Unit 5

Ecosystem Dynamics:

How does changing an ecosystem affect what lives there?

Student Procedure Guide

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Ecosystem Dynamics:

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Ecosystem Dynamics

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References

Readings

Lesson 1: How could buying candy affect orangutan populations in the wild?

Observe an interesting phenomenon: Meet the orangutans.

"Orangutans Face Complete Extinction within 10 Years, Animal Rescue Charity Warns"

—The Independent

With your class

1. Watch the video with your class.
2. Review the *Orangutan* information card.
3. Locate where the orangutan lives using the map.

Meet the potential cause.

"Your Halloween Candy Could Be Killing Orangutans"

—The Huffington Post

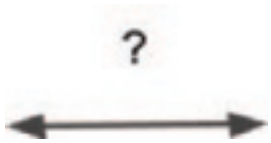
Turn and talk

With your class

4. Think about the following question: *How could <u>our</u> candy-buying habits have any impact on orangutan populations in the wild?*
5. Discuss your initial ideas about this question with your partner.

The Claim: Our candy-buying habits could affect orangutan populations in the wild.

Our Question: How could <u>buying candy</u> affect <u>orangutan populations</u> in the wild?



6. Share your initial ideas with your class.

Examine more information about candy.

With your class

7. Discuss with your class: *How could investigating more about what is in candy help us figure out this connection?*

With your group

8. Examine the top ingredients in common candies.

9. Discuss: Where do the top ingredients come from (plants or animals)?

With your class

10. What are the top ingredients in candy, and what plants or animals do they come from?

Ingredient	Source

Where are ingredients grown?

On your own

11. Examine the map shown on *Global Production: Where Ingredients Are Grown*.

12. Think about the following question: *What connections do you see between what is in our candy and the orangutans?*

With your class

13. Revise your Initial Ideas Diagram to include the new information you learned about the connection between the orangutans and candy.

The Connection between Candy and Orangutans

Turn and talk

14. Discuss with your partner:

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

15. Share your ideas with your class.

Oil Palm Trees and Orangutan Data

With your group

16. Examine the following data: *Land Used to Grow Oil Palm in Indonesia* and *Orangutan Populations Over Time*.

17. Discuss the following in your group:

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

With your class

18. Share your group's ideas with the class.

19. Update your class's Initial Ideas Diagram—Version 2 with what you know now about the connection between orangutans and oil palm.

Navigation and Next Steps

With your class

20. Brainstorm: *What additional information do we need about what is happening in Indonesia?*

Home Learning: Palm Oil Scavenger Hunt

With your class

21. Discuss with your class:

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

22. Create a page in your notebook and title it "Products That Include Palm Oil." Add to the list whenever you notice a product that lists palm oil as an ingredient. Find a few products to share with the class.

Follow up on the palm oil scavenger hunt.

With your class

23. Record 1–3 products that include palm oil on a sticky note (1 product per sticky note).

24. Add your sticky to the class board. Place your sticky near other similar products.

25. Think about the following questions: *What do you notice? What do you wonder about this?*

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

Turn and talk

26. Think about the following questions:

- When you see photos of an oil palm plantation, what do you notice?
- When you hear the word "plantation," what do you think about?

27. Share your ideas with a partner.

With your class

28. Listen to your teacher share some information about the history of the word "plantation."

29. With your class, decide what to call the places where they grow oil palm.

Growing Oil Palm in Indonesia

On your own

30. Read about the practice of growing oil palm in Indonesia. Think about the following questions:

- Why is the number of oil palm trees increasing?
- What other information did you notice?

Develop our initial model.

Our candy-buying habits could affect orangutan populations in the wild. Palm oil is the ingredient that seems to be the problem, and people are planting more and more oil palm trees.

With your class

31. Develop an initial model to explain: How could buying candy that contains palm oil affect orangutan populations and other populations in the wild?

- What components do we all agree should be in the model?
- What additional components do you think there could be in the model?
- What interactions between these things could be happening in the model?

With a partner

32. Once your class agrees on components and interactions, use *Reading: Growing Oil Palm in Indonesia* to record your initial model.

33. Work with your partner to brainstorm ideas. Your model does not need to match your partner's model.

34. Map out the components and the interactions that you think are happening between them.

Initial Consensus Model Discussion

With your class

35. Develop a whole-group record of what your class agrees on and where your classmates have competing ideas across the initial models.

- What do we all seem to agree on?
- What do we disagree on?
- What are some new ideas that we may want to consider?

Home Learning

With your class

36. Think about other examples where changing one component in an ecosystem affected the other living things in the ecosystem. Bring your ideas to the next class.

Share related phenomena.

With your class

37. Share your answers to the following question:

- What examples can you think of where changing one component of an ecosystem affected the things that lived there?

What questions do you have?

On your own

38. Take a minute to review the following:

- your initial model
- your class model
- your list of related phenomena

39. Then, write your questions:

- Write 1 question per sticky note.
- Use big, bold, and clearly readable handwriting.
- Write your initials in pencil on the back of each sticky note.

Driving Question Board (DQB)

With your class

40. Bring your sticky notes with your questions on them, your science notebook, and a chair to our Scientists Circle.

41. Review these steps for forming the DQB:

a. The first student reads his or her question aloud to the class, then posts it on the DQB near the part of the model the question most relates to.

b. Students should raise their hand if any of their questions relate to the question that was just read aloud.

c. The first student selects the next student whose hand is raised.

d. The second student reads his or her question, says why or how it relates, and posts it near the question it most relates to on the DQB.

e. The student selects the next student to share a related question or a new question.

f. Continue until everyone has at least 1 question on the DQB.

42. Organize questions into similar categories or groups.

Brainstorm ideas for data and information we need.

With your group

43. Focus on one category of questions.

44. Brainstorm data and information that could help answer these questions.

45. Write your ideas down in your science notebook and be prepared to share them with your class.

With your class

46. Share your ideas for data and information we need, and help your class build a list for each category of questions.

47. Discuss which questions to investigate next.

Lesson 2: Can we replace palm oil with something else?

Navigation

With your class

1. Make a list of ingredients found in food that come from plants.
2. Examine the images of palm oil and oil palm trees. What do you notice?
3. Discuss: What are some ways for us to remember that *palm oil* is the product or ingredient, while *oil palm* is the plant?
4. Watch the video to see how oil palm is made from palm kernels.

Consider the question for our lesson: "Is there a substitute for palm oil?"

With your class

5. What information did we say would be helpful for answering this question?

Compare different types of oils.

In your notebook

6. How is palm oil similar to and different from canola or soybean oil?
7. Make a box and T-chart in your science notebook.

Similar

Different	
Palm oil	**Canola / soybean oil**

With a partner

8. Read a short article about either *Soybean Farms in the Midwest* or *Canola Farms in Canada*.
9. Review the article *Growing Oil Palm in Indonesia*.
10. Record similarities and differences in your box and T-chart.

Discuss different types of oils.

How is palm oil similar to and different from canola or soybean oil?

With your group

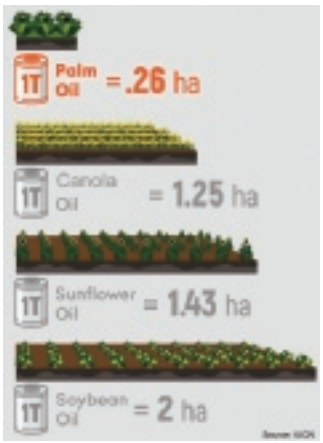
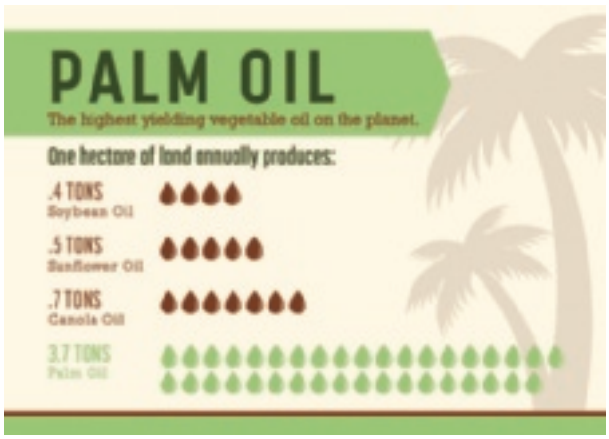
11. Discuss the following:

a. How is your oil similar to and different from palm oil and the other group's oil?

b. Do you think canola or soybean oil could be possible substitutes for palm oil? Use evidence from the readings to back up your claim.

c. Be prepared to share your ideas with the whole class.

12. Review additional data about oil-producing crops.

Land required to produce vegetable oils	*Productivity of main vegetable oils*
	

With your group

13. Discuss:

a. How do these oils compare in terms of how much land is used? How much oil is produced?

b. Do you think canola or soybean oil could be possible substitutes for palm oil? Use evidence from the readings and data to back up your claim.

Building Understandings Discussion

With your class

14. Discuss patterns that we agree upon.

a. What patterns do you notice that are similar across these three different types of oils?

b. Is canola or soybean oil a possible substitute for palm oil?

c. Is canola or soybean oil a good substitute for palm oil?

Progress Tracker

In your notebook

15. Turn to your Progress Tracker section in your notebook. What did we all figure out during this investigation, and how does it help us understand the palm oil problem?

a. Draw a line below your last entry.

b. What question were we trying to figure out?

c. Record what you have figured out and how you learned it.

Navigation

With your class

16. Revisit the Driving Question Board (DQB). What other questions did we have about palm oil?

Lesson 3: Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?

Navigation

Palm oil seems to be better than other oils because the oil palm plant requires less land to grow. If we decide to grow oil palm plants instead of other plants, can we grow them somewhere else?

With your class

1. What questions do we have on our Driving Question Board that relate to growing oil palm plants in other places?
2. If you asked a question like this during Lesson 1, share your thinking with the class.

Identify oil palm plant needs.

Turn and talk

3. Consider the question for our lesson: *Can we grow oil palm trees somewhere else so that we're not cutting down tropical rainforests?*
4. Before we answer this question, we need to know more about what the oil palm trees need to grow. Discuss with your partner:
   - What do you think the oil palm plant needs to grow?

With your class

5. Work with your class to brainstorm a list of oil palm plant needs.

In your notebook

6. Attach the Farmer's Almanac entry to your science notebook.
7. Title the page "Oil Palm Needs."
8. Read about the oil palm plant's needs and highlight important information.
9. Below the reading passage, make a list of specific growing conditions that the oil palm plant needs to survive.

With your class

10. Use a different colored marker to add specific information about the oil palm plant to your list of plant needs.

Locate places to grow oil palm plants.

With your class

11. The goal of the map activity is to identify where we can grow oil palm plants.

12. Assemble the materials needed for the map activity. Each member of your group will need:

- *Conditions to Grow Oil Palm Plants* data map,
- *Location of Rainforests* data map,
- a blank copy of the map handout,
- and colored pencils.

13. Follow your teacher's instructions to complete the overlay activity together as a whole class or in small groups. If completed in small groups, do the following:

With your group

a. Examine the keys on the *Conditions to Grow Oil Palm Plants* data map.

b. Locate the regions on the map where all conditions to grow oil palm are met.

c. Compare these locations on the map to the *Location of Rainforests* data map.

d. Identify locations where oil palm grows but tropical rainforests do not already exist, and do the following:

   i. First, locate places where there is overlap and growing oil palms would require cutting down tropical rainforests. Pick one color and color these regions on the blank copy of your map handout.

   ii. Next, locate places where if we grew oil palms, we would *not* have to cut down tropical rainforests (where there is NO overlap). Pick a different color and color these regions on your map handout.

e. Add a key to show what these colors mean. Then, attach your individual map to your science notebook.

Building Understandings Discussion: Where Oil Palm Grows

With your class

14. Share 1 place you identified where growing oil palms would mean cutting down tropical rainforests, along with any places where we would *not* have to cut down tropical rainforests.

15. Work with your class to color in a new map that everyone in the class agrees upon. This new map represents where we can grow oil palm in the world.

16. Participate in a discussion of your results and conclusions with your class.

Navigation

On your own

17. Complete an exit ticket:

Farmers grow crops, like palm, canola, and soy, to make oil. They need land to do this, but it seems like this means we have to cut down forests and hurt animals.

Why do farmers clear forests and other natural ecosystems to grow crops?

Lesson 4: Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?

Navigation

Farmers grow crops like palm, canola, and soy to make oil. They need land to do this, but it seems like this means we have to cut down forests and prairies, which hurts the animals that live there.

With your group

1. Why do you think that farmers, like the ones who grow oil palms, would cut down tropical rainforests (or other ecosystems) to grow crops?
2. How could we figure out why farmers do this? What evidence would we need?

Hearing from Farmers in Indonesia

Watch a video in which a few farmers are interviewed about how the opportunity to grow oil palm has affected their lives and the lives of their families.

In your notebook

3. Make a table like the one on the slide to record what you notice and wonder about as you watch the video.
4. Record your noticings and wonderings as you watch the video.

Turn and talk

5. What did your partner notice in the video that might help us answer our question: "Why do people cut down tropical rainforests when they know it is harmful to the animals that live there?"
6. What did you notice from the video about what the farmers gain from growing palm oil?
7. Are these farmers the only ones who gain something from palm oil being made?
8. Who else benefits from palm oil being made?

On your own

9. Read through the information on the slide about how growing oil palms impacts the amount of money that farmers, like those in the videos, can make to support themselves.

Consensus Discussion

With your class

10. Use the key points that the class raises in this discussion to update your Progress Tracker.
11. What did the farmers that we heard from say about why they grow oil palms?

12. Why do these people (and others) cut down tropical rainforests to make money?
13. Have you heard or seen other examples in which people use the land around them to make money to support themselves?
14. What do you think would happen if all of a sudden these people couldn't grow oil palms anymore?
15. How does this change what we know about the system that connects our candy purchases to orangutans being endangered?

Navigation

We have heard from some farmers in Indonesia about why they are changing the land where they live. Let's say people living in Indonesia, like the farmers we heard from, got a chance to look at the land where we live.

With your class

16. Do you think they would find evidence that we have changed the land in ways that have impacted living things?
17. How could we better understand how people where we live have changed the land over time?

Home Learning

To see how people have changed the land where we live, it may help to better understand what the land looked like long ago versus how it looks now.

Home learning

18. On your handout under Part 1, draw murals to show what the land where you live looked like a long time ago versus how it looks now.
    a. On the left side of the T-chart, draw and label a mural to show what the land where you live looked like a long time ago.
    b. On the right side of the T-chart, draw and label a mural to show what the land where you live looks like now.
19. Under Part 2, use your murals to describe how the land where you live has changed over time.

Lesson 5: How have changes in our community affected what lives here?

Share your murals.

With your group

1. Share Part 1 of your murals.
2. Look for similarities and differences in what you chose to represent.
3. Share the sources of information you used to construct your murals.

Our Community Before Major Human Disturbance

With your class

4. Discuss with your class:
   - How did people change the land where you live?
   - Why do you think people made these changes to the land where you live?
5. Examine the photos shared by your teacher.
   - Do these photos match what you learned about your area before major human disturbance?
6. Attach your mural to your science notebook.

Outdoor Observations

With your class

7. Discuss with your class:
   - If we went to an oil palm farm in Indonesia, what would we observe living there?
   - Would we see evidence of orangutans or tigers?
   - If we go outside and look around here, what will we observe right now?
   - What types of evidence could we find of the organisms that live here?

Safety Precautions

Safety Precautions

8. Review the safety precautions to take while making observations outdoors.

On your own

9. Obtain the *Observations around Our School* handout, a pen or pencil, and something hard to write on when you are outdoors.

10. Go to the designated location to make your first set of observations.

11. Find a place to sit or stand comfortably.

12. Look around you in all directions.

13. Record what you notice about plant and animal life. You may see organisms directly or see signs that they were once present.

14. After a few minutes, walk to a new location and make additional observations.

15. Make sure to complete Parts 1 and 2 of your handout.

With a partner

16. Share with a partner or small group when your teacher directs you to do so.

17. Add to your handout in Parts 1 and 2.

18. Return indoors at the designated time and location given to you by your teacher.

Home Learning

Home learning

19. Pick 1 organism or group of organisms you found evidence of during your observations. From this organism's perspective, have the changes humans made been good or bad?

20. Brainstorm ideas and be prepared to share in the next class and to complete Part 3 on your handout.

Engage in perspective taking.

On your own

21. Complete Part 3 of your *Observations around Our School* handout.

Turn and talk

22. Share your ideas with a partner. If you think of more ideas to add, do so now.

23. Be prepared to share your ideas and your partner's ideas with your class.

Share observations and look for patterns.

Scientists Circle

24. Gather in a Scientists Circle. Bring your science notebook and *Observations around Our School* handout with you.

25. Share your observations from the previous class. Record a class list of things that you observed and things you did not observe but once lived in your ecosystem:

- What did we notice was present in our community?
- What did we notice was absent from our community?
- What changes did we notice that humans made?

26. Examine the observations made by your class and look for patterns. Use the following guiding questions:

- Based on our observations, can we identify a pattern regarding the types of organisms that are present?
- What initial ideas do we have that could help us explain this pattern?
- Is there a pattern of organisms missing from our observations? What might explain this pattern?

Compare to the palm oil case.

Scientists Circle

27. Discuss the following and offer suggestions:

- How is what we observed here similar to the palm oil case? How is it different?
- How should we represent what we figured out on our model?

Add to the Driving Question Board.

With a partner

28. What questions do you have now about our local ecosystem?

- Write one question per sticky note.
- Write in marker—big and bold.

Scientists Circle

29. Share your question(s) with the class.

30. Post to the DQB in the section marked for questions about the local ecosystem.

31. Post near similar questions.

Navigation

Scientists Circle

32. Let's imagine what could be done differently to have less impact. How can we use the land in ways that work for both humans and other living things?

33. Work with your teacher to add a new unit driving question to the DQB.

Lesson 6: If palm oil is not going away, how can we design palm farms to support orangutans and farmers?

Navigation

We have learned some new things about the problem that makes it more complicated than we originally thought.

Turn and talk

1. What is one new thing that you have learned about this problem, and how did it make the problem more complicated to solve?

Define the problem.

Let's take stock of what we have figured out and see if we can more clearly define the problem.

With a partner

2. What have we figured out about this problem?
   - Use your Progress Trackers to identify what we have figured out.
   - Record each idea we figured out on separate sticky notes.
   - When you and your partner are ready, post your sticky notes near questions on the DQB that you think it helps answer.

With your class

3. Work together to summarize our ideas to more clearly define the problem.

   As ideas are discussed, move the questions we think we can now answer to a new space, with the sticky notes for what we have figured out next to the appropriate questions.

Build a better palm farm.

