Celebrate 50 years of Earth Day by exploring human impact on the environment. How can we take action against climate change? How can we be sustainable even as our population grows?

Reading: Making a Difference for People and the Planet

Lesson Plans:

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

**In Search of Sustainable Life** (science, social studies) – *Students develop an index of the ten factors they identify as most important to a sustainable community and develop models for measuring those factors.*

**Meat of the Matter** (science, social studies) – *Students graph global meat consumption, use manipulatives to explore the environmental impact of four different types of protein, and discuss the pros and cons of a shifting global diet.*

**People and Climate Change: The Data Is In** (science, math, social studies, ELA) – *Students interpret various forms of data (graphic, written, and visual) and identify relationships between population growth, greenhouse gas emissions, temperature rise, ice melt, and sea level rise.*

**What's Up in the Air?** (science, social studies, ELA) – *Students interpret photos, along with historical accounts and online research, to deduce what human activities contribute to air pollution and suggest possible solutions.*

*For more great resources, visit us at [www.PopulationEducation.org](http://www.PopulationEducation.org)!*
You may have heard the saying, “Think globally, act locally.” What does this mean? In Global Family Matters, we read about some of the problems that many members of our global family face around the world, such as poverty, hunger and social injustice. In The Human Footprint, we read about some of the human threats to the global environment, such as deforestation, loss of wildlife, air and water pollution and climate change. These are all huge problems, and learning about them can make us feel powerless. What can one person do? How can one person in 7.5 billion make a difference? The answer may be as close as your own backyard.

COMMUNITY CONNECTIONS
In thinking about how to make this world an even better place, we can start with our own communities – the towns, cities and neighborhoods where we live. Wherever you live, there are probably local concerns about quality of life for people and the environment. Maybe there are debates about how land is being used, where garbage is put, whether the air and water are clean for people and wildlife, whether people are homeless in your area, and whether the streets are safe.

People around the world are talking about how to make their communities more sustainable. A sustainable community is one that meets the basic needs of all its inhabitants without harming the ability of future generations to meet their needs as well. Such a community would have clean air and water, green space, thriving businesses, good transportation, good schools, low crime rates and other things that create a good quality of life. Building sustainable communities requires people to work together and plan ways to manage their areas' resources – cropland, forests, waterways – so that they are there for years to come.

Young people throughout the country have participated in projects that make a real difference in their communities. This is sometimes called service learning. Service learning projects might involve planting gardens and trees to beautify the local area, picking up litter from roadsides, volunteering time to tutor younger children, read to older people or work at a local foodbank. These projects can be organized by clubs at school or by outside youth groups. You could even be the one to suggest a service learning project.
to your friends and get it started. Your efforts may even be recognized by the local media. If they write about your project, it might inspire others to get involved.

Another way to make a difference is get involved in civic life – you don’t have to be voting age to have your say at public meetings (like school board or city council) or to get letters printed in the media. Living in a democracy means that you can speak out about how you think life can be improved for you, your friends and family, and other people in your community.

**DAILY HABITS THAT CHANGE THE WORLD**

You can have an impact on your community and the entire world just by the personal choices you make every day. Choices like what to eat, where to shop, how much to buy, and how to get around. Don’t think of it as the impact of just one person, but one person multiplied by millions, or maybe billions, making those choices, too.

Let's take food, for example. When we decide what to eat, we have a chance to make good choices for our bodies and for the planet. By choosing foods that are grown organically, we are helping to reduce the amount of chemical fertilizers and pesticides that saturate our soil. When we buy mostly fresh food that isn't processed, we are cutting down on the use of chemical preservatives and plastic and cardboard packaging. Better yet, when we look for fresh food in our markets that are grown locally, there isn’t a lot of wasted energy to get it to our tables.

Our choices about animal protein also impact the planet. Fish is a healthy choice but we can help our oceans by selecting types that are plentiful, not those threatened with extinction. Often, grocery stores will label the fish so that you know where it came from. We know that cattle make a lot of demands on our natural resources – from the land needed for grazing to the crops grown to feed the animals. Choosing a diet low in red meat can help preserve tropical rainforests and maintain agricultural land for growing crops to feed people.

