WORLD OF DIFFERENCE

People and the Planet
Lessons for a Sustainable Future

INTRODUCTION

It is estimated that there may be as many as 9 million plant and animal species worldwide, although only 1.2 million have been named. Over half of all species make their homes in the **tropical rainforests** of Asia, Africa and Latin America.[1]

This variety of life not only adds to the beauty and richness of our planet, it is also critical to human health and survival for many reasons. People depend on other species for food, medicines, industrial products, and such "ecological services" as water purification, nutrient cycling, and pollination. The rate of **deforestation**, and therefore habitat loss, is now greatest in the tropical rainforests where people cut down almost 39 million acres (about the size of Georgia) each year.[2]

As human populations grow, we require more space for homes, roads, farmland, etc. There is also an increasing demand for timber for everything from chopsticks and paper to housing and furniture. And in developing countries, where population growth rates are highest, wood is the major source of energy. To meet these human demands for space, resources, and energy, we often clear land that has been home to other species of plants and animals. This can alter the delicate web of life whereby each species depends on other species to survive.

MATERIALS

For each group:

- Student Worksheet
- Forest Grid (provided)
- Die
- Sealable baggie labeled "Temperate Forest"
- Sealable baggie labeled "Tropical Forest"
- Variety of beans, seeds and dry noodles
- Graph paper

CONCEPT

Habitat destruction in more biodiverse areas can lead to extinction faster than habitat destruction in less biodiverse areas. Some of the most biodiverse areas are in countries experiencing the fastest population growth.

OBJECTIVES

Students will be able to:

- Define biodiversity.
- Calculate probabilities to compare and contrast the biodiversity of a temperate forest with a tropical forest.
- Assess how human population growth impacts temperate and tropical forests differently.

SUBJECTS

Science (life, Earth and environmental), social studies (geography), math

SKILLS

Analyzing data, modeling natural systems, critical thinking, calculating probabilities, identifying trends and patterns

METHOD

Through a small group simulation using probability, students explore how different population growth rates are impacting biodiversity levels.

PROCEDURE

1. Before class, prepare a Temperate Forest and Tropical Forest for each group. Make substitutions as necessary.

Temperate Forest baggie
20 dry black beans = White-tailed deer
40 dry red beans = Oak trees

Tropical Forest baggie
20 popcorn seeds = Mahogany trees
20 dry red beans = Miliantus trees
8 dry black beans = Pictoral beetles
5 raw sunflower seeds = Pygmy chameleons
4 dry black eyed peas = Crowned hornbills
2 dry lima beans = Cream-banded swallowtail butterflies
1 dry macaroni noodle = Gorilla

2. If students do not have any background knowledge on the importance of **biodiversity**, they can watch all or a portion of the TED-Ed video "Why is biodiversity so important?"

   You might also have students consider the roots of the word biodiversity and what they mean. Bio = life; Diversity = variety. So biodiversity is the variety of life.

3. Divide the class into groups of two or three, and provide each group with one die, a bag of beans for each forest, a Forest Grid, and a Student Worksheet for each student. If students do not have a flat surface to work on, egg cartons may be used in place of the Forest Grids.

4. Students distribute the beans on their Forest Grid as listed on their Student Worksheet and complete Part 1, comparing the biodiversity of a temperate forest to that of a tropical forest.

5. Students move on to Part 2 of the Student Worksheet, comparing how population growth in the United States and Rwanda impact the biodiversity of those areas.

6. Go over the Discussion Questions as a class.

Answers to Student Worksheet

1. *Answers will vary.*
2. *For the temperate forest, there are many of each kind of bean. Every acre has at least one of each bean. In the tropical forest, each acre is very different in bean composition — no two acres are alike.*

3.

	Temperate Species	*Probability*
a.	*Black beans = White-tailed deer*	*6/6, or 1. All outcomes will impact deer because they are in every acre.*
	Red beans = Oak trees	*6/6, or 1*

b.	*Tropical Species*	*Probability*
	Popcorn seeds = Mahogany trees	*6/6, or 1*
	Red beans = Miliantus trees	*6/6, or 1*
	Black beans = Pictoral beetles	*4/6, or 2/3*
	Sunflower seeds = Pygmy chameleons	*4/6, or 2/3*
	Black eyed peas = Crowned hornbills	*4/6, or 2/3*
	Lima beans = Cream-banded swallowtail butterflies	*1/6*
	Macaroni noodle = Gorilla	*1/6*

4. *a. P = 0/6 or 0. No species is unique to one acre.*
   b. 2/6 or 1/3. Clearing an acre with the gorilla or the butterflies will cause an extinction, because each species is unique to those acres. (If students have placed the gorilla and butterflies in the same acre, then P = 1/6.)
5. *a. P = 5/6*
   b. P = 5/6
   c. The probabilities stayed the same because each roll is an independent event.
6. *Answers will vary, but most likely, the tropical forest was cleared first.*

DISCUSSION QUESTIONS

1. What basic observations can be made about the temperate forest biodiversity and the tropical forest diversity based on this model?

