Earth Day Resources
•Middle Grades•

Reading: Demography in Action

Lesson Plans:

**For the Common Good** (science, social studies) - *In two simulation games, students and determine individual short-term consumption strategies that will maximize resources for the entire group.*

**Timber!** (science, math) - *In small groups, students model what happens to a forest when the demand for wood is greater than the supply and graph their results.*

**Who Polluted the Potomac?** (science, social studies, language arts) - *Through an interactive story, students experience the pollution of a local river over time and propose methods to protect the river from current and future pollution.*

**A World of Difference** (science, math) – *Students use probability to explore how different population growth rates are impacting biodiversity levels.*

*For more great resources, visit us at [www.PopulationEducation.org](http://www.PopulationEducation.org)!*
Are you interested in knowing more about the other people in your community, your country and the world? Maybe learning about how many of us there are or about the many characteristics that can define us? This might include our age, gender, ethnic heritage, religion, education, political views, or jobs. Then, you probably want to learn more about *demography*.

Demography is the **quantitative** study of human populations. The word demography comes from two ancient Greek words, demos, meaning “the people,” and graphy, meaning “writing about or recording something” — so literally demography means “writing about the people.” A *demographer* is someone who studies a human population’s size, structure, distribution, characteristics, and changes over time.

**GATHERING DATA**

To study a population, a demographer must gather data. One of the ways this is done is through a *census*. The United States government conducts a census every ten years. Most other countries also have regularly scheduled censuses. People are surveyed by mail and in person about the size of their households, ages and other demographic information. The first known census was conducted nearly 6,000 years ago by the Babylonians. The information gathered from a census can be used to determine political representation and to assess a region’s needs for government services and facilities (think schools, hospital beds, and roads).

While data gathering can offer a snapshot of the current population, it can also help demographers make predictions about how that population might change in the future. To determine changes in population size, demographers consider the number of births and the number of deaths in a region. **When the birth rate is higher than the death rate,** the population grows. **When the death rate is higher than the birth rate,** the population shrinks. The greater the difference between the birth rate and death rate, the higher or lower that population’s growth rate will be. In most countries of the world, the birth rate is higher than the death rate, resulting in a growing population.
Our global population is growing by 1.2 percent a year, which might seem like a small amount. But, because we had over 7.4 billion people (7,400,000,000) in 2016, that 1.2 percent increase adds 80-90 million people to our global family every year.

Key indicators that demographers look at when trying to predict population growth trends are fertility and life expectancy. The fertility rate is the average number of children a woman has in her lifetime. That varies a lot around the world from a low of about one child (1.2 in Romania) to a high of over seven (7.6 in Niger). For a country to maintain the size of its current population, it must be at replacement-level fertility (roughly 2 children replacing 2 parents). A number of factors can affect how many children people choose to have, including economics, cultural traditions, education and public health. Life expectancy also varies widely from a low of 50 years (Democratic Republic of the Congo) to a high of 84 years (Japan). To predict how long people might live, demographers consider trends in overall health, disease outbreaks and wars.

LIMITS TO GROWTH
Demographers also look at where we live. Did you know that more than half of the world’s population lives in cities? Our global family of 7.4 billion isn’t evenly spaced around the globe. Instead, we cluster in areas like cities or areas with needed natural resources, like good farmland. In fact, demographers often use maps to show population density. Large, densely populated areas need lots of resources to support so many people – energy, food, water, and all sorts of services. Cities can continue to grow because resources are brought in from other places.

But what about our global population? Is there a limit to how large it can grow? Demographers collect and analyze the data on population trends, but other researchers (those who study the environment and society) consider the impacts that a growing population might have and whether there are limits to this growth. We know there are limits to the life-sustaining resources Earth can provide. In other words, there is a carrying capacity for human life on our planet.

Carrying capacity is the maximum number of a species an environment can support indefinitely. Every species has a carrying capacity, even humans. However, it is very difficult for ecologists to calculate human carrying capacity. We do not all use resources the same way. The individual decisions of every person will ultimately determine how many people the Earth can support – from the foods we eat, to our transportation habits, size of our homes, and the sources of all the goods and services we use.
Glossary

**birth rates**: the yearly number of births per 1,000 people.

**carrying capacity**: the maximum number of a species an environment can support indefinitely.

**death rates**: the yearly number of deaths per 1,000 people.

**demographer**: someone who studies the characteristics of human populations.

**demography**: quantitative study of human populations

**ecologists**: scientists who study the interrelationships between organisms and their environments.

**fertility rate**: the average number of children a woman has in her lifetime.

**life expectancy**: the average number of years someone is expected to live based on current health trends.

**population density**: a measurement of population per a unit of area.

**quantitative**: relating to, measuring, or measured by the quantity of something rather than its quality.

**replacement-level fertility**: the average number of children born per woman—at which a population exactly replaces itself from one generation to the next. This rate is roughly 2.1 children per woman for most countries, although it may vary a bit depending on rates of child survival.
INTRODUCTION

Renewable resources, such as trees or fish, can be maintained if managed properly. But if not given an opportunity to replenish, these resources can be exhausted quickly, especially as the demand for the resources grows. Garrett Hardin’s theory, Tragedy of the Commons, asserts that people tend to act in their own self-interest and not in the interest of the “common good.” In managing renewable resources, it is important for people to use them cooperatively and to not sacrifice long-term gain for short-term profits. A similar concept holds true in social dilemmas – cooperation, rather than selfishness, brings more long-term benefits to society. It is valuable to understand the benefits of cooperation and sustainable resource management in order to preserve our limited resource base as the population continues to grow.