Think about eco-friendly ways to use stuff in your everyday life. This could mean using a refillable water bottle instead of throw-away ones, or bringing reusable bags to the store. It might also mean making smart choices about things we buy or want others to buy us. Choosing well-made items (like clothes or electronics) that will last and that we won’t grow tired of too quickly means less disposable items that use more resources.

Our daily transportation habits also affect the environment. When possible, you can choose options that are convenient but also less polluting. This might mean walking or riding a bike or
scooter for short distances, carpooling with friends to school or parties, or taking the bus or other public transportation when possible.

BE AN INFORMED CITIZEN
Being an engaged citizen requires knowledge about the issues important to your community and our global family. Where do you get your information? Today, there are so many sources of news, but they aren’t all reliable. Sometimes people spread information as news that isn’t based on facts because they want to influence people’s thinking on an issue. When taking in information, you need to ask what the source is and what point of view that person or organization might have.

Be a critical consumer of news and information. Your teachers can help guide you to reputable news sources that are known for objective reporting about local, national and global events.

With solid information and a passion for helping others and the environment, there’s no telling what you can do. Throughout history, individuals and groups have done extraordinary things to promote a sustainable future and social justice. Mahatma Gandhi, one of the most famous social activists of the 20th century, said, “Be the change that you wish to see in the world.” This can start with simple, daily actions or grow into involvement in campaigns and movements that lead to a bright future for our communities here and around the world.

Glossary

climate change: a long term change in Earth’s weather patterns attributed largely to increased levels of carbon dioxide produced by the use of fossil fuels.
deforestation: the action of clearing a wide area of trees.
service learning: a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities.
sustainable communities: communities planned, built, or modified to promote sustainable living. These communities tend to focus on environmental and economic sustainability, urban infrastructure, social equity and municipal government.
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.

CONCEPT

Sustaining our natural resource base requires conservation and the cooperative use of resources held in common.

OBJECTIVES

Students will be able to:
• Identify a strategy that would produce a sustainable use of resources in a simulation game.
• Draw parallels between the chips used in the game and renewable resources upon which people depend.
• Analyze how the actions of participants in resource simulation games are similar or different from the actions of people in real-world situations.

SUBJECTS

Science (Earth and environmental), social studies (civics, geography), math, family and consumer sciences

SKILLS

Finding cooperative strategies, critical thinking, identifying trends and patterns, communicating

METHOD

In two simulation games, students determine individual short-term consumption strategies that will maximize resources for the entire group.
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.
IN SEARCH OF SUSTAINABLE LIFE

INTRODUCTION

We all want to live in a community that contains the resources needed to survive, is safe, clean, and provides adequate public services such as schools and a fire department. But it would be shortsighted to consider only the needs of community members here today. The human population is constantly expanding – roughly 80 million people join our ranks every year. How can we ensure future generations continue to benefit from the resources we enjoy today? How do we know if a community is sustainable?

More often than not, the progress of cities, states, and countries is measured with an economic index. The gross domestic product (GDP) measures the value of all goods and services produced in a certain place. And while GDP is a good indicator of economic activity, it does not account for many social and environmental factors that influence a community’s sustainability. The World Resources Institute points out that a “country could sell off its timber and minerals, erode its soils, pollute its aquifers, deplete its fisheries and the national accounts would treat all the proceeds as current income.” But suppose this happened. How would future generations survive and thrive without timber, nutrient soil, and clean water?

Economic activity does not tell the whole story. There are additional factors within a community that point to sustainability but are not measured in economic terms.

MATERIALS

• Community Photo Bank (provided)
• Foldable Template (provided)

CONCEPT

A sustainable community is characterized by environmental, social, and economic factors that allow it to prosper and thrive long-term.

OBJECTIVES

Students will be able to:
• Define sustainable community.
• Name three different types of sustainability and categorize factors representing each.
• Assess and prioritize factors of sustainability to create a Sustainability Index.
• Apply the Sustainability Index to their own community, identifying where improvements could be made and potential challenges.

SUBJECTS

Social studies (economics), science (Earth and environmental)

SKILLS

Analyzing and interpreting visual sources, values identification, decision making, prioritizing, critical thinking

METHOD

Students develop an index of the ten factors they identify as most important to a sustainable community and develop models for measuring those factors.
**PART 1: A SUSTAINABILITY INDEX**

**PROCEDURE**

1. Have ‘Sustainable Community’ written on the board and ask students to quietly consider what the term means. You may need to have them take each word independently first. If your students are not familiar with the concept of sustainability, have them first define the root ‘sustain.’ Additionally, you could use it in a few sample sentences, such as “The amount of money I was paying every week for groceries was not sustainable” or “We are using up our finite supply of fossil fuels so quickly that it’s not sustainable.”

