ASSESSMENT SYSTEM OVERVIEW

Each OpenSciEd unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons, including pre-assessment, formative assessment, summative assessment, and student self assessment. Formative assessments are embedded and called out directly in the lesson plans. Please look for the “Assessment Icon” in the teacher support boxes to identify places for assessments. In addition, the table below outlines where each type of assessment can be found in the unit.

Overall Unit Assessment

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 1	Initial models in science notebooks Driving Question Board	**Pre-Assessment** The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas that your students bring to this unit. Revealing these ideas early can help you be more strategic in how to build from and leverage student ideas across the unit. The initial models developed in the lesson are an opportunity to pre-assess student understanding of systems thinking in the context of ecosystem changes. The two most important times to do this include: (1) on day 2, after students have developed their initial system model and (2) during the Consensus Discussion on day 2 when the class develops an initial model together. For the initial palm system model, look and listen for: • agreement on the living components of the system models (such as the palm trees, orangutans, rats, snakes, tigers, and pigs), • agreement on the needs that these livings components have, such as needs for food, water, air, habitat, or shelter, • agreement on ways that populations of living things can increase (a lot of food or water, a lot of mates, not very many predators) and decrease (very little food or water, can’t reproduce, many predators), • disagreement or uncertainty about interactions between the living things within the system, and • disagreement or uncertainty about which things are causing increases or decreases in the different populations. The Driving Question Board is another opportunity for pre-assessment. Reinforce for students to generate open-ended questions, such as how and why questions, to post to the board, but celebrate any questions that students share even if they are close-ended questions. Make note of the parts of the ecosystem that have many questions and the parts that have few or no questions. If a part of the system has few or no questions, prompt students to generate more questions in this space so that each part of the system has a set of questions with which to guide investigations.

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 5	Generalized model Self-documentation Palm Farm Designs, Part 1 and 2	**Formative** Lesson 5 is a critical Lesson to re-anchor the unit. After students have spent Lessons 2 through 4 digging deeper into the problem and recognizing a solution needs to involve farming palm oil better, the students are ready to re-articulate the problem, define a design goal, and take a 2nd pass at the DQB. This lesson offers several opportunities for formative assessment, including (1) when the class articulates the problem during a Consensus Discussion and represents their thinking in a generalized model, (2) when the students self-document the problem in their own community, and (3) when the students articulate a design goal and criteria for a successful palm farm. When students articulate the problem through a Consensus Discussion, listen for students to explain that the problem occurs when people change the structure of the plant community. Students should recognize that in each case, including the palm oil case, the structure of the plant community changes from more types of plants to fewer types of plants, which changes how the ecosystem functions for other living things. Students represent these through a generalized model. At the end of day 2, students use their model to identify a similar problem in their school, neighborhood, home, or community. This happens through a self-documentation activity. This activity is an opportunity for cultural formative assessment to understand how students are making sense of and applying what they learned to their lives and community. On day 3 students decide on an initial design goal and articulate criteria to measure success. Students should set a goal for their palm farm design to work for farmers and orangutans. Students should also suggest criteria that are aligned to this goal, such as (1) the newly designed palm farm supports animal populations like orangutans and tigers, and (2) the newly designed palm farm supports a farmer's income. Students may struggle to suggest constraints, and that is OK at this point.
