Modeling Food Webs in Darién, Panama

hhmi | BioInteractive

Activity
Educator Materials

OVERVIEW

This hands-on activity supports the WildCam Darién citizen science website (http://www.wildcamdarien.org). Students will identify producers and consumers in the tropical forest ecosystem of Darién National Park in Panama. Using a set of "Darién cards," they will then create a food chain to show the flow of energy in that system, introduce an ecological force or disturbance (e.g., logging), and predict how that force would impact energy flow. Lastly, students will construct a more complex model of the flow of energy by depicting multiple relationships in a food web and again make a prediction about the impact of introducing an ecological force.

KEY CONCEPTS

- All organisms need energy to survive that they obtain from their environment, including by eating other organisms.
- Ecosystems are dynamic, experiencing shifts in population composition and abundance and changes in the physical environment over time, which affect stability and resilience of the entire system.
- Ecological forces or disturbances can have natural or anthropogenic causes.
- An ecosystem can be represented by different types of models, each of which may have different strengths and drawbacks.

STUDENT LEARNING TARGETS

- Classify organisms based on their roles in the transfer of energy in an ecosystem.
- Create a model (e.g., a food chain) showing feeding relationships among organisms.
- Evaluate different models that depict relationships among organisms in a community.
- Predict how ecological forces or disturbances may impact models and justify claims with evidence.

CURRICULUM CONNECTIONS

Standards	Curriculum Connection
NGSS (2013)	MS-LS2-3, HS-LS2-4, HS-LS2-6
AP Bio (2015)	2.D.1, 2.D.3, 4.A.5, 4.A.6, SP1, SP2
IB Bio (2016)	4.1, 4.2, C.2, C.3
AP Env Sci (2013)	II.A, II.B, VII.C
IB Env Systems and Societies (2017)	2.2, 2.3
Common Core (2010)	ELA.RST.6-12.7, WHST.6-12.1, Math.7.RP
Vision and Change (2009)	CC5

KEY TERMS

carnivore, consumer, energy flow, herbivore, omnivore, primary consumer, producer, quaternary consumer, rule of 10 percent, secondary consumer, tertiary consumer

TIME REQUIREMENTS

- One to two 50-minute class periods

SUGGESTED AUDIENCE

- Middle school life sciences
- High school general biology and environmental science

PRIOR KNOWLEDGE

- Predators eat prey and that most organisms have multiple food sources.
- The sun is the primary source of energy for all but a few unique ecosystems. Light energy is converted to a more usable form of energy by plants, or primary producers.

MATERIALS

Each student will need:

- Student handout

Each group of students will need:

- One set of Darién cards
- Large paper (e.g., butcher or flip chart) and markers or pens (or white boards and markers) for indicating arrows for energy flow

TEACHING TIPS

- The Darién food web cards are offered in two formats. If you can print double-sided, then use that file and cut the cards accordingly. If you can only print single-sided, then use that file and cut and fold the cards so that they are double-sided with an image on one side and text on the other.
- Students often reverse the direction of the arrow to show that an animal is eating a plant or other animal rather than using the arrow to show the direction of energy flow. You might want to remind students of that relationship.
- If you would like students to make several food chains or webs, you might consider having them represent arrows on sticky notes for easy recombination. Or have students use white boards as a placemat so arrows can be drawn and erased quickly.
- You might also prompt a discussion of what regulates population sizes at different trophic levels. Populations of organisms at lower trophic levels are commonly regulated by predation, whereas organisms at higher trophic levels may be regulated by prey availability and/or may be more sensitive to habitat disruptions.

PROCEDURE

1. Give the student handout to each student.
2. Divide the students into working groups and provide each group with a complete set of Darién cards.
3. Students can work with their cards on tables, desks, or other workspace and record written answers on the handout provided.

ANSWER KEY

Part 1: Identifying relationships and creating a food chain.

(*For more advanced students, you may skip questions 1-5.*)

Sort the cards into two piles that represent producers and consumers.

1. How many producers do you have? ***4***
2. How many consumers do you have? ***14***
3. A food chain is a model that identifies the feeding relationships and the flow of energy in an ecosystem. Select a producer and a consumer from your piles, then fill in the blanks below and select which model (A or B) correctly shows the flow of energy.

