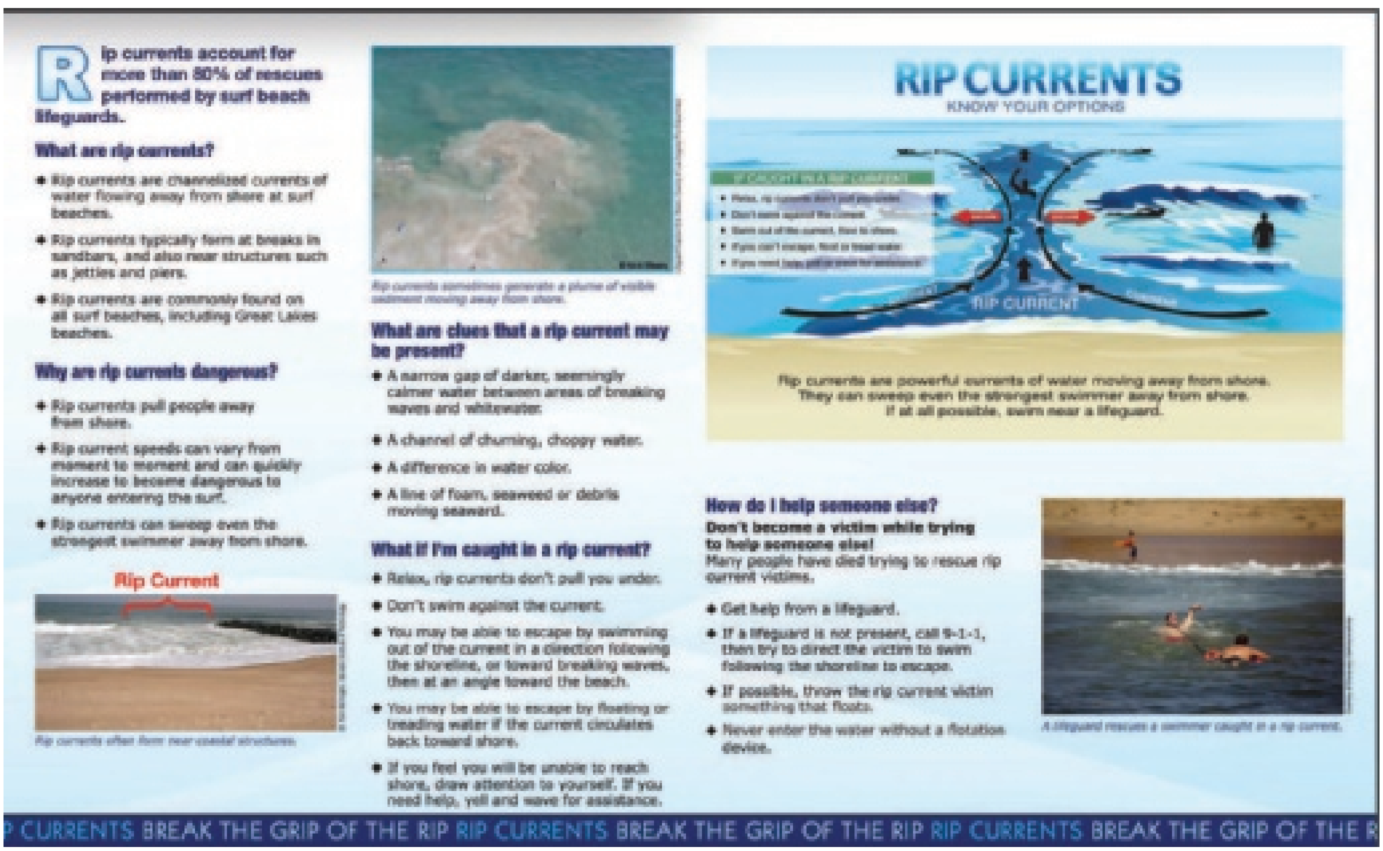
weather.gov/safety/ripcurrent
usla.org/ripcurrents

NOAA's National Weather Service, National Sea Grant College Program, and the United States Lifesaving Association are working to educate the public on the dangers of rip currents.

NOAA's National Weather Service
Analyze, Forecast, and Support Office
www.weather.gov/safety/ripcurrent

BREAK THE GRIP OF THE RIP

RIP CURRENTS!



Rip currents account for more than 80% of rescues performed by surf beach lifeguards.

What are rip currents?

- Rip currents are channelized currents of water flowing away from shore at surf beaches.
- Rip currents typically form at breaks in sandbars, and also near structures such as jetties and piers.
- Rip currents are commonly found on all surf beaches, including Great Lakes beaches.

Why are rip currents dangerous?

- Rip currents pull people away from shore.
- Rip current speeds can vary from moment to moment and can quickly increase to become dangerous to anyone entering the surf.
- Rip currents can sweep even the strongest swimmer away from shore.

Rip currents often form near coastal structures.

Rip currents sometimes generate a plume of visible sediment moving away from shore.

What are clues that a rip current may be present?

- A narrow gap of darker, seemingly calmer water between areas of breaking waves and whitewater.
- A channel of churning, choppy water.
- A difference in water color.
- A line of foam, seaweed or debris moving seaward.

What if I'm caught in a rip current?

- Relax, rip currents don't pull you under.
- Don't swim against the current.
- You may be able to escape by swimming out of the current in a direction following the shoreline, or toward breaking waves, then at an angle toward the beach.
- You may be able to escape by floating or treading water if the current circulates back toward shore.
- If you feel you will be unable to reach shore, draw attention to yourself. If you need help, yell and wave for assistance.

RIP CURRENTS

KNOW YOUR OPTIONS

Rip currents are powerful currents of water moving away from shore. They can sweep even the strongest swimmer away from shore. If at all possible, swim near a lifeguard.

How do I help someone else?

Don't become a victim while trying to help someone else!
Many people have died trying to rescue rip current victims.

