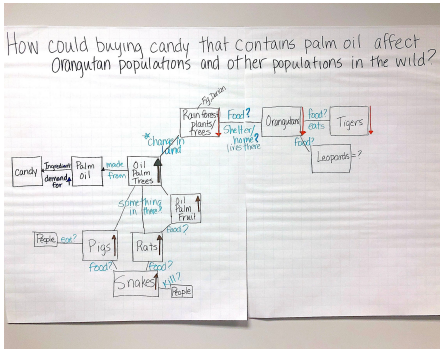
UNIT STORYLINE

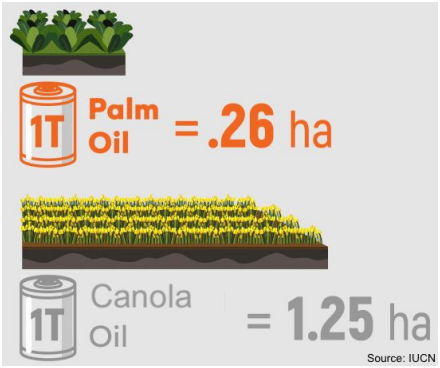
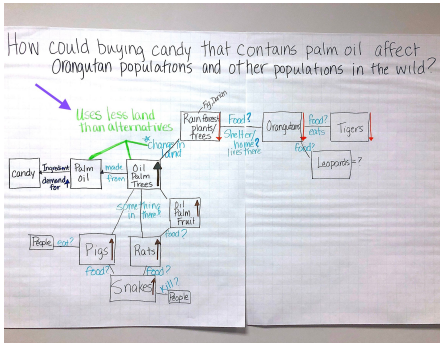
How students will engage with each of the phenomena

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

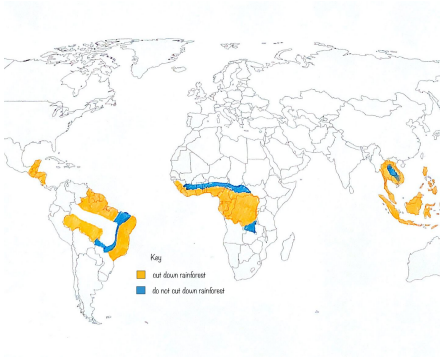
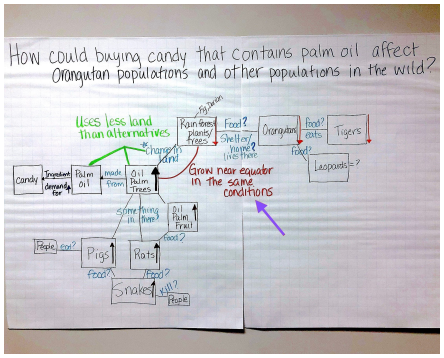
Unit Question: How does changing an ecosystem affect what lives there?

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, rats, pigs, and snake populations also increase.	

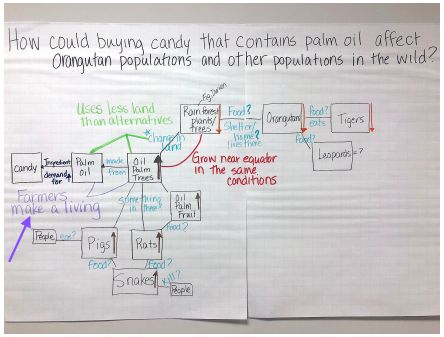
⇓ Navigation to Next Lesson: We figured out that when the number of oil palm trees goes up, the orangutan population goes down. We think this has something to do with orangutans not having enough food or habitat, or being killed when oil palm trees are planted. We wondered whether we could replace palm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

LESSON 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.	

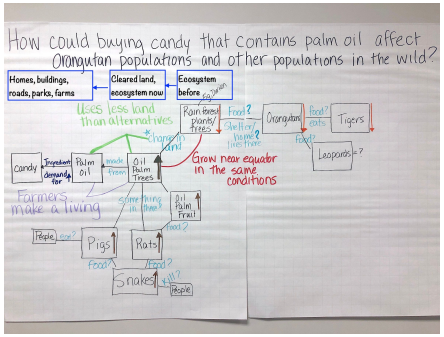
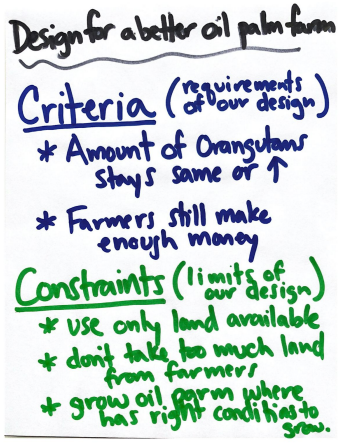
⇓ Navigation to Next Lesson: We figured out that oil palm trees are the most efficient oil plant to grow in terms of land use and that growing other oils takes up more land and also requires the clearing of native grasslands, which hurts grassland plants and animals. Since palm oil is likely not going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

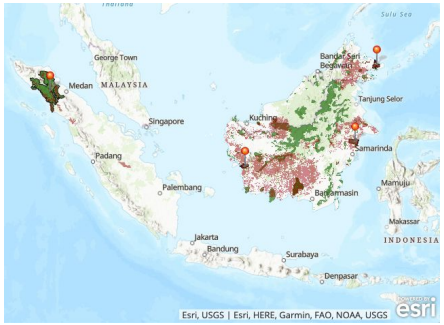
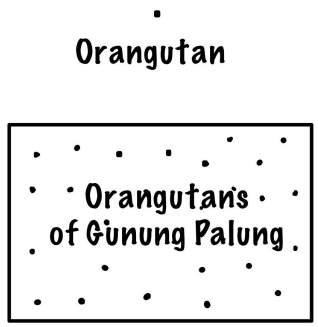
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 3 1 day **Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?** Investigation	 *Oil palm grows best in equatorial regions because of the nonliving conditions suitable 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.

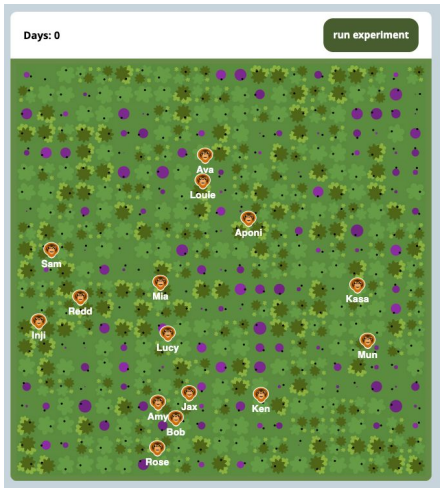
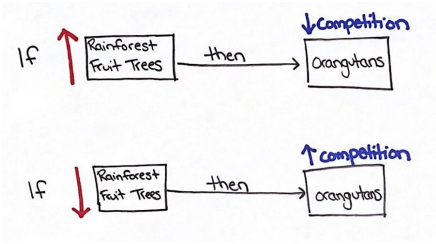
LESSON 4 1 day **Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?** Investigation	 *Interviews with people who work to grow oil palms in developing countries reveal that this practice, though harmful to animals like orangutans, provides them with 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 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 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. 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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
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 km2.*	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 km2, 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 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.