We understand that oil palm is an efficient crop and brings Indonesian farmers a good income to support their families. We need to figure out what we could do to protect the tropical rainforest and still give farmers an income.

With your class

4. Make sure you have a copy of *Palm Farm Designs*.
5. Work with the class to complete Part 1: Define the Problem and set a goal.
   - What would we add to or change about the problem?
   - What goal can we set for living things in the ecosystem and for farmers?
6. Complete Part 2: Define the Criteria and Constraints.
   - What will we measure to see if we are successful?

- Are there limitations on what we can design? If so, what are they?
- What tests can we run to see if our designs meet the criteria and constraints?

What question do you now have?

On your own

7. Record 1-2 new questions that, if answered, would help you design a better palm farm. Write one question per sticky note. Write in marker—big and bold. Put your initials on the back in pencil. Use the following prompts to help you develop your question.

a. What questions do you have about palm farms or the animals and plants that live there?

b. What will we need to investigate in order to solve this problem?

c. What else do we need to know to refine our criteria and constraints?

Driving Question Board (DQB)

With your class

8. Share your questions with the group.

9. Work with the class to organize the questions into categories on the Driving Question Board as they are shared.

Next Steps

With your class

10. Focus your attention on the criteria you listed on the *Palm Farm Designs* handout.

11. What should we investigate next to help us understand what constitutes a "good number" of orangutans to support in our new palm farms?

Lesson 7: How many orangutans typically live in the tropical rainforest?

Navigation

Turn and talk

1. Talk with someone about the following question and be prepared to share your thinking with the class.
   a. How are we going to know the number of orangutans that typically live in the tropical rainforest?

Investigate orangutans in protected areas.

With a partner

2. Today we will investigate the following lesson question:
   a. How many orangutans typically live in the tropical rainforest?
3. Watch the *How to Count Orangutans* video. Share one thing you found interesting about the work that scientists are doing to count orangutans.
4. Prepare to explore the *Orangutans in Protected Areas of Borneo and Sumatra StoryMap*, which provides information about where there are protected tropical rainforest areas, where orangutans live, and information about orangutans in these various protected areas.
   a. Examine information about orangutan numbers in different locations.
5. Working with a partner, use the following process for reviewing the StoryMap:
   a. Read the StoryMap one time together. The StoryMap is located at: https://arcg.is/jbea9.
   b. Discuss the following:
      i. What information do we want to record in our science notebooks?
      ii. How should we organize this information?
6. Read through the StoryMap a second time and record the important information.

Initial Ideas Discussion About the StoryMap

With your group

7. Work with your class to discuss what you have noticed in the *StoryMap* about the number of orangutans in each area.

Population

There are specific areas (the protected national parks and wildlife reserves) that have numbers of orangutans within them, and individual orangutans are not moving in between each park. They are their own distinct groups.

Turn and talk

8. A "population" is the number of organisms living in a specific area.

a. How could we represent the idea of a "population"?

b. How is a population different from one individual orangutan?

Initial Ideas Discussion About the StoryMap

With your group

9. Continue to discuss what you noticed in the StoryMap.

a. Which area had the largest population (the most orangutans)? The smallest population (the least)?

b. What was the approximate population or number of orangutans in each area?

c. Why do you think the population of orangutans in an area didn't always remain the same?

d. Why do you think some areas have larger populations of orangutans than others?

Calculate the space on orangutan needs.

With your group

10. Take a closer look at the sizes of these different protected areas.

a. Examine the StoryMap and think about the sizes of the four different protected areas.

i. The units of the sizes are km^2. Let's break that apart. What is a *kilometer*?

ii. What does a *square kilometer* mean?

11. With your group, discuss the following questions:

a. Is the Leuser Ecosystem orangutan population larger because the area is bigger?

b. How can we standardize the areas so that we can compare them?

c. How many orangutans do you think we would find in 1 km^2 in each of these parks? Would this number be similar?

12. Revise our lesson question to reflect the new focus on area.

With your group

13. Divide the number of orangutans by the total area to compare the various populations to see if they are about the same.

a. How many orangutans live in 1 km^2 in the Leuser Ecosystem?

b. Chart the population sizes on the board.

14. Work with your small group and use a calculator to determine a ratio of orangutans to land area for one or two years in one location.

Navigation

In science, we pose questions that make sense to us, but as we gather more evidence, we may need to revise those questions so that we can answer them.

With your class

15. Remember that we revised the lesson question to include the idea of area in assessing how many orangutans typically live in 1 km^2.

16. We calculated ratios for all of the different locations and times.

17. We need to analyze those data to answer this question:

a. How many orangutans live in a given area of tropical rainforest, like 1 km^2?

Analyzing Data with the I^2 Strategy

With your group

18. Obtain a copy of the *Orangutan Populations in Protected Areas in Indonesia* handout, which includes the class data from the last class period.

19. Work in your small group to use the Identify and Interpret (I^2) sensemaking strategy to mark up the data.

a. First, make observations:

i. Draw an arrow to something you notice in the data table.

ii. Write "What I See" (or WIS); then write your observation in a complete sentence.

iii. Share your observations.

b. Second, interpret what these observations mean:

i. Think about what each observation means.

ii. Write "What It Means" (or WIM); then add your explanation next to the observation.

Building Understandings Discussion

With your group

20. Share your interpretations from the *Orangutan Populations in Protected Areas in Indonesia* handout with your group and make claims about how many orangutans typically live in 1 km^2.

a. What patterns did you notice about the range of orangutans that can live in 1 km^2?

b. Do you think that 20 or more orangutans could live in that same 1 km^2 space? Why?

21. Discuss the relationship between km^2 and hectares.

a. Farmers use a different measurement called hectares. 1 km^2 is equal to 100 hectares. Many large farms and tropical rainforest areas are hundreds of hectares large. Based on what we figured out about orangutans per 1 km^2, how many could live in a large tropical rainforest that is 200 hectares? In 500 hectares?

With your class

22. Work first with a partner to discuss the following questions; then share your ideas with your class.

a. How many orangutans live in a given tropical rainforest area that is 1 km^2 or 100 hectares?

b. Why is it important to think about the number of orangutans per area (or per 1 km^2)?

Progress Tracker

On your own

23. Turn to the Progress Tracker section of your notebook and draw a line below the last entry.

a. Draw a two-column Progress Tracker and fill in both lesson questions.

i. What did we figure out during this investigation, and how does it help us understand the palm oil problem?

b. Use 3–5 minutes to independently fill in your Progress Tracker using words and drawings to show what you have figured out.

c. Draw a line underneath your responses after you finish.

Make predictions.

With your group

24. 1-3 orangutans in 1 km^2 or 100 hectares is really big. That's only 1–3 orangutans in a space that is 186 football fields.

a. Why do we think orangutans need so much space?

b. Why would they need so much space if they fought with each other?

c. Why would you need so much space to get food?

Next Steps

With a partner

25. Tomorrow you will test this idea using a computer simulation.

26. With your group, discuss the following question:

a. If we were going to test the idea that orangutans need so much space to get the food they need, what would we want to see in a simulation?

b. Share your answers with the whole class.

Lesson 8: Why do orangutans need so much forest space?

Navigation

With your class

1. A 1 km^2 or 100 hectare area is really big, and it can only fit 1–3 orangutans. That is the same as only 1–3 orangutans in a space that spans 187 football fields. With your class, share your thinking about the following questions:
   a. What were some of our ideas about why we think orangutans need so much forest space?
   b. What were some of our ideas about what we would want to see in a simulation that could help us test why orangutans need so much forest space?

Orientation to the Simulation: Components

Now that we have specified what we think a simulation should include, we can think critically about how the simulation will be useful in helping us make sense of what is happening in a real ecosystem.

With your class

2. Examine the center image on the slide and identify the following components:
   a. orangutans
   b. rainforest fruit trees
   c. termites
   d. rainforest trees (non-fruit)
3. Notice how the icons used in the simulation map to their counterparts in a real ecosystem.
4. Consider ways in which orangutans interact with the other components in the ecosystem (termites, rainforest trees, and fruit trees).
   a. How do you think orangutans and the rainforest fruit trees interact?
   b. How do you think orangutans and termites interact?
   c. How do you think orangutans and non-fruit rainforest trees interact?

Orientation to the Simulation: Rules

With your class

5. Examine the image on the slide and read the rules of the simulation.
6. Observe as your teacher runs Orangutan Energy Model 1.

Compare the simulation to the real ecosystem.

On your own

7. Recreate the table on the slide in your science notebook.

8. Individually jot down your ideas about the simulation.

a. How is this simulation a good representation of the real ecosystem?

b. How is this simulation a limited representation of the real ecosystem?

9. Share these ideas with the whole class.

a. Record additional ideas in your notebook based on your classmates' contributions.

With your class

10. Knowing that there are some ways that our simulation is similar to a real ecosystem and some ways that it is different from a real ecosystem:

a. What are the advantages of using a simulation to study this ecosystem?

b. What are the limitations?

Prepare for our investigation.

In your notebook

11. Obtain a copy of *Why Do Orangutans Need So Much Forest Space?* and attach *Experiment A: Normal Fruit Production* to your notebook.

12. Obtain an Orangutan Name Card for your assigned orangutan.

Prepare for Experiment A: Normal Fruit Production.

In your notebook

13. Use the simulation to figure out why orangutans need so much forest space.

14. On your own:

a. Gather around the projected simulation and locate your assigned orangutan.

b. Using the prompts under "Before the Experiment," record your orangutan's name, the independent variable, and make a prediction about your orangutan.

Conduct Experiment A: Normal Fruit Production.

With your class

15. With your class:

a. Your teacher will run *Experiment A: Normal Fruit Production*. Keep track of your orangutan throughout the investigation.

b. Keep track of what makes it harder or easier for your orangutan to find food.

Analyze data from Experiment A: Normal Fruit Production.

With your class

16. Using the prompts under "Run the Experiment":

a. Record the ending energy for your orangutan.

b. Record the minimum, maximum, and average energy for the population of orangutans.

c. Construct and record a class histogram.

17. With your class, discuss the following questions:

a. Which orangutans were most successful at finding food? What made it so your orangutans could get a lot of food?

b. Which orangutans were least successful at finding food? What prevented your orangutans from finding food?

c. Which orangutans were moderately successful at finding food? What made it so that your orangutans could get food when they needed it?

Make sense of data from Experiment A: Normal Fruit Production.

In your notebook

18. On your own, record the following for both your individual orangutans and the orangutan population:

a. In your notebook, circle the claim that you most agree with based on your findings from *Experiment A*.

b. Provide data from *Experiment A* to support your claim.

c. List factors that contributed to the success of the individual orangutans or the population as a whole.

Conduct Experiment B: Fewer Fruit Trees.

In your notebook

19. Attach *Investigation B: Fewer Fruit Trees* to your notebook.

20. Using the prompts under "Before the Experiment," record your orangutan's name, the independent variable, and make a prediction about your orangutan.

21. Closely track the same orangutan that you tracked in *Experiment A*.

22. Using the prompts under "Run the Experiment":

a. Record the ending energy for your orangutan.

b. Record the minimum, maximum, and average energy for the population of orangutans.

c. Construct and record a class histogram.

23. Using the boxes under "Make Sense," circle a claim, provide data to support your claim, and record factors contributing to the outcomes for your individual orangutan and the population of orangutans.

Analyze data from Experiment B: Fewer Fruit Trees.

With your class

24. With your class, discuss the following questions:

a. When there were fewer fruit trees, what happened to the energy levels of individuals? The population?

b. How might the energy levels of orangutans in this investigation relate to their chance for survival?

Conduct Experiment C: More Fruit Trees.

In your notebook

25. Attach *Investigation C: More Fruit Trees* to your notebook.

26. Closely track the same orangutan that you tracked in *Experiments A* and *B*.

27. Using the prompts under "Run the Experiment":

a. Record the ending energy for your orangutan.

b. Record the minimum, maximum, and average energy for the population of orangutans.

c. Construct and record a class histogram.

28. Using the boxes under "Make Sense," circle a claim, provide data to support your claim, and record factors contributing to the outcomes for your individual orangutan and the population of orangutans.

Analyze data from Experiment C: More Fruit Trees.

With your class

29. With your class, discuss the following questions:

a. When there were more fruit trees, what happened to the energy levels of individuals? The population?

b. How might the energy levels of orangutans in this investigation relate to the orangutans' chance for survival?

Building Understandings Discussion

With your class

30. With your class, discuss the following questions:

a. What claim can you now make about why orangutans need so much forest space?

b. What claim can you now make about how changing the percentage of fruit trees in the tropical rainforest (independent variable) affected individual orangutan energy and the orangutan population as a whole (dependent variable)?

Progress Tracker

On your own

31. Take some individual time to update your Progress Tracker using words and drawings to show what we figured out.

32. What did we figure out during this investigation, and how does it help us understand the palm oil problem?

a. Turn to the Progress Tracker section in your notebook.

b. Draw a line below your last entry.

c. What question were we trying to figure out?

d. Record what you have figured out and how you learned it.

Navigation

With your class

33. Working with your class, imagine that we could add births (when an orangutan's energy level is high enough) and deaths (when an orangutan's energy level falls below 0) to our simulation.

a. What do you predict will happen to the orangutan population when there are many fruit trees available?

b. What do you predict will happen to the orangutan population when there are *not* many fruit trees available?

Lesson 9: Would planting more rainforest fruit trees help the orangutan population increase?

Navigation

With your class

1. Our overall design goal is to figure out a way to protect the orangutan populations and potentially cause the orangutan populations to increase.
   a. Based on our investigations yesterday, what are some of your ideas about how we could increase the orangutan populations?
   b. How could we test those ideas using our simulation?

Orientation to the Simulation: Updates

With your class

2. View updates in the *Orangutan Population Model* by showing the "allow orangutans to die if their energy points drop to 0 and reproduce if their energy points reach 200" feature.

Prepare for our investigations.

In your notebook

3. Obtain a copy of the investigation handout.
4. Attach each page of the handout to your science notebook, as directed by your teacher.

Conduct Experiment 1: Births/Deaths, Normal Fruit Availability.

With a partner

5. Direct your attention to *Experiment 1: Births/Deaths, Normal Fruit Availability*. Focus on the orangutan population as a whole rather than on just one individual orangutan in the simulation.
6. You probably noticed that in the handout you are prompted to run two trials of your experiment. With your class, discuss the question "Why do you think it is important to run two trials?"
7. With your partner, investigate the question "What will happen to the orangutan population if we add births and deaths to our simulation with normal fruit availability?"
   a. **Before the experiment:** Create your experiment plan and make predictions.

With a partner

b. **Run the experiment:** Open the Orangutan Forest Model 2 sim from https://www.openscied.org/general/population/
   i. Run trial 1 and record your results (using 1 color).
   ii. Run trial 2 and record your results (using a different color).
c. **Make sense:** Respond to the "Make Sense" questions.

Make sense of Experiment 1: Births/Deaths, Normal Fruit Availability.

With your class

8. During the class discussion, add new ideas to your handout.

9. With your class, discuss the following:

a. What claims can you make about the question "What will happen to the orangutan population if we add births and deaths to our simulation with normal fruit availability?"
b. Why did the population size increase and decrease (i.e., fluctuate)?
c. Why was it important for us to conduct two trials?

Conduct Experiment 2: Increased Rainforest Fruit Trees.

With a partner

10. Locate the *Experiment 2: Increased Rainforest Fruit Trees* section of the handout.

11. Recall the investigation question "Could planting more fruit trees help the orangutan population increase?"

a. What is the independent variable in our simulation?
b. What is the dependent variable in our simulation?

12. With your partner, complete *Experiment 2*.

a. **Before the experiment:** Create your experiment plan and make predictions.
b. **Run the experiment:**
   i. Run trial 1 and record your results (using 1 color).
   ii. Run trial 2 and record your results (using a different color).
   iii. Add to the class data table.
c. **Make sense:** Respond to the "Make Sense" questions.

Make sense of Experiment 2: Increased Rainforest Fruit Trees.

With your class

13. During the class discussion, add new ideas to your handout.

14. With your class, discuss the following:

a. What trends do you notice in the class data table?

b. What claims can you make about the question "Would planting more fruit trees help the orangutan population increase?"

c. Why can you make this claim? What is your evidence?

d. What questions do you have now?

Conduct Experiment 3: Smallest Percentage of Fruit Trees.

With a partner

15. Locate the *Experiment 3: Smallest Percentage of Fruit Trees* section of your handout.

16. Recall the investigation question: "What is the smallest percentage of fruit trees that could still support an orangutan population?"

17. With your partner, complete *Experiment 3: Smallest Percentage of Fruit Trees.*

a. **Before the experiment:** Create your experiment plan and make predictions.

b. **Run the experiment:**

i. Run trial 1 and record your results (using 1 color).

ii. Run trial 2 and record your results (using a different color).

iii. Run trial 2 and record your results (using a third color).

iv. Add to the class data table.

c. **Make sense:** Respond to the "Make Sense" questions.

Make sense of Experiment 3: Smallest Percentage of Fruit Trees.

With your class

18. During the class discussion, add new ideas to your handout.

19. Discuss the following questions with your class as we make sense of findings from the investigation.

a. What trends do you notice in your class data table?

b. What claims can you make about the question "What is the smallest percentage of rainforest fruit trees that could still support an orangutan population?"

c. Why can you make this claim? What is your evidence?

d. How might our findings help us design a solution to the palm oil problem?

Connecting Our Findings to Real Ecosystems

With a partner

20. Identify which of the following ecosystems you and your partner will review:

a. Leuser Ecosystem

b. Gunung Palung National Park

c. Kutai National Park

d. Tabin Wildlife Reserve

21. Flip back to *Orangutan Populations in Protected Areas in Indonesia*, which is in your science notebook.

a. Review what we know about our ecosystem from Lesson 7.

22. Based on our investigations in this lesson, what claims can you make about the population sizes and resource availability in your ecosystem?

23. Be ready to share your ideas with the class.

With your class

24. Share your ideas with the class.

a. Why would some ecosystems support more orangutans per square kilometer than others?

Progress Tracker

On your own

25. Take some individual time to update your Progress Tracker using words and drawings to show what we figured out.

26. What did we figure out during this investigation, and how does it help us understand the palm oil problem?

a. Turn to the Progress Tracker section in your notebook.

b. Draw a line below your last entry.

c. What question were we trying to figure out in this lesson?

d. Record what you have figured out and how you learned it.

Navigation

With your class

27. Recall that we developed a model for explaining the decline in orangutan populations due to palm oil farming.

28. With your class, discuss where else we can use this model (or a similar model) to explain changes in populations.

Lesson 10: How do changes in the amount of resources affect populations?

Navigation

With your class

1. With your class, discuss the following:
   a. Why is planting oil palm trees making the number of orangutans decrease?

Prepare for our case studies.