2. Using student input, create a working definition of “sustainable” on the board for easy reference throughout the lesson.

3. One by one, display the photos found in the Community Photo Bank and for each, ask students to answer the question: Is this community sustainable? Why or why not?

   **Note:** Students’ answers at this point will be guesses; they will be deciding what makes a sustainable community throughout the remainder of the lesson.

4. Explain the three types of sustainability to students and provide one example of each.

   **Three Major Types of Sustainability**

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples of factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human/Social – pertaining to the health and happiness of individuals and the society</td>
<td>Access to education; health care, and nutritious food; citizen involvement; community safety/low crime</td>
</tr>
<tr>
<td>Environmental – pertaining to the natural environment and resources on which all living things depend</td>
<td>Proper waste management; accessible green spaces (parks); public transportation; clean air/water/land</td>
</tr>
<tr>
<td>Economic – pertaining to monetary capital (money)</td>
<td>Healthy businesses; revenue for the city; job opportunities</td>
</tr>
</tbody>
</table>

5. In small groups, challenge students to brainstorm what factors found in a community would make it sustainable. Encourage students to think in a broad sense, considering more than what would make their own life sustainable, and to be specific. Refer students to the example you shared for each type of sustainability if they need guidance getting started. At this point, focus on quantity with the expectation that each group’s list may include 15-20 factors.

6. As the students work in their groups, divide the board into three sections with the following labels: Human/Social, Environmental, and Economic.
7. Come together as a class and ask a representative from each group to share their factors. With each factor shared, discuss which type of sustainability it represents and write it on the board in the appropriate column. Some factors may contribute to more than one type of sustainability and be listed under more than one heading. For instance, bike lanes could be a social factor because they improve quality of life but also an environmental factor because they reduce emissions from automobiles.

8. Now it’s time to produce a usable index that measures the sustainability of a community. Based on all the factors listed on the board, conduct a vote to determine which 10 factors the class considers most vital in determining whether or not a community is sustainable. These factors will make up the class Sustainability Index. You may want to give students time to consider the large list independently and perhaps do their own ranking of top 10 factors before the class vote.

### Sample Sustainability Index

<table>
<thead>
<tr>
<th>Human/Social</th>
<th>Environmental</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste management</td>
<td>Green space</td>
<td>Citizen involvement</td>
</tr>
<tr>
<td>Access to fresh and nutritious food</td>
<td>Water conservation</td>
<td>Small business support</td>
</tr>
<tr>
<td>Quality health care</td>
<td>Low pollution</td>
<td></td>
</tr>
<tr>
<td>Quality education</td>
<td>Mass transit options</td>
<td></td>
</tr>
</tbody>
</table>

### PART 2: SUSTAINABILITY IN MY COMMUNITY

**PROCEDURE**

1. The class Sustainability Index is complete and now students will put it to use in their own community. Divide students into nine groups and distribute a copy of the Foldable Template to each group. (The printed side with text will be the “outside” of the foldable so the text serves as the cover.)

2. Assign, or have each group select, one factor from the class Index. There should be one factor left unassigned.

3. Follow the diagram below to model for students how to create their foldable – both how to fold and cut it (fold on dotted line; cut on zigzag line) and how to fill it in, using the remaining factor that was not assigned to a student group.

#### FOLDED:

<table>
<thead>
<tr>
<th>Our Community</th>
<th>Improvements</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do we know about this factor in our community?</td>
<td>What can we do to improve this factor in our community?</td>
<td>What challenges might we face when trying to make these improvements?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FACTOR</th>
</tr>
</thead>
</table>
### UNFOLDED:

<table>
<thead>
<tr>
<th>Observation</th>
<th>Improvement</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### FACTOR

### EXAMPLE:

| • Lots of trees by school | • Plant a tree in my neighborhood | • Getting money for a tree |
| • No trees near my house  | • Turn old parking lot into a park | • Convincing the owner of the lot to change it to a park |
| • Not many parks          |                                         |                         |
| • Most people have big lawns | • Caring for the park – mowing the grass | • Making sure people know about the park |
| • Lots of shrubs in front of businesses |                                         |                         |

### GREEN SPACE

4. When finished, have groups pair up and discuss their foldables. Each group should first explain their foldable and then field questions from the other group.