Lesson 9	Student Assessment L9 Assessment Scoring Guidance	**Formative + Summative** There is a formative and summative assessment at the end of Lesson Set 2. In addition to eliciting ideas about competition for resources and normal and unusual population changes, the task asks students to use mathematical reasoning and computational thinking and data analysis and interpretation. The focal crosscutting concept is stability and change. The teacher reference document provides a scoring guide specific to this unit assessment. Prior to engaging in the individual assessment, spend 15-20 minutes setting up the new context of monarch butterflies on the prairie and a classroom model for explaining their relationship. Keep this model visibly displayed for students to use during the assessment. If students struggle with interpreting the data and engaging in mathematical reasoning, ask them to draw parallels to the types of mathematical reasoning they did for the orangutan and palm oil problem. This midpoint assessment is formatively important to make sure the class is on the same page and ready to move forward in the unit. At this point, students should be able to explain that resource availability affects individual organisms' survival and reproduction, which ultimately affects population size. Land use change by farming has decreased resource availability. Students demonstrate their new understanding using a related phenomenon of monarch butterfly populations that depend on the prairie, which has largely been converted for agricultural use. There is room to use this assessment formatively with respect to competition for resources because students will expand on the idea of competition from competition within a population (Lessons 7 and 8) to competition between populations (Lesson 10). Therefore, you have the opportunity to use this assessment to adjust how you approach competition in the next lesson. The assessment serves as a summative assessment for mathematical reasoning and computational thinking, as students do most of their work with this practice across Lessons 6-9. They will return to this practice in Lesson 14 but will not be summatively assessed at that time.

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 13	Student Assessment L13 Assessment Scoring Guidance	**Summative** This is a summative assessment at the end of the unit and occurs just prior to students' culminating task (Lesson 14). This assessment elicits students' ideas about how ecosystem respond when disruptions occur and also engages students in modeling and constructing explanations. The focal crosscutting concepts are systems models and cause and effect. The teacher reference document provides a scoring guide specific to this unit assessment. In this assessment, students have an opportunity to demonstrate that they can take ideas about biodiverse ecosystems and apply them to a new scenario: the effects of invasive species on riparian ecosystems. At this point, students should be able to explain how changing components in an ecosystem (e.g., an ecosystem disruption) affects the other components in the ecosystem by tracing the interactions within the ecosystem. Prior to engaging in the individual assessment, consider what about the new scenario students might need to discuss as a class before the assessment. It might be the idea of an invasive species or the kinds of plants in the ecosystem that they might not have heard of before.
Lesson 14	Part 8, Palm Farm Design Task	**Instructionally Embedded Design Task** This lesson in the field-test version of the unit includes an instructionally embedded task to design palm farms that support orangutan and tiger populations, while also supporting farmers. Parts of this task can serve as a summative assessment: for example, students' final designs and written explanations on day 4. Because this is an instructionally embedded task, some parts are not appropriate to grade, while other parts of the task can be used as is or modified so that students can demonstrate their understanding. The task includes students revising the design task from Lesson 5 and working on designs of palm farms that meet criteria to financially support palm farmers (days 1 and 2) and also creating ecosystems that support orangutans (days 3 and 4). Students produce a written explanation supporting two design features and how a diversified palm farm meets the design goal, which can be used as a summative assessment.
After each lesson	Lesson Performance Expectations Assessment Guidance	**Formative Assessment** Use this document to see which parts of lessons or student activity sheets can be used as embedded formative assessments.
Occurs in most lessons	Progress Tracker	**Formative and Student Self-Assessment** The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and to figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment in time. In this way, the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding throughout the unit. Because the Progress Tracker is meant to be a thinking tool for kids, we strongly suggest that it is not collected for a summative "grade" other than for completion.
Anytime after a discussion	Lesson 10 Student Self-Assessment Discussion Rubric	**Student Self-Assessment** Lesson 10 includes an opportunity for self-assessment after students' have received feedback on their rainforest and oil palm system models. The student self-assessment discussion rubric can be used anytime after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week. Initially, you might give students ideas for what they can try next time to improve, such as using sentence starters for discussions. As students gain practice and proficiency with discussions, ask for their ideas about how the classroom and small-group discussions can be more productive.