In your notebook

2. In your notebook, create a table like the one on the slide. Make sure to leave plenty of space to add more rows.
3. With your class, discuss the following:
   a. How has the amount of rainforest trees changed over time?
   b. How has the population of orangutans changed?
4. Create a new row in your table to keep track of what you learn from your group's case study.
   a. **Before reading:** Add the name of your organism to the first column of this new row.
   b. **After reading:** Complete the rest of this row using the information you gathered from your group's case study.

Compare with your jigsaw group.

In your notebook

5. Add 3 more rows to your table for each of your group members to share what they learned from their groups' case studies.
6. As each group member shares, keep track of their findings in a new row in your table.

Consensus Discussion

With your class

7. During the class discussion, add to your table as needed.
8. With your class, discuss the following:
   a. What patterns do you see in how the amount of resources changed across different case studies?

b. How did the population of different organisms change when the amount of resources changed?

c. How can we make a model to explain, *How does the population of an organism change when the amount of resources it needs increases or decreases?*

Monarch Butterflies and Milkweed

In your notebook

9. Add a new row in your table for monarch butterflies.

10. With your class, discuss the following:

a. What resource would be for the monarchs like the rainforest trees are for orangutans?

11. Turn and talk with a partner:

a. How are the monarch butterflies and the milkweed connected in this ecosystem?

b. How does this relationship compare to other examples from our table of organisms and resources? How is it similar? How is it different?

12. On your own, complete the Monarch Butterflies on the Prairie Assessment.

Summarize what you learned from the assessment.

With a partner

13. With your class, discuss the following:

a. How has the amount of milkweed changed over time?

b. How has the population of monarchs changed?

14. Add what you learned to the third and fourth column of the last row of your table.

Navigation

Turn and talk

15. With your partner, discuss the following:

a. How could our new understanding of changes in resources help us explain the other populations in the rainforest and oil palm ecosystems that we were curious about (like rats, snakes, and tigers)?

b. What questions on our DQB do we still need to answer about these populations?

Lesson 11: How does planting oil palm affect other populations?

Navigation

With your class

1. We had some questions about other populations. Look at the Driving Question Board to find those questions.
2. Discuss with your class:
   - What is our current thinking about the questions we asked concerning other populations, like rats, snakes, pigs, and tigers?
   - What is confusing, and why is it confusing?

Developing an Oil Palm System Model

With your class

3. You will work in groups to develop a system model for an oil palm farm.
4. Work with your class to agree on how to represent the system (e.g., boxes, lines, colors).

With your group

5. Read about populations in the oil palm system.
6. Draw the populations on your whiteboard or paper:
   - Start with plants at the bottom.
   - Then animals that eat plants and insects.
   - Then predators at the top.
7. Draw the interactions between populations:
   - Start with food.
   - Then add other kinds of interactions.
   - Use the agreed-upon colors.
8. Pick a new color to represent what is changing in the system.
9. Label the box that is the main resource that is changing in the system. Draw a big or little arrow onto the resource box to show how it's changing.
10. Then, draw big or little arrows on the population boxes to show how you think the populations are changing.
11. Discuss the question "How could a change in resources be related to changes in the rat, snake, and pig populations?"
12. Place your group's model in the location designated by your teacher.

Share noticings and ideas to answer our questions.

With your class

13. Examine the different models. What do you notice when looking across the different models?

- What is similar?
- What is different?

14. Let's use our models to try to explain:

- What is the main resource, and how is it changing?
- Why are both rat and snake populations increasing at the same time in the oil palm farms?

Self-assess participation in discussion.

On your own

15. Obtain a copy of the *Self-Assessment for Classroom Discussions* handout.

16. Think about how you participated today in your small-group and whole-group discussions.

17. Reflect on what went well and where you want to improve. Write down 2 ideas for what you can do in the next class.

Taking Stock on Progress

With your class

18. Share with your class:

- What did we figure out in the last class about rat, pig, and snake populations?
- Why do we think these populations do not increase in the tropical rainforest?

Developing a Rainforest System Model

In your notebook

19. Use the same conventions and process that your group used for the *Oil Palm System Model*.

20. Read about populations in the rainforest system.

21. Draw the populations on your whiteboard or paper:

- Start with plants at the bottom.
- Then animals that eat plants/insects next.
- Then predators at the top.

22. Draw the interactions:

- Start with food.
- Then add other kinds of interactions.
- Use the agreed-upon colors.

23. Pick a new color to represent what is changing in the system.

24. Label the box that is the **main** resource that is changing in the system. Draw a big or little arrow onto the resource box to show how it is changing.

25. Then, draw big or little arrows on the population boxes to show how you think the populations are changing.

26. Discuss the question "Why are rat, snake, and pig populations *not* increasing as much in the tropical rainforest?"

27. Place your group's model in the location designated by your teacher.

Share noticings and ideas to answer our questions.

With your class

28. Examine the rainforest system models. What do you notice when looking across the different models?

- What is similar?
- What is different?

29. Let's use our models to try to explain:

- What is the main resource, and how is it changing?
- Why are rat and snake populations not really increasing in the tropical rainforest?

Consensus Discussion: Compare the Systems

With your class

30. Discuss with your class:

- What is similar between the oil palm system and rainforest system?
- What is different?
- How are our system models limited?

Progress Tracker

In your notebook

31. Turn to the Progress Tracker section of your science notebook and draw a line below the last entry.

- Draw a two-column Progress Tracker.
- Write the lesson question.
- Use words and drawings to show what you have figured out.

Navigation

Turn and talk

32. We had some questions about what would happen if orangutans went extinct.

- Examine the rainforest system model.
- Make predictions about what you think might happen.

Lesson 12: What would happen if orangutans go extinct?

Questions about Orangutans Becoming Extinct

With your class

1. Some of you were curious about what would happen if orangutans went extinct. Look for questions related to this on the DQB.
2. Discuss:
   - What were we wondering about when we posed these questions?
   - What did we predict *could* happen if orangutans become extinct?
   - What more information do we need to better understand what could happen?

Meet a scientist studying orangutans.

Scientists at the Gunung Palung Orangutan Conservation Program have been researching orangutans for decades. They study orangutans in Gunung Palung National Park, which is a protected area for orangutans, which we studied a few class periods ago. Dr. Andrea Blackburn is one of the scientists at the park. She and her fellow scientists have been tracking and recording data from the orangutans for many years. Let's take a look at her research to see what she's studying about orangutans and how it could help us answer our questions.

On your own

3. Read more about Andrea Blackburn and her research.

With your class

4. Share connections from the interview to our own DQB questions.
   - What is Andrea researching?
   - How does this relate to the questions we had?
   - If we examine her data, what do we need to pay attention to in order to answer our questions?

Analyze data from Andrea's research.

Andrea is in the middle of her research. She has not found out all the answers yet. But she was willing to share some of her data with us. Let's see what she's learned about orangutans' spreading of seeds around the tropical rainforest, and how the data she's collected could help us answer our questions.

With your class

5. Think back to what you already know about what fruit orangutans eat. Share what you remember with your class.

6. Examine the photos of fruits that orangutans eat. Some of these may be familiar to you, and some are likely new fruits you didn't know about before. Orangutans eat hundreds of different kinds of rainforest fruits.

Turn and talk

7. Orangutans do a few different things with the fruit seeds.
8. Examine the pie chart of Andrea's data. What do you notice?
9. Share your noticings with your partner.
   - What do you notice from Andrea's data on what orangutans do with seeds?
   - What do you think happens to the seeds that they spit out or swallow and defecate later?

With your class

10. Watch a video of orangutans spitting out seeds. Think about what you do with seeds. Which do you spit out? Digest for energy? Swallow whole and defecate?

With your group

11. Examine sample data from Andrea's research. For each piece of data,
    - read the question first,
    - examine the data,
    - then share what you notice.
12. Now work on your claim-pass with your group. Your group should respond to the prompt: What claim can you *tentatively* make from these data about what *could* happen if orangutans go extinct.
13. Follow these procedures:
    - One person in each group writes the group's agreed-upon claim at the top of a piece of paper.
    - Pass the paper to the group member to the left.
    - The next group member writes one piece of evidence to support the claim.
    - Pass the paper to the group member to the left.
    - Repeat until each group member has added a piece of evidence to support the claim.

Building Understandings Discussion

With your class

14. Your group will share your claim with other groups. Be ready to answer questions from the other groups and to also ask questions when the other groups share.

15. Share and discuss the following

- What claims can we make?
- What questions or uncertainties do we have?
- What additional data would we want to collect to know for sure?

16. Help revise your class's *Rainforest System Model*.

- What can we say about the relationship between orangutans and fruit trees?
- If orangutans go extinct, how would that affect fruit trees? How would that affect the rest of the rainforest ecosystem?
- How should we represent this relationship in our system model?

Navigation

Turn and talk

17. Orangutans seem important to the tropical rainforest, but so do fruit tree populations.

- Predict what would happen if fruit tree populations changed.
- How could we use our model to test our ideas?

Lesson 13: How does an ecosystem change when the plants change?

Navigation

With your class

1. We were wondering what would happen if fruit tree populations were impacted. Take a moment to reflect on the progress we have made:
   - What did we figure out about the connection between the orangutan and fruit tree populations?
   - How did we think losing the orangutan could impact the fruit trees?
   - If fruit trees are affected by the loss of the orangutan, what do we predict could happen to the whole rainforest system?

With a partner

2. Brainstorm other cases that you know about related to our questions about fruit trees in the tropical rainforest.
   - What other stories, cases, or examples do you know about where a plant in an ecosystem experienced a big change?
   - How did the change affect the whole ecosystem? Was the effect big or small?
3. Generate a list of related cases with your class.
4. These kinds of changes to the ecosystem that we have been talking about are called "disruption." Define this term with your class. Practice using it as you continue to talk about changes that happen to ecosystems.

Model disruption scenarios in the tropical rainforest.

With your class

5. Brainstorm different kinds of disruption events or changes:
   - Think about situations or events that could cause **big** problems in the fruit trees.
   - Think about situations or events that could cause **small** problems in the fruit trees.
6. Decide to test 3–4 scenarios where the fruit tree populations could experience a disruption.

With a partner

7. Partner up and obtain 1 copy of the *Updated Rainforest System Model* handout and 8 paper squares (or an alternative).
8. You will be testing the following scenarios (or similar ones that you decided on with your teacher):

- Scenario 1: A major drought that lasts many years
- Scenario 2: A disease that affects durian fruits only
- Scenario 3: A disease that affects figs only
- Scenario 4: An important seed disperser goes extinct (orangutans)

9. For each scenario, cover up the affected population on your model.

10. Discuss with your partner:

- Who will be impacted by this change? How?
- Is the change to the whole system big or small? Why?

Make sense of disruptions in the tropical rainforest.

With your class

11. Discuss with your class what you and your partner predicted using the model.

12. Think about which kinds of disruptions affected the system as a whole.

Discuss and compare disruptions in the oil palm farm.

With your class

13. Brainstorm with your class about what kinds of disruptions could affect the oil palms that grow right next to the tropical rainforest?

Turn and talk

14. Examine the oil palm system model. If a disruption affects the oil palm, predict what could happen to other populations.

- What do you predict would happen if this system experienced a drought or crop disease?
- What other examples do you know about where a crop was impacted by a disruption?

With your class

15. Make observations of the system models and photographs to compare the rainforest to the oil palm system.

16. Share what you notice. What is similar? What is different?

17. We have been looking at two systems. One system has many kinds of living things in one area, while the other system only supports a few living things. This relates to the systems' "biodiversity." Define "biodiversity" with your class. The oil palm system is an example of a "monocrop" because it is predominantly one plant, or crop. "Mono" means one. Define "monocrop" with your class.

18. Summarize important noticings:

- Why can the rainforest system tolerate some disruptions that affect plants while the oil palm system cannot?
- What were some differences we noticed between the tropical rainforest and oil palm farm that may be important if we want to design better ways to farm?

Home Learning: Noticings of Plants in Our Lives

With your class

19. Pay attention to the plants in your lives.

20. Notice around your home, school, and community.

21. Where do you observe biodiverse plants, and where do you observe plants that are more like a monocrop (single plants of the same kind)?

Share home learning.

Turn and talk

22. Share with your partner:

- Where did you observe biodiverse plants?
- Where did you observe plants like a monocrop (or single plants of the same kind)?
- Why do you think humans prefer monocrop/single plant type in some places instead of more diverse plants?

Create a summary chart of key takeaways.

With your class

23. Summarize important ideas with your class.

- What conclusions can we draw about the kinds of disruptions that may impact the fruit trees in the tropical rainforest?
- What conclusions can we draw about how the disruptions could affect the oil palm farms nearby?

Apply to a new case: the willow flycatcher.

With your class

24. Meet the southwestern willow flycatcher.

25. Meet the tamarisk tree, which was introduced to the ecosystem over 100 years ago.

26. Compare the two models.

27. Discuss: What changed for the flycatcher when tamarisks were introduced?

28. Meet the tamarisk beetle.

29. Discuss: What do you predict will happen to the system with this new beetle?

30. Compare the new system model for the flycatcher case to our system model for the orangutans and the tropical rainforest.

- What do we notice is similar between the model we used for orangutans and the new one for flycatchers?
- What is different?

With a partner

31. What would happen to the flycatcher population if the tamarisk beetle was introduced to an area with

- mixed tamarisk, willows, and cottonwoods
- mixed tamarisk and willows, no cottonwoods
- mostly tamarisk, a few willows, no cottonwoods
- only tamarisk, no willows or cottonwoods

32. Predict whether the flycatcher population would increase, decrease, or stay the same, and discuss why.

Individual Assessment: The Willow Flycatcher

On your own

33. Record patterns you notice from the data. You can draw and annotate the graphs as needed.

34. Then, read the two claims from scientists. Choose the claim you think the data best supports. Write an argument to support the claim using the data you have and the model for the system.

Navigation: Oil Palm Monocrop

With your class

35. Share what you know about Indonesian oil palm farms.

- What do we know about these kinds of farms so we can design new farms that work better for both people and other living things?

Lesson 14: Are there ways people can grow food without harming the tropical rainforest?

Ways to Grow Food that Help Population in Ecosystems

With a partner

With your class

1. Discuss: How can we grow food in ways that might help plants and animals?
2. Be prepared to share your ideas with the class.
3. Discuss with the class:
   - Are our ideas realistic?
   - How can we investigate real ways that people grow food that do not harm orangutans or other populations in ecosystems?

Obtain information about different ways to grow food.

On your own

4. We are investigating: *Are there ways people can grow food without harming the tropical rainforest?*
5. To answer this question, read one of the following: *Summarizing ways to grow food*, *Diversified Farming in Costa Rica*, *Sustainable Palm Oil in Indonesia*, *Customary Forests in Indonesia*.
6. Take notes using *Two-Column Notes*.
   - Markup the text.
   - Read for the main ideas of the reading—skim the title, headings, and captions on images.
   - Identify the ideas from the text that support the main ideas.
7. As you read, think about the following questions. Be prepared to share with your small group.
   - Describe the method of growing food that you investigated.
   - How is it different from large-scale monocrop farming?
   - How does this help populations in ecosystems?
   - Who could do this?

With your group

8. Discuss with your group and take notes on *Reading: Customary Forests in Indonesia*:
   - Describe the method of growing food that you investigated.
   - How is it different from large-scale monocrop farming?

- How does this help populations in ecosystems?
- Who could do this?

Progress Tracker

In your notebook

9. Turn to the Progress Tracker section of your notebook and draw a line below the last entry.

- Draw a two-column Progress Tracker and fill in both lesson questions.
- What did we figure out during this investigation, and how does it help us answer the question: *Are there ways people can grow food without harming the tropical rainforest?*
- Use 3–4 minutes to independently fill in your Progress Tracker using words and drawings to show what you have figured out.
- Use 3–4 minutes to discuss with your group the answer to the lesson question, and add any new ideas to your Progress Tracker.
- Draw a line underneath your responses after you finish.

Share strategies.

With your class

10. Discuss with the class:

- What method of growing food did you investigate?
- Why might someone want to do this?
- What might not work for them?
- Which kinds of farmers or people might this approach work best for? Why?

Lesson 15: How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?

Navigation

With your class

1. Share with the class:
   - the approach to growing food that you read about in the last lesson, and who benefited from that approach
   - why people would use these approaches to growing food if only animals and plants benefit

With a partner

2. Discuss with a partner how to figure out why people would choose to use these approaches if they only benefit plants and animals.

Hear from people using different ways to grow food.

With your group

3. View your assigned StoryMap: https://arcg.is/0ymbDy0
4. Read the text and listen to the videos. Take notes using the *Two-Column Notes* handout.
5. Add a column on *Summarizing ways to grow food* after "Who is doing this?" Label the column "Benefits people receive."
6. Discuss with your group what you learned from the StoryMap about the benefits people receive, and jot down your ideas. Be prepared to share with the class.

Navigation/Problematize

With your class

7. Share with the class:
   - ways people benefitted from the approach to growing food that you read about in your StoryMap.
   - what would happen to someone if there were a disruption on their farm, such as a disease that kills their plants or a pest that eats their crops.

Turn and talk

8. Discuss with a partner what benefits you think matter for people as well as for plants and animals in the natural ecosystem.

Lesson 16: What approach to growing food works for everyone and why?

Navigation

With your class

1. Share with the class:
    - What did you figure out about how people can benefit from growing food in ways that support plants and animals in the natural ecosystem?

Add monocrop farm to our table.

With your class

2. Take out *Summarizing ways to grow food*.
3. Add a row at the bottom.
4. In the first column, under "describe the way to grow food," add "monocrop farm."
5. Add a brief description to describe a monocropped farm.

With a partner

6. Discuss with a partner and share with the class.
    - How does monocropped farming help populations in ecosystems?
    - Who is using a food growing approach like monocropping?
    - How does monocropping benefit people?
7. Write your responses in the last row in the appropriate column.

Synthesizing Approaches to Growing Food

With your group

8. Review your notes from Lessons 14 and 15 with your group. Prepare to share what you learned with other groups.
9. Join your new group and share what you learned about the approach to growing food you read about.
    - Meet with your new group.
    - Each person in the group is an expert on one approach. The "expert" shares what they know. The other group members record notes.
    - Each expert will share for about 5 minutes. The other group members can ask clarifying questions.
    - Repeat until all experts have shared and your table is complete.
10. Be prepared to share with the class what you learned.

Navigation: Make an Initial Claim

With your class

11. Our question is, What approach to growing food works for everyone and why? If you had to make a claim right now to answer this question, what claim would you make?

Scientists Circle

Scientists Circle

12. The question we are trying to answer: What approach to growing food works for everyone and why?

13. Review your completed jigsaw handout, *Summarizing ways to grow food*.

- Decide which approach to growing food is best for animals and plants, then choose a second- and third-best.
- Decide which approach to growing food is best for people, then choose a second- and third-best.
- Put your choices on sticky notes and place them in the appropriate box.