### ASSESSMENT

Evaluate students’ participation in the creation of the Index and class discussion in Part 1. Review the groups’ foldables and monitor small group discussion in Part 2.
1. In addition to their observations from the foldable, students conduct focused research on their individual factor in your community and report their findings back to the class. For their factor, have students determine a source where they could find relevant information and then track it down. For example, they could contact the city’s department of public works and ask if they have statistics on recycling participation. Once students know statistics of their factor, have them consider questions such as:

   • How does my community rank in terms of this factor? If it’s poorly, how could this be improved?
   • How does my community compare to neighboring communities in terms of this factor?
   • Has this factor improved or gotten worse in recent years?

2. Students choose one of their possible improvements to the community, outline a detailed proposal for this plan, and send it to select local government officials. They might also want to send the full Sustainability Index so that city officials can determine what students care about in their community.

3. Students apply their Sustainable Community Index more narrowly to your school itself; for example, consider whether the building and grounds have adequate green space, a strong recycling program, and access to nutritious food in the cafeteria. Students could design improvements and action plans to submit to school administrators based on their findings.

4. Have students compare the level of sustainability in your community to one that has been studied in class in a different country. How are they similar and dissimilar? Have students write a one-page paper comparing the two communities.
IN SEARCH OF SUSTAINABLE LIFE
COMMUNITY PHOTO BANK

“1st Street NE cycletrack, Washington DC” by BeyondDC

“Whitefield Park” by Mikey
Photo from "Healthy Harbor Announces Campaign for New Canton Water Wheel" from the Waterfront Partnership of Baltimore

"Langley Farm Market" from Dennis S. Hurd
Photo from "Police Investigating Shots Fired on Drummond Court In Halifax" from haligonia.ca
### IN SEARCH OF SUSTAINABLE LIFE

#### FOLDABLE TEMPLATE

<table>
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<tr>
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</tbody>
</table>
MEAT OF THE MATTER

INTRODUCTION

Meat production is an incredibly resource-intensive process that threatens the health of our environment. Much of meat’s environmental footprint comes from the energy it takes to feed and raise livestock. Consider this: 33 percent of all cropland is used to farm grains, fruits, and vegetables for livestock and 25 percent of the planet’s ice-free land is used for livestock grazing. Meanwhile, global meat consumption has nearly doubled since 1961 and demand is not expected to slow anytime soon.

Rising per-capita meat consumption, particularly in the developing world, compounds future risks for global food security. The Food and Agriculture Organization of the United Nations (FAO) estimates that rising incomes in the developing world will require meat production to double by 2050. Making smarter choices about the type and quantity of meat we eat and understanding the environmental risks of industrial agriculture are critical to sustainable resource management.

MATERIALS

• Student Worksheet
For each group:
• Environmental Impact Grids 1 – 4 (provided)
• Set of assorted bingo chips

PART 1: GLOBAL MEAT CONSUMPTION TRENDS

PROCEDURE

1. To get students thinking about historical trends in meat consumption, ask the following: Do you think people today eat more or less meat on a global per-capita basis than they did 50 years ago? Why or why not?
2. Divide students into pairs and distribute the Student Worksheet to each pair. Have each pair graph the data provided on the Worksheet.

3. Once students have graphed their data, each pair should briefly discuss their initial observations with another pair.

4. As a class, briefly discuss trends observed and then ask students to hypothesize why global meat consumption has been on the rise for the past 50 years. 

   **Answer:** We have made many changes to the way we produce our meat in the last 50 years. Industrial-style agricultural practices (factory farming) and the use of pesticides and fertilizers have allowed us to mass produce more food, including meat. Faster production in mass quantities has caused the price of meat to drop substantially, making it more accessible to a greater proportion of the population. Historically, much meat consumption occurred in the developed world. However, as incomes rise in developing nations, like China and India, it has become more affordable for individuals to add meat to their daily diet, resulting in a greater demand for meat.

5. Ask students if they think there are any social or environmental consequences of the rising demand and consumption of meat around the world.