- Get help from a lifeguard.
- If a lifeguard is not present, call 9-1-1, then try to direct the victim to swim following the shoreline to escape.
- If possible, throw the rip current victim something that floats.
- Never enter the water without a flotation device.

A lifeguard rescues a swimmer caught in a rip current.

RIP CURRENTS BREAK THE GRIP OF THE RIP RIP CURRENTS BREAK THE GRIP OF THE RIP RIP CURRENTS BREAK THE GRIP OF THE R

Name: ____________________ Date: ____________________

PSA Communication Plan

Developing Your Communication Plan

Use the tables below to plan your communication strategy for your public service announcement (PSA).

Considerations	What your group is planning for your PSA
What audience are you targeting with your PSA?	
What actions are you suggesting to your audience? What are some challenges your audience might have with taking action?	
How are you going to convince people in your audience who might be skeptical or unwilling to take action?	
What media and strategies (visual, audio, etc.) will you use to present this information?	
How will you present your information so that it's informative, engaging, and convincing?	

LESSON 19: TEACHER REFERENCE 1

PSA Project Choice and Platform Information

Below is a list of considerations for each type of project. Think about these options when allowing your students to select their project choice. Consider the devices that are available to you, the space in your room, and other factors, such as how students are expected to turn in work. Remove any options from the student handout if they do not fall in line with your privacy policies or student expectations. Student privacy policies vary widely by school and district. Remember to check with your student privacy school policies before approving the use of any specific projects, sites, or apps.

Project type	Considerations
Meetings	• Consider who the targeted audience is. • Communicate about the meeting with parents/caregivers, especially if the meeting involves community members. • Craft an agenda and talking points for the meeting and a list of action items. • Handouts with information and graphics can help meeting attendees and provide information.
Posters, Brochures, Flyers, Billboards	• This more traditional option can be done without any digital tools. • Paper can easily be lost by students without a paper management system. • This can be done on a variety of digital platforms as well. • Different digital tools have different sharing settings and capabilities.
Commercials, Podcasts, Newscasts, Mock Social Media, Jingles, Songs	• Some recording options are easier than others—help students find an appropriate tool based upon their individual strengths. • Make sure all students have permission to be recorded if their voices or bodies end up on the project. • Recorded items could be shared—check student privacy policies.
Infographic, Newspaper Article	• These are more susceptible to copying and pasting. • Note these might require additional sources of data.
Website	• Can be done on a variety of platforms. • Check sharing settings of any blogs or sites. • Check student privacy policies before any sites go live.
App	• This could be a draft on paper or an actual app. • If students create an actual app, monitor student privacy. • Creating an actual app could take more time than a more traditional project format.

Potential Project Platforms

Below is an alphabetical list of some widely used project creation platforms, along with their pros and cons. This list is not all-inclusive, but will give an idea of different ways students can demonstrate their learning. Each platform is linked to the Commonsense.org review when available, if you would like further information regarding the digital tool.

Platform	Use	Pros	Cons
Adobe Spark	The Adobe Creative Suite has many different applications and uses. Can be used to create: • Billboards • Flyers • Posters • Charts • Websites • Children's books read-alouds • Comic strips • Mock apps and social media pages	• Very versatile • Many different presentation options • Looks professional • Web-based platform	• Meant for ages 13 and up, if no school login is available • Check sharing settings against school policies • Choices could be overwhelming to some students • Steeper learning curve than Google platforms
Anamaker	Versatile creation tool Can be used to create: • Posters • Billboards • Pages in children's books • Flyers • Social media pages • Commercials • YouTube videos • Instagram stories • WhatsApp stories	• Web-based platform • Easy to navigate • Create a variety of projects	• Check sharing settings against school policies • Only the lite version is free, with limited features • Need to create a login or use Google credentials
Anchor	Simplistic platform used to make podcasts	• Record an actual podcast • Has basic editing functions • Up to 10 can work together on the same podcast • Can import music	• Available on Androids, iPhones, and web-based applications • Must be 13 years old • Can only share publicly

Platform	Use	Pros	Cons
Auxy studio	Music creation app Can be used to create: • Songs • Jingles • Podcasts	• A variety of tools to create sounds, beats, and loop tracks • Can create current-age sounding music	• Only available as an iOS app • Has features to upload content to social media
Book Creator	Digital storybook creation website	• Free to register for the site • Large selection of graphics to choose from • Easy to use • Sharing options available	• Some features require a subscription upgrade • Compatible only with iPad and Google Chrome
Clips	Video recording and sharing platform Can be used to create: • Commercials • YouTube videos • Newscasts • Children's books read-alouds • Mock TikTok	• Captions are available in many different languages • Can be easier to use than GarageBand • Can upload any videos or pictures on your iOS device for use	• Requires an Apple ID login • Very easy for students to share work-check with student privacy policies • Only available with iOS apps • No classroom-specific template
Flipgrid	Video recording and sharing platform Can be used to create: • Commercials • YouTube videos • Newscasts	• Teacher can create an account and control accessibility, sharing features • Single videos can be recorded • Web-based platform	• Not a lot of editing is available with Flipgrid • Teacher has to create a class site and distribute codes to students
GarageBand	Video recording and sharing platform Can be used to create: • Podcasts • Songs	• Various audio editing options • Easy to trim music and audio files	• Can be too complex for some students • Learning curve involved • Some background music has to be purchased • Only available on iOS