MATERIALS

• Poker chips
• Candy or stickers
• Music

PART 1: SOMETHING FOR EVERYONE

PROCEDURE

1. Count out, but do not distribute, 10 chips for each student playing the game.

2. Seat students in a circle.

3. In the center of the circle, place a pile comprising one-fourth of all the chips. For example, if you have 10 students, you use 100 chips, and put 25 in the center.
4. Read the following rules twice to the students:

**Rules**
1. The chips belong to all of you.
2. Music will be played, and while it is playing, everybody may take chips out of the pool of chips in the center.
3. You may not put chips back into the pool once you have taken them out.
4. You may trade in 10 chips for a piece of candy (or sticker).
5. As soon as the music stops, I will double the number of chips left in the pool at that time, and then continue the game.
6. There will never, however, be more chips in the pool than there are at the start of the game; this is the maximum number of chips the pool can hold.
7. **MOST IMPORTANTLY:** You may not talk or communicate in any way to anyone during the game. This includes gestures, eye-contact, etc.

**Notes to the teacher:**

- DO NOT explain the significance of the chips before playing the game. The rules are the only instruction the players get.

- The players will most likely empty the pool at the start of the game. Point out that, as it’s impossible to double zero, the game is over. Ask if they’d like to try again. Each student must return all of his/her chips to the pool.

- Continue to play the game for several rounds without giving the students time to communicate with one another in between.

- When doubling the chips in the pool, remember there can “never be more chips in the pool than at the start of the game.” This is the pool’s carrying capacity for chips.

- After several rounds, you may allow the students to talk while the music plays so they can discuss strategies.

- After five or six rounds, ask students how they feel about the way the game worked out. As a group, help students think of ways they could cooperate to allow more of them to get their 10 chips without depleting the pool of resources. Play again using the strategies developed by the students.

**DISCUSSION QUESTIONS**

1. What do the chips represent?

*Renewable resources, such as fish or trees. A resource is renewable if it can replace itself in the course of a human lifetime. Fossil fuels and minerals are examples of non-renewable resources, and therefore aren’t applicable in this exercise. Water is also not a renewable resource; we have the same amount of water now as we ever had or will.*
2. The chips, we said, belong to everyone. Can you think of examples of resources that belong to everyone?

*Answers may include: water, land and air resources, classroom materials.*

3. Can we draw any parallels between the way the group treated the chips and the way individuals and society as a whole use or overuse renewable resources?

*Answers may include: Deforestation: cutting trees down without planting replacements or at a rate that does not give new trees enough time to grow to maturity before harvesting. Overfishing: taking so many fish that not enough are left to reproduce and replenish the stocks for next year. Overfarming: depleting the soil of nutrients without giving it time to regenerate.*

4. What happened in the first round of the game? How did it make you feel about the other members of the group?

5. How did removing the 'no talking' rule change how the game was played? Did it allow you to strategize? What are some of the strategies you came up with?

6. Was there an ideal number of chips to take out of the pool? If so, what was it and why?

*Students build up their supply of chips the fastest if they take exactly half of the chips out of the pool during each round. That allows the maximum number to be added for the next round. If students take more than half, the number of chips to be doubled is lower, and there will be fewer available to take in the future. If they take fewer than half, it will take them much longer to build up the supply that they need for trade-in. Wildlife managers call this concept the Maximum Sustainable Yield and use it to figure out limits for hunting and fishing.*

7. What would happen if we added people to the game? What do you think this would represent?

*It would be harder and harder to cooperate with everyone and develop a strategy for sharing resources. It would take longer for everyone to get a piece of candy. Adding people would represent global population growth and the challenges of sustainably managing resources as demand increases.*

8. Do you have an experience where you have had to share a resource with others? If so, what was the commodity, and what were the results?