In the temperate forest, there were not many types of beans, but there were many individuals of each type. Almost every acre had at least one of each bean. In the tropical forest, there were more types of beans but less individuals of each. Every acre was very different in bean composition – no two acres were alike.

2. Why do you think a greater variety of beans were used in the tropical forest?

Biodiversity is much higher in tropical forests. In fact, a 2:7 bean ratio (2 beans/species in the temperate forest versus 7 beans/species in the tropical forest) does not even come close to reflecting the overwhelming number of species that make tropical forests their home.

3. How was biodiversity affected by human activity in the temperate forest? In the tropical forest?

In the temperate forest, there was a decline in the number of individuals of both species, but they still existed in the other acres that were not destroyed. In the tropical forest, there was significant loss of biodiversity. Some species were rare to begin with, and their numbers were further reduced. Some species may have only existed in the acres that were cut.

Many tropical forest species are vulnerable to extinction because they depend on other species in extremely specific ways. Whenever this kind of partnership exists, the extinction of one species often leads to the extinction of other species.

4. Can you think of ways that people could benefit from the richness of tropical forests without cutting them down? (Hint: What are some things we value that are grown in the rainforest?)

   Biodiversity is immensely valuable, but this value is often not recognized. The forest itself regulates regional temperatures and moisture levels and generates oxygen, while destroying forests release greenhouse gases that negatively impact the entire world. A healthy rainforest provides many goods that are valuable – the fruits, nuts, resins, oils, medicinal plants and tree bark, and subsistence food – to the people who live there. These goods are often ignored in economic assessment of forest use, but studies show their value may far exceed that of timber or crops that will only grow for a few seasons in the poor rainforest soil. People who live near rainforests can also profit from ecotourism (visitors coming to see a specific ecosystem), which depends on preserving tropical forests.

5. What are some advantages to using this model to explore biodiversity? What are some limitations to using this model? How might you change the model to be more realistic?

   Answers will vary. Using this model, it's easy to see how quickly species can go extinct in a tropical forest as compared to a temperate forest. However, there are limitations that include: human population growth does not have to lead to deforestation; countries can choose to protect wild lands and support a growing population at the same time. Deforestation can also be caused by things other than population growth: the U.S. has lower population growth but could see high deforestation rates due to wildfires or rapidly expanding suburban areas. There are also many missing species in this model. Plants and animals are connected in complex webs that might lead to extinction, even if the acre where the species lives is not cleared.

   Encourage your students to think creatively to improve the model. There could be a simple change like adding more species. Or, they might come up with something more complex, like including a chance number on the dice. When when you roll a specific number, you take a chance card with a possible scenarios like "The local community replants tress in the tropical forest. Return trees to one of the cleared acres, along with half of the animals" or "The government opens a new apartment-style housing complex in Kigali, Rwanda so people do not have to move to the edge of the forest. The next time you roll a 2-6, do NOT destroy an acre of tropical forest." There are many possibilities for creative improvements.

ASSESSMENT

Students complete the following sentences:

Define: Biodiversity is _____.

Explain: Biodiversity is important to humans and the environment because _____

_____.

Compare/Contrast: A _____ forest and a _____ forest are similar in that they

both _____.

However, differences between the two include _____

_____.

FOLLOW-UP ACTIVITIES

1. Ask students to consider the ways that they could redesign the model to make it more realistic. What kind of impacts do they believe the changes to the model will make on biodiversity in their two forests? Have students rerun the simulation using their updated model to see if their outcomes match their expectations. What implications does their data have for real-world forests and real-world biodiversity?

2. Pose the following scenario to your students: There is a native plant that grows only in the area around your community. A particular butterfly will only lay eggs on this plant. Its roots are an important food for a species of native gopher, which in turn is a major food source for local hawks and coyotes. A group of your neighbors wants to plow the fields that contain one of the last of the plants to build a golf course.

   Ask students to create a persuasive argument either for or against plowing the fields. They might consider if the argument would change if, instead of a golf course, the land were being developed for housing for low-income families, a factory that would give 200 people jobs, or a retirement home for senior citizens.

3. Each student should research an obscure plant or animal found in a tropical forest, or an endangered plant or animal found in your community. Have students research the species and create a poster displaying what they learned. This might include a map of where the species is found, a photo or drawing of the species, characteristics such as what it eats and/or who eats it, the climate it requires, how it is used in local communities, etc.

Adapted with permission from Sheila Jones, Wake Soil and Water Conservation District, Raleigh, NC, as printed in *The Conservation Catalyst Newsletter*, Winter 1993-94.

[1] Mora, C., et. al. How Many Species Are There on Earth and in the Ocean? PLoS Biology, 2011; 9 (8): e1001127 DOI: 10.1371/journal.pbio.1001127

[2] Leahy, S. "Tropical Forest Loss Slowed in 2017- To the Second Worst Total Ever." National Geographic, 27 June 2018. https://www.nationalgeographic.com/news/2018/06/tropical-deforestation-forest-loss-2017/

[3] "Population growth (annual percentage)." The World Bank. Data retrieved 10 October, 2020 from https://data.worldbank.org/indicator/SP.POP.GROW

WORLD OF DIFFERENCE
STUDENT WORKSHEET

Name: _____ Date: _____

Place beans on your Forest Grid according to the instructions below. Each type of bean represents a species, and each bean is an individual of that species.