Platform	Use	Pros	Cons
Google Docs	More traditional word processing application Can be used to create: • Articles • Create comic strip layout to print and draw • Write lyrics to a song • Write up a script • Brochures	• Easy to use • Familiar to most students • Web-based platform • Different layouts exist on the Google suite for a variety of purposes • Can be shared with select stakeholders	• Limited ability to reformat pages • Charts can be hard to layout or organize in different ways • Text direction cannot be changed
Google Drawings	Online drawing tool similar to Microsoft paint application Can be used to create: • Billboards • Posters • Charts • Flyers • Any other simplistic visual product	• Easy to use • Integrates with other Google applications • Can import images from search features • Can be shared with select stakeholders	• Has limited tools to utilize • No premade templates or layouts • Simplistic look versus a more sophisticated look achieved with Adobe tools
Google Slides	Tool traditionally used to create presentations Can be used to create: • Posters • Billboards • Pages in children's books • Flyers • Social media pages	• Easy to use • Familiar to most students • Web-based platform • Multiple premade layouts and color schemes • Can be shared with select stakeholders	• Hard to create detailed drawings • Harder to export as a JPG if needed
iMovie	Tool traditionally used for creating and editing videos Can be used to create: • Commercials • YouTube videos • Newscasts • Children's books read-alouds • Mock TikTok	• Easy to use • Templates and layouts available • Allows for voice-overs • Would need a webcam or camera to create mock TikTok	• Available only on iOS platforms • Limited video editing available

Platform	Use	Pros	Cons
Keynote	Tool traditionally used to create presentations Can be used to create: • Posters • Billboards • Pages in children's books • Flyers • Social media pages	• Similar to Google Slides • Has more features than Google Slides • Basic graphics and layouts available • Voice-overs can be added but are more difficult to integrate	• Available only on iOS platforms • Harder to share with classmates and stakeholders
Microsoft PowerPoint	Tool traditionally used to create presentations Can be used to create: • Posters • Billboards • Pages in children's books • Flyers • Social media pages	• Similar to Google Slides • Has more features than Google Slides • Basic graphics and layouts available • Easy to record and play audio over slides	• Harder to share with classmates and stakeholders • School needs Microsoft Office license to utilize • Doesn't function as well on iOS devices
Piktochart	Application typically used to create infographics Can be used to create: • Infographics • Posters • Flyers • Billboards	• Students can create professionallooking graphs and charts • Templates available • Controlled sharing settings available	• Basic features are limited • Does require a free login
Pixton	Comic creation tool	• Easy to use • Has a lot of graphics to choose from • Can create multiple frames • Many options to share work • Available for Android and iOS	• Mostly human figures—upgrade is needed for additional characters • Teacher has to create a class site and distribute codes to students

Platform	Use	Pros	Cons
Powtoon	Tool traditionally used to create presentations Can be used to create: • Posters • Pages in children's books • Flyers • Commercials • YouTube videos • Newscasts	• Many different presentation formats • Premade templates • Many different ways to share the product • A multitude of images and videos are available to use • Easy to use • May need recording device if doing a newscast • Can upload and use your own videos • Web-based platform	• Students can add pictures and videos from a variety of sources, including Flickr, which may not be supported by some schools • Check with student privacy policies if students use images or likenesses due to the shareability of Powtoon
QuickTime	Traditional recording, video editing, and playback software included on Mac devices Can be used to create: • Commercials • YouTube videos • Newscasts • Children's books read-alouds • Mock TikTok • Podcasts • Songs	• Easy to use • Can upload or modify any videos • Can be used to record audio	• Microsoft version is no longer supported by Apple • Comes with macOS • Does not have a lot of standard templates or music to utilize
Scratch or Scratch Jr.	Coding application designed to introduce K-8 students to basic coding language Can be used to create: • Animated commercials • Interactive children's stories	• Unique way to create a children's book or commercial • Interesting for students who like to code • Can easily be shared with others via email • Scratch Jr is very simplistic—easy to use	• Involves a coding learning curve for some students • Can take more time than other options • All text—no voice-over option • Only available on Google Chrome, iOS, and Amazon

Potential Accompanying Standards

Different projects will lend themselves to different potential standards for ELA, Mathematics, and Technology based upon their modality and presentation style. Use the tables below to help develop any accompanying rubrics or materials for students in your classroom. Consider sharing these standards with teammates who may also teach these content areas to develop a cross-curricular connection. The list below is not exhaustive and contains only suggestions, not recommendations. Many states that do not use Common Core standards have similar areas, such as reading, writing, speaking, and listening, that can be cross-referenced. Ultimately, consult your own state-adopted standards when deciding on any potential additional standards.

ELA Common Core College and Career Readiness Standards Connections

Consider the following Common Core ELA standards for student use. Many standards are applicable to more than one project. Depending on the state, this alignment may vary. Consult your state standards documents for further guidance.

Standard	Indicator	Statement
	Reading	
Integration of Knowledge and Ideas	CCSS.ELALITERACY.CCRA.R.7	Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
	Writing	
Text Types and Purposes	CCSS.ELALITERACY.CCRA.W.2	Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
Production and Distribution of Writing	CCSS.ELALITERACY.CCRA.W.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Production and Distribution of Writing	CCSS.ELALITERACY.CCRA.W.6	Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Standard	Indicator	Statement
Research to Build and Present Knowledge	CCSS.ELALITERACY.CCRA.W.8	Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
	Speaking and Listening	
Comprehension and Collaboration	CCSS.ELALITERACY.CCRA.SL.2	Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
Presentation of Knowledge and Ideas	CCSS.ELALITERACY.CCRA.SL.4	Present information, findings, and supporting evidence such that listeners can follow the line of reasoning, and the organization, development, and style are appropriate to task, purpose, and audience.
Presentation of Knowledge and Ideas	CCSS.ELALITERACY.CCRA.SL.5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

Common Core Mathematics Standard Connection

Consider the following Common Core math standard for student use. This math standard tends to correlate to projects that are more data-driven, such as a quantitative infographic, and is pulled from the 7th grade standard set. While measurement standards seem applicable for this project, note that they are developed in elementary grades, utilized in relational and expressive domains in middle school, and revisited in high school to develop an understanding of probability. Depending on the state, this alignment may vary. Consult your state standards documents for further guidance.