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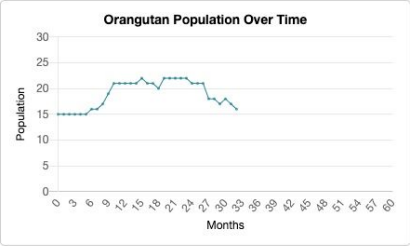
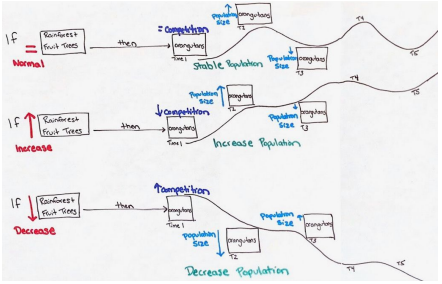
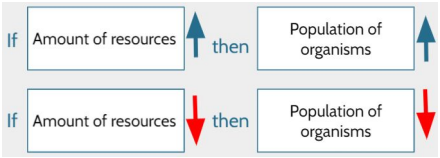
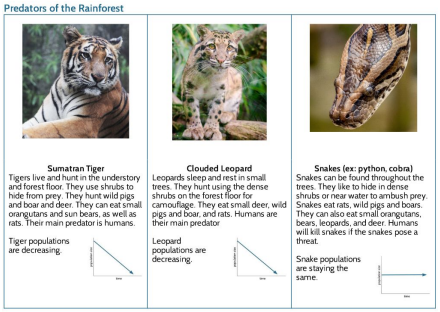
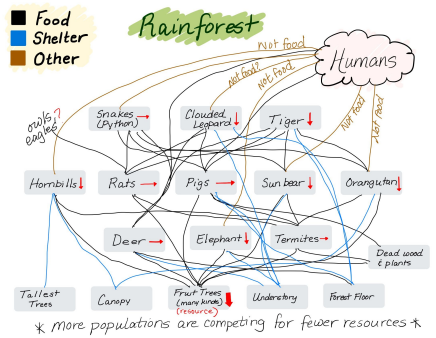
LESSON 9 2 days **Would planting more rainforest fruit trees help the orangutan population increase?** Investigation	**Population** **Orangutan Population History** Low: 15 | High: 22 | average: 18.5 | births: 12 | deaths: 11  *Orangutan population sizes increase when resources are plentiful and decrease 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.			
LESSON 11 2 days **How does planting oil palm affect other populations?** Investigation	 *Rat and snake populations are exploding in the oil palm system, but those populations are not exploding in the rainforest system.*	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.	
⇓ **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.			

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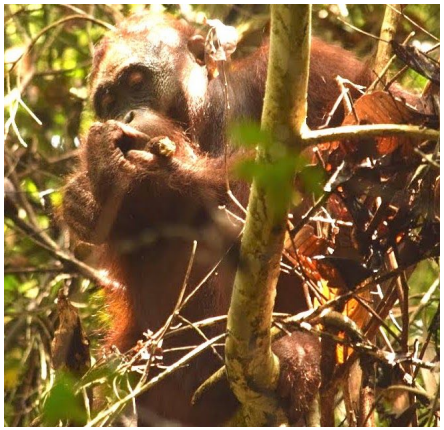
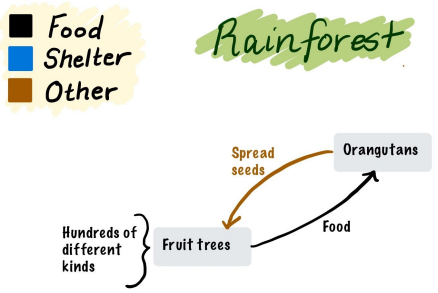
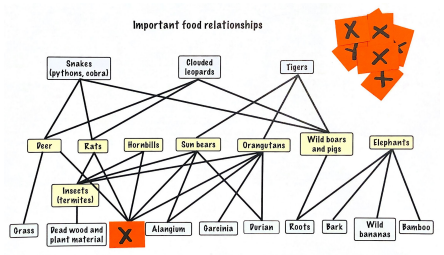
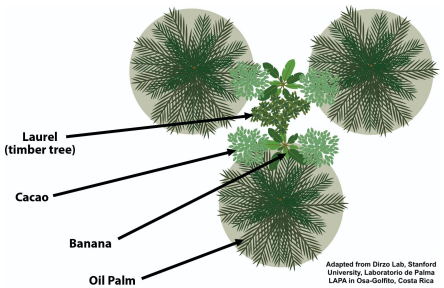
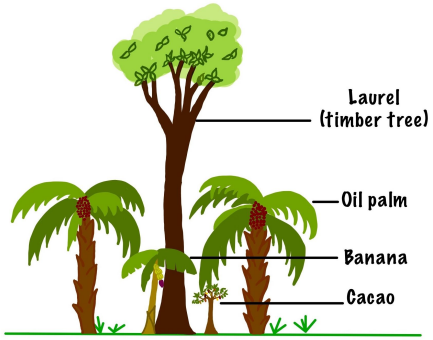
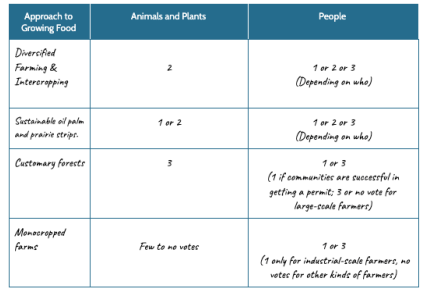
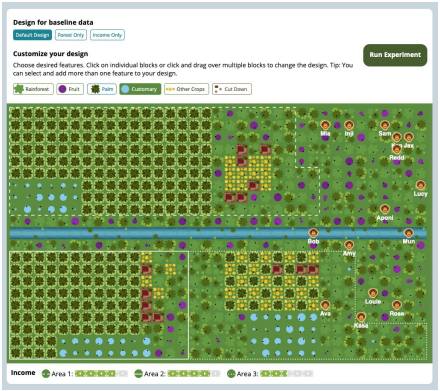
LESSON 12 1 day **What would happen if orangutans go extinct?** Investigation	 *Many seeds from fruit trees are found in spit and fecal samples of orangutans. These seeds germinate better compared to control seeds.*	We are curious about what would happen if orangutans went extinct. We read an interview 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 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.	**Summary chart** **Rainforest versus oil palm** If there are many kinds of plants and a disruption affects... ...a few plants, then some plants may struggle or die but the system will be mostly OK ...most plants, then many plants may struggle or die and the whole system will be impacted If there are one or few kinds of plants and a disruption affects... ...most plants, then the whole system will be impacted
⇓ 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.			

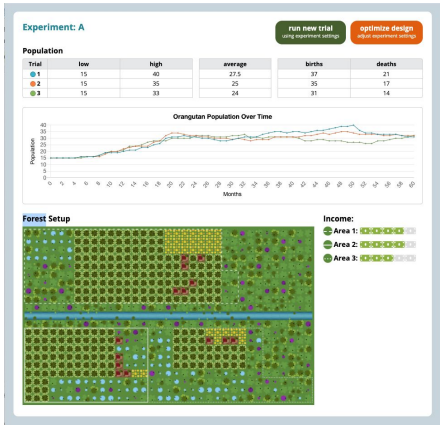
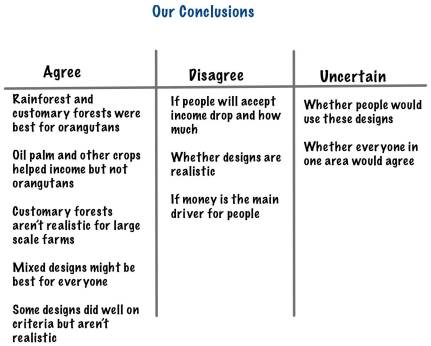
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 1 day **Are there ways people can grow food without harming the tropical rainforest?** Investigation	 *Farmers and other community members in Indonesia and Costa Rica observe positive impacts on plant 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 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.			

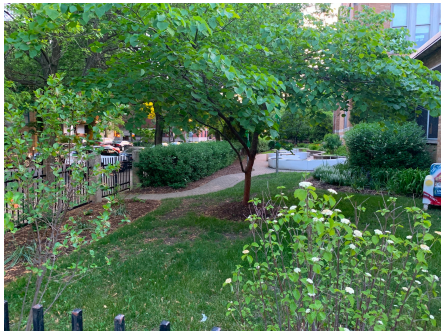
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 16 2 days **What approach to growing food works for everyone and why?** Putting Pieces Together	 *People can use many approaches to growing food, and there are trade-offs to using them that have consequences 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.	

⇓ **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.

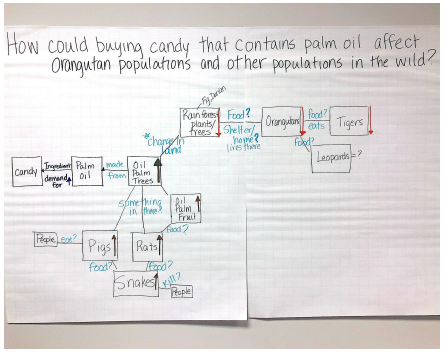
LESSON 17 3 days **How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?** Investigation	 *Students redesign and optimize the way land is used to support orangutans and people.*	Working in groups of three, students use a computer simulation to redesign 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.