   **Answers may include:** health complications from overconsumption of meat (particularly red meat), increased demand for meat may increase demand for factory farms, increased CO2 emissions, and environmental degradation.

6. Explain that there are very large, often hidden, environmental footprints associated with meat consumption due to all of the resources it takes to raise livestock for meat production and the animal wastes produced.

   **Answer to Student Worksheet**
PART 2: THE ENVIRONMENTAL IMPACTS OF AN ANIMAL PROTEIN-RICH DIET

PROCEDURE

1. Divide students into groups of four. You may want to have them work with the pairs they grouped into at the end of Part 1.

2. Distribute the following to each group:
   a. One of each environmental impact grid (beef, pork, poultry, soy).
   b. One pre-assembled set of bingo chips for each group of four, which contains:
      • 67 blue bingo chips
      • 47 red bingo chips
      • 14 green bingo chips

   Note: Numbers do not have to be exact, as long as students have more than what they need to complete the activity.

3. Explain to students that they are going to compare the environmental impacts of four different sources of protein (beef, pork, poultry, and soy) by examining their water, carbon, and land footprints using grids and different colored bingo chips. Each group member is responsible for completing one environmental impact grid.

4. From the Teacher Environmental Impact Sheet, read aloud the Water Footprint statistics for each protein type. Students must listen for their protein and add the appropriate number of blue “water” chips to their grid.

5. Repeat the process for the Carbon Footprint and Land Footprint statistics.

6. Allow students a few minutes to discuss their observations with their group.

7. Spend a few minutes as a class comparing and contrasting the environmental impacts of animal protein to plant-based protein (soy).

DISCUSSION QUESTIONS

1. How did soy’s environmental footprint compare to the animal-based proteins’ environmental footprints (beef, pork, and poultry)?

   Soy has a much smaller environmental footprint than animal protein. For example, poultry’s carbon footprint is about 3 times larger than soy’s. Pork and beef’s carbon footprints are 6 times and 26 times larger, respectively.
2. Soy is not the only plant-based protein. Can you think of other alternatives to soy?

   Answers may include: beans, chickpeas, lentils, peas, nuts, and quinoa.

3. Why do you think meat has such a large environmental footprint?

   Meat has a large environmental footprint because a lot of energy is lost in the food chain. Much of meat's environmental footprint comes from growing crops to feed livestock. The ten percent law – or law of tens – refers to the idea that with each transfer of energy through the trophic structure, only a small fraction of the energy, approximately 10 percent, remains available for the organism to use. The other 90 percent of energy is lost in the transfer as waste or heat. In the case of meat, 90 percent of the energy from the sun is lost when plants convert sunlight to carbohydrates (glucose) through photosynthesis and 90 percent of that 10 percent is lost again when animals, such as cattle, ingest grass or feed for energy. In short, meat has a larger environmental impact because so much more energy and water are used to produce each pound of meat, relative to a pound of fruits, vegetables or grains.

4. Look at your global meat consumption graph and environmental impact grids. Which type of protein poses the biggest environmental risk?

   Beef has the largest environmental footprint. We cannot tell which type of protein poses the largest environmental risk because our grids do not tell us the quantities of each type of protein consumed each year. If we refer back to our global meat consumption graph, we will notice that global demand for poultry and pork is much higher than beef.

5. Global meat production is expected to double by 2050. What challenges does this present for the environment? For the global community?

   Rising trends in meat production (and per-capita consumption) present a multitude of problems for the environment and society. Environmental problems include: land degradation caused by industrial-style farming and overgrazing, reliance on pesticides, deforestation, surface and groundwater contamination from chemical runoff and animal wastes, and elevated levels of atmospheric carbon dioxide and methane. Social problems include: health and obesity problems, the threat of antibiotic resistance, and the inhumane treatment of animals in concentrated animal feeding operations (CAFOs).

6. Do you have any ideas for how to curb demand for meat products?

   Answers may include: eating less meat, increasing public awareness about the environmental and social impacts of meat, and changing public health and dietary guidelines through legislation.
7. A rise in global meat consumption means a rise in the demand for animal feed. Currently, 75 percent of all soybeans grown are used to feed livestock. The graph below shows historic and projected global soy production. What does this graph tell you about the need for farmland? Can you think of any negative environmental consequences that stem from this demand?