Standard	Indicator	Statement
Grade 7—Ratios and Proportional Relationships	CCSS.MATH.CONTENT.7.RP.A.2	Recognize and represent proportional relationships between quantities.

ISTE Standard Connection

Consider the following technology standards for student use. Many ISTE standards are applicable to more than one project. Depending on the state, this alignment may vary. Consult your state standards documents for further guidance.

Standard	Indicator	Statement
Knowledge Constructor	3b	Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.
Computational Thinker	5b	Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
Creative Communicator	6a	Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
Creative Communicator	6c	Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects, such as visualizations, models, or simulations.
Creative Communicator	6d	Students publish or present content that customizes the message and medium for their intended audiences.
Global Collaborator	7a	Students use digital tools to connect with learners from a variety of backgrounds and cultures, engaging with them in ways that broaden mutual understanding and learning.
Global Collaborator	7c	Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

Reference: Peer Feedback Guidelines
Teacher Instructions

There will be times when helping students give each other feedback will be very valuable both for their three-dimensional learning and for learning to give and receive feedback. We suggest that peer review happen at least once, but preferably two times, per unit. This document provides options on how to support this in your classroom. It also includes student materials to support giving and receiving feedback, along with self-assessment rubrics with which students can reflect on their experience with the process.

When is a good time to facilitate peer review?

Peer feedback is most useful when complex and diverse ideas are visible in student work and not all work is the same. Student models or explanations are good opportunities for which to use a peer feedback protocol. They do not need to be final pieces of student work; rather, peer feedback will be more valuable to students if they have time to revise their work after receiving the feedback. It should be a formative, not summative, type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities so that they can use these experiences as evidence for their feedback.

What classroom structures can I use for peer review?

Below are three examples of ways to organize peer review in your classroom. You may choose to use all of them as your time or material constraints allow, or you may choose to always use the same structure so that your students get familiar with it and become better at it over time.

Sticky Note Peer Review: In this protocol—shared on *Tools for Ambitious Science Teaching–students* use sticky notes to leave questions and comments on posted student work. Time is built in for students to respond to the feedback. Use the self-assessment rubrics in this document at the end of the class period to have students reflect on their experience in this feedback session.

Peer Review with Unit Rubrics: Each unit—and the curriculum overall—has Science and Engineering Practice (SEP)–specific rubrics for teachers to assess student work. You can also use these as a way for students to assess each other's work and give feedback on how to improve. For example, in the first lesson set of Unit 8.2, *How can a sound make something move?* (Sound Waves Unit), students develop models of how objects vibrate to produce sound. We suggest having students use the rubric to give each other specific feedback You can use this in a gallery walk context or have students exchange models.

Group Review: Ask students to form groups of four and bring their individual models or explanations (or other work) to their group. Review the peer feedback guidelines as a class, giving examples of productive and nonproductive feedback. Then, in pairs, have students provide feedback on the other two pieces of student work. They can use sticky notes or write directly on the work. Make sure to allow time, after feedback is exchanged, for students to individually revise their models and complete the self-assessment rubrics.

Giving Feedback to Peers

This tool was inspired by the Sticky Note Feedback resource originally developed by Ambitious Science Teaching at ***https://ambitiousscienceteaching.org/sticky-note-student-feedback/****.*

Feedback needs to be specific and actionable.

For feedback to be productive, it needs to be related to science ideas and provide suggestions for improvement.

Here are some examples of productive feedback:

- "Your model shows that the sound source changes position when it is hit. I think you should add detail about how the sound source moves back and forth after it is hit."
- "You said that the drum moves when it makes a sound, but the table doesn't move when it makes a sound. We disagree and suggest reviewing the observation data from the laser investigation."

Here are some examples of nonproductive feedback that does not help other students improve:

- "I like your drawing."
- "Your poster is really pretty."
- "I agree with everything you said."

How to Give Feedback

Your feedback should give ideas for specific changes or additions the person or group can make. Use the sentence starters below if you need help writing feedback.

- "The poster said ______________________. We diagree because ______________________. We think you should change."
- "I like how you ______________________. It would be more complete if you added ______________________."
- "We agree that ______________________. We think you should add more evidence from the ______________________ investigation."
- "We agree/disagree with your claim that ______________________. However, we do not think the ______________________ (evidence) you used matches your claim."

Receiving Feedback from Peers

The purpose of receiving feedback is to get ideas from your peers about things you might improve or change to make your work more clear, more accurate, or better supported by evidence. It can also help you communicate your ideas more effectively to others.

When you receive feedback, you should take these steps:

- Read it (or listen to it) carefully. Ask someone else to help you understand it, if necessary.
- Decide if you agree or disagree with the feedback, and say why you agree or disagree.
- Revise your work to address the feedback as needed.

Self-Assessment: Giving Feedback

How well did you give feedback today?

Today, I...	Yes	No
Gave feedback that was **specific and about science ideas.**		
Shared a suggestion to help improve my peer's work.		
Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave.		

One thing I can do better the next time I give feedback is:

Self-Assessment: Receiving Feedback

How well did you receive feedback today?

Today, I...	Yes	No
Read the feedback I received carefully.		
Asked follow-up questions to better understand the feedback I received.		
Said or wrote why I agreed or disagreed with the feedback.		
Revised my work based on the feedback.		

What is one piece of feedback you received?

What did you add or change to address this feedback?