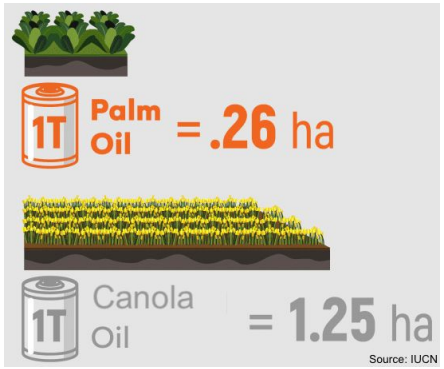
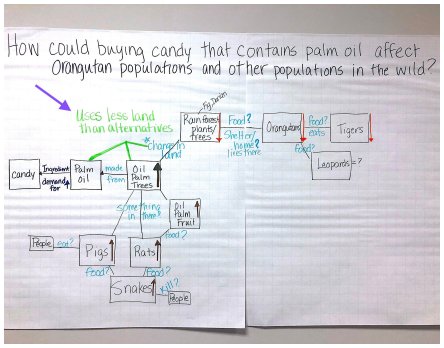
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 18 3 days **How do our designs work for orangutans and people in Indonesia?** Putting Pieces Together	 *The design solutions with mixed land use and some intact forests worked best for people and orangutans.*	We present our best designs to our peers and evaluate each other's designs based on the agreed-upon 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 19 0 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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 20 0 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.	

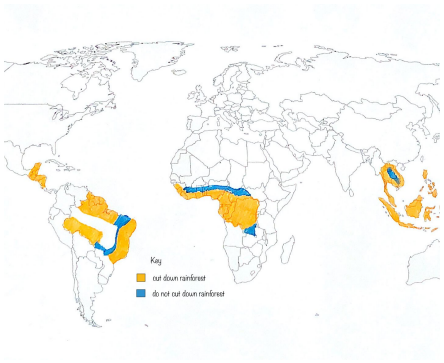
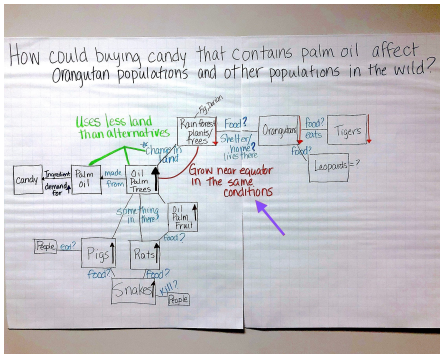
⇓ **Navigation to Next Lesson:** We applied science ideas to a problem in our community. We are now ready to look back at our DQB and celebrate what we have accomplished.

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, rats, pigs, and snake populations also increase.	

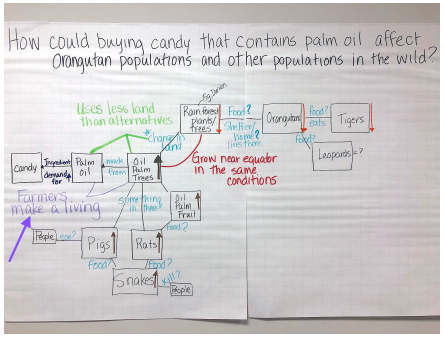
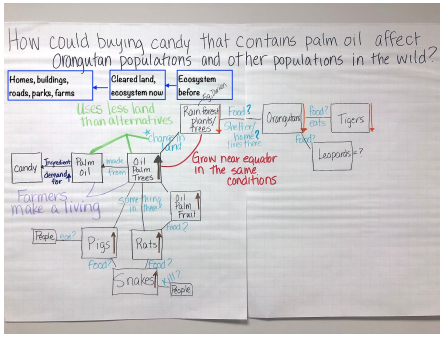
⇓ **Navigation to Next Lesson:** We figured out that when the number of oil palm trees goes up, the orangutan population goes down. We think this has something to do with orangutans not having enough food or habitat, or being killed when oil palm trees are planted. We wondered whether we could replace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

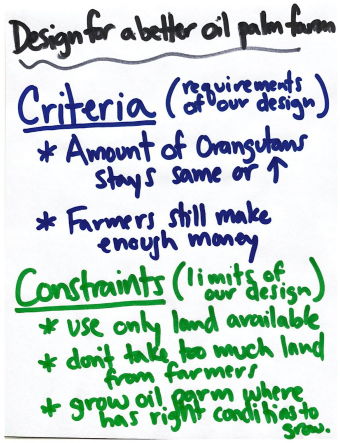
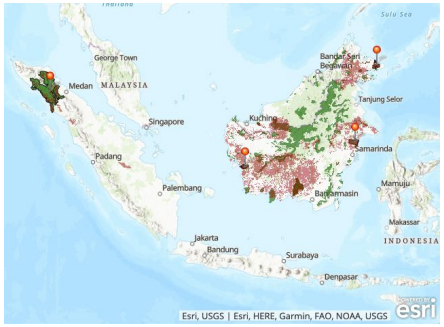
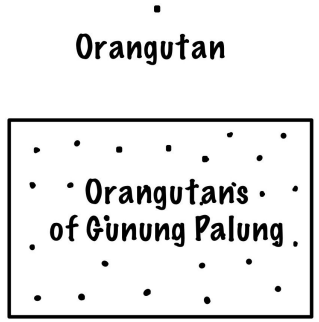
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 1 day **Can we replace palm oil with something else?** Investigation	 *Vegetable oils require land and produce different yields of oil.*	We explore other crops as a substitute for palm oil. We analyze data 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.	

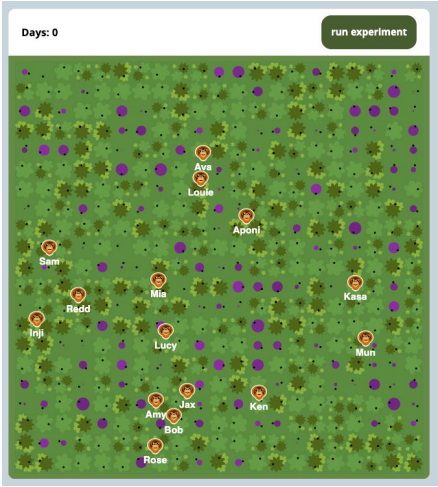
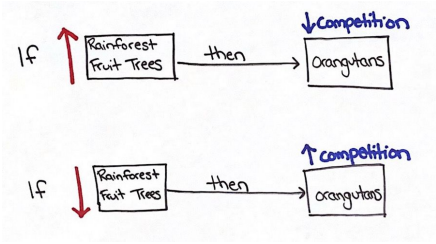
⇓ **Navigation to Next Lesson:** We figured out that oil palm trees are the most efficient oil plant to grow in terms of land use and that growing other oils takes up more land and also requires the clearing of native grasslands, which hurts grassland plants and animals. Since palm oil is likely not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

LESSON 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.	

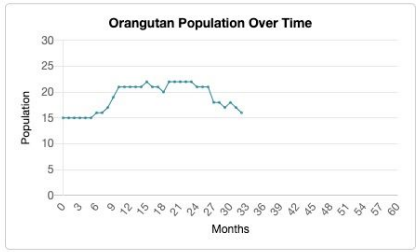
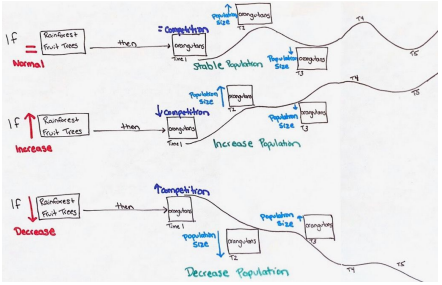
⇓ **Navigation to Next Lesson:** We figured out that palm oil grows best near the equator, where tropical rainforests are located. We wonder why people cut down tropical rainforests when they know this is bad.

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 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.			