Temperate Forest:
Deer (20 black beans): Place at least 1 in each acre, but no more than 5 in any acre.
Oak tree (40 red beans): Place at least 3 in each acre, but no more than 10 in any acre.

Tropical Forest:
Mahogany tree (20 popcorn seeds): Place at least 3 in each acre, but no more than 4 in any acre.
Miliantus tree (20 red beans): Place at least 1 in each acre, but no more than 8 in any acre.
Pictoral beetle (8 black beans): Place at least 1, but no more than 3, in any 4 acres. DO NOT place pictoral beetles in 2 acres.
Pygmy chameleon (5 sunflower seeds): Place at least 1, but no more than 2, in any 4 acres. DO NOT place pygmy chameleons in 2 acres.
Crowned hornbill (4 black eyed peas): Place 1 in each of four acres. DO NOT place crowned hornbills in 2 acres.
Cream-banded swallowtail butterfly (2 lima beans): Place 2 in the same acre.
Gorilla (1 macaroni noodle): Place 1 in any acre.

Part 1

1. Fill in the tables below to show the distribution of species in each forest. If at least one individual of a species lives in an acre, place an "X" in that space on the table. To find total species per acre, count the squares with an X in the column for that acre.

Temperate Forest

Species	Acre A	Acre B	Acre C	Acre D	Acre E	Acre F
Black beans = White-tailed deer						
Red beans = Oak trees						
Total species per acre						

Tropical Forest

Species	Acre A	Acre B	Acre C	Acre D	Acre E	Acre F
Popcorn seeds = Mahogany trees						
Red beans = Miliantus trees						
Black beans = Pictoral beetles						
Sunflower seeds = Pygmy chameleons						
Black eyed peas = Crowned hornbills						
Lima beans = Cream-banded swallowtail butterflies						
Macaroni noodle = Gorilla						
Total species per acre						

WORLD OF DIFFERENCE
STUDENT WORKSHEET - PAGE 2

2. How does the biodiversity of the temperate forest compare to that of the tropical forest?

3. Look at your forests to find out what happens when an acre of forest is cleared:

a. What is the probability that the population of each species in the temperate forest will *change* if you clear an acre there? (A population changes if the number of individuals increases or decreases.) Fill in the table.

Species	Probability
Black beans = White-tailed deer	
Red beans = Oak trees	

b. What is the probability that the population of each species in the tropical forest will *change* if you clear an acre there? (A population changes if the number of individuals increases or decreases.) Fill in the table.

Species	Probability
Popcorn seeds = Mahogany trees	
Red beans = Miliantus trees	
Black beans = Pictoral beetles	
Sunflower seeds = Pygmy chameleons	
Black eyed peas = Crowned hornbills	
Lima beans = Cream-banded swallowtail butterflies	
Macaroni noodle = Gorilla	

4. What is the probability that any species will become *extinct* if you clear one acre in the temperate forest?

What is the probability that any species will become *extinct* if you clear one acre in the tropical forest?

Part 2

The United States, which contains temperate forests, has a population growth rate of 0.5 percent annually. In East Africa, Rwanda has tropical forests and a population growth of 2.6 percent annually, approximately 5 times that of the U.S.[3] When you roll the die, a roll of 1 represents population growth in the U.S., and you should clear one acre of temperate forest to meet the needs of society. Rolls of 2, 3, 4, 5, or 6 represent population growth in Rwanda, and therefore one acre of tropical forest should be cleared.

WORLD OF DIFFERENCE

STUDENT WORKSHEET - PAGE 3

5. a. What is the probability that you will clear an acre of tropical forest on your first roll? _____

b. What is the probability that you will clear an acre of tropical forest on your second roll? _____

c. Does the probability change from one roll to the next? Why or why not? _____

_____

_____

Now roll the die and take out all the beans in Acre A of the forest indicated by your roll. Record your data in the table below. Continue rolling and clearing acres until one of your forests is gone. Record your data after each roll.

6. Which forest was eliminated first? _____

7. How many rolls did it take to eliminate that forest? _____

Roll Number	Forest (Circle One)		Acre Cleared (A-F)	Number of Temperate Species Remaining	Number of Tropical Species Remaining	Did any species go extinct? Which species?
1	Temperate	Tropical				
2	Temperate	Tropical				
3	Temperate	Tropical				
4	Temperate	Tropical				
5	Temperate	Tropical				
6	Temperate	Tropical				
7	Temperate	Tropical				
8	Temperate	Tropical				
9	Temperate	Tropical				
10	Temperate	Tropical				
11	Temperate	Tropical				
12	Temperate	Tropical				

Bonus

Draw a pair of line graphs on the same axes to show the fates of the forests. Die rolls can go on the x-axis, number of species remaining goes on the y-axis.

WORLD OF DIFFERENCE

FOREST GRID

Each square represents one acre.

Temperate Forest

A	B	C
D	E	F

Tropical Forest

A	B	C
D	E	F