Obtaining and Communicating Information about the Palm Oil Problem

Category	1	2	3
Communicate information about the problem and what is contributing to the problem.	Shares limited information about the problem and what is causing it.	Shares detailed information about the problem and/or some information about what is causing it.	Shares detailed and relevant information about the problem and what is causing it, and tailors that information for a specific audience.
Communicate information about possible action steps.	Provides information about a single action to address the problem. Action might not be accessible to many.	Provides information about several actions that can be taken to address the problem.	Provides information about several actions that can be taken to address the problem. Provides options for additional actions if they cannot do the actions suggested.
Communicate information to the audience about how small changes in behaviors can have large impacts.	Shares information about how the solution is a small change to make.	Shares information about how the solution is a small change to make but, when done with others, can have a large impact.	Shares detailed information about how small everyday changes in behaviors across individuals and communities can add up to large impacts.
Information is presented in a way that is informative and positive and is not meant to cause fear, sadness, or anxiety.	Final product raises fear, sadness, or anxiety.	Final product attempts to be informative and not raise fear, sadness, or anxiety.	Final product was thoughtfully designed and explained in a way to be informative and to not raise fear, sadness, or anxiety.
Information is accessible to a targeted audience.	Final product communicates basic information to the target audience.	Final product uses everyday language, along with symbols and images, to communicate information.	Final product thoughtfully pairs symbols, images, and text in a way that communicates important ideas to the target audience group(s) in everyday language commonly used by the target audience.

LESSON 20: TEACHER REFERENCE 1

Pathway A: Local Project Planning Guide

Pathway A Overview

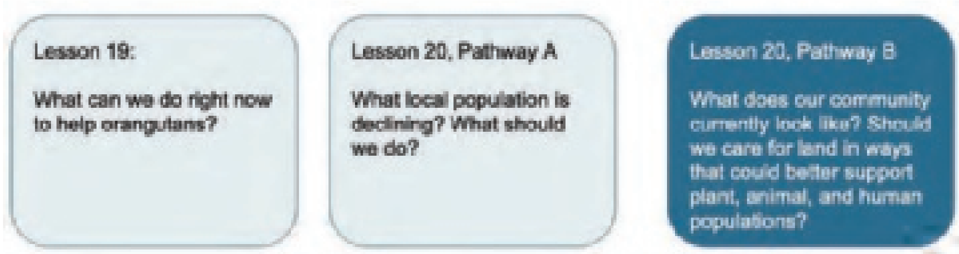
Lesson question:

In this local project, you and your students explore:

- What local population is declining? What should we do?

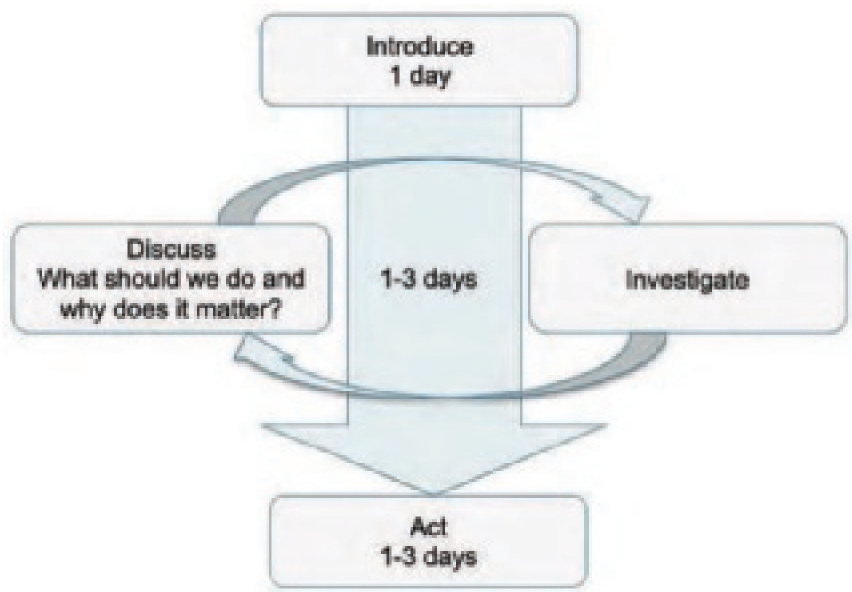
Purpose:

The purpose of this local project is to give students a chance to apply what they learned (through their investigation of orangutan populations declining) to their own communities. In this pathway, students learn about and take local community action in service of a specific local population that is struggling. Alternative pathways for the local community action project include science communication and action in service of orangutans (Lesson 19, "Public Service Announcement") and surveying their local schoolyard or neighborhood landscape to see how land is being used (see Pathway B in this lesson).



5-Day Lesson-at-a-Glance

- **Introduce** a phenomenon of a local population declining.
- **Investigate** the local population.
  - What is happening? What is causing the population decline?
  - What do they need to survive?
- **Discuss** what we should do and why it matters.



- **Act** directly to support this population. Some examples (details below):
- Habitat restoration
- Science communication
- Monitor populations or biodiversity

Planning guidance:

1. Determine what population of organisms you want students to explore.

Populations decline for many reasons. Students explore some of these reasons in the unit, while not others. To enable students to apply the understandings they developed throughout the unit, we suggest that you select a population that is primarily declining due to habitat degradation or loss or competition with invasive species. Students will be able to apply what they figured out about resource availability, competition, and biodiversity to these contexts. Reasons why populations decline involving climate change, exploitation, pollution, and introduced diseases are not addressed in the unit, and we suggest you steer clear of populations struggling primarily due to these reasons.

This chart includes example related phenomenon students may have generated throughout the unit that you may consider designing for.

Populations that are declining	Reasons why populations decline	Ideas students can draw on from Lessons 1-19	Actions to consider taking
Pollinators	Habitat degradation or habitat loss	Yes. Competition for resources, limited biodiversity.	• Restoration • Science communication • Biodiversity monitoring
Burmese python in the Everglades	Invasive species	Yes. Competition for resources, predator-prey dynamics.	• Restoration • Invasive species removal • Science communication • Biodiversity monitoring
Rhinos, sea otters	Exploitation	No	
Polar bears	Climate change	No	
Sea turtles and Bald eagles	Pollution (air, pesticides, plastics)	No	
Sudden oak death	Introduced disease	No	

Resources to identify important populations that are threatened or declining

- US Fish and Wildlife Endangered Species Database. Search by state. Note that actually monitoring threatened or endangered species will likely be difficult if you are wanting to do a citizen science monitoring project.
- Connect with local community partners with expertise to identify a population to focus on.