The graph tells us that we will need more farmland in the future to keep up with the growing demand for soy products. Negative environmental consequences associated with this rising demand include land conversion and deforestation. A spike in demand for soy has resulted in large-scale deforestation in much of South America, where biodiverse rainforests are being converted into fields for soybean cultivation.

[Graph showing global soy production]

Source: WWF Global

8. While soy production has a lighter environmental footprint than meat production, it still has its drawbacks (converting rainforest and savanna to farmland, industrial farming practices that harm the soil and wildlife, and displacement of small farmers). Can you think of some options for more sustainable ways to grow plant-based proteins?

Answers may include: organic farming, crop rotation, and sustainable agriculture.

9. Most people in the U.S. (97 percent) include meat in their diet. Given the popularity of meat, is there anything that we can do to lower meat production's impact on the environment? What are the pros and cons of these solutions?

Purchasing sustainably farmed and locally-raised meat can significantly reduce the adverse environmental and social impacts of meat consumption. Sustainable farms recognize the importance of environmental stewardship and use responsible agricultural practices, like crop and livestock integration, to improve the health of soils and the environment. Additionally, purchasing meat from local farms cuts back on the fossil fuels required to transport goods from farm to table, which shrinks its carbon footprint. Unfortunately, sustainably and locally sourced meats can often be more expensive than their conventional counterparts and many people cannot afford to pay the higher price. There are ways to make sustainably-raised meat more accessible to a wide range of socio-economic groups. Across the United States, cooperative grocery stores and wholesale retailers work to provide low-income communities with high quality, sustainably-sourced meat and produce.
ASSESSMENT

Students create a visual representation, through words or drawing, of three things they learned about global meat consumption and its impact on the environment.

FOLLOW-UP ACTIVITIES

1. Have students explore three interactive maps from Ensia to identify projected changes in beef, pork, and poultry consumption by country and document their observations.

2. Have your students reflect on their experience by creating a poster or brochure to educate the public about the environmental impacts of meat consumption.

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3WWF. Soy: Facts & Data.
4National Geographic. The Hidden Water We Use.
TEACHER ENVIRONMENTAL IMPACT SHEET

**Water Footprint**: 1 blue chip = 50 gallons of water

**Soy**: It takes approximately 220 gallons of water to produce 1 pound of soybeans. Place 4 blue chips on your grid.

**Poultry**: It takes approximately 470 gallons of water to produce 1 pound of poultry. Place 9 blue chips on your grid.

**Pork**: It takes approximately 580 gallons of water to produce 1 pound of pork. Place 12 blue chips on your grid.

**Beef**: It takes approximately 1800 gallons of water to produce 1 pound of beef. Place 36 blue chips on your grid.

**Carbon Footprint**: 1 red chip = 5 pound of carbon

**Soy**: Approximately 10 pounds of CO2 are emitted to produce and transport 1 pound of soybeans. Place 2 red chips on your grid.

**Poultry**: Approximately 30 pounds of CO2 are emitted to produce and transport 1 pound of poultry. Place 6 red chips on your grid.

**Pork**: Approximately 60 pounds of CO2 are emitted to produce and transport 1 pound of pork. Place 12 red chips on your grid.

**Beef**: Approximately 130 pounds of CO2 are emitted to produce and transport 1 pound of beef. Place 26 red chips on your grid.

**Land Footprint**: 1 green chip = 20 square feet of land

**Soy**: Approximately 20 square feet of land are needed to produce one pound of soybeans. Place 1 green chip on your grid.

**Poultry**: Approximately 40 square feet of land are needed to produce 1 pound of poultry. Place 2 green chips on your grid.

**Pork**: Approximately 60 square feet of land are needed to produce 1 pound of pork. Place 3 green chips on your grid.

**Beef**: Approximately 160 square feet of land are needed to produce 1 pound of beef. Place 8 green chips on your grid. However, if we take into account the space needed for pasture, it takes 1,560 square feet of land to produce 1 pound of beef. Place an additional 70 green chips on your grid*. 

*Note: students will realize that there are not enough spaces on their grid or green chips at their workstation. Stop the activity and discuss as a class why meat requires more land than vegetables and other forms of protein.
MEAT OF THE MATTER
STUDENT WORKSHEET

Name: ___________________________________________ Date: ____________________

Directions: Work with your partner to graph and label the data provided below.