When	Assessment and Scoring Guidance	Purpose of Assessment
After students complete substantial, meaningful work	Lesson 10 Peer Feedback Facilitation: A Guide	**Peer Feedback** Lesson 10 includes an opportunity for peer feedback on students' rainforest and oil palm system models. There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning and for learning to give and receive feedback from others. We suggest that peer review happen at least two times per unit. This document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback, along with self-assessment rubrics on which students can reflect on their experience with the process. Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work; rather, peer feedback will be more valuable to students if they have time to revise after receiving peer feedback. It should be a formative, not summative, type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities so that they can use these experiences as evidence for their feedback.

For more information about the OpenSciEd approach to assessment and general program rubrics, visit the OpenSciEd Teacher Handbook.

Lesson-by-Lesson Assessment Opportunities

Every OpenSciEd lesson includes one or more lesson-level performance expectations (LLPEs). The structure of every LLPE is designed to be a three-dimensional learning, combining elements of science and engineering practices, disciplinary core ideas and cross cutting concepts. The font used in the LLPE indicates the source/alignment of each piece of the text used in the statement as it relates to the NGSS dimensions: alignment to Science and Engineering Practice(s), alignment to Cross-Cutting Concept(s), and alignment to the Disciplinary Core Ideas.

The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance

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Lesson 1	Develop an initial systems model to describe a phenomenon in which changes to one living component of an ecosystem (cause) affects the other living parts of the ecosystem (effect). Ask questions that arise from initial observations of populations in an ecosystem to help seek additional information about the parts of the ecosystem and how they interact.	**Modeling; Systems and System Models; Cause and Effect** **When to check for understanding:** After students develop their initial models on day 2,it may be helpful for your students to leave their notebooks in the classroom for you to assess their work. **What to look/listen for:** (1) agreement on the living components of the system models (such as the palm trees, orangutans, rats, snakes, tigers, and pigs); (2) agreement upon the needs that these livings components have, such as needs for food, water, air, habitat, or shelter; (3) agreement on ways that populations of living things can increase (a lot of food or water, a lot of mates, not very many predators) and decrease (very little food or water, can't reproduce, many predators); (4) disagreement or uncertainty about interactions between the living things within the system; and (5) disagreement or uncertainty about which things are causing increases or decreases in the different populations. **What to do:** If your students struggle with identifying important components of the ecosystems, refer them back to the class-developed list of ecosystem components. Students may also wish to revisit *Growing Oil Palm in Indonesia* to find more information about the components in the ecosystem. **Asking Questions; Systems and System Models** **When to check for understanding:** On day 3, students are directed to develop open-ended questions for the DQB using how and why prompts. It is important that *all* questions posed by students be placed on the DQB regardless of whether they are open-ended or close-ended. **What to look/listen for:** For students' DQB questions, make note of any close-ended questions and use navigation time throughout the unit to turn close-ended questions into open-ended ones that necessitate a need to examine additional evidence. As you move into Ideas for Additional Data We Need, have students focus on categorizing their questions and then identifying the kinds of data and additional information that would be helpful in answering a category of questions. **What to do:** Make note of the parts of the ecosystem that have many questions and the parts that have few or no questions. If a part of the system has few or no questions, prompt students to generate more questions in this space so that each part of the system has a set of questions to guide investigations.
Lesson 2	Define a pattern of design problems for systems that provides food resources that humans need (cause) but transforms the land and the biosphere once occupied by native plants and animals (effect).	**Defining Problems, Patterns** **When to check for understanding:** During the Building Understandings Discussion toward the end of the lesson. **What to look/listen for**: Students share ideas, such as (1) all three of these crops are grown for use in food or products, (2) all crops need land to grow, (3) to farm, we need to clear land, which means cutting down native forests or grasslands, and (4) palm oil uses less land and produces more oil, so it is more efficient. Listen for students to connect patterns with causal reasoning. **What to do**: If students are struggling to conclude that the oil palm is more efficient than soybean or canola oil in terms of the amount of land it uses, help them connect the idea that more efficient plants mean less land is needed for agriculture by asking them, "How much rainforest would need to be cut down to produce one ton of palm oil versus grasslands to produce one ton of soybean oil? What impact would that have on the populations living there?"