9. This game is a called ‘For the Common Good.’ Have you ever heard this phrase? What does it mean?

*Explain to students the meaning of the phrase, namely that the ‘common good’ refers to Aristotle’s philosophical/ethical theory wherein moral choices are balanced by weighing the benefits of the group over benefits for the individual. You can also refer students to the ‘Tragedy of the Commons,’ Garret Hardin’s theory that individuals will often overlook the consequences to others when drawing from a shared resource.*

It may also help students to look at and reflect upon the following videos:

*National Science Foundation: The Tragedy of the Commons, part 1: Chalk Talk*
*National Science Foundation: The Tragedy of the Commons, part 2: Chalk Talk*
PART 2: A SOCIAL DILEMMA

PROCEDURE

1. Distribute small pieces of paper to the class and read aloud the following rules:
   
   **Rules**
   1. You must write either a C or a D on your paper.
   2. If you write a C, I will give you nothing, but I will give everyone else in the class $1 (pretend money).
   3. If you write a D, I will give you $2, but I will give everyone else nothing.
   4. You aren’t allowed to see what anyone else is writing.
   5. The result is that you’ll get however many dollars you gave yourself, plus however many dollars everyone else gave you.
   
2. Give students a short time to make their decisions and write a C or D.

3. Then tell students to consider the following questions:
   
   a. How many dollars would you get if everyone in the class writes a C?
      **Answer:** The number of students in the class minus one.
   
   b. How many dollars would you get if everyone in the class writes a D?
      **Answer:** Each student will only get $2.

4. Give students time to reconsider and change their answers if they so choose. Then ask the students to reveal their final choices, whether they’ve changed, and why.

5. Ask the class what C and D might stand for and brainstorm a list. Record students’ answers on the board. Remind them what choosing C or D did in terms of dollar amounts to them as individuals vs. the group.

DISCUSSION QUESTIONS

1. In this activity, C stands for cooperating and D for defecting. What do these terms mean? How would you feel if you cooperated and everyone else defected? How would you feel if you defected and everyone else cooperated?

2. In this game, when do all the participants get the most? The least?
   
   **Participants get the most when everyone playing writes a C.**

3. What are some examples of C-type (cooperative) behavior in the real world?
   
   **Answers may include:** contributing to public TV, not trying to evade the law, keeping promises, doing one’s job wholeheartedly in the absence of supervision, not taking more than one’s share of a public resource, not polluting the air.

4. Think of a real-life social dilemma in which too few people cooperate. How could people be encouraged to cooperate more?
ASSESSMENT

Students complete the following sentence:

When talking about resources, “for the common good” means _________________________.

FOLLOW-UP ACTIVITY

Have students research a renewable resource in their local community (or state) and determine if the resource is being managed sustainably.

Part 1 adapted with permission from an activity developed by Kurt and Ursula Frischknecht and Karen Zimbelman found in Thinking Globally and Acting Locally: Environmental Education Teaching Activities by Lori D. Mann and William B. Stapp, ERIC/SMEAC ©1982.

Part 2 adapted with permission from an activity developed by Jonathan Baron, Decision Science Consortium Inc., Reston, VA, 1988.
INTRODUCTION

People rely on wood from trees to heat their homes, to cook their food, and to provide building materials and paper for homes, schools, and businesses. The more people there are, the greater the demand for wood. While it takes only seconds to cut down a tree, it takes years to grow a new one. The time it takes for a tree to reach maturity varies and depends on many factors (rainfall, species, and climate). Some trees are slow growers (20-30 years to reach full size) and some are fast (10-15 years). For example, the Red Maple, given the right growing conditions, is a moderately fast grower and could grow 1-2 feet per year once established. We depend on forests to regulate climate, clean the air, filter water, conserve precious soil, and provide homes for many birds and animals. In almost every part of the world, trees are being cut down at a faster rate than they are being replaced.

MATERIALS

For each group:
- Plastic baggie holding 120 craft sticks
- Plastic baggie holding 32 craft sticks
- Watch with second hand
- Forest Chart (provided)
- Graph paper

PROCEDURE

1. Divide the class into groups of four students. Ask students to create a list of:
   a. ways people use wood, both here in the U.S. and around the world
   b. where the wood comes from
   c. how wood is acquired
   Answer: Wood is used for building materials, paper, and furniture, or to heat homes and cook food. Wood comes from trees and those trees must be cut down in order for the wood to be used.
2. For each group, assign the following roles: lumberjack, forest, forest manager, and timer. Tell your students that a town is being developed near a forest and that they will be simulating how trees are harvested for development.

3. Give a baggie of 120 craft sticks to each student representing the forest. These sticks represent the trees in the forest – the supply of trees available to the lumberjack for cutting.

4. Give a baggie of 32 craft sticks to each student representing the forest manager. These sticks represent trees that will grow during the game.

5. The timer records the transfer of trees, both those added to the forest and those cut down, for every minute on the Forest Chart.

6. Begin the game when the timer gives the signal. After 15 seconds, the timer tells the forest manager to give the forest one tree. Every 15 seconds for the rest of the game, the forest manager adds one tree to the forest (that is four trees every minute). In doing so, the forest manager represents the annual growth rate of our hypothetical forest (one minute = one year). This simulates the rate at which trees grow to maturity and become timber reserves in the real world.