Teacher planning notes

Population decline I want students to explore:

Primary driver of this population decline:

What new ideas do I need to introduce to students that they haven't yet encountered in this unit (e.g., invasive or introduced species)?

If you decide to incorporate a population declining primarily due to competition from invasive species, consider how you frame invasive species as "*plants who have lost their original relationships*." See Indigenous STEAM Learning about Weeds, page 1.

2. Consider the kinds of action you want to support students in taking at the end of the lesson.

There are many possible actions students could take. You may need to pre-plan if you need to coordinate a field trip to plug into an existing effort such as citizen science monitoring, restoration, or invasive species removal projects. Consider co-creating actions with students, particularly if you decide on a science communication action or if there are places where students could participate in decision-making (e.g., researching and determining what kinds of plants to put in the schoolyard).

Kinds of actions you and your students might decide to take:

Option 1: Habitat restoration (may or may not include invasive species removal)

- Look for existing community projects through local nonprofits or city governments that you could plug into on a field trip, during which students could do habitat restoration work or invasive species removal.
- Partner with your school groundskeepers and administration to purchase native plants and install a native plants area on your campus or to purchase and plant diversified crops in an existing school garden area.

Option 2: Communicating with authentic audiences about the population and what people can do

- If you don't have access to an area where you can directly control or contribute to how land is managed, this might be a good option. There are many levers for change for students, including audiences they can communicate with and various modes of communication. One important piece here is that students communicate with people that they care about—real and authentic audiences.
- Consider the parental permissions that will be needed for different formats.
- See Lesson 19 in this unit for supports for a "Public Service Announcement" science communication project that could transfer to other formats. Some moves to support students in their drafting process include:
  - Look at examples of the format. Analyze what is good about it.
  - Create an outline, storyboard, or main ideas to communicate.
  - Draft your communication. Practice if giving an oral presentation.
  - Get peer, parent, and/or community feedback and revise your communication.
  - Share with your intended audience.

Audiences	Formats
Friends and family members School grounds managers or administration City, regional, or state government General public	Public Service Announcement (see Lesson 19) Infographic Blog Writing Social Media Campaign Letter Writing Podcast or Perspective Writing In-Person Presentations

Option 3: Monitor this population for biodiversity, such as important habitat plants.

- Another important aspect of this issue is, How do we even know how a population is doing? How do we know if important populations are declining? This important information can help communities make important decisions that impact populations, such as land-use regulations. There are many opportunities to contribute to ongoing biodiversity monitoring projects through citizen science. Citizen science projects are diverse, ranging from monitoring night sky brightness or water quality to documenting crabs on the beach. If you are focused on a population in decline, it may be difficult to monitor that population. Consider monitoring populations this one depends on, such as important habitat plants or invasive species that may be competing with that population. Here are some places to find national or regional projects that focus on population monitoring.
  - Clearinghouse for many projects
    - Scistarter.org. Clearinghouse for hundreds of projects. To find a project focused on animals and population monitoring, try filtering projects by animals, birds, insects, and pollinators.
    - Citizenscience.gov. Government-sponsored projects.

- Bird projects
  - eBird. Global bird monitoring.
  - Celebrate Urban Birds. Urban bird monitoring.
- Pollinator projects
  - Monarch Larva Monitoring Project. Monarch larva monitoring, which requires setting up an area of milkweed.
  - The Great Sunflower Project. Pollinator monitoring, including bees, butterflies, birds, and bats.
- Frog projects
  - Frogwatch USA. Monitoring frog calls.
- General biodiversity projects
  - iNaturalist. Photograph any kind of living thing using a handheld device. You can easily set up a school site project and have ongoing biodiversity monitoring.
- Resources to help you think about how to facilitate students with citizen science
  - Cal Academy of Sciences Teacher Toolkit. Toolkit to help with planning for a citizen science project.
  - UC Davis Youth Focused Community and Citizen Science. Case studies and resources to help you visualize what a project could look like.

Teacher planning notes

Kinds of actions I want to support students in taking:

Do I need to plan what we'll do in advance? Are there places where students could be involved in the decision-making process?

What kinds of support and/or resources will I and my students need (e.g., technology, platforms for hosting)?

Do I need parent or guardian permission for any of my ideas (e.g., field trips, if students are going to post on social media)?

<table>
<tr><th colspan="3">3. Develop instructional resources</th></tr>
<tr>
<td><u>Introduce</u> a phenomenon of a local population declining.</td>
<td>Develop a way to introduce the population decline and a way for students to generate observations and questions. Examples could include:
News headlines from local newspapers or radio stories
Data or graphs
Inviting community members to share their stories</td>
<td>What do you want students to notice?</td>
</tr>
<tr>
<td><u>Investigate</u> the local population.
What is happening? What is causing the population decline?
What do they need to survive?</td>
<td>Develop materials for students to obtain information about what is causing the decline and this population’s needs. Examples could include:
Readings
Videos
Interviews
Inviting local experts to share their stories</td>
<td>What big ideas do you want students to take away from the materials they read or listen to?</td>
</tr>
<tr>
<td><u>Frame</u> actions we could take.
What can we do?
What should we do?
Why does it matter?</td>
<td>If you’ve planned an action in advance, determine how you want to frame the action you’ve planned for students to take.
Ask students, Why does this matter?
If you want students to participate in co-constructing the actions we should take, assemble materials for students to learn about one action or multiple kinds of actions they might consider. Examples could include:
Readings
Videos
Interviews
Inviting local experts to share their stories</td>
<td>Do you want to pre-plan opportunities for action? Do you want to co-construct ideas for action with your students?

What big ideas do you want students to pull out of materials they read or listen to?</td>
</tr>
</table>

• **Act** directly to support this population.	• See guidance in step 3 about how to plan for different local action options. Examples could include: ◦ Habitat restoration ◦ Science communication ◦ Monitor populations or biodiversity • Assemble supports or scaffolds needed for the action pathway you select.	What kinds of support will students need to work productively in groups while engaging in local action?