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 3	Define a problem in which oil palm is dependent upon the same environmental interactions with nonliving factors as other tropical rainforest plants (pattern).	**Defining Problems, Patterns** **When to check for understanding:** During the Building Understandings Discussion toward the end of the lesson. **What to look/listen for:** Students share ideas, such as (1) rainforest and oil palm areas overlap more than they are separate, (2) rainforests are mostly found in warm areas of the world that receive a lot of sunlight and rain, (3) there is a pattern in that a lot of plants or forests tend to grow near the equator for the same reasons. (4) planting oil palm farms requires the space that rainforests need, and (5) oil palm plants compete for this space (and other abiotic conditions) and "win" with the help of farmers. **What to do:** If students are struggling to conclude that the oil palm needs to grow near the equator, bring the issue closer to home. Ask them, Why do we not grow oil palm in the United States or near our town? What abiotic condition does the plant need that our location may not give it? What if we were to plant large farms of oil palm near our hometown—how would that change the ecosystem around us? Not that while students are working with map overlays to identify spatial relationships, Analyzing and Interpreting Data is a science practice that is scaffolded during instruction, but not assessed.
Lesson 4	Define a new criterion for a solution to more sustainably grow oil palm in ways that protect the rainforest ecosystem but that also recognizes the needs of local farmers, who are part of the palm oil production system.	**Defining Problems, Systems and System Models** **When to check for understanding**: During the Consensus Discussion toward the end of the lesson, as well as when students are adding to their Progress Trackers. **What to look/listen for**: Students share or record ideas, such as (1) many people in countries like Indonesia rely on cutting down rainforests to harvest resources for money; (2) farming oil palms provides many people with a stable income; (3) in many places in which oil palms are grown, people do not have a lot of opportunities for making money to support their families; and (4) any solution to the palm oil problem will also have to account for the people who support themselves by growing and harvesting oil palms. **What to do**: If students struggle to identify or justify reasons that farmers feel they need to cut down rainforests to grow oil palms, prompt them to consider how they might react if they only had the land around them as a resource to support themselves. Remind them that we have previously figured out that the rainforest has optimal conditions for growing oil palms and point out the vast numbers of people who would be left without income if these plants could no longer be farmed in these areas. Provide cases of what happens when disease or drought keeps key crops from being harvested and the fallout that these events have for the people who farm and make money from these crops. If your students are from a farming or ranching community, leverage their personal experience of reliance on the land as a way to connect to these principles within their own community.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 5	Define a design problem based on patterns in land use change and its effect on populations that lived in the original ecosystem. Define a design problem about the structure of palm farm systems to generate ideas for how to better design these systems to function for populations that live in or near the rainforest and for farmers who depend on the farms for their livelihoods.	**Define the Problem, Patterns** **When to check for understanding**: on day 2 when students articulate the problem using the patterns they identified during the cases on day 1 and analysis of images on day 2. **What to look/listen for**: students to articulate that the problem happens when people change the structure of the plant community, which affects other living things. **What to do**: To help students articulate the problem, focus students on using the box-and-line models for each case (on day 1, depicted on **slide I**) to show how a change in land has impacted things that live there. Then focus on what changed structurally with the plants that impacts other parts of the ecosystem. Co-construct a general version of the box-and-line model that could apply to all of the cases in which the plant structure was changed dramatically. **Defining the Problem, Structure and Function** **When to check for understanding**: On day 3, students develop a goal for a better designed palm farm and criteria and constraints to guide their designs. **What to look/listen for**: Students should set a goal for the design based on a structure for the palm farm system that functions for farmers, orangutans, and other living things. Students should also suggest criteria that are in-line with this goal, such as (1) the newly designed palm farm supports animal populations like orangutans and tigers and (2) the newly designed palm farm supports the farmers' income. Students may struggle to suggest constraints, and that is OK at this point. Students may suggest constraints, such as not taking land away from farmers, not cutting down new forests, etc. **What to do**: If students are uncertain about constraints, suggest that they will redesign a single farm with a set amount of land so that their land area cannot increase. Also, students will be limited to plants that can grow in tropical areas. As students share their thinking about criteria, use structure and function as a lens for thinking about how certain criteria would affect the design. In this instance, the criteria can help students articulate a function (e.g., we want to support orangutans so that they have food and homes). Push students to justify these criteria, asking, *So if we want a system that functions in this way, what structures do we think would support this in our designs?*