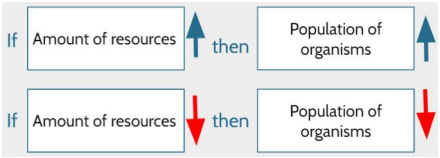
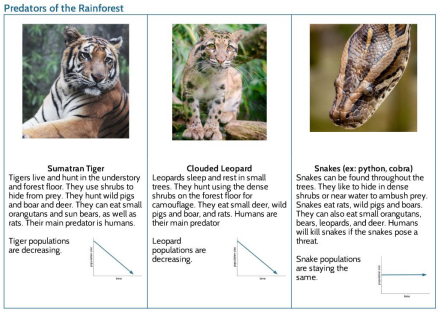
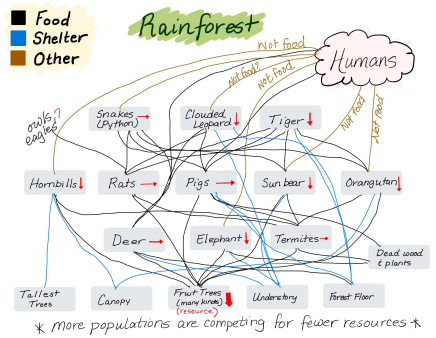
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 6 1 day **If palm oil is not going away, how can we design palm farms to support orangutans and farmers?** Problematizing	 *Palm farms that grow a single crop do not function well for tropical rainforest 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 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. 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 km2.*	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 km2, 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.			

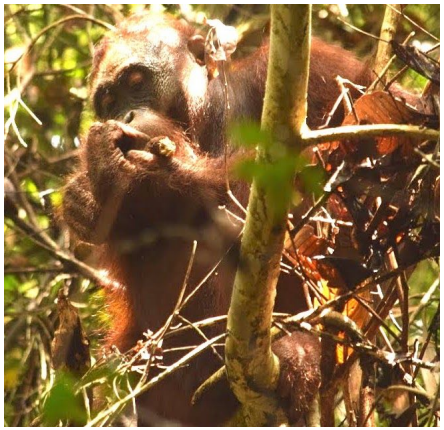
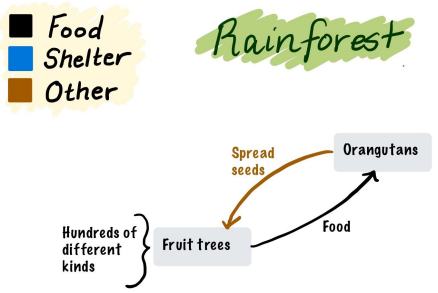
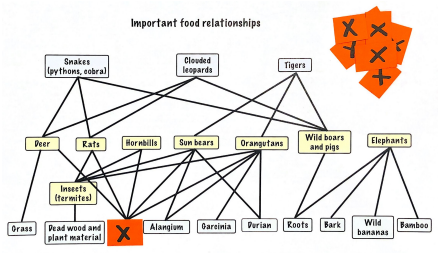
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 8 2 days **Why do orangutans need so much forest space?** Investigation	 *Orangutans compete for food resources in three different environmental conditions.*	We gather data from a computer simulation in which 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.	

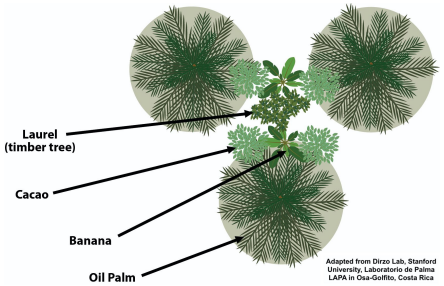
⇓ **Navigation to Next Lesson:** We figured out that orangutans eat mostly fruits because they get energy from these food sources. They compete with other orangutans for this food, and slight changes in the amount of fruit can have large impacts on orangutan competition and survival. We wonder if all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

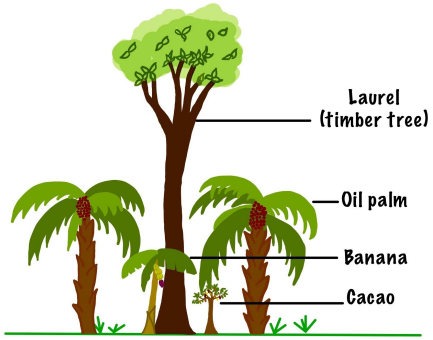
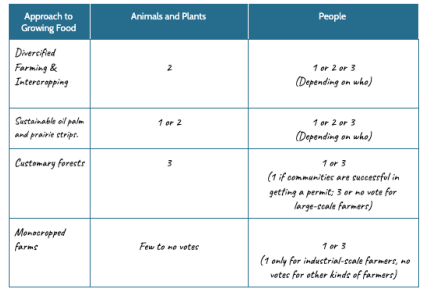
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 2 days **Would planting more rainforest fruit trees help the orangutan population increase?** Investigation	**Population** **Orangutan Population History** Low: 15 | High: 22 | average: 18.5 | births: 12 | deaths: 11  *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.

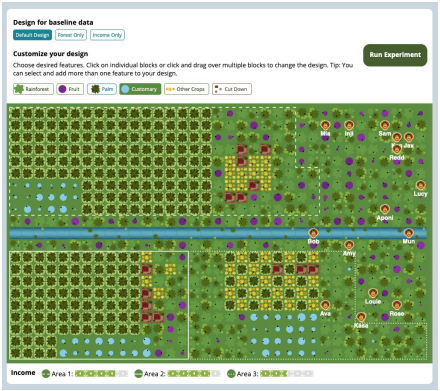
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 10 2 days **How do changes in the amount of resources affect populations?** Putting Pieces Together	 *The loss of short and tallgrass prairies to soybean oil production in the Midwest of the United States 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.			
LESSON 11 2 days **How does planting oil palm affect other populations?** Investigation	 *Rat and snake populations are exploding in the oil palm system, but those populations are not exploding in the rainforest system.*	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.	
⇓ **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 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.	**Summary chart** **Rainforest versus oil palm** If there are many kinds of plants and a disruption affects... ...a few plants, then some plants may struggle or die but the system will be mostly OK ...most plants, then many plants may struggle or die and the whole system will be impacted If there are one or few kinds of plants and a disruption affects... ...most plants, then the whole system will be impacted
⇓ 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.			

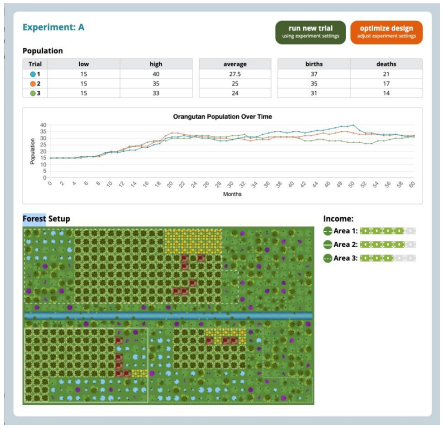
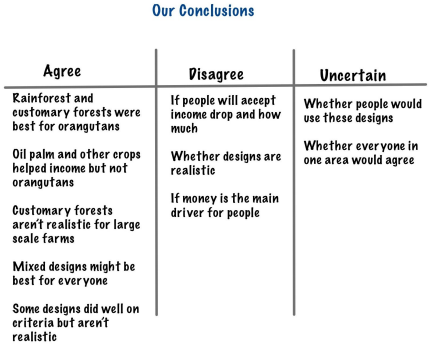
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 1 day **Are there ways people can grow food without harming the tropical rainforest?** Investigation	 *Farmers and other community members in Indonesia and Costa Rica observe positive impacts on plant 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 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.			

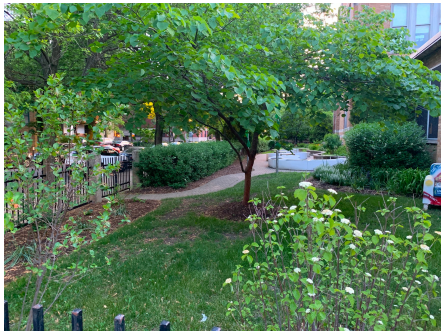
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 16 2 days **What approach to growing food works for everyone and why?** Putting Pieces Together	 *People can use many approaches to growing food, and there are trade-offs to using them that have consequences 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.	

⇓ **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.

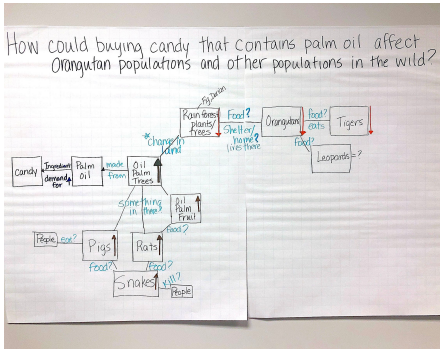
LESSON 17 3 days **How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?** Investigation	 *Students redesign and optimize the way land is used to support orangutans and people.*	Working in groups of three, students use a computer simulation to redesign 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.