14. Look for patterns across the sticky notes in how your peers ranked each approach. Share your noticings with the class.

15. Clarify your claims with evidence: Why did you categorize an approach to growing food as first-, second-, or third-best?

16. Complete the summary table in your notebook, *Best Approaches to Growing Food for Animals, Plants, and People*.

17. Discuss the following with your class:

- What claims can we make about the approaches that work best for plants and animals? For people?
- Why do we not completely agree on this?
- What are the trade-offs (or compromises) to each approach?

Add to the individual Progress Trackers.

In your notebook

18. Turn to the Progress Tracker section of your notebook and draw a line below the last entry.

- Draw a two-column Progress Tracker and fill in both lesson questions.
- What did we figure out during this investigation, and how does it help us understand what approach to growing food works for everyone and why?

- Use 5 minutes to independently fill in your Progress Tracker, using words and drawings to show what you have figured out.
- Draw a line underneath your responses after you finish.

Navigation/Problematize

With your class

19. If we test our claims about which approaches to growing food work best in a simulation, then:

- What would we want our simulations to look like to do these tests?
- What ways of growing food should we include in the simulation?
- How would we know if our designs are successful? What outcomes should we measure?

Lesson 17: How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?

Navigation

With your group

1. Last class, we discussed the trade-offs of different ways of growing food. In groups of 3, you will redesign the way land is used in Indonesia to support orangutans and people at the same time. Assign each group member one of the following roles:
   - Large-scale oil palm company
   - Small-scale oil palm farmer
   - Village elder
2. From the perspective of your role, which ways of growing food would you try? Why? Share your ideas with your group.

Navigate to Padu Banjar, Indonesia.

With your group

3. We are going to use a computer simulation to help us answer the question: *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* The simulation was designed to represent Padu Banjar, Indonesia.
4. Look at the pictures on the slides as your teacher shows satellite images that zoom in on Padu Banjar (slides B-D).

Make observations about Padu Banjar, Indonesia.

With your class

5. Navigate to Padu Banjar, Indonesia, using Google Earth or other mapping software: https://tinyurl.com/padubanjar
6. Make observations about Padu Banjar by zooming in on important features. On your handout, *Padu Banjar*, label the key features.
   - Where do you think orangutans may spend most of their time in this area?
   - Where do you think people may spend most of their time in this area?

Compare Padu Banjar to the computer simulation layout.

With your class

7. View the computer simulation layout at: https://www.openscied.org/general/collaborative/.

The layout design is based on Padu Banjar. In your handout, try to identify the same important features that you identified in the satellite image of Padu Banjar.

- How is the simulation a good representation of Padu Banjar?
- How is the simulation a limited representation of Padu Banjar?

Orient to the computer simulation.

With your class

8. Open the computer simulation and explore the new features using this link: https://www.openscied.org/general/collaborative/.

Redesign Challenge—Parts A and B: revise and add to our definition of the problem and our criteria and constraints.

With your class

9. Obtain a copy of the handout, *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?* You will use this handout throughout the redesign challenge. Attach the pages to your notebook.

10. Part A—Read the problem summary statement on the handout. Edit or add to it based on the progress you have made since we last defined the problem. Discuss your revisions and additions with your class. Your teacher will keep a record of your revisions on chart paper.

11. Part B—Review the Criteria and Constraints your class identified in Lessons 1 and 6. Review your copy of the handout, *Palm Farm Designs*, from Lesson 6. Revise and add to your list of criteria and constraints. Discuss your revisions and additions with your class. Your teacher will keep a record of your revisions on chart paper.

Part C: gather baseline data.

With your class

12. Part C—Follow the steps outlined in the handout and on the slides to gather baseline data from the computer simulation and further refine the criteria and constraints. Record the baseline data on the handout *How can we redesign the way land is used in Indonesia to support orangutans and people at the same time?*.

13. Further refine your criteria and constraints according to what you found when you gathered baseline data.

Part D: plan ways to redesign the land.

With your group

14. Determine your assigned area and role with your group
    - Area 1: Large-scale oil palm company
    - Area 2: Small-scale oil palm farmer
    - Area 3: Village elder
15. Plan ways to redesign your area. Use the space on your handout to sketch or describe a redesign plan for your area.

Part E: test the redesign.

With your group

16. With your group, navigate to the Collaborative Oil Palm Model computer simulation at:

    https://www.openscied.org/general/collaborative/.

    Work together with your group to redesign the land and run tests. You may redesign and test as many times as you would like in order to optimize your design. Remember that your goals are as follows:

    - Design a better way to use the land (see Part A: Revise or Add to Our Goal).
      - Support the largest orangutan population possible (see Part C: Gather Baseline Data, "Forest Only").
      - Support adequate income for the people (see Part C: Gather Baseline Data, "Income Only").
    - Meet the criteria and constraints (see Part B: Revise or Add to Our Criteria and Constraints).
17. Save and load your work according to your teacher's direction. The simulation will save your optimization and trial history. If at any point you would like to save your current work to return to it later, you may save the "Current Work Code" in the "Saving and Loading Your Work" section. You can load saved work by pasting the code into the "Load Saved Work" box and pressing "Recreating Experiment."
18. Reflect on the redesign. Record your responses to the following questions on your handout: *Review your experiment and trial history. What were some key adjustments you made in your redesign? How did the adjustments help the orangutans, the people, or both?*

Part F: evaluate draft solutions.

With your group

19. Evaluate the redesigns from at least two other groups. As you review the redesign, respond to the following questions on your handout. Remember to leave the group a sticky note with some suggestions for improvement.

a. What were the key features of the redesigns you viewed? How did the features support people, orangutans, or both?

b. What is working well about the redesign?

c. What could the group change about the design, and why would this change better support orangutans or the people? (In addition to recording your response on the handout, be sure to record a group response to this question on a sticky note to provide feedback to the group.)

Part G: optimize redesign solutions.

With your group

20. Review the feedback you received from other groups. Record your key takeaways on your handout. Optimize your redesign based on the feedback you received.

21. Review your experiment and trial history. What were some key adjustments you made in your optimized redesign? How did the adjustments help the orangutans, the people, or both?

Part H: construct an explanation to support a redesign.

On your own

22. Construct an explanation about how your farm meets the goal for the design task.

a. Identify 2 features of your design that worked (met the criteria).

b. Explain why each feature supports people, orangutans, or both.

c. Construct an explanation about how your group's farm meets the goals for the design task. Explain how or why combining the features above benefitted both people and orangutans at the same time. Remember to use the science ideas our class figured out in your explanation. You can also use data from the simulation in your explanation.

Navigation

Turn and talk

23. Next time, we will present and evaluate our design solutions.

a. What is one weakness in your design solution that you think others might identify?

b. How could you respond if a group uncovers this weakness?

Lesson 18: How do our designs work for orangutans and people in Indonesia?

Prepare to evaluate our design solutions.

Our goal is to evaluate our design solutions for redesigning the way land is used in Indonesia. This involves comparing and critiquing our designs. We want to see if we notice any designs that seem particularly strong, or if we notice any features across the designs that seem to work well.

Scientists Circle

1. Critiquing each other's work can be challenging. Review our classroom norms and focus on critiquing the designs using evidence and scientific reasoning. Avoid critiquing your peers who present.
2. Discuss: What do we need to pay attention to in order to evaluate the designs fairly?
3. Examine the *Solutions to Redesign the Land: Evaluations* handout. What do we want to add to or change on our evaluation document?
4. Make changes to the handout so that everyone agrees on what is being evaluated when groups present their designs.
5. Review the procedures for presenters and for evaluators.

Present and evaluate design solutions.

Scientists Circle

6. As the presenters:
   - Share your design and point out features that you think are important.
   - Share your orangutan population data and income levels for each area.
   - Share 2–3 things your group discussed as you optimized your design.
   - Answer clarifying questions from your peers.
7. As the evaluators:
   - Record the orangutan population data and income.
   - Make notes about the features you like and the trade-offs they made.
   - Add questions you have to your sheet.
   - Ask clarifying questions of the presenters.

Example Clarifying Questions

Clarifying questions help you understand the design and the group's thought process as they worked on their designs.

General clarifying questions include:

- Can you say more about that?
- What do you mean when you say the word "_____"?

More design-specific questions may include:

- Did putting _____ feature in Area ___ help the orangutan population?
- Did planting palm oil in Area ___ lower the orangutan population?
- What is one thing you did to optimize your design?

As your peers present, think about how the system would respond if there was a disruption. Ask questions like:

- In what ways is the design solution stable?
- What might cause this solution to become unstable or imbalanced?
- How do we think the design would respond to a disruption?
- Would the system be diverse enough to support people and orangutans through a disruption?

Add an entry to your Progress Tracker.

In your notebook

8. Open your science notebook to your Progress Tracker. Find your last entry and draw a line underneath it.

9. Write the question we have been working on in the left column:

How do our designs work for orangutans and people in Indonesia?

10. Write down what you have figured out about this question. Use words and/or pictures to share your thinking.

Consensus Discussion About What Worked and Trade-offs Made

The question our designs are trying to answer is, **How do our designs work for orangutans and people in Indonesia?** We are going to make claims to answer this question.

Scientists Circle

11. Talk with your group about the claims you want to make about what worked well.

12. Then, share the claims you have to answer our question:

    How do our designs work for orangutans and people in Indonesia?

13. As you share:
    - use evidence from our design trials.
    - use science ideas we have figured out in the unit.

14. Think about the trade-offs that the groups shared as they presented, or ones that you noticed. Discuss the following questions:
    - What trade-offs did your group make to improve your results?
    - What trade-offs did you notice other groups make?
    - Which trade-offs do we think are acceptable and to who? Which ones are not acceptable and to whom?

15. Think about whether the designs are realistic and how stakeholders in Indonesia would respond to them. Discuss the following questions:
    - Do we think we have designs that all the stakeholders in Indonesia—the large companies, villagers, small-scale farmers, people protecting orangutans—would support? Why or why not?
    - What claims can we make and support about which designs are most realistic?

16. Work with your class to record what everyone agrees on and where disagreement still exists.

Construct a convincing recommendation for land use in Indonesia.

You will make recommendations for how you think the land in Indonesia should be redesigned to support people and orangutans. Your recommendations will be in the form of a claim. You will need to support your claim with a clear and convincing argument.

Scientists Circle

17. Brainstorm how to make your recommendation more convincing. Discuss:
    - What makes an argument convincing?
    - What would make an argument more convincing to someone in Indonesia?
        - To large-scale oil palm company?
        - To a small-scale farmer?
        - To a village elder?

On your own

18. Receive 1 copy of *Argument for the Best Redesign of Land* from your teacher.

19. Make a claim to answer the question, ***If you could make one recommendation to redesign the land in Indonesia to support people and orangutans, what would you recommend and why?***

20. Write a convincing argument to support your claim. Your argument should include:

- Evidence from the simulation and investigations
- Scientific reasoning that draws upon the science ideas we have figured out
- Trade-offs that are important to know about

Peer Feedback and Revisions

With a partner

21. Present your argument to a peer for about 1 minute.

22. Listen to feedback about what to add or change to make it more convincing for about 1 minute.

23. Then, switch and repeat for the other partner's argument.

On your own

24. Reflect on the feedback you received.

25. Complete Question 3 on your handout: *What additional information do you want to add or change?*

Navigation

In your notebook

26. Listen to your teacher's instructions to add a reflection to your science notebook.

Making Arguments Convincing

Scientists Circle

27. Reflect on what made some arguments more or less convincing.

- What made arguments more convincing?
- Who would our arguments most convince?
- How could we make them more convincing to others?

Revisit our Driving Question Board.

On your own

28. Identify the questions that we have made progress on.

29. Take 10 sticky dots over to the DQB.

30. Place your sticky dot on the sticky notes that match questions you think we have made progress on.

31. Once you have placed your 10 dots, move back to the Scientists Circle.

32. As you are waiting for others to place their sticky dots:

a. Notice and wonder about which questions have the most sticky dots.

Scientists Circle

33. Share what you notice about the Driving Question Board now.

- Which questions have we made the most progress on?
- What have we figured out?
- What can we say now about the big question on our DQB:
  How does changing an ecosystem affect what lives there?

Celebration Graffiti!

We have three graffiti boards. These boards are a space to reflect on your learning. The board topics include:

- How does changing an ecosystem affect what lives there?
- What is one action I want to take to have a positive impact on natural systems?
- What is one thing I learned in the unit that I would like to share with others?

On your own

34. Pick 2 of 3 boards to visit (or visit all 3).

35. Write your response to the question on the board.

36. Sign your name or leave your comment anonymous.

Scientists Circle

37. Reflect and celebrate all that you have figured out in this unit:

- How would you summarize the comments you observed?
- Did you notice a comment on the graffiti board that resonates with you?
- Did you notice a pattern in what we agreed on or disagreed on?

Lesson 19: How can we inform others in our community about the palm oil problem and convince them to take action?

Navigation

With your class

1. Share with the class:
   - Why did we say we wanted to raise awareness about the palm oil problem?
   - How does raising awareness about the problem help orangutans?
   - What are some ways we could raise awareness about this problem?

Public Service Announcements (PSAs)

With your class

2. Skim the Distracted Driving PSA.
3. Share with the class:
   - What do you notice about this PSA?
   - Who do you think is the audience for this PSA?
   - What do you think the authors were trying to tell their audience?

Example PSAs

In your notebook

4. Make a T-chart in your science notebook.
5. As your class views the example PSAs, use your T-chart to record the similarities and differences you notice between the different PSAs.

What makes a PSA effective?

With your class

6. Share with the class:
   - Based on what you saw in the example PSAs, what do you think needs to be in a PSA to make it effective?
   - What makes a PSA effective?
7. With your class, create a PSA checklist listing everything your PSA should include.

Turn and Talk

Turn and talk

8. Discuss with your partner:

- What science ideas are important to include in our PSAs?
- Why do you think it's important to include those ideas?

9. Jot down your ideas as a list in your notebook.

What actions can our audiences take?

With your class

10. Share with the class:

- What actions do you think we could suggest to people to help address the palm oil problem?
- Can everyone do all the actions that we brainstormed? Who can and who can't?
- Would you take all of these actions yourself?
- Can we ask people to take actions that we're not willing to ourselves?

Plan for and develop your PSA.

With your class

11. Using the resources provided by your teacher, work with your group to develop a PSA that informs people about the palm oil problem and encourages them to take action.

Goal: Plan for and develop a PSA to inform people about the palm oil problem and encourage them to take action to protect natural systems like tropical rainforests.

Plan your communication:

- What audience(s) are you targeting with your PSA?
- What solutions are you suggesting to them? Can they implement these solutions? Do they need help? If so, who can help them?
- What media and strategies (audio, visual, etc.) will you use to present this information?
- How will you present your information so that it's informative, engaging, and convincing?

You will present these products to the class and give and receive feedback.

Navigation

With your class

12. Share with the class:

- Who do you think our PSAs need to be shared with?
- How do you think we could share our PSAs with these audiences?

Progress on the DQB

With your class

13. Identify questions that you added at the start of the unit or later in the unit.

14. Think about how you might answer the question now.

15. Pick 1 question you had. In your notebook, write the question and how you would respond to it now.

Lesson 20: What should we do to take care of our local land, plants, and animals?

Navigation

With your class

1. We started to think about a new problem in our community. We made some initial wonderings about it. Share with the class:
   - How do we think this new problem could be similar to or different from the palm oil and orangutan problem?

Make noticings and wonderings.

In your notebook

2. Set up your science notebook with a T-chart. On the left, write "noticings." On the right, write "wonderings."
3. Make observations of the new problem and record your noticings.
4. Then add wonderings that come up for you.

Share noticings.

With your class

5. Share with the class:
   - What did you notice?
   - What did you notice that might be similar to or different from the palm oil and orangutan problem we investigated?

Share wonderings by posting new questions to the DQB.

On your own

6. Review your wonderings. Think about which question you have about the problem that you would like to post to the Driving Question Board.
7. Write 1 question per sticky note. Write in large, dark writing so others can see your question. Put your initials on the question.

Scientists Circle

8. Share your new question with the group.
9. Help your class organize the questions into categories as they are shared.
10. Brainstorm with your class the information and data you need, or investigations you need to conduct.

Investigate the new problem.

With your class

11. Follow your teacher's guidance to investigate the new problem.

Orangutan

Where They Spend Most of Their Time

Orangutans live on the islands of Borneo and Sumatra, which are part of Indonesia and Malaysia. There are more orangutans in areas of the forest where more fruit trees grow. Orangutans like to live where fruit is plentiful all year long. They spend most of their lives living in the trees.

What They Eat

Orangutans mostly eat fruit (90%), like figs and durian fruit. They also eat insects, like termites and ants. They sometimes eat bark, leaves, and flowers.

Figs

Durians

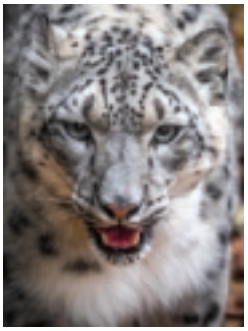
Termites

What Eats Them

Orangutans' primary predator on Sumatra is the Sumatran tiger. On Borneo, there are no tigers, so the clouded leopard is their primary predator.