Lesson 6	Apply mathematical concepts (ratio) to find patterns in numerical relationships about the number of orangutans that can live in a 1 km^2 area.	**Apply Mathematical Concepts (ratio), Patterns** **When to check for understanding**: during the Building Understandings Discussion toward the end of day 2. **What to look/listen for**: Students share ideas about patterns they are noticing including that (1) most of the parks have a ratio of slightly above or below 1 orangutan per km^2, which means only one orangutan lives in that area; (2) the larger parks do not necessarily have more orangutans per area; and (3) the ratio of orangutans per area does not go above 3 orangutans per km^2, which means that 3 orangutans can live in the same area. **What to do**: If students are struggling to understand the concept of the ratio of orangutans per area, model the ways in which students can represent ratios (including as fractions, as numbers separated by a colon, etc.), emphasizing the importance of preserving the order of the quantities and labeling them in calculations. Consider drawing a square (labeling the area), populating that square with a certain number of orangutans, then modeling how to represent a ratio of number of orangutans to land area. You can also model how to translate data from a table (like how many orangutans there are) into one side of a ratio whose other side is another value (land area). It is important, in this step, to emphasize the meaning of the order of this ratio as it relates to the question that the class is trying to answer.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 7	Carry out a series of investigations using a simplified computer simulation (system model) in which individual orangutans compete with each other for two different food sources in a variety of environmental conditions. Analyze measures of central tendency and range in class-constructed histograms to make claims about how populations of orangutans responded to a variety of environmental conditions and the ways in which the environmental conditions contributed to the stability of the population or changes in the population.	**Planning and Carrying Out Investigations, Systems and System Models** **When to check for understanding:** During the Building Understandings Discussion at the end of the lesson and in student Progress Trackers **What to look/listen for:** Students should draw the following conclusions: (1) organisms in the same population compete with each other for food, (2) competition between individuals within a population increases when availability of resources is limited, (3) populations of organisms like food sources that give them energy, but can eat things with less energy to survive, and (4) if an organisms cannot meet its needs, it may not grow and survive. **What to do:** If students struggle to compare outcomes from plentiful resources to outcomes with limited resources, consider placing the class histograms from each investigation next to one another and having the students note the similarities and differences between the histograms. Then support students in describing *why* they think they noticed those differences. It might help to have students focus specifically on what happened to their individual orangutan before generalizing to the population of orangutans. **Analyzing and Interpreting Data, Using Mathematics and Computational Thinking, Stability and Change** **When to check for understanding:** In the sensemaking section of *Predictions, Investigations, and Results: Why Do Orangutans Need So Much Forest Space?*, following each investigation. **What to look/listen for:** Students cite the mean and range of energy levels of the orangutan population to support their claims. Students also reference their individual orangutan's energy level in relation to the mean and range of energy levels for the orangutan population. Students conclude that small changes in environmental conditions can have large impacts on their individual orangutan and on the orangutan population as a whole. **What to do:** If students are struggling to draw the connection between their individual orangutan and the orangutan population as a whole, point out their orangutan's sticky note on the class histogram. Ask students whether the orangutan did better, worse, or about the same as the rest of the class. Prompt students to explain how they know. Consider drawing a vertical line in the class histogram to delineate the mean energy level for the population.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 8	Collect data from an investigation to draw conclusions about how stable populations of orangutans fluctuate over shorter periods of time based on resource availability. Use mathematical representations to draw conclusions about how the size of orangutan populations changes over the long term, depending upon resource availability.	