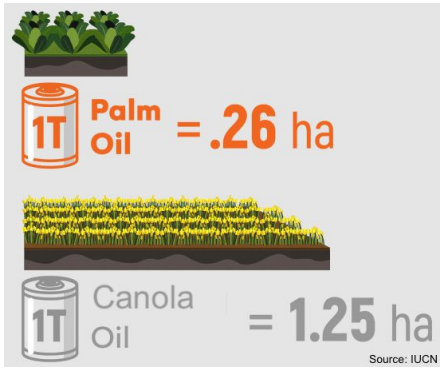
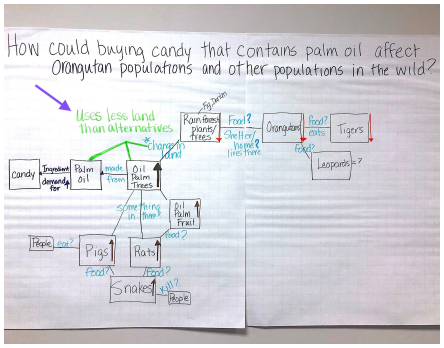
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 18 3 days **How do our designs work for orangutans and people in Indonesia?** Putting Pieces Together 	 *The design solutions with mixed land use and some intact forests worked best for people and orangutans.*	We present our best designs to our peers and evaluate each other's designs based on the agreed-upon 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 19 0 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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 20 0 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.	

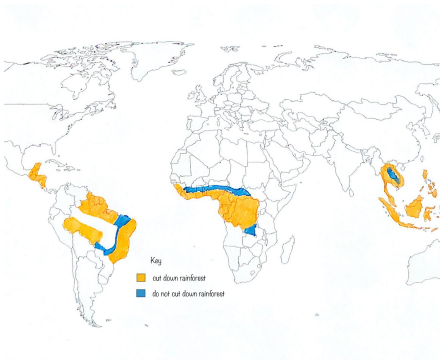
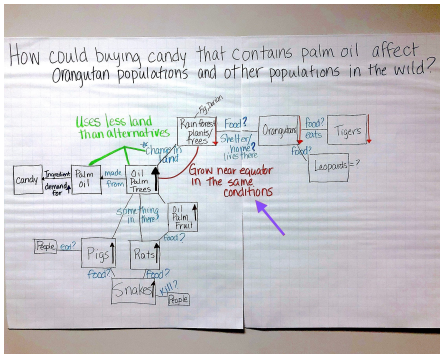
⇓ **Navigation to Next Lesson:** We applied science ideas to a problem in our community. We are now ready to look back at our DQB and celebrate what we have accomplished.

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, rats, pigs, and snake populations also increase.	

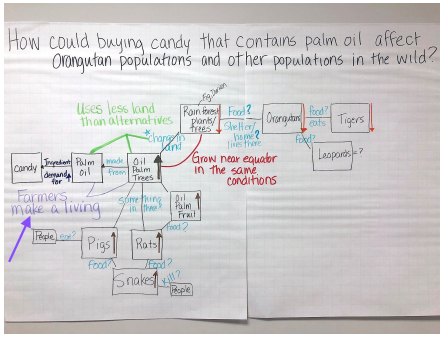
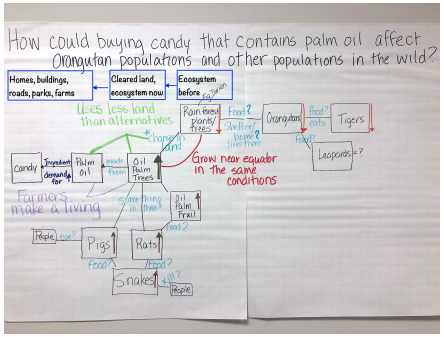
⇓ **Navigation to Next Lesson:** We figured out that when the number of oil palm trees goes up, the orangutan population goes down. We think this has something to do with orangutans not having enough food or habitat, or being killed when oil palm trees are planted. We wondered whether we could replace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

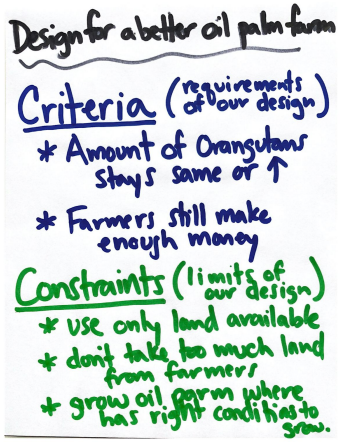
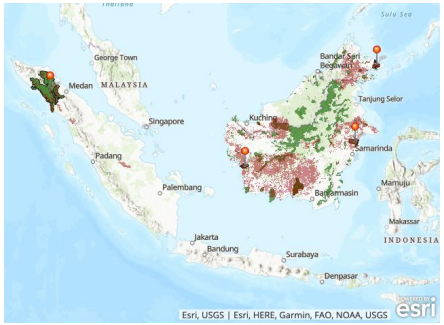
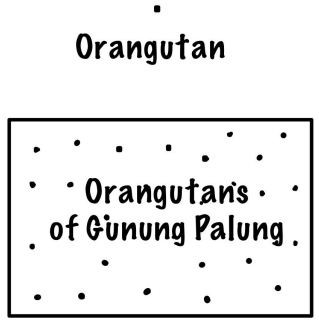
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 1 day **Can we replace palm oil with something else?** Investigation	 *Vegetable oils require land and produce different yields of oil.*	We explore other crops as a substitute for palm oil. We analyze data 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.	

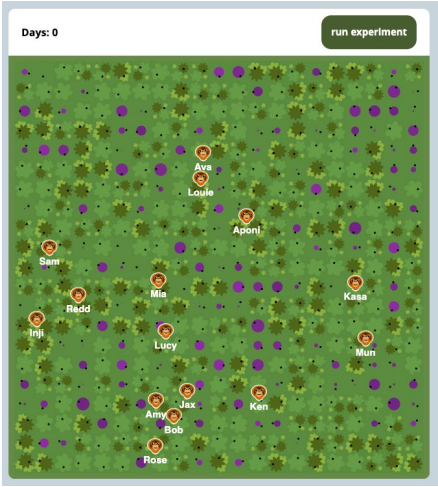
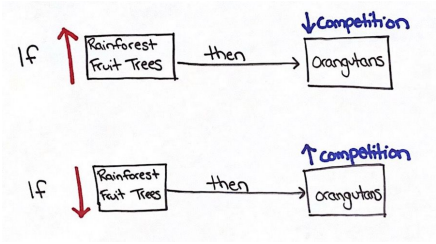
⇓ **Navigation to Next Lesson:** We figured out that oil palm trees are the most efficient oil plant to grow in terms of land use and that growing other oils takes up more land and also requires the clearing of native grasslands, which hurts grassland plants and animals. Since palm oil is likely not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

LESSON 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.	

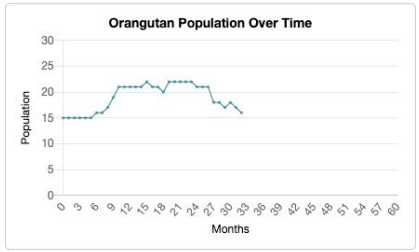
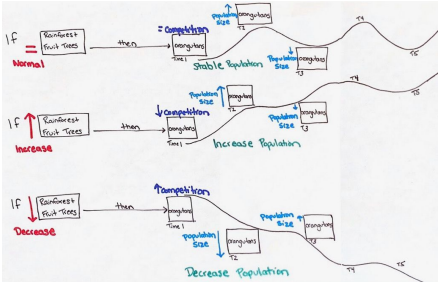
⇓ **Navigation to Next Lesson:** We figured out that palm oil grows best near the equator, where tropical rainforests are located. We wonder why people cut down tropical rainforests when they know this is bad.

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 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.			