Sumatran Tiger

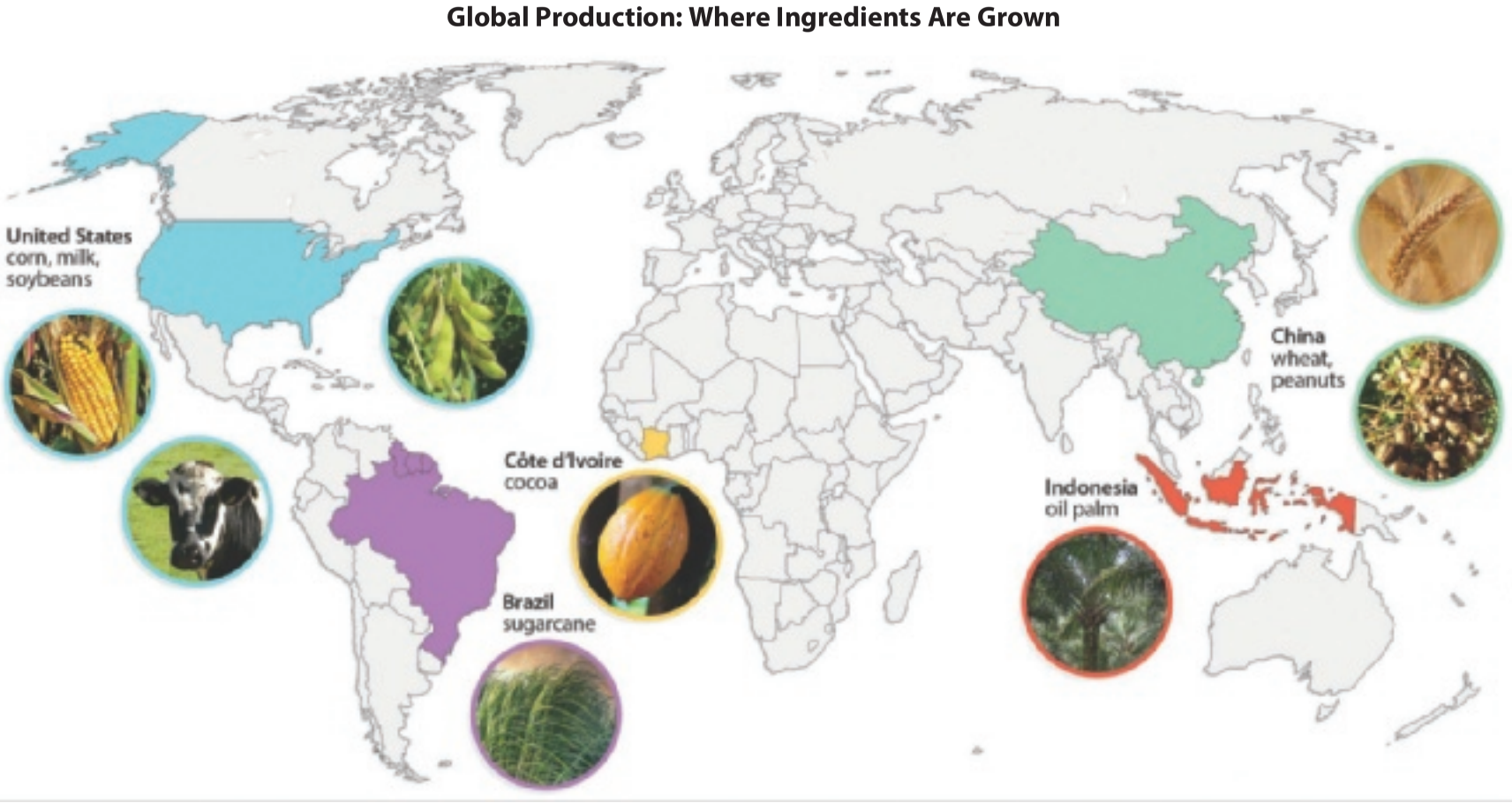
Clouded Leopard



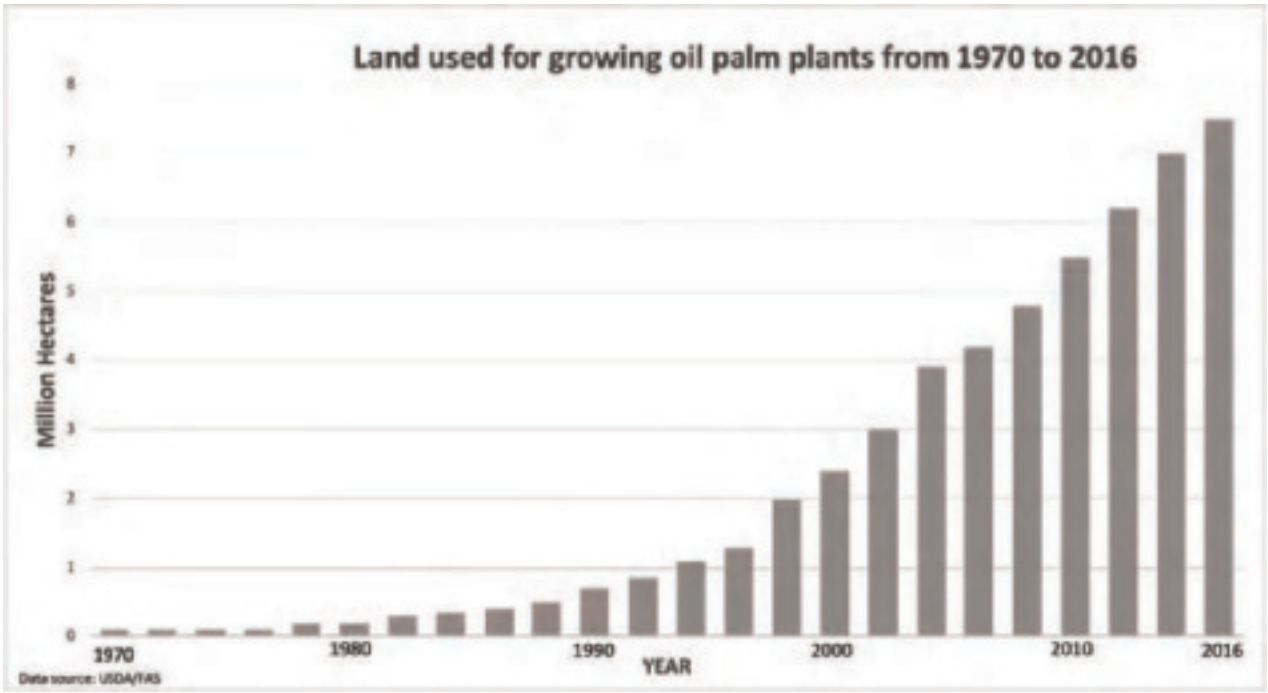
Special Role in the Ecosystem

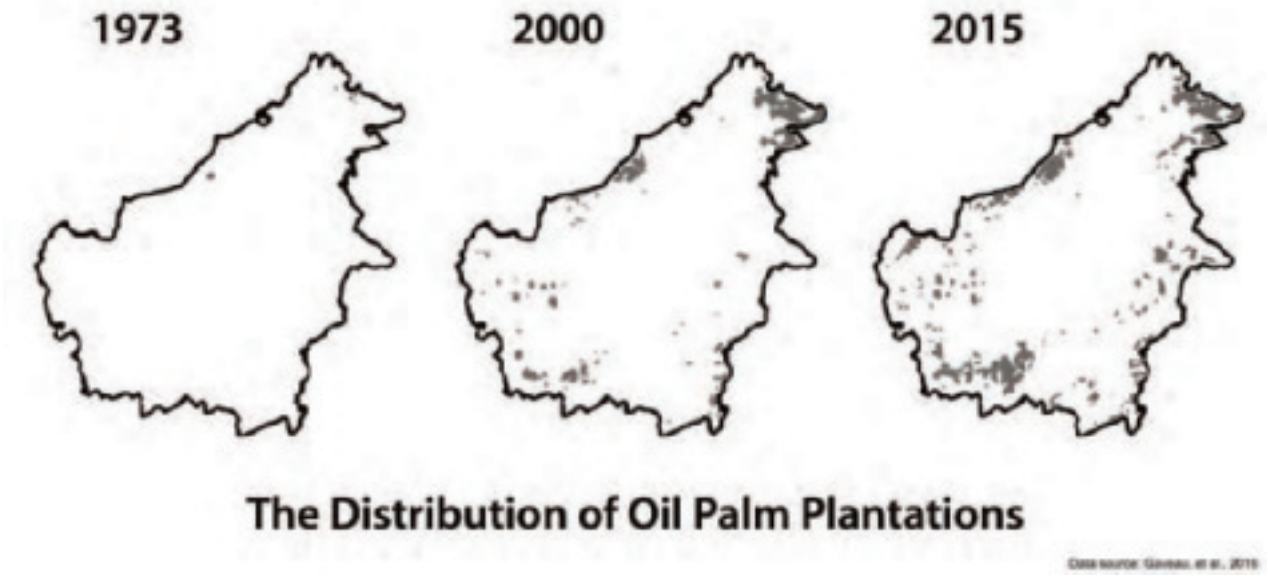
When orangutans eat durian fruit, they spit out the seeds, which helps spread the seeds to grow plants in new places. Other seeds are spread when orangutans poop. This makes orangutans especially important to fruit trees, because they help spread seeds to grow new fruit trees.

Global Production: Where Ingredients Are Grown



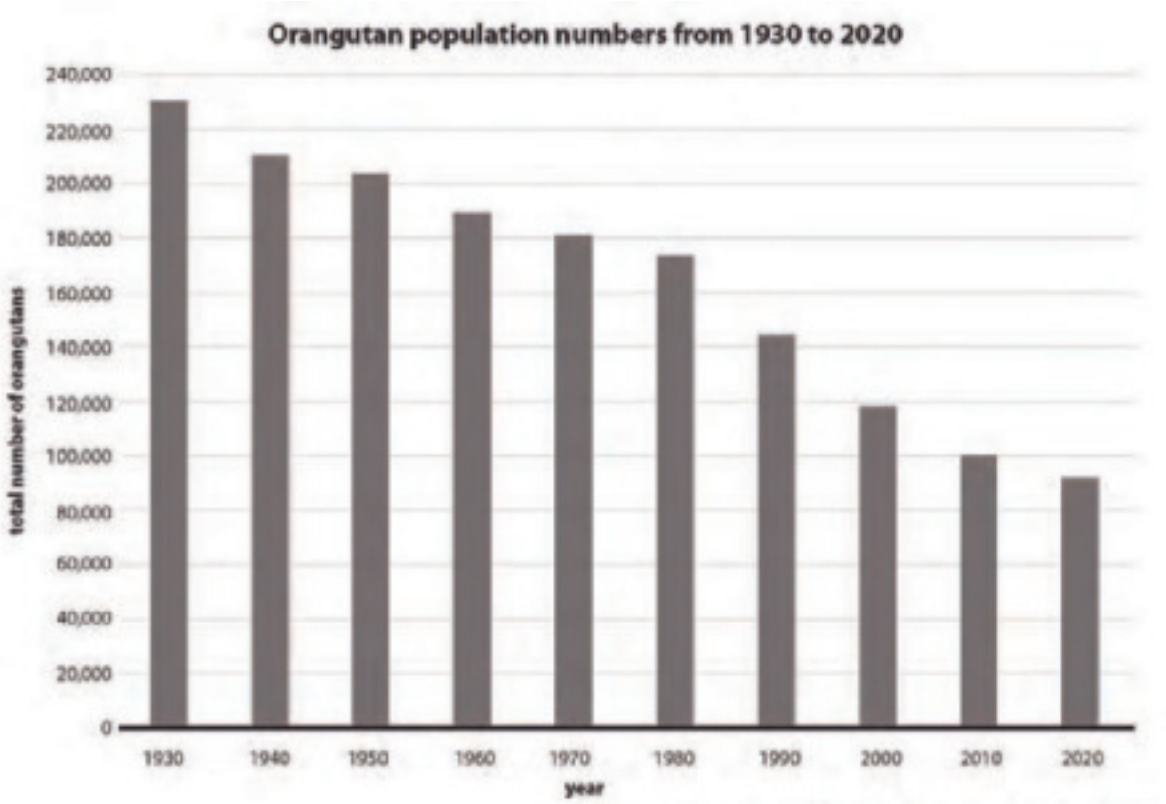
Land Used to Grow Oil Palm in Indonesia

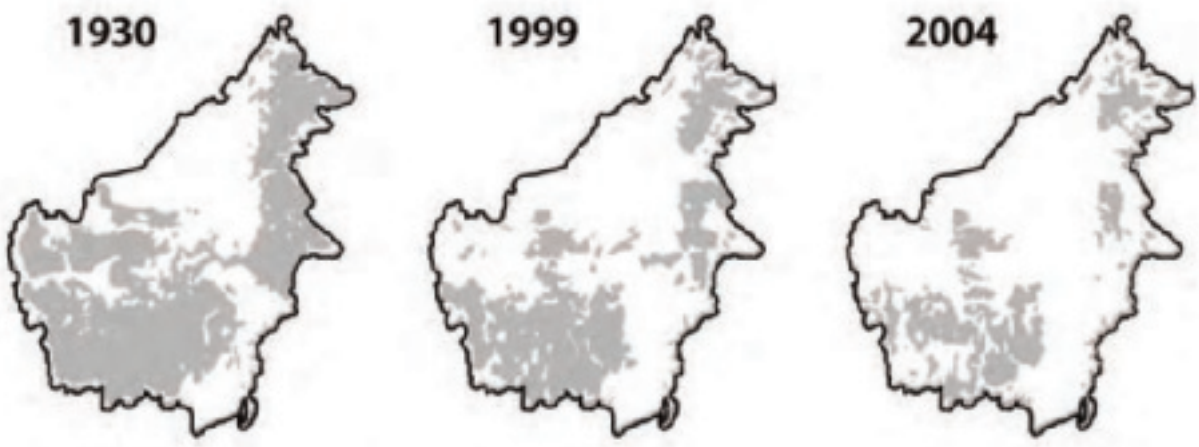




The Distribution of Oil Palm Plantations

Orangutan Populations Over Time





The Distribution of Orangutans between 1930 and 2004

Soybean Farms in the Midwest

Soybeans are native to East Asia and are used to make tofu, soy milk, soy sauce, soybean oil, and numerous other ingredients in processed foods. Soybean oil comes from crushing the seeds of soybean plants. The soybean oil we get from these plants is one of the most widely consumed cooking oils, often found in vegetable oil blends. It is also an ingredient in many processed food items, as well as products like printing inks and oil paints.

The largest producers of soybean oil globally are the United States and Brazil. Within the United States, soybeans are primarily grown in the upper Midwest, including Illinois, Iowa, and Minnesota. Producing 1 ton of soybean oil requires 2 hectares (almost 4 football fields). To make space for soybean farms, large areas of tallgrass prairies have been transformed for farming.

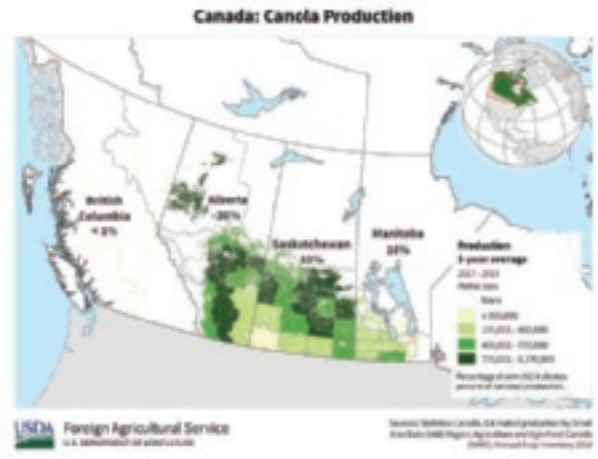
A tallgrass prairie is an ecosystem with many different types of grasses, flowering plants, shrubs, and trees. Less than 2 percent of the tallgrass prairies that once covered large areas of the Midwest remain. This has negatively impacted bison, prairie dog, fox, bird, and butterfly populations.

Tallgrass prairies	Soybean farms
	

Canola Farms in Canada

Canola is one of the oldest plants farmed by people, with documented uses in India, China, and Japan. Canola oil comes from crushing the seeds of canola plants, which are related to broccoli, cabbage, and cauliflower. The canola oil we get from these plants is used primarily for cooking and in food products. It was historically used for oil lamps and is now used in cosmetics, printing inks, and other non-edible products.

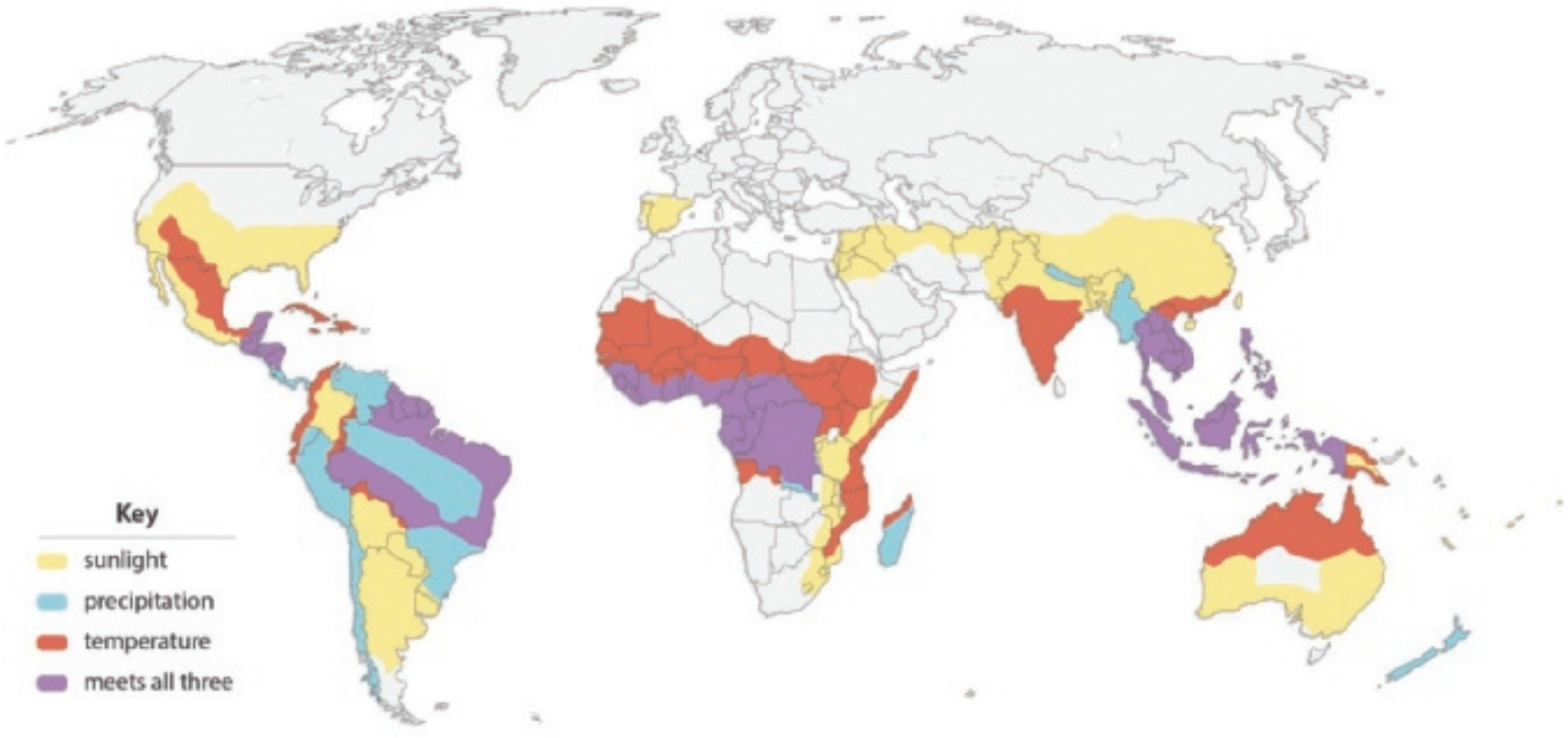
Canola grows in cooler regions. Canada and China are the largest producers of canola oil. Most canola is grown in Alberta, Saskatchewan, and Manitoba. Producing 1 ton of canola oil requires 1.25 hectares of land (just over 2 football fields). To make space for canola farms, large areas of shortgrass prairies have been changed for farming. The shortgrass prairie is an ecosystem that includes many types of grasses, flowering plants, shrubs, and trees.