**Planning and Carrying Out Investigations, Stability and Change** **When to check for understanding:** In the sensemaking section for *Investigation 1* on the *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* handout the Building Understandings Discussion, and in the Progress Tracker. **What to look/listen for:** Students will reference the line graph, ranges, and averages from *Investigation 1*, showing that populations can increase and decrease in size, but generally hover around an average size. The fluctuations in population size are due to increased births or deaths based on short-term availability of food resources. Students should be able to claim that a population that hovers around the average is a stable population, even though there may be fluctuations in the size of the population. **What to do:** If students are struggling to understand how a population can remain stable yet still fluctuate, consider demonstrate the concept using a cereal box with a bag of coins in the box. Push slightly on the side of the box, temporarily disrupting the box. Then, let go. The box will wobble back and forth until it reaches its stable state. In this analogy, the box is still stable, even though a minor disruption caused small fluctuations in the box. **Using Mathematics and Computational Thinking, Stability and Change** **When to check for understanding:** In the sensemaking section following *Investigations 2* and *3* on the *Predictions, Investigations, and Results: Planting Fruit Trees and Orangutan Population Size* handout, the Building Understandings Discussion, and in the Progress Tracker. **What to look/listen for:** Students will reference the line graph, ranges, and averages from *Investigations 2* and *3* to support the claim that major changes in ecosystems (e.g. more or fewer fruit trees) can increase or decrease the population size of orangutans. In some cases, the change in the ecosystem can be so drastic that the ecosystem can no longer support the population. If an organism can't meet its needs, it may not grow and survive or reproduce, which can affect the population size. **What to do:** If students are struggling to understand the differences between minor disruptions leading to small fluctuations in ecosystems and major disruptions, which lead to significant changes in population sizes, consider extending the cereal box example. Push hard on the cereal box so that it falls over. This push represents a major disruption. The cereal box cannot return to its stable state. Link this demonstration back to the concepts of fluctuation and stability within populations. Additionally, you can zoom in on a section of the graph that shows a steep decline in the population. Point out that even during the decline there is some up and down happening (it is not a straight line down). Ask students to explain why this might be.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 9	Develop a model based on evidence from investigations to explain how changes to resource availability in the ecosystem in which orangutans live affect the size of the population living there. Apply mathematical concepts and processes to explain how the loss of short and tallgrass prairies to soybean oil production has caused a decline in the size of monarch butterfly populations.	**Developing and Using Models; Stability and Change** **When to check for understanding**: on day 1, when students offer proposals for the consensus models explaining the decrease in orangutan populations in areas in which oil palm farming has expanded. **What to look/listen for**: Students (1) making connections between changes to the amount of available resources in areas with expanded oil palm farming, including both the slow and fast changes identified in investigations and decreases to the size of local orangutan populations and (2) representing these connections through a model that displays the relationships between these factors and key ecosystem actors, including orangutans. **What to do**: If students struggle to piece the ideas together, ask them to tell the story, beginning with the growth of oil palm farming into areas previously occupied by rainforests. Encourage students to make use of the incremental models that the class has constructed, asking students to start with components the class has identified and to consider what interactions they can map between these components. Then, prompt students to use these relationships to reason through what changes have caused orangutan populations to decrease. **Using Mathematics and Computational Thinking; Cause and Effect** **When to check for understanding**: on day 2, when students use math concepts and representations to explain changes in butterfly populations on their individual assessments. **What to look/listen for**: Students (1) using rate and ratio language and reasoning to represent changes in populations linked to changes in ecosystem factors and (2) explaining the mechanisms they have discussed in prior lessons for how change to these ecosystem factors, such as amount of rainfall or available milkweed, causes changes to the amount of individual butterflies a prairie ecosystem can sustain. **What to do**: Encourage students to use the data and representations from lessons during which they gathered and analyzed data from simulations on changes in population size. Prompt students to look back through their work on analysis questions and Progress Trackers from these and other investigations during which students discussed the mechanisms that explain how changes to key ecosystem factors caused changes to the size of local populations. If students need extra support with rate and ratio reasoning or representations, consider offering math supports, like targeted questioning or anchor charts on ratio language or graphing on the coordinate plane, so that students can demonstrate their understanding of key science concepts through mathematical language and representations.