A. _____ (consumer) → _____ (producer)

or

B. _____ (producer) → _____ (consumer)

4. Justify why you chose A or B as the correct model.
   Students should choose B, which accurately shows that energy flows from producer to consumer. Their justification should include the reasoning that since consumers eat producers, energy flows from the producer to the consumer. Students' answers will vary depending on their particular choices. For example, students may write, "Tapirs (consumers) eat leaves and fruits from trees (producers), so energy flows from trees to tapirs."

5. Select four cards to create a food chain, starting with a producer. Label the trophic level of each organism in your food chain as follows: producer, primary consumer, secondary consumer, tertiary consumer. Record your food chain in the space below using species names and arrows.
   Answers will vary, but two possibilities are plant →insect →opossum →ocelot or plant →insect →coati →jaguar.

6. Ecosystems include both biotic (living) and abiotic (nonliving) components that can influence food chains. In this activity, the abiotic components are referred to as an ecological force or disturbance. Choose one of the disturbance cards, read the information provided, and then make a prediction about how it might impact the food chain you created above.
   Answers will vary. Example below is based on a food chain of plant →insect →opossum →ocelot.

Ecological Force (list the title)	Describe four ecosystem impacts noted on the card	Predict how these impacts would affect each trophic level
Seasonal Cycles	*New nutritious leaves and fruit reach their lowest abundance during the late rainy season.* *Leaf-eating insects and those that feed on fallen fruit may become less common.* *Animals may need to travel more, using precious energy to find food rather than for growth and reproduction.* *Animals may experience changes in the nutritional value of their food and the frequency of their eating. This could lead to hunger and weakness, making some animals more prone to diseases, parasites, and predators.*	*Tertiary consumer: Ocelots might actually have an easier time finding opossums to eat at first if they move more searching for food, but over time, if the opossum population dwindles, the ocelots might need to switch their prey or expand their hunting territory, using precious energy to hunt.* *Secondary consumer: Opossums might look for additional food sources or expand their foraging ranges to gather enough food. This could make them more prone to exposure to predators.* *Primary consumer: Insects that rely on green plants or fruit would face stiffer competition as nutritious plants become scarce. Their numbers may decrease.* *Producer: Plants might stop growing in the late rainy season because cloudy conditions don't provide enough light for growth.*

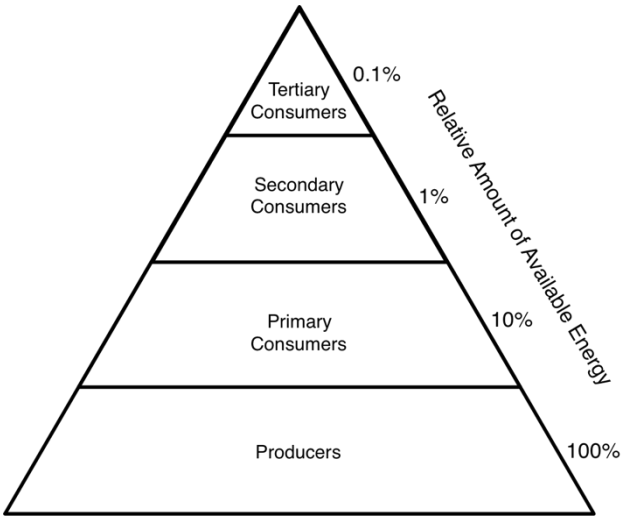
7. Not all disturbances have negative consequences for all trophic levels. In one or two sentences, describe a possible benefit that one trophic level in your food chain may gain from the disturbance you selected.
   Answers will vary but should be consistent with logic from each student's food chain.

Part 2: Quantifying energy flow and the rule of 10 percent

Three hundred trout are needed to support one man for a year. The trout, in turn, must consume 90,000 frogs, that must consume 27 million grasshoppers that live off of 1,000 tons of grass.
-- G. Tyler Miller, Jr., American Chemist (1971)

Only a small fraction of the energy available at any trophic level is transferred to the next trophic level. That fraction is estimated to be about 10 percent of the available energy. The other 90 percent of the energy is needed by organisms at that trophic level for living, growing, and reproducing.

This relationship is shown in the energy pyramid above. It suggests that for any food chain, the primary producer trophic level has the most energy and the top trophic level has the least.



8. Why is a pyramid an effective model for quantifying energy flow?
   The pyramid shape shows a hierarchy but also relative amounts at each level.