Teacher-facing resources you might draw on:

- Resources from Learning in Places
  - Ethical Deliberation and Decision-Making in Socio-Ecological Systems Framework
  - Socio-ecological Histories of Places Framework
- Resources from STEM Teaching Tools
  - Designing and Participating in Community and Citizen Science Efforts to Support Equity and Justice
  - How Place-Based Science Education Strategies Can Support Equity for Students, Teachers, and Communities
  - Using Science Investigations to Develop Caring Practices for Social-ecological Systems

Student-facing resources and tools you might draw on:

- Obtaining, Evaluating, and Communicating Information Checklist
- Analyzing and Interpreting Data and Using Mathematical and Computational Thinking Checklist

LESSON 20: TEACHER REFERENCE 2

Pathway B: Local Project Planning Guide

Pathway B Overview

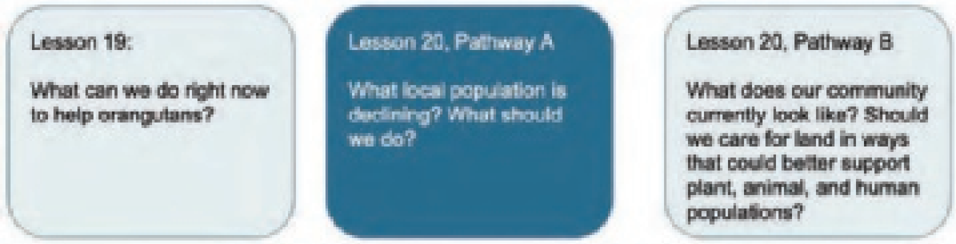
Lesson question:

In this local project, you and your students explore:

- How is our community currently caring for the land? Should we care for the land in ways that could better support plant, animal, and human populations?

Purpose:

The purpose of this local project is to give students a chance to apply what they learned (through their investigation of orangutan populations declining) to their own communities. In this pathway, students consider what the community currently looks like and if there are ways we should care for the land that might help plants, animals, and people. Other options for a local community action project include community action in service of orangutans (Lesson 19, "Public Service Announcement") or focusing on one specific population decline (see Pathway A in this lesson).



5-Day Lesson-at-a-Glance

- **Introduce** a phenomenon of community land uses today.
  - How is land being cared for currently?
  - Who might this be positively and negatively impacting?
- **Investigate**
  - What kinds of plants or animals live here currently?
  - What kinds of plants or animals used to live here? Why are they not here anymore?
  - Who might be positively or negatively impacted by current ways of caring for the land?
  - What do community members think should happen?
- **Discuss** what we should do and why it matters.
  - Brainstorm different kinds of things we could do.
  - Consider the goals and values that would guide our decision-making.
  - Decide what we should do (including nothing).
- **Act** directly to change community land-uses. Some examples (details below):
  - Habitat restoration
  - Science communication
  - Monitor biodiversity

1. Prepare materials for students to explore community land use today and in the past

Determine the scale you want students to investigate and prepare materials for students to observe what kind of land cover is present in their local or regional communities today.

- **Schoolyard scale**
  - Prepare a schoolyard walk for students to notice and wonder about the kind of land cover that is around the school and other nearby places. How does the community care for the land?
  - Focus students on places where it seems like people, plants, and animals are doing well. What is it about these places that seems positive and for whom? What are the surfaces like? What is the vegetation like? How are community members caring for the land?

Surfaces	Vegetation	Who do we observe here?
• Bare soil • Pavement	• Monocrop (e.g., lawns) • Ornamental plants (shrubs, trees) • Habitat plants (native plants) • Food plants	

- **Community scale**
  - Prepare resources for students to notice and wonder about the kind of land cover in their community by looking from a birds-eye view on Google Earth. Look at coarser categories of land cover, including:

Buildings	Surfaces	Vegetation—community
• Types of buildings	• Bare soil • Pavement	• Trees and shrubs (coarse vegetation) • Herbs and grasses (fine vegetation)

Assemble resources to investigate what land cover used to be like.

- Historic images or maps
  - **https://www.mrlc.gov/viewer/**. This website shows an interactive map with land cover information across the United States. There are several different layers of land cover. The earliest is 2001 (2001 Conus Land Cover), and the most recent is 2016 (2016 Conus Land Cover). Turn them on and off. To see the legend, click the small icon on the top-right. If you live in a fairly urban environment, you may not see major changes from 2001 to 2016. If you look for resources that go back 50-100 years, then you will likely see more evidence of change.
- Invite community members, elders, local historians, or other experts to share their stories.

Identify areas you and your students might consider cultivating plant biodiversity.

- These might include riparian areas with creeks or rivers, areas that used to have lots of habitat plants, areas that students can access to plant things (e.g., vacant lots, areas on the school grounds where they could plant), wildlife corridors, food production gardens, and landscaped areas.
- Consult your school groundskeepers about areas where students might be able to do some kind of planting.

Teacher planning notes

Areas my class might identify as places where we or someone else could care for the land in a different way:

What community experts might I draw on?

2. Consider the kinds of actions you want to support students in taking at the end of the lesson.

There are many possible actions students could take. You may need to pre-plan if you need to coordinate a field trip to plug into an existing effort such as citizen science monitoring, restoration, or invasive species removal projects. Consider co-creating actions with students, particularly if you decide on a science communication action or if there are places where students could participate in decision-making (e.g., researching and determining what kinds of plants to put in the schoolyard).

Kinds of actions you and your students might decide to take:

Option 1: Habitat restoration

- Look for existing community projects through local nonprofits or city governments that you could plug into on a field trip, during which students could do habitat restoration work or invasive species removal.
- Partner with your school groundskeepers and administration to purchase native plants and install a native plants area on your campus or to purchase and plant diversified crops in an existing school garden area.