Lesson 10	Develop two system models to compare the components and interactions that are similar and different in the two ecosystems.	**Developing Models; Systems and System Models** **When to check for understanding**: during the Building Understandings Discussion and Progress Tracker at the end of day 2. **What to look/listen for**: Students share ideas about the rainforest, including more numbers/types of populations and more interactions between populations compared with the oil palm system in which there are fewer numbers/types of populations and fewer interactions. **What to do**: Keep a rainforest system and oil palm system model next to each other. Count the number of populations in each system (boxes) and the number of interacting lines between the populations. Revisit photos of the rainforest and oil palm farm to observe the variety of populations in the rainforest system compared with the oil palm system.

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Lesson 11	Critically read scientific texts to determine patterns in ecosystem plant biodiversity in modern and historical diversified farming systems.	**Obtain Information; Patterns** **When to check for understanding**: during the Building Understandings Discussion and Progress Tracker at the end of day 2. **What to look/listen for**: Students share ideas about the patterns they notice in the numbers and types of plants and animals in the farming and native plant ecosystems, including: (1) native plant ecosystems and diversified farms have more different kinds of plants and animals and, therefore, more biodiversity and (2) monoculture farms have fewer types of plants and animals and, therefore, less biodiversity. **What to do**: If students are struggling to understand the concept of biodiversity, have them review the images and systems models for the rainforest, diversified oil palm farm, and monoculture oil palm farm developed in Lesson 10 and in this lesson. In the images, ask them to identify how many different kinds of plants they see. In the systems models, ask them how many different types of plants and other organisms are in each system by counting all of the boxes (components). Emphasize that, the more different kinds of plants and animals a system has, the greater biodiversity it has.
Lesson 12	Use a model to predict how a sudden change (cause) to a physical or biological component of a monoculture system and a diversified system will affect populations in the system and farmers (effect).	**Use a Model; Stability and Change; Cause and Effect** **When to check for understanding**: while students are modeling scenarios on oil palm farms individually and in their small groups on day 1. **What to look/listen for**: Students share ideas about how a disturbance will affect populations in ecosystems and the resources that farmers can get from their farms to sell. Some ideas may include the following: (1) a limited availability of resources due to a disruption (e.g., less water or fewer oil palm plants) will cause declines in populations that rely on those resources; (2) a decline in oil palm plants or prices will cause farmers to get less money from those resources; and (3) differences in plant biodiversity (monoculture or diversified farms) affect how much impact a disturbance will have on the populations in the ecosystem and farmers' livelihoods. **What to do**: If students are struggling to make predictions about what will happen to populations, have them use a highlighter to draw attention to the first population that is affected (e.g., oil palm) and then trace any interaction lines to other populations that would be affected. This will help students see the ripple effects and how they are stronger in the monoculture than in the diversified farm. If students are struggling to make predictions about what will happen to farmers and their income, have students highlight the plants that farmers can sell in a different color in each system.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 13	Use a general model to show how changing one component of an ecosystem has ripple effects on other living things in the ecosystem (system modeling). Construct an explanation using models to show how changing part of an ecosystem (cause) affects the populations that live in the ecosystem (effects).	