7. Stop at the end of the first minute of the game and let the lumberjack remove one tree from the forest. The tree represents the amount of wood needed for building materials and other uses in the new town.

8. Continue the game. At the end of each succeeding minute, the town’s demand for wood doubles as a result of a growing population. At the end of the second minute, the lumberjack cuts two trees from the forest. At the end of the third minute, the lumberjack cuts four trees from the forest; at the end of the fourth minute, the lumberjack cuts eight trees from the forest; then 16, 32, 64, and 128.

9. End the game when the wood reserves in the forest can no longer meet the demands of the lumberjack. At the end of each minute, students should have found the following number of trees available: 123, 125, 125, 121, 109, 81, 21, 0.

10. Tell students to sort the trees back into their original bags (they can simply separate out 32 sticks for the “forest manager” bag and put the remainder in the “forest” bag).

11. Distribute graph paper to students. Explain that graphing situations like that of our forest can give us a clearer picture of the quantity of a resource over time.

12. Students should set up their graph with “Number of Trees” on the y-axis and “Time in Minutes” on
the x-axis. Instruct students to use the numbers from their Forest Charts to make a line graph that plots both the number of trees that were cut and the number of trees left in the forest at each minute mark during the game. Alternatively, students can create their graph on-line at http://nces.ed.gov/nceskids/createagraph/default.aspx.

Hint: When you create your data set on this site, there will be “seven items” (the minutes) and “two groups” (trees cut down and trees in the forest).

13. Have students suggest possible modifications to the supply (how/why trees are being planted) and demand (how/why trees are being cut) of trees in the forest and run the simulation several more times implementing these changes. Students will discover how changing the supply and demand can impact the fate of the forest and ultimately, will be able to determine a method for sustainable management. Ask your students to determine what human behaviors would need to change in order to achieve their sustainable management strategy.

DISCUSSION QUESTIONS

1. How many minutes did it take for the lumberjack to cut all the trees in the forest?

   Just over seven minutes. At seven minutes there were only 21 trees left. In the eighth minute, there would not be enough trees to meet the demand.
2. Was the forest always shrinking? Explain.

   No. After the first minute, the forest increased by two trees and stabilized for another minute. After the third minute, the doubling of trees being cut made the forest start to shrink and eventually led to the end of the forest.

3. Do you think this simulation is representative of how real-world forests are harvested? Why or why not?

4. What are some of the dangers of cutting down trees faster than we can plant them?

   Answers may include: loss of biodiversity in forest communities, loss of habitat for animals that live in forests, less oxygen, air quality suffers since trees neutralize CO2.

5. In this simulation we looked specifically at logging for development. Can you think of any other reasons why trees are cut down?

   Answers may include: clear-cutting for agriculture or ranching, harvesting of a certain fruit (e.g. palm oil).

6. If the forest manager could develop a tree that grows at a rate of one tree per second, would tree growth keep up with timber demand? Why or why not?

   No. The doubling of the use of wood due to increased population size would still lead to the demise of the forest. If the simulation was done with 60 sticks given to the forest each minute, it would only increase the life of the forest by two years.

7. What could be done to prevent the demise of the forest?

   The forest can be maintained only if we replace what we cut down. This means conserving the use of tree products such as paper, packaging, and lumber. This conservation will become especially important as our global population continues to grow, creating more of a demand for packaging, building, and paper products.

8. What other natural resources do humans use that, if not managed sustainably, could suffer the same fate as the forest?

   Answers may include: water, arable land, fish, etc.

**ASSESSMENT**

Students write a short summary that answers the "who, what, where, when, why, how" questions about sustainable forest management.
FOLLOW-UP ACTIVITIES

1. Poet Ogden Nash wrote the following verse to describe his feelings about the beauty of trees and the danger they are in:

   “I think that I shall never see
   A billboard lovely as a tree.
   Indeed, unless the billboards fall,
   I’ll never see a tree at all.”

   As a class, discuss the meaning of the poem and how, with only a few words, the author has delivered a powerful and memorable lesson. Invite students to write their own short verse about trees. This could be in the form of a limerick, haiku, or other rhyming or non-rhyming verse.

2. Wangari Maathai was awarded the Nobel Peace Prize in 2004 for her efforts in conservation. She is a prime example of how to think globally but act locally, as her devotion to planting trees in her home country, Kenya, has turned into a worldwide tree planting movement called the Green Belt Movement. Have your students research Wangari’s conservation efforts and the Green Belt Movement and write a summary on their findings.

3. Organize a tree planting event at your school or in your community. To organize a tree planting event and secure saplings, contact your local nursery. Alternatively, contact The National Arbor Day Foundation at www.arborday.org for more information.
### TIMBER!
#### FOREST CHART

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Number of Trees at Beginning of Minute</th>
<th>Number of New Trees</th>
<th>Number of Trees Cut</th>
<th>Number of Trees at End of Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120</td>
<td>+4</td>
<td>-1</td>
<td>123</td>
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</table>
WHO POLLUTED THE POTOMAC?