Option 2: Communication to authentic audiences about what should happen in this place.

- If you don't have access to a place in which you can directly control or contribute to how land is cared for, this might be a good option. There are many levers for change for students, including audiences they can communicate to and formats for communicating. One important piece here is that students communicate with people who they care about—real and authentic audiences.
- Consider parental permission needed for different formats.
- See Lesson 19 in this unit for supports for a "Public Service Announcement" science communication project that could transfer to other formats. Some moves to support students in their drafting process include:
    - Look at examples of the format. Analyze what is good about it.
    - Create an outline, storyboard, or main ideas to communicate.
    - Draft your communication. Practice if giving an oral presentation.
    - Get peer, parent, and/or community feedback and revise your communication.

- Share with your intended audience.

Audiences	Formats
Friends and family members School grounds managers or administration City, regional, or state government General public	Public Service Announcement (see Lesson 19) Infographic Blog Writing Social Media Campaign Letter Writing Podcast or Perspective Writing In-Person Presentations

Option 3: Monitor biodiversity in this place.

- Another important aspect of this issue is, How do we know how populations are doing? How do we know if the way land is being cared for is positively or negatively impacting populations? This important information can help communities make important decisions that impact populations, such as land-use regulations. There are many opportunities to contribute to ongoing biodiversity monitoring projects through citizen science. Citizen science projects are diverse, ranging from monitoring night sky brightness or water quality to documenting crabs on the beach. We suggest finding a project that engages participants in biodiversity or population monitoring that would align best with the unit focus on animal populations. These types of projects provide baseline data that help scientists understand how populations are doing. With some projects, you can participate anywhere, such as on your school campus. Others require a specific location outlined by the project. Some projects have places at which students can upload data, as well as view and visualize data that other participants have collected. Here are some places to find national or regional projects that focus on population monitoring.
- Clearinghouse for many projects
  - Scistarter.org. Clearinghouse for hundreds of projects. To find a project focused on animals and population monitoring, try filtering projects by animals, birds, insects, and pollinators.
  - Citizenscience.gov. Government-sponsored projects.
- Bird projects
  - eBird. Global bird monitoring.
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- Pollinator projects
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- Frog projects
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- General biodiversity projects
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- Resources to help you think about how to facilitate students with citizen science
  - Cal Academy of Sciences Teacher Toolkit. Toolkit to help with planning for a citizen science project.
  - UC Davis Youth Focused Community and Citizen Science. Case studies and resources to help you visualize what a project could look like.

Teacher planning notes

Kinds of actions I want to support students in taking:

Do I need to plan what we'll do in advance? Are there places where students could be involved in the decision-making process?

What kinds of support and/or resources will I and my students need (e.g., technology, platforms for hosting)?

Do I need parent or guardian permission for any of my ideas (e.g., field trips, if students are going to post on social media)?

3. Develop instructional resources		
Introduce a phenomenon of community land uses today. • How is the land being cared for currently? • Who might this be positively and negatively impacting?	Develop a way to introduce the current ways land is being cared for to your students (see above, step 1).	What do you want students to notice?
Investigate • What kinds of plants or animals live here currently? • What kinds of plants or animals used to live here? Why are they not here anymore? • Who might benefit or be harmed by current ways of caring for the land? • What do community members think should happen?	Develop materials for students to obtain information about what kinds of plants or animals live here, used to live here, and might benefit. Examples could include: • Biodiversity data • Readings or videos • Community member stories • Interviewing community members about what they want to see happen	What big ideas do you want students to pull out of the materials they read or listen to?
Discuss what we should do and why it matters. • Brainstorm different kinds of things we could do. • Consider the goals and values that would guide our decision-making. • Decide what we should do (including nothing).	If you've planned an action in advance, determine how you want to frame the action you've planned for students to take. • Ask students, Who would this matter for and why? If you want students to participate in co-constructing the actions we should take, assemble materials for students to learn about the one action or multiple kinds of actions they might consider. Determine how you want to bring in goals and values that would guide our decision-making. Examples could include: • Readings • Videos • Interviews • Inviting local experts to share stories	Do you want to co-construct ideas for what to do, or do you want to pre-plan action opportunities? What big ideas do you want students to pull out of the materials they read or listen to?

Act directly to change the way the community cares for the land.	See the guidance in step 3 about how to plan for different local action options. Examples could include: • Habitat restoration • Science communication • Monitoring populations or biodiversity Assemble the supports or scaffolds needed for the action pathway you select.	What kinds of support will students need to work productively in groups in their actions?

Teacher-facing resources you might draw on:

- Resources from Learning in Places
  - Ethical Deliberation and Decision-Making in the Socio-Ecological Systems Framework
  - Socio-ecological Histories of Places Framework
- Resources from STEM Teaching Tools
  - Designing and Participating in Community and Citizen Science Efforts to Support Equity and Justice
  - How place-based Science Education Strategies Can Support Equity for Students, Teachers, and Communities
  - Using Science Investigations to Develop Caring Practices for Social-Ecological Systems

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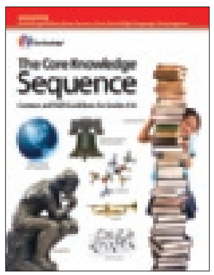

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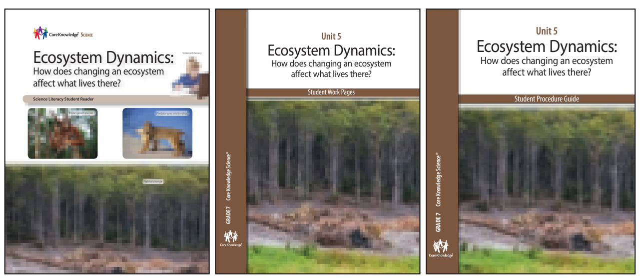

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