**Developing and Using Models; Systems and System Models** **When to check for understanding**: during the Consensus Discussion at the beginning of day 2. **What to look/listen for**: Students should share a number of ideas from previous lessons, but listen especially for (1) changes to one component of the system has ripple effects throughout the system on other populations and (2) in the context of many land use changes, people change the entire system from one system to another, which has even more drastic impacts on populations. **What to do**: Project the system models from Lessons 10 and 11 that are specific to rainforests and palm farms. Similar to using the Basic Ecosystem Model, use sticky notes to cover up one component of the system and ask students what other populations would be affected. Then cover up an entire group of components, such as the majority of the plants, and ask how this change would impact populations. **Constructing an Explanation; Cause and Effect** **When to check for understanding**: on the individual student assessments on day 2. **What to look/listen for**: Refer to the Lesson 13 scoring guidance for detailed information about what to look for in each response. In general, students' responses should focus on using models to predict how disruptions to the system (cause) impact other populations (effect). **What to do**: Encourage students to use the model provided on their assessment in their explanation. For example, when prompted to think about a disruption, have students use their thumb to cover up the component of the system that is changed in the disruption. They can then trace the interactions from the component under their thumb to other components in the system to identify how other components will be impacted. Encourage students to annotate the models using the symbols on the model key and/or the class's agreed-upon modeling conventions.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 14	Use digital tools and mathematical concepts to compare proposed diversified palm farm designs to provide stable income for farmers based on growing and harvesting rates of crops. Undertake a design project to construct a diversified palm farm system that improves biodiversity and resilience, which benefits both farmers and orangutans. Construct an explanation using a diversified palm farm as an example of a system that supports biodiversity and minimizes the risk of disruptions impacting populations.	**Mathematical Reasoning and Computational Thinking; Stability and Change** **When to check for understanding**: during the Building Understandings Discussion on day 2 and on students' written explanations on Part 5 of their *Palm Farm Design Task* handout. **What to look/listen for**: Students should identify that they can make a farm provide relatively stable income with 3 or more crops but that they need to be strategic about how much land (ratio) they plant of each crop if they want to achieve a stable income over a 50-year period. Look for students to point to difficulty in achieving stable income during certain time periods during which some productive crops are replanted and growing. **What to do**: Have students who did and did not achieve a relatively stable income with their crop selection and ratios present their designs to the class and discuss the trade-offs each design presented. **Designing Solutions; Systems and System Models** **When to check for understanding**: throughout the lesson using students' *Palm Farm Design Task* handout. **What to look/listen for**: Students should focus on whether their designs are meeting the criteria and also whether their overall designs are aligned to the design goal (biodiversity, resilience). After day 2, students should identify that their diversified farms have potential to support farmers. After day 4, students should identify that combining the 20% of forest they set aside with neighboring farms and existing forest has notable positive impacts on orangutan populations. **What to do**: The *Palm Farm Design Task* handout is structured so that you can check for understanding at each "Part" on the handout. You may want to collect and scan through students' design handouts or circulate around the room as students work to complete a quick check on each part of the handout. **Constructing Explanations; Systems and System Models** **When to check for understanding**: on day 4 when students write an explanation on Part 8 of their design handout. **What to look/listen for**: Students should identify 2 features of a diversified palm farm that supported farmers and biodiversity and why each of these features worked. Students should explain that together these features create a system that better supports a farmer because it minimizes the farmer's risk in case of a disruption. These features better support biodiversity by having more types of plants in the farm area, which support more kinds of consumers. The corridors combined with more diverse crops provide animals with more space and habitat in which to live. **What to do**: If students struggle with the explanation, have them work on it in sections. Have students revisit Parts 3 and 4 and write 2 or 3 summary sentences, even looking back at what they wrote on Part 5. Then have students review Parts 6 and 7 and add on 2 to 3 more summary sentences. Encourage students to use data from their tests to support their claims.
Lesson 15	Students can apply their learning to a local land use change problem to make sense of the problem and design solutions.	