INTRODUCTION

The history and health of our rivers is inextricably tied to the history of the human communities that have settled along their banks. Rivers are a vital water source, home to wildlife, a means of transportation, and more. As the numbers and sizes of our communities have increased over time, the health of our rivers has suffered. Sewage, agricultural runoff, and industrial wastes are just some of the pollutants that find their way into our rivers. This activity demonstrates that, just as we each contribute to the problem, we must also be part of the solution.

MATERIALS

- Clear gallon jar or bowl of water
- Film canisters or other small lidded containers
- Canister Labels (provided)
- Canister Ingredients
- Story: “Who Polluted the Potomac?” (provided)

PROCEDURE

1. Before class, prepare and label the film canisters using the items in the chart below. Prepare enough canisters for each student to have at least one. There are 16 different canister labels, so for large classes, double some characters and some students will have identical canisters.
2. Fill a clear jar or bowl with water. Place the container in a location that can be seen by all students.

3. Distribute one canister to each student. Ask them to keep the canisters closed and upright, and not to reveal the identities of their characters.

4. Read the story “Who Polluted the Potomac” aloud to the class. Add emphasis as you read each bolded character name, and pause after each question to give the students time to think and respond.

   **Note:** You may want to change the name of the river to a waterway in your region that is familiar to the students.

5. Go over the Discussion Questions as a class.

**DISCUSSION QUESTIONS**

1. Who polluted the Potomac?

   *Everyone played a role.*

2. What effect did the increasing population have on the health of the river? Can you think of any ways population increases could improve a river’s health?

<table>
<thead>
<tr>
<th>Character (Canister Label)</th>
<th>Canister Ingredients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees</td>
<td>Leaves (dry)</td>
</tr>
<tr>
<td>Construction site</td>
<td>Soil (dry, clayish)</td>
</tr>
<tr>
<td>Person fishing</td>
<td>Fishing line or dental floss</td>
</tr>
<tr>
<td>Farmers</td>
<td>Baking soda</td>
</tr>
<tr>
<td>Gardeners</td>
<td>Baking soda</td>
</tr>
<tr>
<td>Beach party</td>
<td>Litter, assorted</td>
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<tr>
<td>Picnicking</td>
<td>Litter, assorted</td>
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<tr>
<td>Barnyard</td>
<td>Water + instant coffee granules</td>
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<tr>
<td>Washing the car</td>
<td>Water + 1 drop dishwashing soap</td>
</tr>
<tr>
<td>Antifreeze</td>
<td>Water + 1 drop green food coloring</td>
</tr>
<tr>
<td>Mysterious liquid</td>
<td>Water + 1 drop red food coloring</td>
</tr>
<tr>
<td>Homeowner</td>
<td>Water + 1 drop yellow food coloring</td>
</tr>
<tr>
<td>Coal mine</td>
<td>Vinegar</td>
</tr>
<tr>
<td>Electric power plant</td>
<td>Vinegar</td>
</tr>
<tr>
<td>Commuters</td>
<td>Vinegar</td>
</tr>
<tr>
<td>Motorboats</td>
<td>Water + 1 drop each red and green food coloring</td>
</tr>
</tbody>
</table>
In this situation, population growth led to increases in pollution sources and decreases in open space and in available wetlands, which filter water. However, an increase in population may also lead to stronger environmental laws, more efficient uses of resources and public services like sewage treatment plants.

3. Think about the pollution represented in the canisters. Could something be done to prevent those types of materials from entering the water in the first place? How?

Answers may include: implementing soil erosion control at the construction site, applying smokestack technology at the power plant, walking or riding a bike instead of driving, picking up trash off the ground, taking a car to the car wash, keeping cars and boats in good repair, etc.

4. Many of the pollutants were the result of an individual person’s action. Is an individual the only person impacted by his or her decision? Does something added to the river in one location, stay there? Where does it go and what is the impact?

No. Rivers are a shared resource, so individual actions and choices impact the entire community. Because rivers run through multiple municipalities and states, pollutants that enter the river at one point move downstream and the effects are felt along the river’s path and across municipal and state boundaries.

5. Do upriver cities or states have a responsibility to keep rivers clean for downriver cities or states? Do you think they should?

6. Challenge students to come up with ways to clean the water in the bowl. Once these types of pollution have entered the river, how can we get them out? How can we clean up the river?

In the classroom, solids can be strained using a kitchen strainer or netting. Students may also find coffee filters or absorbent cotton helpful. In reality, humans clean up waterways using a variety of methods. Examples include using nets to retrieve large items, treating the water with chemicals, or introducing organisms that filter or digest pollutants from the water.

7. Do you think that it is easier to prevent pollution, or to clean water that is already polluted? Have students explain their ideas. What could each of us do to help improve the health of our rivers by preventing some of this pollution?