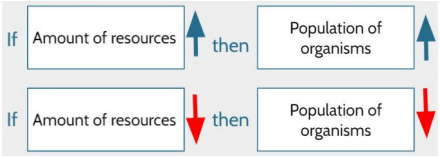
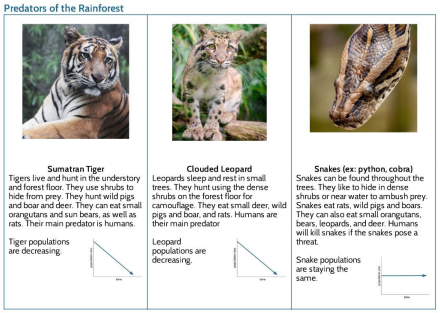
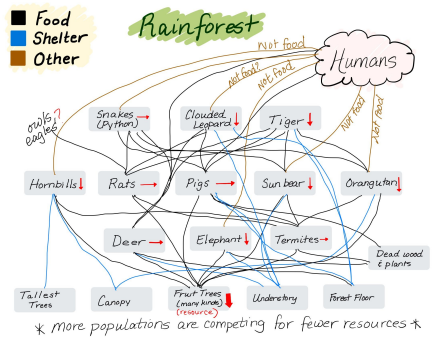
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 6 1 day **If palm oil is not going away, how can we design palm farms to support orangutans and farmers?** Problematizing	 *Palm farms that grow a single crop do not function well for tropical rainforest 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 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. 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 km2.*	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 km2, 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.

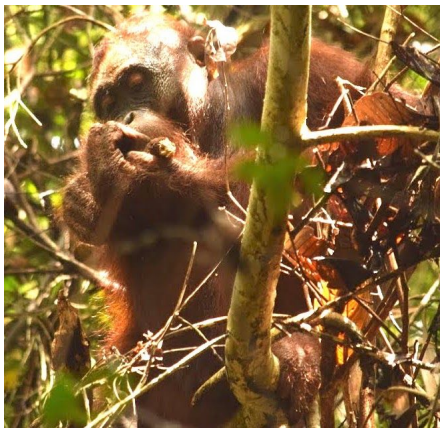
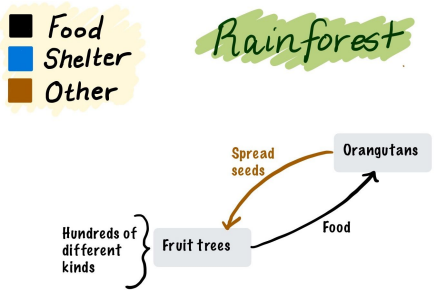
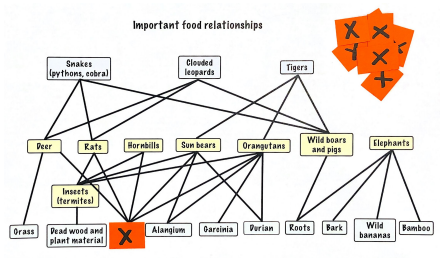
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 2 days **Would planting more rainforest fruit trees help the orangutan population increase?** Investigation	**Population** **Orangutan Population History** Low: 15 | High: 22 | average: 18.5 | births: 12 | deaths: 11  *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.	
LESSON 11 2 days **How does planting oil palm affect other populations?** Investigation	 *Rat and snake populations are exploding in the oil palm system, but those populations are not exploding in the rainforest system.*	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.	

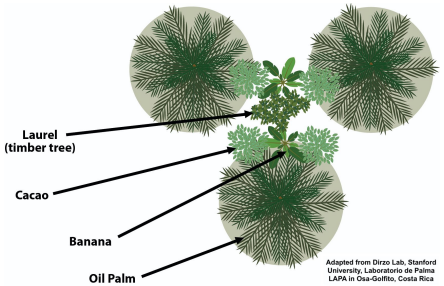
⇓ **Navigation to Next Lesson:** We feel like we understand how the population of orangutans changes when more oil palms are planted in place of rainforest trees. We are curious if a change in resources also explains what we observed with other populations like tigers, rats, snakes, and pigs.

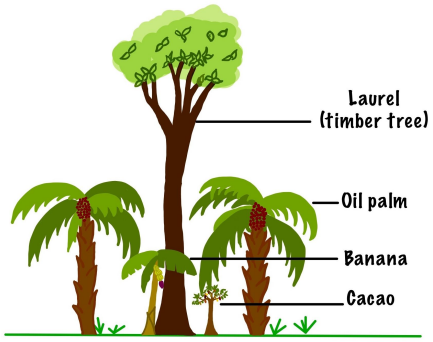
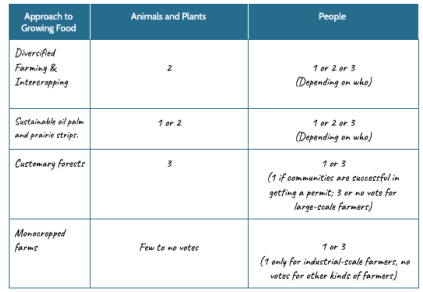
⇓ **Navigation to Next Lesson:** We figured out that the rainforest system has more components and interactions compared with the oil palm system. We think this is why the tropical rainforest supports so many living things. We are wondering how to make the oil palm farm have more components and interactions, 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.	
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.	**Summary chart** **Rainforest versus oil palm** If there are many kinds of plants and a disruption affects... ...a few plants, then some plants may struggle or die but the system will be mostly OK ...most plants, then many plants may struggle or die and the whole system will be impacted If there are one or few kinds of plants and a disruption affects... ...most plants, then the whole system will be impacted

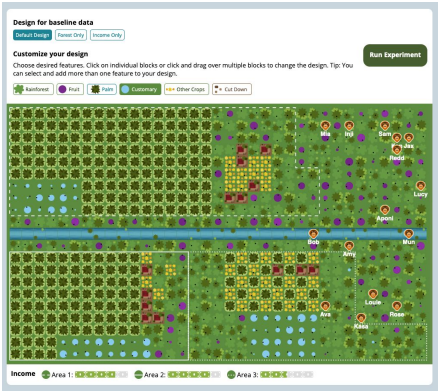
⇓ **Navigation to Next Lesson:** We figure out that fruit tree populations depend on orangutans to disperse seeds. If orangutans go extinct, there could be several effects throughout the tropical rainforest. We wonder if something were to happen to other populations, what kinds of changes we would see.

⇓ **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.

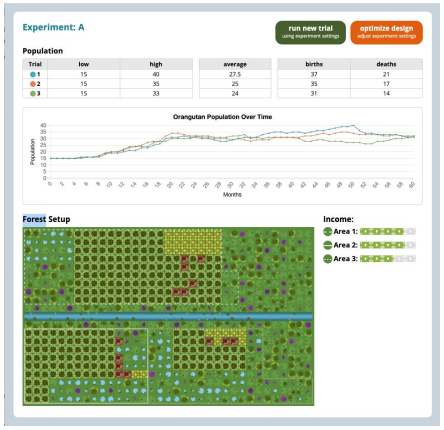
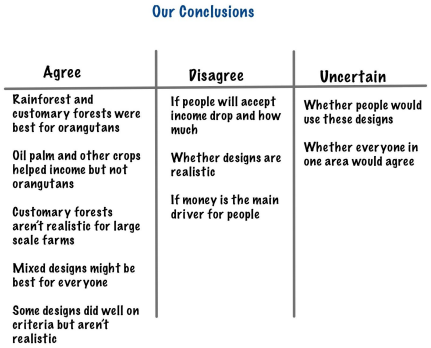
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 1 day **Are there ways people can grow food without harming the tropical rainforest?** Investigation	 *Farmers and other community members in Indonesia and Costa Rica observe positive impacts on plant 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 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.			

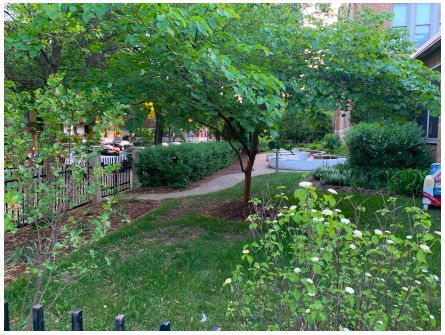
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 16 2 days **What approach to growing food works for everyone and why?** Putting Pieces Together	 *People can use many approaches to growing food, and there are trade-offs to using them that have consequences 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.	

⇓ **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.

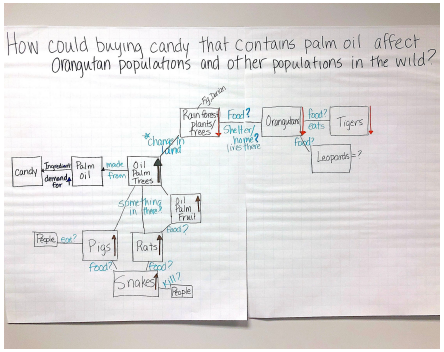
LESSON 17 3 days **How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?** Investigation	 *Students redesign and optimize the way land is used to support orangutans and people.*	Working in groups of three, students use a computer simulation to redesign 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.