There are very few shortgrass prairies left. Prairies once provided large habitats for bison, prairie dog, hawk, and butterfly populations in the United States and Canada.

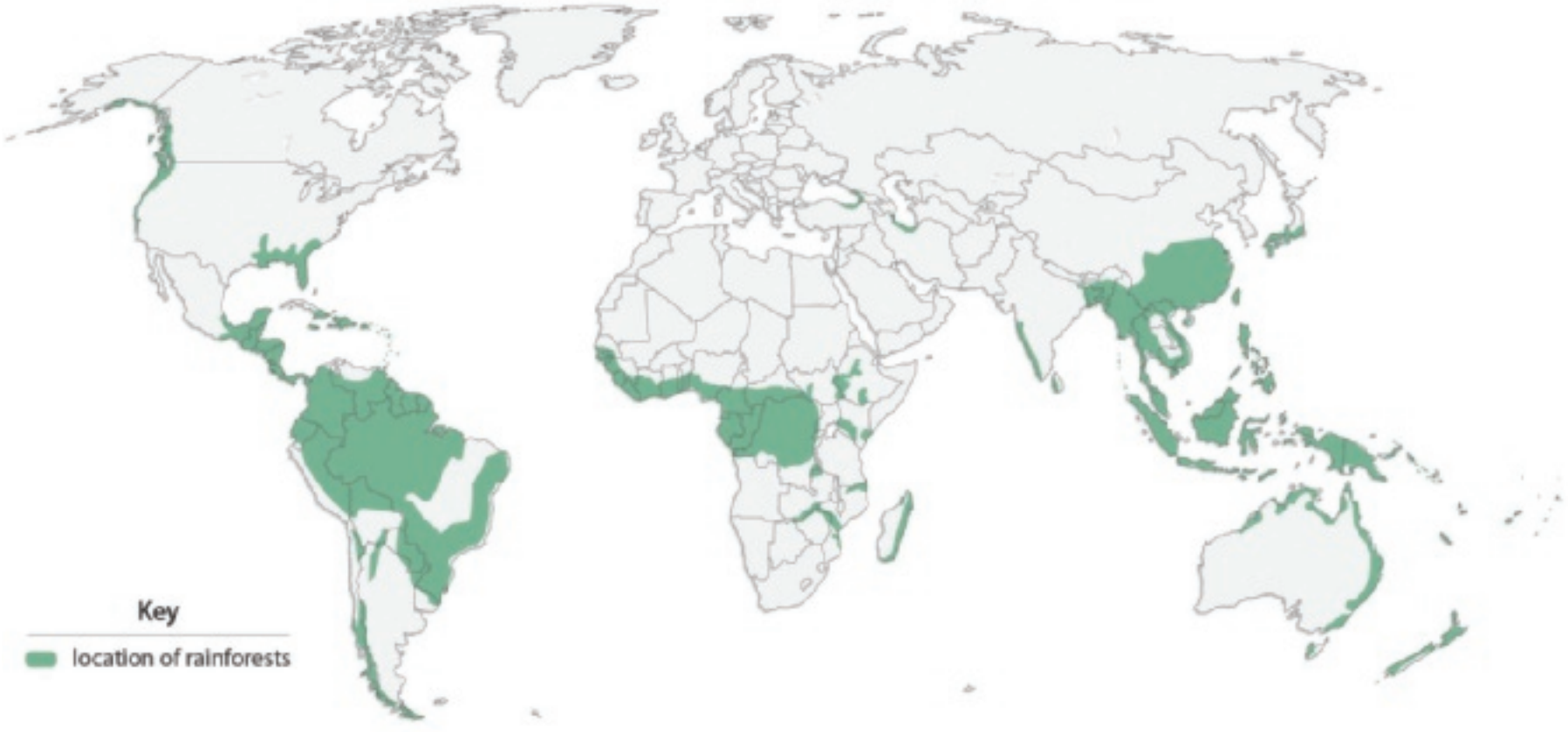
Shortgrass prairies	Canola farms
	

C1: Conditions to Grow Oil Palm Plants



C2: Conditions to Grow Oil Palm Plants

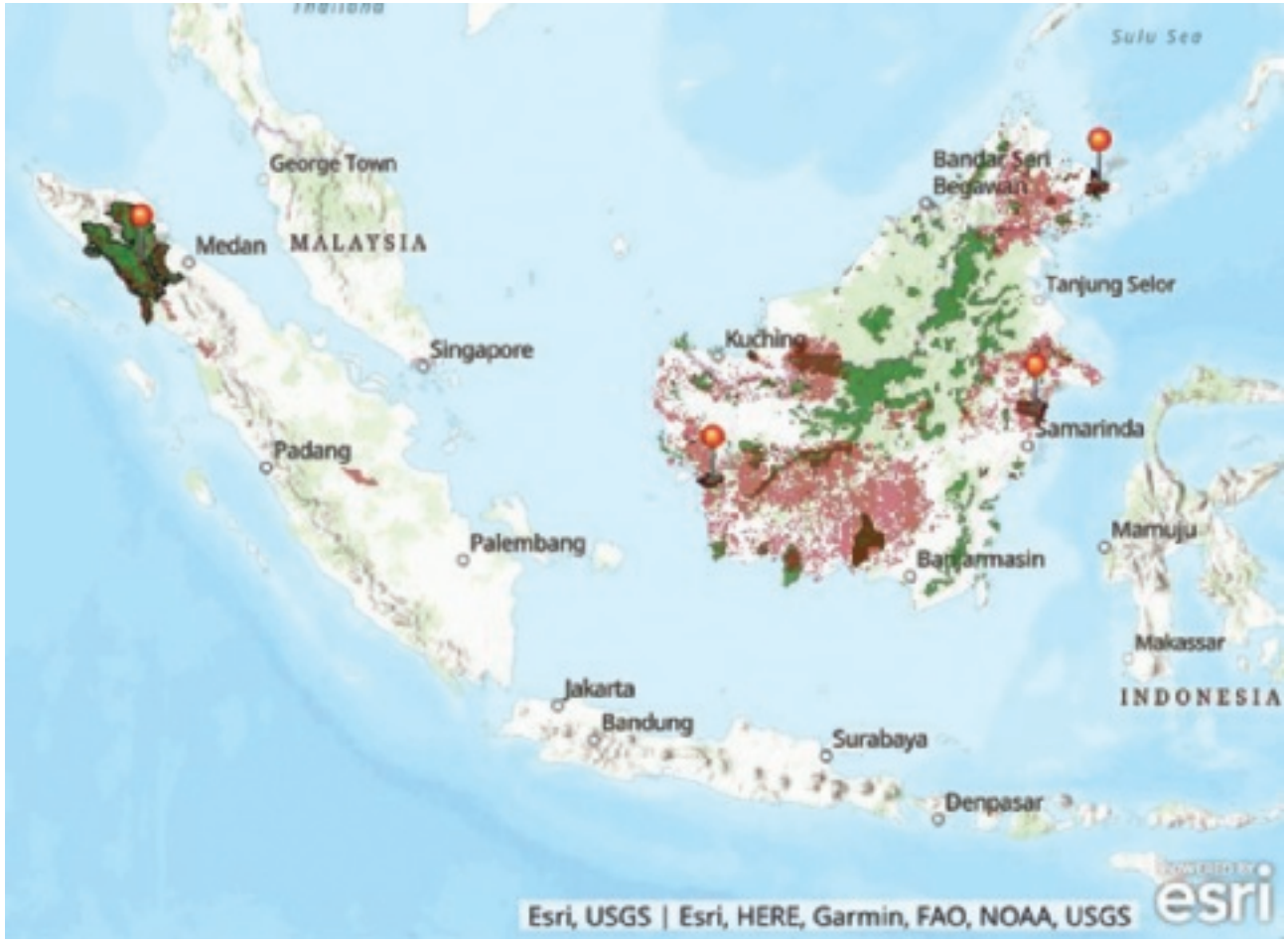
C: Location of Tropical Rainforests



Map of Protected Areas and Orangutan Distribution

The dark green areas on this map are protected areas in Borneo and northern Sumatra, including wildlife reserves and national parks. Protected areas like these have policies that limit the amount of tropical rainforest that can be converted for use in agriculture or development.	The pink areas show where orangutan populations live, from a data source in 2014. Orangutans prefer high-quality tropical rainforest habitats, but they can live in areas that are disturbed or not protected.
	

This map shows the overlap between protected areas (dark green) and where orangutans live (pink). Areas in brown are places of overlap. National parks and wildlife reserves are important sanctuaries in which some of the largest numbers of orangutans live. You can explore four specific protected areas where there is overlap in this StoryMap. These areas have red pins: the Leuser Ecosystem, Gunung Palung National Park, Kutai National Park, and Tabin Wildlife Reserve.



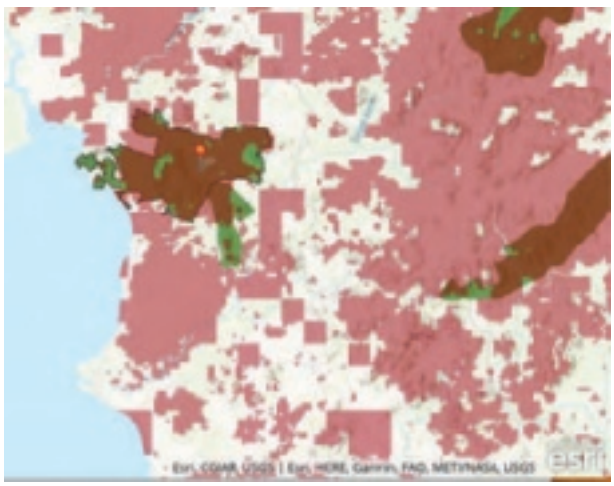
Orangutans in Four Protected Areas in Indonesia

Leuser Ecosystem

The Leuser Ecosystem is located in northern Sumatra and has the largest number of orangutans on the island. The Leuser Ecosystem has approximately 7,000 km^2 of habitat for orangutans. Scientists have documented the number of orangutans in the Leuser Ecosystem at 4 different points in time over the past 25 years.

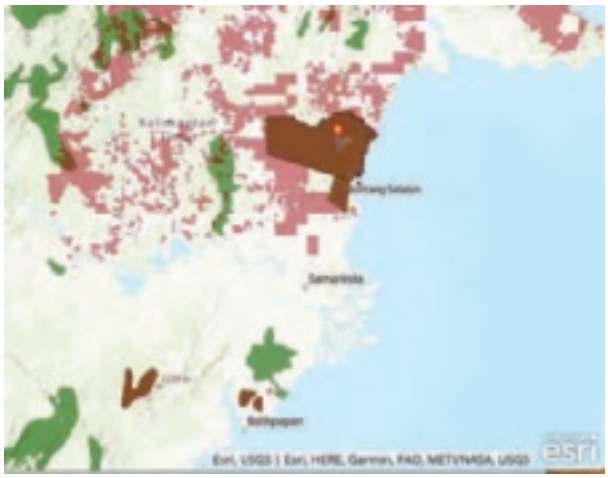
Gunung Palung National Park

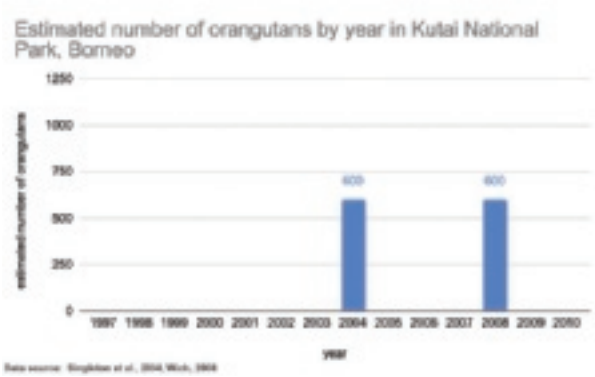
Gunung Palung National Park is a protected area in Borneo where orangutans live. It has approximately 1080 km^2 of orangutan habitat. Scientists have documented the number of orangutans in the Gunung Palung National Park at 4 different points in time over the past 25 years.



Kutai National Park

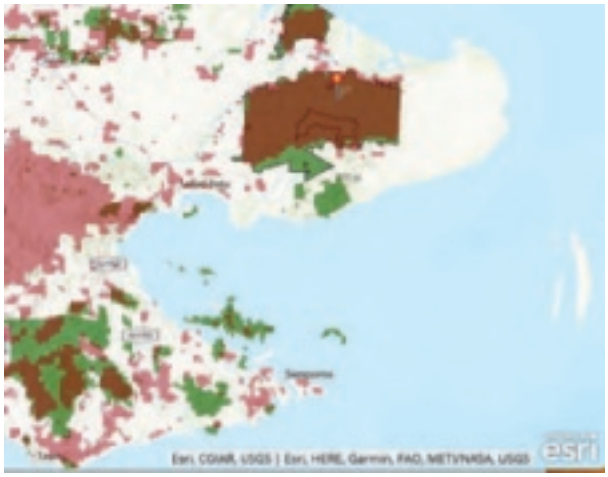
Kutai National Park is on the east side of Borneo. It has approximately 750 km^2 of orangutan habitat. Scientists have documented the number of orangutans in the Kutai Palung National Park at 2 different points in time over the past 25 years.

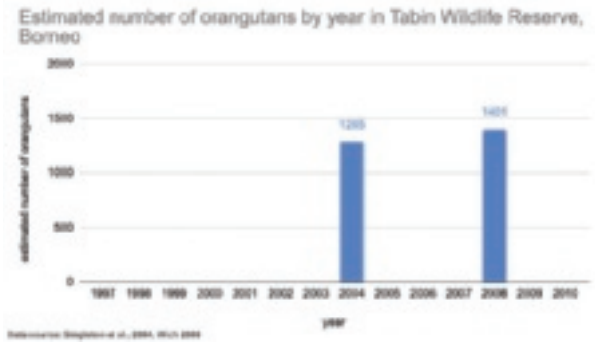




Tabin Wildlife Reserve

The Tabin Wildlife Reserve is located in Sabah and has approximately 1,100 km^2 of orangutan habitat. Scientists have documented the number of orangutans in the Tabin Wildlife Reserve at 2 different points in time over the past 25 years.





Oil Palm Farm Plants and Animals

Plants in the Oil Palm Farm

The palm farm mostly includes the oil palm plant. There is grass that grows between the oil palm plants.

Oil Palm Plant

Oil palm plants grow into tall trees. They start producing palm kernels after 4 years and continue producing for about 25 years. The oil palm kernel is an important food source for insects, rats, and wild pigs and boars. It is also an important food and fuel source for humans.

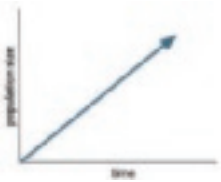
Grass

Grass grows between the oil palm plants. The grass can provide protection for snakes to stalk their prey.

Animals in the Oil Palm Farm

Rats

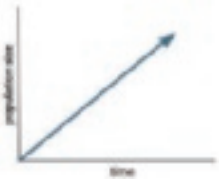
Oil palm farms are ideal places for rats to find palm kernels that have fallen to the ground. Rats also eat insects found in oil palm trees. They make their homes in the oil palm plants. Farmers protect their crops by killing rats. Rats' natural predators are snakes.



Rat populations are increasing a lot in oil palm farms.

Insects (example: Termites)

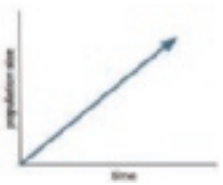
Many kinds of insects are found in oil palm farms. They feast on the oil palm kernels and the bark of trees. Insects make a tasty treat for rats, wild pigs, and boar. Farmers spray their crops to kill insects because they are considered pests and destroy the crop.



Some insect populations continue to increase in the oil palm farms even with predators and chemical sprays.

Wild Pigs and Boars

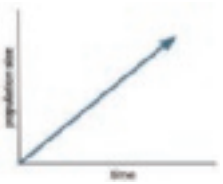
Wild pigs and boars dig in the dirt for their food. They love to eat insects they find in the soil and the oil palm kernels that have fallen to the ground. Large snakes can kill wild pigs and boar and farmers and villagers hunt them for food or to keep them from destroying crops.



Even though they are hunted, wild pig and boar populations are increasing a little in the oil palm farms.

Snakes (example: Python, Cobra)

Large reticulated pythons and cobras live in the oil palm farms. They hide in the trees and grass to stalk their prey. They eat rats, wild pigs, and boars. Oil palm farmers must be careful when they harvest the kernels. When farmers find snakes, they kill them.



Snake populations are increasing a lot in oil palm farms.

Rainforest Plants and Animals

Plants of the Tropical Rainforest

There are thousands of types of plants found in tropical rainforests. These plants create different layers. Some plants grow near the ground. Other plants form the canopy, and the tallest trees can be as high as 300 feet from the ground. Each kind of plant serves a different purpose in the ecosystem.

Tallest Layer

The tallest tree layer consists of very large and tall trees in the tropical rainforest. The trees can be 300 feet tall with trunks that are 10-30 feet thick. Tall trees mostly support bird and insect populations.

Canopy Layer

Beneath the very tallest layer is the canopy layer. The canopy layer is made from very large trees that can be 150 feet tall. Canopy trees provide shelter for birds, snakes, apes, and insects. These animals swing, jump, glide, and hop between the gaps in the trees. Canopy trees also provide food resources, such as fruits, for many rainforest animals.

Understory Layer

The understory layer is made of mostly smaller trees, low-lying shrubs, ferns, and climbing plants that do not get much taller than 15 feet. Understory plants provide shelter for snakes, insects, lizards, frogs, and some large mammals. Mammals, like clouded leopards, hide in this layer looking for food. The understory also has fruit trees, flowering plants, and house insects that provide food for many populations.

Fruit Trees

Fruit trees are found in the canopy and understory layers. Fruit trees are widely spaced in the rainforest ecosystem. Fruit trees provide food for birds, like the hornbill. Orangutans and sun bears also eat fruit, along with insects and butterflies. When fruit falls to the forest floor, rats and pigs feast on it.

Floor Layer

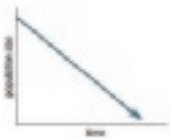
The forest floor is dark and moist. This layer is made of moss, ferns, and low-lying plants. Animals that live on the floor layer are the largest in the tropical rainforest. These animals include tigers, cloud leopards, sun bears, elephants, pigs, and deer. The forest floor is also home to frogs, lizards, insects, and rat populations. Mushrooms and fungi live here, too.