Preventing pollution is known to be a more effective approach to ensuring clean waterways. Answers may include: biking or walking instead of driving, conserving water, picking up litter, pulling weeds instead of spraying them, etc.
ASSESSMENT

Students complete the following sentences and share with a partner.

Water pollution happens because _________________.
Water pollution can be prevented by _________________.
Human population growth impacts water sources because _________________.

FOLLOW-UP ACTIVITIES

1. Although this activity relates the story of the Potomac River and the history of Washington, D.C., similar situations exist in many watersheds throughout the country. You may wish to use the story of the Potomac as an example for comparison with your local river, or you may want to adapt the story to special concerns within your local watershed. Students can search for local services on a city or county web site or you can ask a local government official to visit your class and discuss your region’s facilities and programs for waste and pollution management.

2. For a STEM connection, have students come up with an invention, product, or system that would minimize the impact of pollution on the river. The solution can be realistic or far-fetched but the invention should alleviate one of the pollutants and its subsequent impact on the river. Students should submit a rough draft and design of their solution.

3. Introduce your students to Mr. Trash Wheel, a water wheel located in Baltimore’s Inner Harbor that sustainably cleans trash from the water. Learn more about the conservation initiative here: http://baltimorewaterfront.com/healthy-harbor/water-wheel/. A short video provides an interesting overview of Mr. Trash Wheel in under five minutes. Stream here: https://www.youtube.com/watch?time_continue=98&v=RkQbcrzyAeE.

Adapted with permission from Hard Bargain Farm Environmental Center, Accokeek, MD.
STORY: WHO POLLUTED THE POTOMAC?

For many thousands of years, people have lived on the banks of the Potomac River. They hunted in the forests, harvested foods from wetlands, and caught fish in the river. Imagine that the jar of water in front of you was taken from the Potomac River by a Native American about 500 years ago.

- How does the water look to you?
- Does this look like water that you might drink? Swim in? Eat fish from?

One of the first explorers to visit the river kept a journal of his discoveries. He wrote about the Native American villages, the tributaries of “sweet water,” and seeing so many fish that he and his crew tried to scoop them out with a frying pan. Soon, colonists began to arrive. They found fertile land, forests teeming with wildlife, and a river that provided ample food and water. It was an outstanding environment for settlement, and the colonists prospered.

- How do you think the colonists used the river?
  Answers may include: bathing, food, drinking and cooking water, transportation, etc.
- Do we use our rivers in any of the same ways today? What are similarities and differences in the way we use the river?
  Answers will vary. Students may immediately recognize direct similarities like transportation and food, but may not realize that the water they use every day also may come from a local waterway to their tap.

But the river has changed a lot since it was first explored. This is the story of those changes. Listen for the name of the character printed on your canister. When you hear your character named, come up to the river (bowl of water), open the canister and dump in its contents.

Years went by and occasional storms drenched the area. High winds whipped through the TREES and blew leaves into the water.

Gradually, the city of Washington, D.C. grew on the banks of the Potomac. Developers cleared wet-lands and forests to build houses and businesses. Rains washed loose soil from CONSTRUCTION SITES into the river.

- Is this water safe to drink? (If the response is “no,” ask if the river had leaves or soil in it when explorers first drank from it).
- Would you swim in it? Is it safe for wildlife?

At first, the city was small. Upstream, FARMERS planted crops to feed the city’s growing population. Some of these crops grew right up against the banks of the river, and fertilizer washed off the land and into the water. Other farmers kept pigs and other animals in their BARNYARDS. As rainwater drained out of the barnyard, it carried some of the manure into a little creek behind the farm. The creek flows into the river.

- Would you drink this water now? Would you go swim in it? Go boating on it?
- Is it safe for wildlife?

As the city grew, more and more people began to move to the nearby countryside. These rural houses
were not connected to the city sewer system. Waste water from these houses flowed into septic tanks under the ground. One HOMEOWNER did not maintain the septic tank and poorly treated sewage seeped into the river.

To meet the electricity needs of the city, area officials decided that they needed to generate more power. Far upstream, a COAL MINE was dug. Rain water drained down into the mine shaft and soaked the piles of wastes and scraps from mining. This made the rain-water become acidic – sort of like a strong vinegar. Then the acid water trickled off the banks and back out into the river.

To burn the coal and produce the power, an ELECTRIC POWER PLANT was built along the river. Gasses coming out of the smokestacks combine with moisture in the air to form acids. The pollution falls back to the Earth as acid rain or smog.

- Would you drink this water now? Would you swim in it? Go boating?
- How could we determine if this water was safe for wildlife? Answers may include: noticing evidence of dead animals, testing for pH levels with litmus paper or chemical testing, viewing water samples under a microscope, performing organism counts, etc.