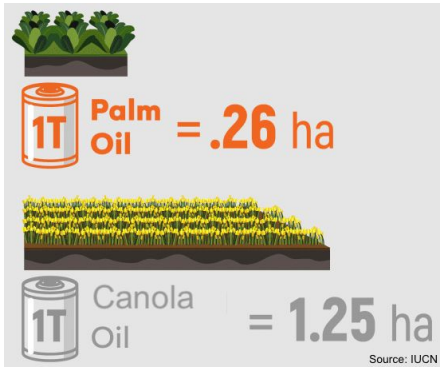
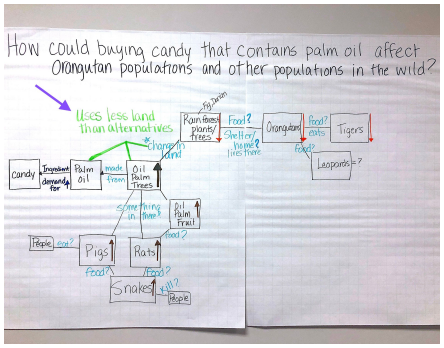
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 18 3 days **How do our designs work for orangutans and people in Indonesia?** Putting Pieces Together	 *The design solutions with mixed land use and some intact forests worked best for people and orangutans.*	We present our best designs to our peers and evaluate each other's designs based on the agreed-upon 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 19 0 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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 20 0 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.	

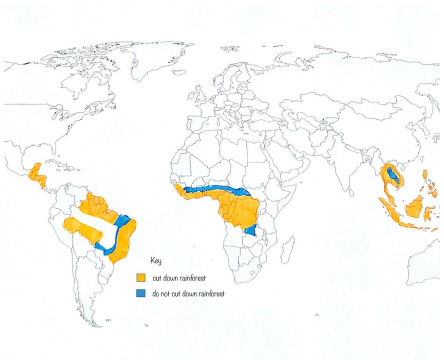
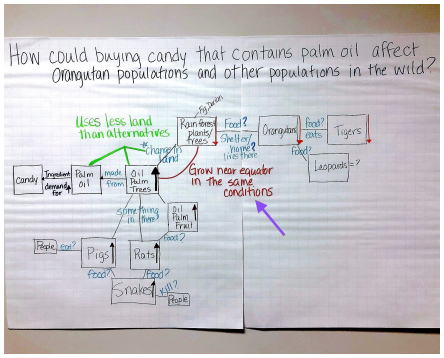
⇓ **Navigation to Next Lesson:** We applied science ideas to a problem in our community. We are now ready to look back at our DQB and celebrate what we have accomplished.

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, rats, pigs, and snake populations also increase.	

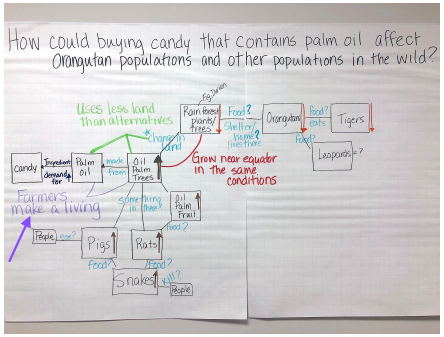
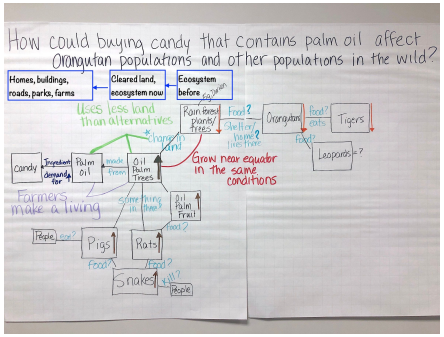
⇓ **Navigation to Next Lesson:** We figured out that when the number of oil palm trees goes up, the orangutan population goes down. We think this has something to do with orangutans not having enough food or habitat, or being killed when oil palm trees are planted. We wondered whether we could replace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

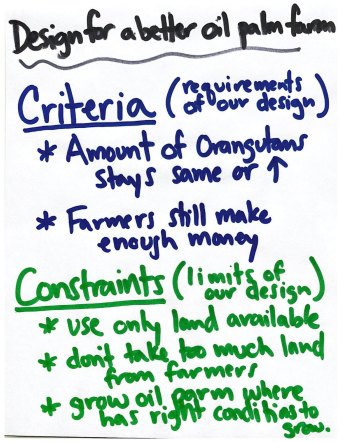
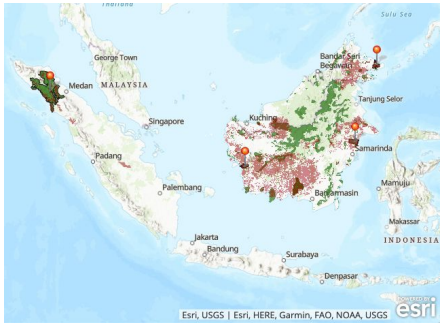
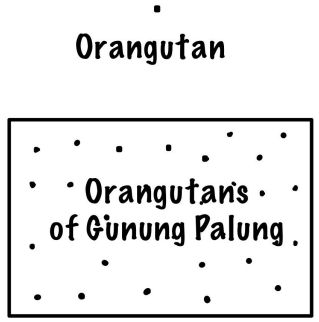
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 1 day **Can we replace palm oil with something else?** Investigation	 *Vegetable oils require land and produce different yields of oil.*	We explore other crops as a substitute for palm oil. We analyze data 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.	

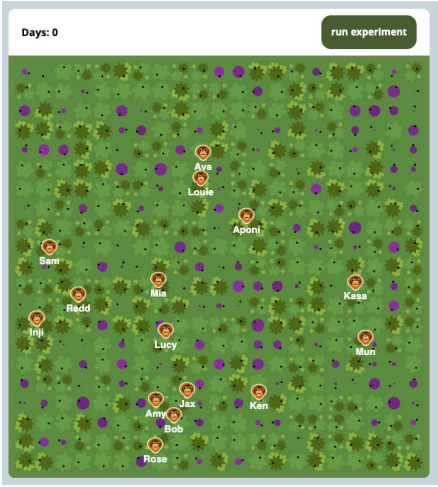
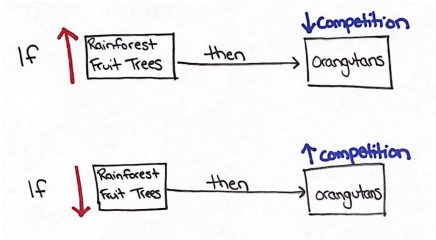
⇓ **Navigation to Next Lesson:** We figured out that oil palm trees are the most efficient oil plant to grow in terms of land use and that growing other oils takes up more land and also requires the clearing of native grasslands, which hurts grassland plants and animals. Since palm oil is likely not 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.	

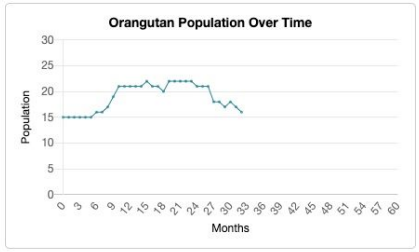
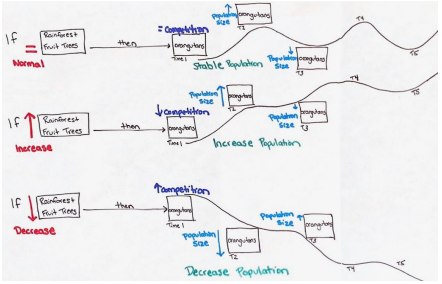
⇓ **Navigation to Next Lesson:** We figured out that palm oil grows best near the equator, where tropical rainforests are located. We wonder why people cut down tropical rainforests when they know this is bad.

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 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.			