9. Place the organisms from your original food chain on the pyramid provided.

10. Using the rule of 10 percent in energy transfer, record the species names for each trophic level and the amount of energy available at that level if your producer level had 3,500,000 kilocalories of energy/area.
    Organisms filled in will vary, but amounts for each trophic level, starting at the bottom of the pyramid, should be 3,500,000 kilocalories, 350,000 kcal, 35,000 kcal, 3,500 kcal.

11. In one or two sentences, describe how the available energy may affect the population sizes of organisms at different trophic levels.
    Students should observe that since the energy available at each trophic level decreases, the populations of animals at higher trophic levels will be smaller than the populations at lower trophic levels. For example, many deer can support relatively few jaguars.

Part 3: Creating a food web

Food chains are simple models that show only a single set of energy-transfer relationships, but many organisms obtain energy from many different sources and in turn may provide energy to several different consumers. A food web illustrates all these interactions and is a more accurate model of how energy moves through an ecological community.

12. Starting with your original food chain, add another plant and four more animal cards to construct a food web that shows how energy flows from producers through primary consumers, secondary consumers, tertiary consumers, and possibly a quaternary consumer. When making your food web, you can have more than one arrow leading to and from each organism. Draw a version of your food web below.
    Answers will vary.

13. In one or two sentences, describe any patterns you notice in the relationships between trophic levels.
    Possible answers could include that the opossum has more prey species that provide energy to it than the ocelot, and the jaguar has even fewer. Insects provide energy to several species.

14. Now choose and read a different disturbance card and predict its impact on your food web. Complete the table below:

Ecological Force (list the title)	Describe four ecosystem impacts noted on the card	Predict how this impact would be seen in your food web
Cattle ranching	*Trees are removed that provide leaves and fruit as food for animals.* *There is less cover to provide hiding places from predators.* *Cattle compact the soil, preventing recovery of forest.* *Ranchers hunt animals for food and to prevent predation on their stock.*	*Tertiary consumers: Jaguars will have fewer natural prey to eat and may be forced to prey on livestock. Ranchers will hunt them and their numbers will decrease.* *Secondary consumers: Coatis and opossums will have less habitat and food, and their numbers may decrease. This could be counteracted if the number of tertiary consumers that prey on them decreases further.* *Primary consumers: Deer and tapirs will have less habitat and food. Fewer jaguars might permit their populations to increase, but hunting by ranchers could counteract that.* *Primary producers: Grasses and some plants that grow in open areas will increase, but most woody vegetation will decline.*

15. Describe whether some trophic levels benefit from the disturbance while others do not. If the disturbance was caused by humans, was it negative or positive for each trophic level in the food chain?
Answers will vary, but students should grasp that negative impacts at one trophic level might act as positive impacts on lower trophic levels. In ecology, this is called a trophic cascade.

Part 4: Model evaluation

In science, models are used to represent explanations and predications. The food chain, food web, and energy pyramid are all models that show feeding relationships and allow us to make predictions. Compare and contrast the strengths and weaknesses of each model by filling in the table below.

Model	List two things this model is useful for illustrating or predicting	Identify one feature that this model lacks or one that could lead to a misconception
Food chain	*Possible answers:* *1) Identifies levels and easy to see relationship* *2) Trophic levels easily identified*	*Does not show that animals eat more than one thing; very simple*
Energy pyramid	*Possible answers:* *1) Shows hierarchy of trophic levels* *2) Relative amount of energy or number of organisms is indicated by space of pyramid level for each trophic level*	*Does not show that animals eat more than one thing; very simple*
Food web	*Possible answers:* *1) Multiple feeding relationships depicted.*	*Trophic levels not as easily observed.*

	2) Consumers that are specialized (limited prey choices) versus more general consumers (multiple prey choices) can be depicted.	*The hierarchy shown in previous models might not be as easily maintained in a food web. Some prey might appear physically higher than their predator(s), making it look like it is a higher trophic level.*

16. Select the model that you think is most effective in representing relationships among organisms in the Darién ecosystem and justify your choice in two or three sentences.

One possible answer is that the food web best represents the relationships in Darién, as it allows for multiple prey species for the second- and third-level consumers. This is more realistic, as most carnivores eat more than one prey animal. Some carnivores might have a preferred prey species but will switch prey depending on conditions and availability.

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