Washington, D.C. is now one of the largest metropolitan areas in the country. Traffic congestion is a big problem for COMMUTERS who drive their cars to and from work. Car exhaust fumes (just like power plant fumes) cause acid rain. If a car is not kept in good repair it may also leak oil or other fluids, which will be washed off the pavement and into the river with the next rain.

And how do the residents of the city and its suburbs spend their time? In one neighborhood, GARDENERS are out working in their yards. Many of them are using weed killers and insect sprays to keep their lawns pretty. The next rain will wash these poisons into a little creek nearby, and then into the river.

One father is teaching his daughter how to change the ANTIFREEZE in their truck. They pour out the used antifreeze into the driveway. Antifreeze is sweet tasting and can poison animals that lick it. It can also get into the nearby creek and poison fish.

Nearby, a boy is WASHING THE CAR. The soapy water rushes down the driveway into the storm drain; the storm drain empties into the river. The grease and grime on a car can contain asphalt from the roads, rubber particles from the tires, toxic metals, and rust. If the boy had gone to a local car wash, the water would have been treated before it returned to the river.

Next door is a family cleaning out their garage. They find an old rusty can with a tattered skull and crossbones label still stuck on it. This MYSTERIOUS LIQUID looks dangerous and they want to get rid of it before someone gets hurt. They decide to pour it down the storm drain out by the curb. The mysterious liquid is out of sight, but it is headed for the river.

On nice days, many people head down to the river. Some zoom up and down the water in MOTORBOATS and don’t notice that a little engine oil leaks into the water. A group of friends have spread blankets on the shore for a BEACH PARTY. Lots of families are PICNICKING in the parks, too. Some of these people have left trash on the shore. With the next storm, that trash will wash into the river. Further upstream is a PERSON FISHING. The person snags their hook on a log and rather than untangling it, breaks off the nylon fishing line.
### WHO POLLUTED THE POTOMAC?

#### CANISTER LABELS

<table>
<thead>
<tr>
<th>Icon</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>🌳</td>
<td>Trees</td>
</tr>
<tr>
<td>🏞️</td>
<td>Barnyards</td>
</tr>
<tr>
<td>🌍</td>
<td>Electric Power Plant</td>
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<tr>
<td>🤖</td>
<td>Antifreeze</td>
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<tr>
<td>📷</td>
<td>Motorboats</td>
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<tr>
<td>🛹</td>
<td>Person Fishing</td>
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<td>🐋</td>
<td>Construction Sites</td>
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<td>🏡</td>
<td>Homeowner</td>
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<td>💰</td>
<td>Farmers</td>
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<td>Homeowner</td>
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<tr>
<td>💡</td>
<td>Coal Mine</td>
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<tr>
<td>🌱</td>
<td>Gardeners</td>
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<tr>
<td>🚗</td>
<td>Washing the Car</td>
</tr>
<tr>
<td>🗺️</td>
<td>Mysterious Liquid</td>
</tr>
<tr>
<td>🏖️</td>
<td>Beach Party</td>
</tr>
<tr>
<td>🎤</td>
<td>Picnicking</td>
</tr>
</tbody>
</table>
INTRODUCTION

It is estimated that there may be as many as 30 million plant and animal species worldwide, although only 1.4 million have been named. Over half of all species make their homes in the tropical rainforests of Asia, Africa and Latin America.

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 38 million acres (an area larger than Florida) each year.

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
• Counting Grid (provided)
• Die
• Sealable baggie labeled “Temperate Forest”
• Sealable baggie labeled “Tropical Forest”
• Variety of beans, seeds and dry noodles
• Graph paper

CONCEPT

Biodiversity is vital for maintaining the health and beauty of the Earth. Tropical forests are some of the most biodiverse places on the planet but many are located in areas experiencing high population growth rates, resulting in rapid habitat loss.

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.

<table>
<thead>
<tr>
<th>Temperate Forest baggie</th>
<th>Tropical Forest baggie</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 dry black beans = White-tailed deer</td>
<td>20 popcorn seeds = Mutuba trees</td>
</tr>
<tr>
<td>40 dry red beans = Oak trees</td>
<td>20 dry red beans = Fluted milkwood trees</td>
</tr>
<tr>
<td></td>
<td>8 dry black beans = Goliath beetles</td>
</tr>
<tr>
<td></td>
<td>5 raw sunflower seeds = Forest green snakes</td>
</tr>
<tr>
<td></td>
<td>4 dry black eyed peas = African green broadbill</td>
</tr>
<tr>
<td></td>
<td>2 dry lima beans = Cream-banded swallowtail butterfly</td>
</tr>
<tr>
<td></td>
<td>1 dry macaroni noodle = Gorilla</td>
</tr>
</tbody>
</table>

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 Counting 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 Counting Grids.