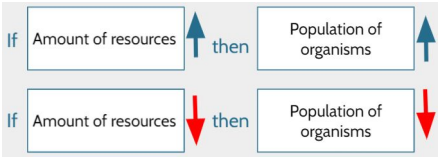
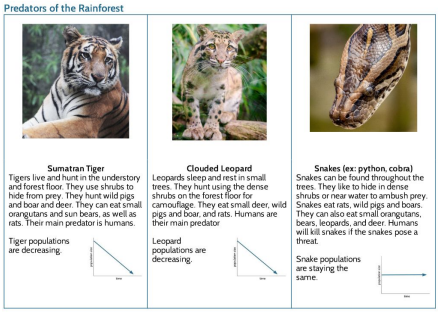
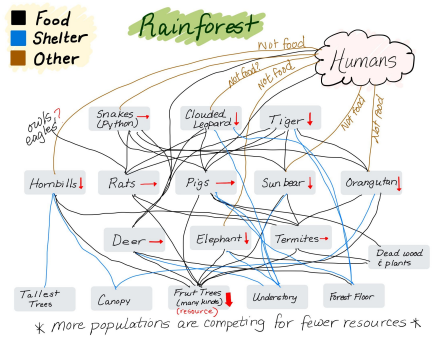
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 6 1 day **If palm oil is not going away, how can we design palm farms to support orangutans and farmers?** Problematizing	 *Palm farms that grow a single crop do not function well for tropical rainforest 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 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. 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 km2.*	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 km2, 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.			

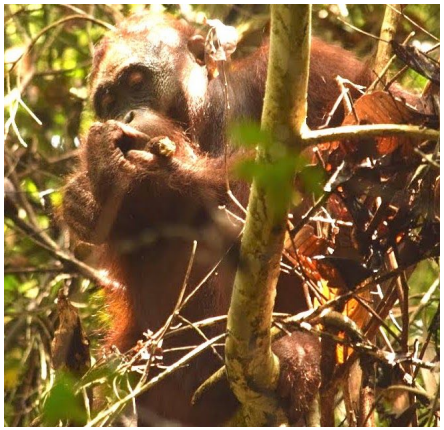
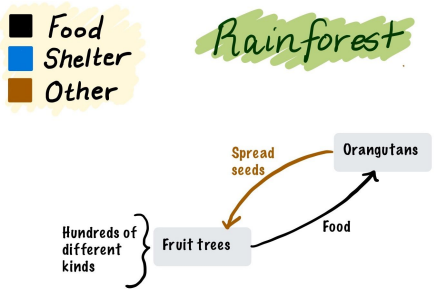
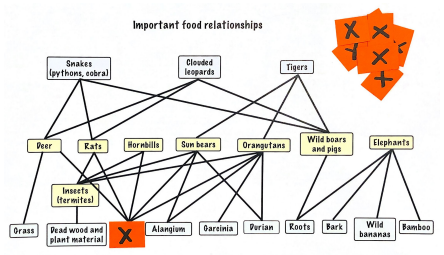
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 8 2 days **Why do orangutans need so much forest space?** Investigation	 *Orangutans compete for food resources in three different environmental conditions.*	We gather data from a computer simulation in which 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.	

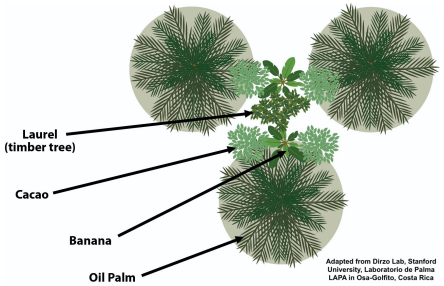
⇓ **Navigation to Next Lesson:** We figured out that orangutans eat mostly fruits because they get energy from these food sources. They compete with other orangutans for this food, and slight changes in the amount of fruit can have large impacts on orangutan competition and survival. We wonder if all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

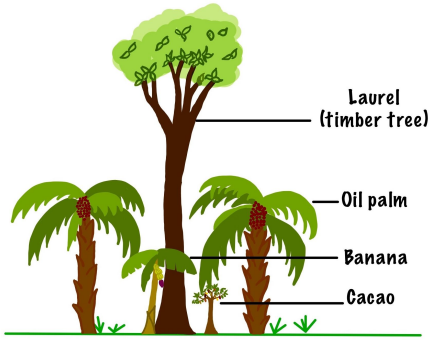
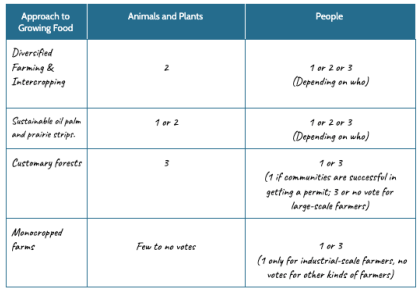
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 2 days **Would planting more rainforest fruit trees help the orangutan population increase?** Investigation	**Population** **Orangutan Population History** Low: 15 | High: 22 | average: 18.5 | births: 12 | deaths: 11  *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.

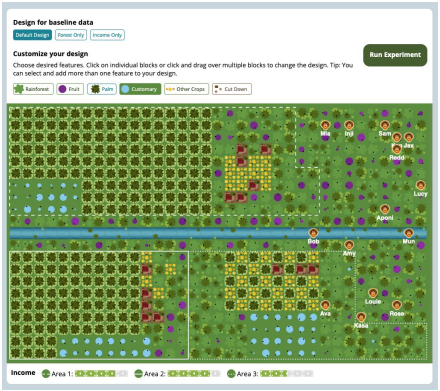
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 10 2 days **How do changes in the amount of resources affect populations?** Putting Pieces Together	 *The loss of short and tallgrass prairies to soybean oil production in the Midwest of the United States 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.			
LESSON 11 2 days **How does planting oil palm affect other populations?** Investigation	 *Rat and snake populations are exploding in the oil palm system, but those populations are not exploding in the rainforest system.*	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.	
⇓ 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 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.	**Summary chart** **Rainforest versus oil palm** If there are many kinds of plants and a disruption affects... ...a few plants, then some plants may struggle or die but the system will be mostly OK ...most plants, then many plants may struggle or die and the whole system will be impacted If there are one or few kinds of plants and a disruption affects... ...most plants, then the whole system will be impacted
⇓ 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.			

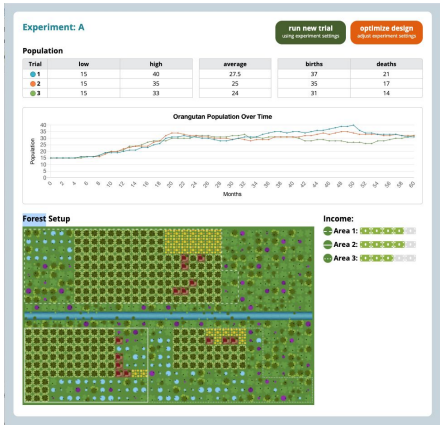
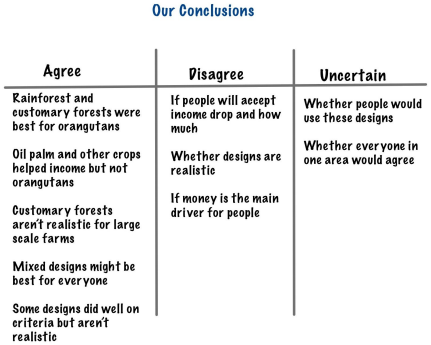
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 1 day **Are there ways people can grow food without harming the tropical rainforest?** Investigation	 *Farmers and other community members in Indonesia and Costa Rica observe positive impacts on plant 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 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.			

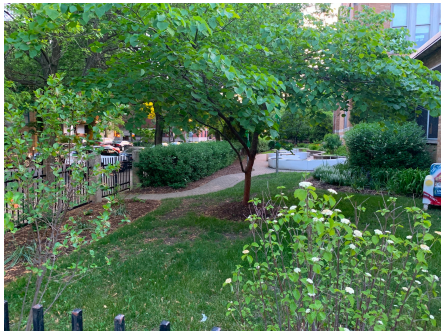
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 16 2 days **What approach to growing food works for everyone and why?** Putting Pieces Together	 *People can use many approaches to growing food, and there are trade-offs to using them that have consequences 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.	

⇓ **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 agreed-upon 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 19 0 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 Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 20 0 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.	

⇓ **Navigation to Next Lesson:** We applied science ideas to a problem in our community. We are now ready to look back at our DQB and celebrate what we have accomplished.

LESSONS 1-20

33 days total