Plant and Insect Eaters of the Tropical Rainforest

Birds (example: Hornbills)

Hornbills live and eat in the canopy and tallest trees of the tropical rainforest. They eat from trees with smaller fruits, like figs. They also eat insects. Their main threat is humans, who kill the hornbills for their "ivory" beaks.

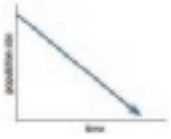
Hornbill populations are decreasing.



Sun Bear

Sun bears roam the forest understory and floor searching for fruits and insects. They also eat other seeds and nuts. The sun bears' main threat is humans if the sun bears eat crops. They can also be killed by tigers and large pythons.

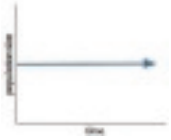
Sun bear populations are decreasing.



Wild Pigs and Boars

Wild pigs and boars roam the forest floor, digging in the dirt for insects, roots, and fruits that have fallen from trees. Their main predators are humans, tigers, clouded leopards, and snakes.

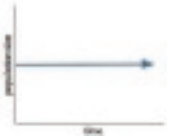
Wild pig and boar populations are staying about the same.



Rats

Rats live throughout the understory and forest floor of tropical rainforests that have been logged of the largest trees. Rats eat fruits and insects. They are eaten by snakes, clouded leopards, tigers, and larger birds like owls and eagles.

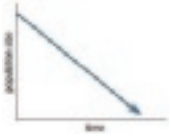
Rat populations are staying the same in the protected tropical rainforests but increasing in areas that have been logged.



Orangutans

Orangutans live and eat in the canopy. They primarily eat fruits and are one of the few animals that can eat large, hard-sided fruits. They feast on insects when fruits are not available. Their main predators are tigers and large snakes, but they are also killed or captured by humans.

Orangutan populations are decreasing.



Plant Eaters of the Tropical Rainforest

Deer (example: Sambar Deer)

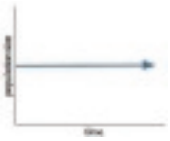
Deer roam the understory of the tropical rainforest and use shrubs for protection. They eat grass and other plants, as well as fruits. Their predators are tigers and humans. Small deer are killed by snakes and clouded leopards, too.

Deer populations are staying the same.

Insects (example: Termites)

Insects live throughout the trees and forest floor. They eat fruits, wood, and the leaves of plants. They are a food source for hornbills, sun bears, orangutans, rats, and wild pigs and boars.

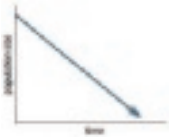
Some insect populations, like termites, are staying the same. Some populations are decreasing.



Elephant (example: Sumatran and Bornean Elephant)

Elephants live throughout the understory and eat fallen fruits, flowers, leaves, bark, and roots. Humans are their main threat.

Elephant populations are decreasing.

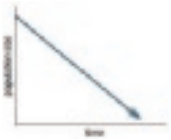


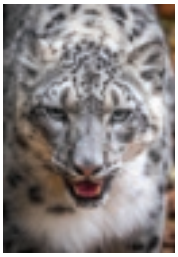
Predators of the Tropical Rainforest

Sumatran Tiger

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

Tiger populations are decreasing.

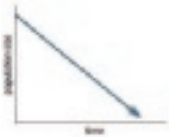




Clouded Leopard

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

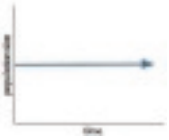
Leopard populations are decreasing.



Snakes (example: Python, Cobra)

Snakes can be found throughout the trees. They like to hide in dense shrubs or near water. Snakes eat rats, wild pigs and boars. They can also eat small orangutans, bears, leopards, and deer. Humans kill snakes if the snakes pose a threat.

Snake populations are staying the same.



Interview with a Scientist Studying Orangutans

Dr. Andrea Blackburn

How did you become interested in orangutans?

I have always been interested in wildlife and animal behavior. In college, I became interested specifically in studying primates after taking courses on primates and their ecology. I was able to go on a research trip to a field station in Costa Rica, where I was able to observe monkeys in the wild. After these experiences, I wanted to learn more about wild primates. I pursued research opportunities, and this led me to the orangutans in Indonesia.

Dr. Andrea Blackburn

What do you study about orangutans?

I study how orangutans spread, or disperse, seeds around the tropical rainforest. **Seed dispersal** is the movement of seeds away from the original parent plant to a new location. Plants have different strategies for dispersing their seeds, including wind, gravity, water, and animals. Animals spread seeds in several ways: seeds can catch on the animals' fur; animals may move seeds by knocking them loose; or animals may eat a fruit, swallow its seeds, and later defecate (or poop) the seeds in a new location. By spreading seeds in the tropical rainforest, animals can "plant" seeds to grow new fruit trees in new locations.

Orangutans have powerful jaws and have been labeled as "seed predators." This means they can chew and digest seeds. However, my research is testing an alternate hypothesis. I predicted that orangutans are also swallowing seeds intact and dispersing these seeds throughout the tropical rainforest when they defecate (poop).

What are your research questions?

Orangutans love to eat fruit, and how orangutans eat different fruits is one of my main research questions. Orangutans do not eat all fruits in the same way. Sometimes the orangutan chews the seeds and destroys them. Other times, the orangutan eats the pulp part of the fruit but spits the seeds out. Finally, sometimes the orangutan swallows the whole seed and the seed passes through the orangutan's digestive system and is pooped out. I am interested in which seeds orangutans destroy, which they spit out, and which seeds pass through their digestion and are pooped out. I am also interested in what happens to the seeds then, and if they germinate and grow into new seedlings.

How do you collect your data?

I get up very early in the morning so that I can arrive at the orangutan's nest before they wake up. I then follow the orangutan throughout the day. When the orangutan decides to eat in a fruit tree, I use my binoculars to carefully watch how the orangutan eats the fruit. During the day, when the orangutan poops I help collect the feces for analysis in the lab. I am interested in knowing which types of seeds, and how many, are intact in the feces. I then collect the seeds from the feces and try to grow them in a controlled environment.

You don't do this work alone. Can you tell us more about how the team works together to research orangutans?

Excitingly, I was able to do my research alongside Ahmad Rizal, an undergraduate student from Jakarta, who is also interested in understanding the ecological role of orangutans as seed dispersers.

The large research team at Gunung Palung Orangutan Conservation Program is incredibly important to the scientific study of orangutans. With a large team of people, we can study multiple orangutans in the tropical rainforest at the same time. Our research team is composed of students, volunteers, field staff and technicians, and researchers. Our research team is also important for entering and organizing data, identifying plant samples, sieving the fecal samples for seeds, and many other important jobs!

Gunung Palung Orangutan Conservation Program (GPOCP)

Gunung Palung Orangutan Conservation Program Research Team, Dr. Andrea Blackburn (back row, third from right) and Ahmad Rizal (back row, far right).

Sample Data from Dr. Andrea Blackburn's Research

Andrea's Main Research Questions:

- What role do orangutans play in their ecosystem?
- What happens to the seeds from plants that orangutans eat?

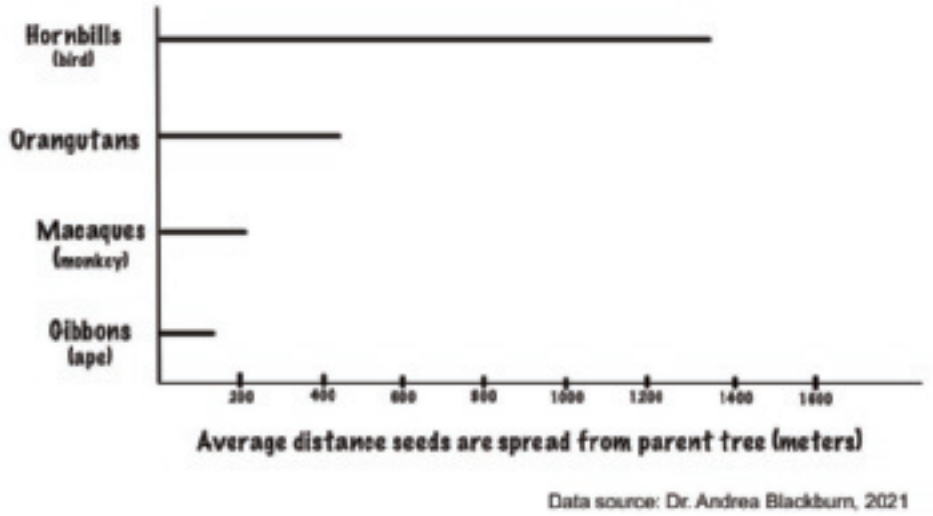
What do orangutans do with the different kinds of seeds they eat?

Types of seeds	What they do with them
Nuts, legumes	Eat and digest for energy
Drupes, which are fruits with a single seed in the middle	Spit out
Berries	Swallow and defecate (poop)

Image of a fecal (poop) sample	Image of a spit sample
	
Cayce from Malaysia, CC BY-2.0	Dr. Andrea Blackburn
	Seeds are usually not spat out in clumps like this; instead, they are more widely scattered.

How far do orangutans spread seeds in the tropical rainforest?

On average, orangutans spread seeds about 450-600 meters from the "parent plant" where they ate the seed. Orangutans can spread seeds far distances by swallowing them and then defecating them in a new location. Orangutans can spread seeds as far as 2,200 meters (2.2 km) or more. The fecal sample data on the next page were collected by following the orangutans in the canopy until they defecated.



Data source: Dr. Andrea Blackburn, 2021

Fecal Sample Data

Picture of a fecal sample before cleaning	Information about how it is cleaned
 Dr. Andrea Blackburn	70% of fecal samples contain whole seeds. Here's an example of an orangutan fecal sample before we "sieved it" with water to wash away all the fecal material so that just the seeds remain. By sieving the samples, it becomes much easier to identify and count any seeds. Fecal samples can also be used to collect other data about orangutan digestion or genetics.

Photo of seeds in a fecal sample after cleaning

Gunung Palung Orangutan Conservation Program (GPOCP)

Gunung Palung Orangutan Conservation Program (GPOCP)

Gunung Palung Orangutan Conservation Program (GPOCP)

Do seeds that orangutans spit out or defecate grow?

Andrea planted the seeds she collected to see if they would grow into young plants. She collected 3 kinds of seeds:

- Seeds that fell to the forest floor. These were control seeds. For half of the seeds, she kept the surrounding pulp. For the other half, she removed the pulp.
- Seeds spit out by orangutans. When orangutans spit out the seeds, Andrea collected the seeds from the ground.
- Seeds defecated by orangutans. When orangutans defecated, Andrea collected the fecal sample.

Dr. Andrea Blackburn

She planted these seeds in containers and watched to see how often a young plant grew. The chart shows the percentage of instances where a plant grew from the seeds she planted.

Fruit tree	Control seeds that fell to the forest floor Lower end: pulp left on Higher end: pulp removed	Seeds that orangutans spit out	Seeds that orangutans defecated
Alangium	10-47%	17%	70%
Nephelium	19-82%	68%	87%
Xanthophyllum	2-32%	64%	81%
Willughbeia	68-91%	43%	96%

What other interesting things have you observed?

In the tropical rainforest, dung beetles roll the orangutan feces into balls in order to move it. They then bury it, which means they're burying the seeds, too. So, at first, the seeds are dispersed by orangutans. Then, dung beetles help "disperse" and "plant" them in the soil.

Diversified Farming Cases

How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?

The picture to the right shows a field where a farmer grows food using **intercropping**. The field contains a mix of grains, rye, and oats. Intercropping is a way to grow food that mixes two or more crops on the same area of farmland. This is sometimes called "diversified farming" because there is more than one crop grown.

Field of mixed grains-rye-oats

Case 1: Diversified farming in Costa Rica with palm oil

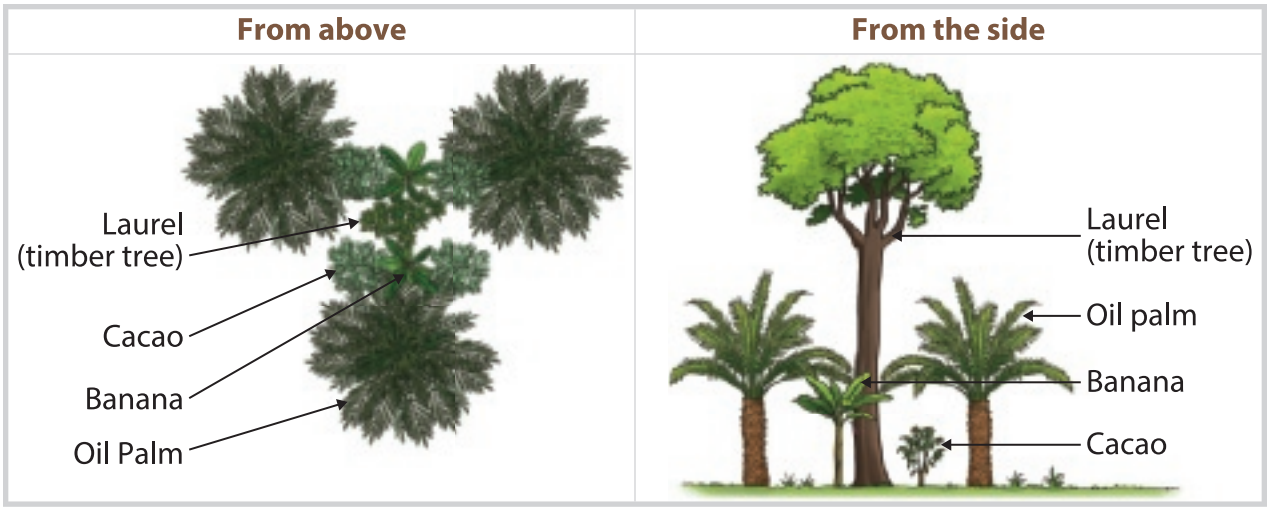
Dr. Rodolfo Dirzo and his team work with palm oil farmers in Costa Rica to practice intercropping. When they intercrop, they mix other kinds of crops with the oil palm plants. They explain why they use diversified farming to grow oil palm with other crops.

oil palms and bananas intercropping

Farmers in Costa Rica have noticed a fungus that causes oil palm trees to die. Farmers are worried about the money they have invested in their oil palm crops. Also, the price of palm oil in international practices has started to decline. This means farmers will make less money from their crops. With farmers, we came up with solutions to these problems. We decided to grow cacao trees for their cocoa beans and banana trees. If the price of palm oil declines dramatically or the fungus devastates the oil palm trees, then farmers would have bananas and cocoa beans to sell. Some farmers also grow timber trees.

We found that bees, which are important pollinators, is higher in diversified oil palm plantations than in monocrops. This is important because bees pollinate many plants, including plants that people eat. When there are large fields growing only oil palm, then there are no flowers for the bees to pollinate.

Dr. Rodolfo Dirzo



Dirzo Lab, LAPA

Case 2: Diversified farming in North Dakota with other crops

Gabe Brown took over his family's small farm in North Dakota in 1991. When he started farming, he tilled his land every year. Tilling breaks up the soil and can cause soil erosion. He also planted the same type of plants every year, which can decrease the nutrients in the soil unless fertilizers are added.

Gabe Brown on his farm in North Dakota
Gabe Brown

Then, in 1995 and 1996, major storms in North Dakota destroyed his crops. This meant that for two years in a row, Mr. Brown could not sell the food he grew on his farm. Selling his crops was a major source of his family's income. A couple years later, a storm destroyed his crops for a third time! That is when Mr. Brown decided that he needed to change how he grew his food.

Mr. Brown decided to grow more than one crop in the same area. He found that when he grew radishes and turnips together in a field, he ended up growing more food than when he planted them separately! Turnips repel bugs that like to eat radishes. Radishes provide nutrients to the soil that turnips use to grow. Farmers can also plant peas and canola together. Pea plants provide nutrients to the soil that canola plants use to grow. Canola plants act like a trellis that holds pea plants off the ground.

By growing different types of crops together, Mr. Brown increased the amount he produced to sell and also improved the soil on his land. He also didn't need to spray as much pesticide to kill insects eating his crops. Now, Mr. Brown travels around the United States and talks to small family farmers about the dangers of **monocropping** (only growing one type of crop) and the benefits from intercropping. Farmers like Mr. Brown who intercrop instead of monocrop are more protected if a problem arises. For example, if one type of plant does not grow well because of a disease, pests, hot or cold temperatures, or too little or too much rain, another crop often does grow well and can be sold to make money.

Questions to discuss:

- How are the things that Dr. Dirzo is doing in Costa Rica similar to what Mr. Brown is doing in North Dakota?
- How are the two farming methods different?
- What do farmers get from using these methods? Why would farmers do these things?

Sources:

- Case 1: Diversified Oil Palm farming in Costa Rica, Dr. Rodolfo Dirzo, personal communication, August 24, 2021
- Case 2: Diversified Farming in North Dakota, "How Did Farmer Brown Bring His Dying Land Back from the Brink?" Retrieved June 16, 2021 from https://www.nrdc.org/onearth/how-did-farmer-brown-bring-his-dying-land-back-brink
- "Brown's Ranch: Regenerating Landscapes for a Sustainable Future," Retrieved June 16, 2021 from http://brownsranch.us/cropping/

Sustainable Palm and Prairie Strip Cases

How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?

The picture to the right shows a sustainable oil palm illustration. Many kinds of farming place pressure on resources and the environment. **Sustainable farming** is a solution some farmers use to protect the environment and resources and still make a living from farming. Sustainable farming often includes setting aside some areas of the land (15–20%) for the natural environment and plants that grew on that land before the farm was there. It can also involve protecting soil and water and using less chemicals, as well as protecting the workers on the farm.

Case 1: Protecting forests with sustainable palm oil

You learned that large-scale farms and small family farms can get certified as sustainable palm oil. There is a group called Roundtable on Sustainable Palm Oil (or RSPO) who provides this certification. Read the quote below about how RSPO certification helps large and small farmers:

The RSPO certification brings immediate environmental benefits, such as the reduction in the use of chemicals and protection of valuable ecosystems. At the same time, RSPO farming methods enable farmers to produce higher yields (more crops), increasing their profits, which in turn means they don't have to expand their plantations into pristine forests.

Large-scale companies and small family farmers who practice sustainable oil palm farming receive benefits, such as:

- They can sell their product for a higher price.
- They can grow more oil palm plants and increase crop production on less land.
- They spend less money on chemicals to grow the plants.
- They have less chemicals getting into their water sources, so they have more access to clean, fresh water.

Case 2: Protecting prairie with more sustainable corn and soybean farming

Farmers and scientists are studying a new method of farming soybeans and corn. Instead of growing only soybeans or only corn on all of their land, some farmers grow native prairie plants on 10-20% of the land. They call these areas "prairie strips." Prairie strips are a way that farmers can attract pollinators like bees and butterflies to their land and also protect the land from flooding. Scientists and farmers have found that farmland with prairie strips still produces the same amount of soybean and corn crops even though slightly less land is being used to grow the crops.