4. Students distribute the beans on their Counting 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 Uganda 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. a. Temperate Species               | Probability
   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**

<table>
<thead>
<tr>
<th>Species</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Popcorn seeds = Mutuba trees</td>
<td>6/6, or 1</td>
</tr>
<tr>
<td>Red beans = Fluted milkwood trees</td>
<td>6/6, or 1</td>
</tr>
<tr>
<td>Black beans = Goliath beetles</td>
<td>4/6, or 2/3</td>
</tr>
<tr>
<td>Sunflower seeds = Forest green snakes</td>
<td>4/6, or 2/3</td>
</tr>
<tr>
<td>Black eyed peas = African green broadbills</td>
<td>4/6, or 2/3</td>
</tr>
<tr>
<td>Lima beans = Cream-banded swallowtail butterflies</td>
<td>1/6</td>
</tr>
<tr>
<td>Macaroni noodle = Gorilla</td>
<td>1/6</td>
</tr>
</tbody>
</table>

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. \( P = 4/6 \)
   b. \( P = 4/6 \)
   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 biodiversity?

   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 rainforest?

   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 rainforest 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. For example, 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 the rainforest.

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. 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 the last of the plant 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.
2. Each student should research an obscure plant or animal found in a tropical rainforest. 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, 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.
WORLD OF DIFFERENCE
STUDENT WORKSHEET

Place beans on your Counting 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:**
- **Mutuba tree** (20 popcorn seeds): Place at least 3 in each acre, but no more than 4 in any acre.
- **Fluted milkwood tree** (20 red beans): Place at least 1 in each acre, but no more than 8 in any acre.
- **Goliath beetle** (8 black beans): Place at least 1, but no more than 3, in any 4 acres. DO NOT place Goliath beetles in 2 acres.
- **Forest green snake** (5 sunflower seeds): Place at least 1, but no more than 2, in any 4 acres. DO NOT place snakes in 2 acres.
- **African green broadbill** (4 black eyed peas): Place 1 in each of four acres. DO NOT place African green broadbills 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

<table>
<thead>
<tr>
<th>Species</th>
<th>Acre A</th>
<th>Acre B</th>
<th>Acre C</th>
<th>Acre D</th>
<th>Acre E</th>
<th>Acre F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black beans = White-tailed deer</td>
<td></td>
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<tr>
<td>Red beans = Oak trees</td>
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<tr>
<td>Total species per acre</td>
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</table>

### Tropical Forest

<table>
<thead>
<tr>
<th>Species</th>
<th>Acre A</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Popcorn seeds = Mutuba trees</td>
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<td></td>
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<tr>
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<tr>
<td>Black beans = Goliath beetles</td>
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<td></td>
</tr>
<tr>
<td>Sunflower seeds = Forest green snakes</td>
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<tr>
<td>Black eyed peas = African green broadbill</td>
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<tr>
<td>Lima beans = Cream-banded swallowtail butterfly</td>
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<tr>
<td>Macaroni noodle = Gorilla</td>
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<tr>
<td>Total species per acre</td>
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</tbody>
</table>
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? Fill in the table.

<table>
<thead>
<tr>
<th>Species</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black beans = White-tailed deer</td>
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</tr>
<tr>
<td>Red beans = Oak trees</td>
<td></td>
</tr>
</tbody>
</table>

b. What is the probability that the population of each species in the tropical forest will change if you clear an acre there? Fill in the table.

<table>
<thead>
<tr>
<th>Species</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Popcorn seeds = Mutuba trees</td>
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<td></td>
</tr>
<tr>
<td>Macaroni noodle = Gorilla</td>
<td></td>
</tr>
</tbody>
</table>

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 0.8 percent annually. In central Africa, Uganda has tropical forests and a population growth rate of 3.3 percent, approximately 4 times that of the U.S. 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, or 5 represents population growth in Uganda and therefore one acre of tropical forest should be cleared. If you roll a 6, do not clear any acres or count it as a roll, and re-roll the die.
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? ________________________________

<table>
<thead>
<tr>
<th>Roll Number</th>
<th>Forest (Circle One)</th>
<th>Acre Cleared (A-F)</th>
<th>Number of Temperate Species Remaining</th>
<th>Number of Tropical Species Remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperate</td>
<td>Tropical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Temperate</td>
<td>Tropical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Temperate</td>
<td>Tropical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Temperate</td>
<td>Tropical</td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>Temperate</td>
<td>Tropical</td>
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<tr>
<td>6</td>
<td>Temperate</td>
<td>Tropical</td>
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<td>7</td>
<td>Temperate</td>
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<td>9</td>
<td>Temperate</td>
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<td>10</td>
<td>Temperate</td>
<td>Tropical</td>
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<tr>
<td>11</td>
<td>Temperate</td>
<td>Tropical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Temperate</td>
<td>Tropical</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
COUNTING GRID

Each square represents one acre.

**Temperate Forest**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>E</td>
<td>F</td>
</tr>
</tbody>
</table>

**Tropical Forest**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>E</td>
<td>F</td>
</tr>
</tbody>
</table>