Darwin Pierce is a farm manager who uses prairie strips. Read about why:

My goals in using the prairie strips were to primarily improve water quality and reduce soil erosion. I think that more landowners will be interested if we can figure out the money benefits of prairie strips. On the farm where we put the strips project we increased our productiveness of the farm.

Maggie McQuown owns a small family farm in Montgomery County, Iowa. In 2014, Mrs. McQuown planted prairie strips on her farm. She chose to grow prairie strips when she noticed that some areas of her farm were flooding after large storms. The flooding also caused soil erosion. She tells us why she decided to plant native prairie plants between her fields, and how it helps her farm:

Heavy equipment packs soil down and we want soil to absorb water. Another real interest is wildlife habitat and natural biodiversity. I'm worried about the bees. When I was young we thought milkweeds were bad. Now I love the milkweeds. I pamper the milkweeds so the monarchs can live. There's only a certain number of natural resources. We've abused them enough, so we really need to preserve the resources that are here.

For Maggie McQuown and Darwin Pierce, making sure that water is able to move into the soil for use by plants is important. If soil is too hard, flooding can occur and cause soil erosion. Flooding can also hurt crops, and mud can be hard for tractors to move through. Prairie strips help reduce problems caused by too much rain or hard soil. Another benefit described by Maggie McQuown is preserving resources, including biodiversity. Prairie strips help attract wildlife including birds and pollinating insects.

Questions to discuss:

- How is sustainable palm farming similar to using prairie strips?
- How are the two farming methods different?
- What do farmers get from using these methods? Why would farmers do these things?

Sources:

- Roundtable on Sustainable Palm oil: https://rspo.org/about#about-sustainable-palm-oil
- STRIPS at Iowa State University: https://www.nrem.iastate.edu/research/STRIPS/
- Darwin Pierce - Farm Manager Testimonial located at https://www.nrem.iastate.edu/research/STRIPS/testimonials/darwin-pierce-farm-manager
- Maggie McQuown - STRIPS the Movie Outtakes: Preserving a Family Legacy https://vimeo.com/118500641

Customary Forests

How can people benefit from growing food in ways that support plants and animals in the natural ecosystem?

Some people who live in Indonesia do not want to be part of the palm oil industry. They want to protect the forests. They also need to make money and have food for their families. They can do this by applying to the government for a **customary forest** permit. This allows them to farm and harvest foods and other materials in the tropical rainforest near their village. In the United States, Indigenous peoples also farm and harvest foods in forests on tribal lands. As in customary forests, this is done to protect the environment and to provide economic benefits to communities.

Case 1: Customary forest of Laman Satong

The people who live in Laman Satong, Indonesia, did not want the tropical rainforest near their village cut down. In 2011, after many years of trying to save their nearby rainforest, the village received a Customary Forest permit. The permit allows them to manage and use a large area of forest. Some village farmers have small oil palm farms next to the customary forest, but the permit means they can no longer cut down native trees to grow new oil palm. Hear from Viktor Sriyanto, the village head of Laman Satong:

The community applied for a village forest permit because we realized the forest is important for our livelihoods. Oil palm plantations and the village forest can exist side by side. People are aware of the benefits of the village forest, such as clean water and the protection against floods and landslides, and people can enjoy the clean and fresh environment. If the forest is healthy, the community will be strong, mentally, morally, and physically.

Viktor Sriyanto, Village Head
Source: Tropenbos International,
"Village Forest and Oil Palm: Friend or Foe?"

Case 2: *Hutan desas* (village forests) near Gunung Palung National Park

Many villages surround Gunung Palung National Park. The park is home to 2,500 orangutans and is a protected forest for them. Much of the forest around the park has been cut down for oil palm plantations, but Edi Rahman and the Gunung Palung Orangutan Conservation Program are working with villages to stop deforestation. They are showing people how to earn income from harvesting **non-timber forest products**, instead of cutting down trees, or timber, to make money:

I am very proud that over the past 5 years GPOCP has initiated these 7 Customary Forests. In total, there are now 7,962 hectares (about 20,000 acres) of land, designated for management by local villages. These nontimber forest products provide an alternative to community economic income– if village members can rely on the use and sale of sustainable forest products, they are less likely to harmfully exploit other resources as a means of income. We have now formed 22 groups of

craftspeople, who have successfully earned income using forest products like rattan, nipa palm, coconuts and honey.

Edi Rahman, GPOCP Field Director
Source: Gunung Palung Orangutan Conservation Program,
"Building Community Participation to Conserve Orangutans and Their Forests: My 18 Years at Yayasan Palung"

Non-timber forest products

Honey	Crafts made from coconuts	Crafts made from grasses
		

Case 3: Forest farming in the United States


Making a longleaf pine needle basket USDA

Forest farming is when people grow local, high-value plants and other non-timber forest products within a forest. It requires actively managing the forest land and tending to plants. This sometimes includes using "cultural" or "prescribed" burns to clear brush or plants that should not be growing there. People who farm this way think about what they can grow on the ground and also vertically up into the forest canopy. These practices come from a long history of forest farming, or **agroforestry**, used by Indigenous peoples to sustainably harvest plants for food and other products. This practice has both cultural and economic value to people. Below are two examples:

Haudenosaunee (Iroquois Six Nations): People of the Mohawk Tribe of the Iroquois Six Nations are working with both New York State Department of Forestry and the US Fish and Wildlife Service to restore black ash trees for use in traditional basketry. Additionally, they harvest maple syrup from maple trees grown in an agroforestry context, as they have done for generations. Both the ash and maple trees were part of the Haudenosaunee agroforestry landscape that European colonists encountered when they came to America.

Karuk, Yurok, and Hoopa: In Northern California, the Karuk, Yurok, and Hoopa Tribes are using thinning and prescribed burns to manage tanoak and Douglas-fir dominated forests for acorns, huckleberries, mushrooms, hazelnuts, firewood, and beargrass for basketry. Their burns clear dense underbrush, making it easier to access and harvest these resources. These projects are being conducted on tribal lands, private, and adjacent public national forest lands. USDA National Agroforesty Center, *Agroforestry Notes*, 44, May 2014

Questions to discuss:

- How are Customary Forests in Indonesia similar to forest farming in the US?
- How are the two methods different?
- What do people get from using these methods? Why would they do these things?

Sources

- Gunung Palung Orangutan Conservation Program: https://savegporangutans.org/
- Tropenbos International: https://www.tropenbos.org/
- Tropenbos Indonesia: https://www.tropenbos-indonesia.org/
- USDA Agroforestry: https://www.usda.gov/topics/forestry/agroforestry

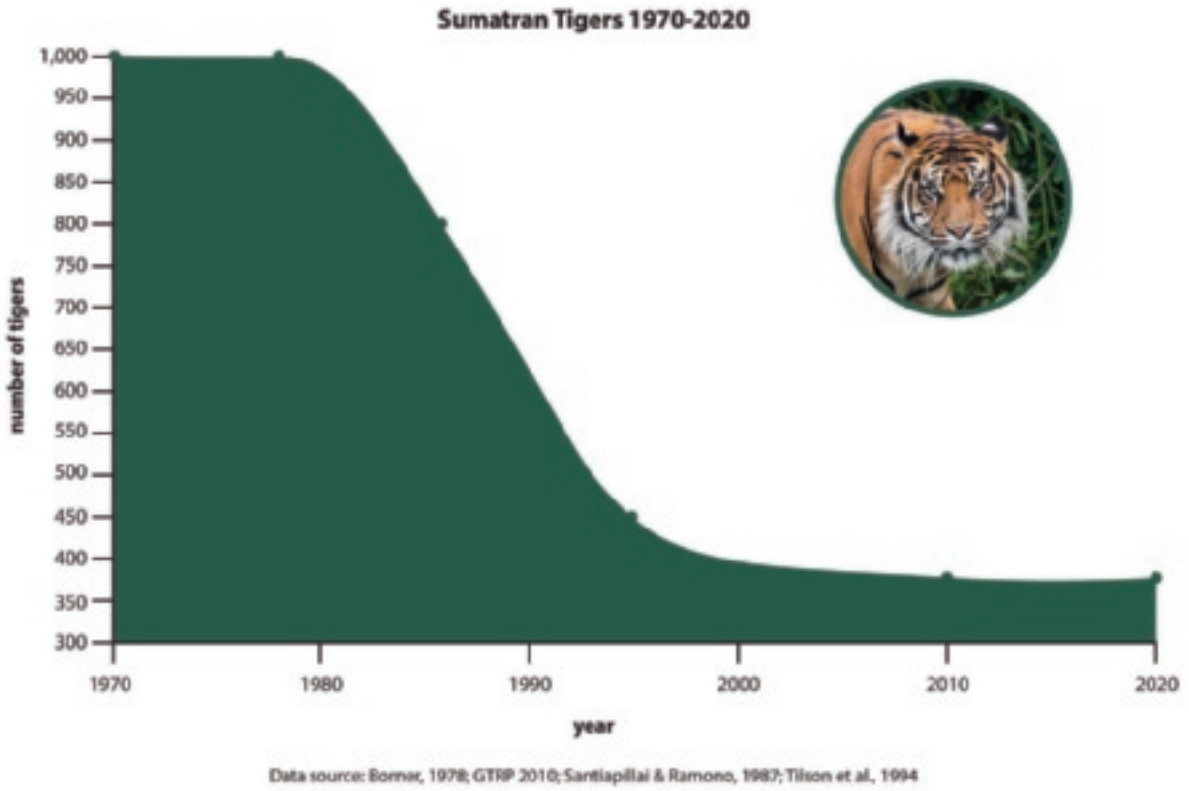
Reading: Growing Oil Palm in Indonesia

Palm oil comes from the fruit of oil palm trees. Oil palm trees are grown in warm areas near the equator. The palm oil we get from these trees can be used for cooking. It is also used in food products, detergents, and cosmetics. Palm oil is found in more than half of all packaged products that Americans consume, like lipstick, soaps, candy, and even ice cream. Many food and beauty products need oil as an ingredient to achieve the right consistency. Some of the original oils used in food and beauty products were bad for our health, so scientists were excited when they discovered palm oil as a replacement.

Oil palm trees produce a lot of palm oil and use less land compared to other types of plants that make oil. The demand for palm oil is increasing rapidly, so more land needs to be used to grow this plant. Producing 1 ton of palm oil requires .25 hectares of land (just under half of a football field). Indonesia is the largest producer of palm oil. Most of the Indonesian oil palms are grown on the islands of Borneo and Sumatra. To make space for large oil palm plantations, large areas of tropical rainforest trees and plants (for example, fig trees, tall trees, small bushes) have been cut down.

There is concern about orangutans and tigers, whose populations appear to be decreasing. Orangutans live high in the forest trees and eat fruits. Palm kernels are not a food source for orangutans.

Tigers hide in the brush to hunt their prey. Palm oil plantations do not have much brush. Indonesia has already lost two types of tigers to extinction: the Bali tiger and the Javan tiger. The only remaining tiger population is that of the Sumatran tiger. Scientists estimate that there are fewer than 500 Sumatran tigers remaining.

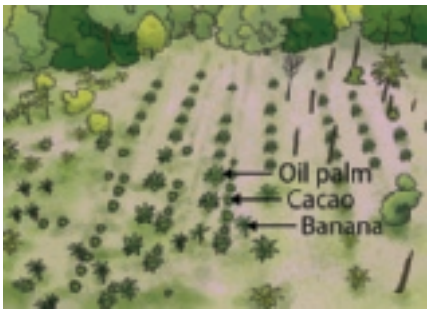


Even though some animal populations are decreasing in this area, other animal populations are thriving, such as local rats, pigs, and snakes.

Python	Rat
	

Reading: Diversified Farming in Costa Rica

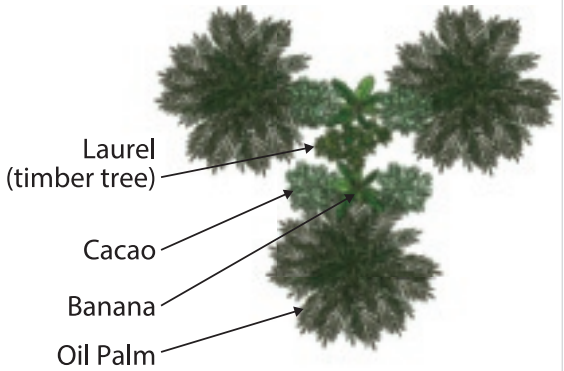
Diversified oil palm farming in Costa Rica

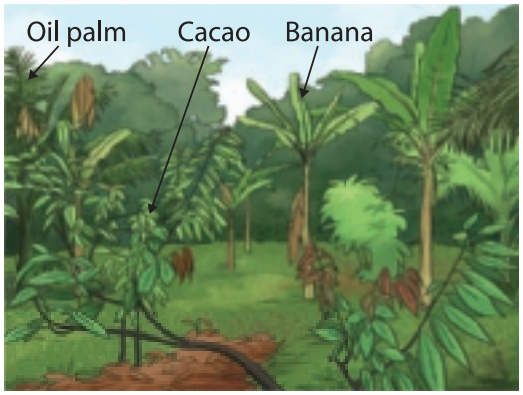


Rodolfo Dirzo is a professor at Stanford University. He and his team are working with oil palm farmers in Costa Rica. They are studying how to farm oil palm and support populations in ecosystems.

Unlike oil palm monocrop farms, they grow oil palm and three different kinds of trees together. Farmers grow laurel trees in the middle of the oil palms. After about 30 years, when the laurel trees are full-grown, farmers can cut them down and use them for timber. Around the laurel trees, the farmers grow bananas and cacao plants. These food crops grow quickly. They are ready to eat or sell within about 5 years. Oil palm trees take about 10 years to mature. Eventually their shade covers the banana and cacao trees. At this time, farmers rely on palm oil harvests for money. This type of farm is called a *diversified farm* because there are various species of trees growing together.

Diversified oil palm farm





Diversified farming is used around the world. Large or small farms can use this approach. Large farms need to plant in wider rows. This helps machines like tractors and planters drive through.

Diversified farming and populations in ecosystems

Rodolfo and his team are collecting biodiversity data at their diversified farm and a monocrop oil palm farm. They found that the diversified farm has fewer rodents, like rats, than the monocrop farm. They also found many more types of birds, bats, and beetles in the diversified farm. The birds and bats eat pests like caterpillars. The beetles eat dead plant material and return nutrients to the soil. Both farms produce the same amount of oil palm. This experiment is in progress and will last for 8 years.

Sources:

- Experimental Sustainable Palm Laboratory. (n.d.). Retrieved June 15, 2021, from https://inogo.stanford.edu/palm?language=en
- R. Dirzo, personal communication, November 21, 2019

Reading: Sustainable Palm Oil in Indonesia

Sustainable palm oil in Indonesia

Some large-scale farms and family farms get certified as sustainable palm oil. Their products have a label that says they used sustainable palm oil. Farms need to meet several criteria to get certified. This article highlights two of these criteria.

Not clearing new forests

The first criteria to get certified is to not clear any new forest for oil palm farms. People could only use land that was already cut down, or deforested, in the past. In Indonesia, farmers can decide to not cut down forests for farming. In Costa Rica, the government made a law in 1996 to stop the cutting down of forests without permission. No farmer can clear a forested area to plant crops.

Evidence from Costa Rica suggests that stopping deforestation will help populations in ecosystems. Since the new law, Costa Rica replanted about half of the deforested land. That land is now forest again. Plant and animal populations thrive because they have resources to meet their needs.

Growing areas of wildlife habitat on the farm

A second criterion for getting certified is protecting areas of wildlife habitat on the farm. Some farmers plant habitat plants on the edges of the farm. Others maintain habitat areas alongside rivers. Some farmers also plant wildlife habitat between fields. Farmers must keep 15-20% of the land as wildlife habitat to be a sustainable palm farm. Around the world, farmers grow areas of wildlife habitat on the farm. For example, some farmers in Iowa plant native prairie plants between their fields.

Growing areas of wildlife habitat on farms helps populations for four reasons. First, plants that grow there prevent wind and erosion. This helps the soil stay healthy for plants to grow and critters to live. Next, they provide a habitat for pollinators and birds. Third, they act like sponges to keep water, soil, and nutrients on the farm. This helps plants get the water and nutrients they need. Finally, they connect existing areas of forest. In Indonesia, this helps orangutans travel to areas of forests next to the farms. They don't come into conflict with farmers.

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- Ethics and Environmentalism: Costa Rica's Lesson. (December 27, 2011). Retrieved June 15, 2021, from https://unu.edu/publications/articles/ethics-and-environmentalism-costa-ricas-lesson.html
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Reading: Customary Forests in Indonesia

Customary Forests in Indonesia

The government owns the land in Indonesia. This means that individuals do not have the right to own land. Indigenous communities who traditionally cared for the land also cannot own land. The government can sell land to companies for large-scale monocrop oil palm farms. Small villages in Indonesia can apply for a Customary Forest permit to protect their village forests. The Customary Forest permit stops the government from selling the land to companies. It also prevents community members from cutting down the forest. People can use Customary Forests for forest farming.

Indonesian communities build Customary Forests. Gunung Palung Orangutan Conservation Program (GPOCP)

Forest farming

Forest farming involves people growing high-value crops in the forest. Example crops include maple syrup, honey, mushrooms, medicines, and plants for decoration or crafts. In Customary Forests, people take care of plants that grow in the forest. They harvest and sell them for food, medicine, and crafts. They also harvest food for their families and communities to eat. This way to grow food is new to science. However, it is very old. Taking care of plants in the forest is a way of life for Indigenous peoples. People need a deep knowledge of plants and animals to grow food in this way. For example, they need to know when and how much to harvest. They also need to know how to harvest so that plant and animal populations stay healthy for future generations. Today, Indigenous peoples who have rights to their lands continue to take care of plants in this way.

Customary forests provide materials to make crafts. Gunung Palung Orangutan Conservation Program (GPOCP)

Customary Forests and populations in ecosystems

Researchers from the Gunung Palung Orangutan Conservation Program, a nonprofit organization, are studying animal populations in Customary Forest near Gunung Palung National Park. They monitor animals in Customary Forests to learn if their populations are healthy. This includes counting orangutan nests. In 2018, they found evidence from counting nests that approximately 54 orangutans lived in the forest. This was an increase from only 16 orangutans the year before. There were many fruit trees in the Customary Forests that orangutans like to eat. This is more evidence that the forest is healthy for orangutans. They found evidence that other animals, like wild bees and bears, are also thriving.

One orangutan nest found during biodiversity survey. Mike Prince, CC BY-2.0

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