Global Meat Consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Poultry (Tons)</th>
<th>Pork (Tons)</th>
<th>Beef (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>26,483</td>
<td>73,779</td>
<td>86,439</td>
</tr>
<tr>
<td>1971</td>
<td>46,777</td>
<td>115,349</td>
<td>118,334</td>
</tr>
<tr>
<td>1981</td>
<td>80,916</td>
<td>158,011</td>
<td>141,975</td>
</tr>
<tr>
<td>1991</td>
<td>128,073</td>
<td>208,663</td>
<td>165,030</td>
</tr>
<tr>
<td>2001</td>
<td>207,530</td>
<td>258,572</td>
<td>171,613</td>
</tr>
<tr>
<td>2011</td>
<td>300,131</td>
<td>321,757</td>
<td>195,166</td>
</tr>
</tbody>
</table>

Source: Food and Agricultural Organization of the United Nations.
### MEAT OF THE MATTER

**ENVIRONMENTAL IMPACT GRID 1: BEEF**

| Water Footprint: 1 blue chip = 50 gallons of water |
| CO₂ Footprint: 1 red chip = 5 pounds of carbon |
| Land Footprint: 1 green chip = 20 square feet of land |
**MEAT OF THE MATTER**

**ENVIRONMENTAL IMPACT GRID 2: PORK**

<table>
<thead>
<tr>
<th>Water Footprint: 1 blue chip = 50 gallons of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Footprint: 1 red chip = 5 pounds of carbon</td>
</tr>
<tr>
<td>Land Footprint: 1 green chip = 20 square feet of land</td>
</tr>
</tbody>
</table>

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MEAT OF THE MATTER
ENVIRONMENTAL IMPACT GRID 3: POULTRY

💧 Water Footprint: 1 blue chip = 50 gallons of water

氪 CO₂ Footprint: 1 red chip = 5 pounds of carbon

농 Land Footprint: 1 green chip = 20 square feet of land
MEAT OF THE MATTER
ENVIRONMENTAL IMPACT GRID 4: SOY

💧 Water Footprint: 1 blue chip = 50 gallons of water
🔥 CO2 Footprint: 1 red chip = 5 pounds of carbon
🌱 Land Footprint: 1 green chip = 20 square feet of land
INTRODUCTION

There is scientific consensus that our climate is changing and it’s happening at an alarming rate. Concentrations of atmospheric carbon dioxide are at the highest levels seen in centuries and are steadily climbing, average annual temperatures continue to soar, and all of Earth’s environmental systems are suffering as a result. The root cause of all this sudden change is people. Around the dawn of the Industrial Age, human population began growing exponentially. The burning of fossil fuels powered a new modern life and led to a sharp increase in the amount of greenhouse gases in the atmosphere. This growing abundance of greenhouse gases (largely carbon dioxide) has had a ripple effect around the world, causing temperatures to increase, ice to melt, and, ultimately, seas to rise.

Scientists continuously collect data to monitor the many impacts of climate change and to make predictions about the future. By analyzing climate-related graphs, visual images, and news articles, people can begin to understand the many cause and effect relationships that are shaping our changing world.

MATERIALS

- Butcher paper
- Glue sticks or tape
- Markers
- Data Bank Items* (provided)
- 2 computers/tablets with internet access
*To access the two Data Bank articles, you will need to sign up for a free Educator account at Newsela (https://newsela.com/join)

PROCEDURE

1. Before class, sign-up for a free Newsela account at https://newsela.com/join. Select “I am an Educator” and print the two articles, “Earth is getting hotter,
scientists say, pointing to 2014’s record warmth” and “Greenland has lost vast amount of ice, and it’s melting faster, study finds.” Make copies of each article and the additional items from the Data Bank – you will need to make one copy for each pair of students. For example, a class of 20 would need 10 copies of each Data Bank item.

2. Place stacks of each data piece at the front of the classroom at random (don’t have all the information related to temperature rise in the same area).

3. Divide the class into pairs.

4. Ask students to discuss three things they already know about climate change with their partner. (This lesson will work best if students already have a working knowledge of the basic causes and impacts of climate change.)

5. Point out the Data Bank at the front of the classroom and explain that students will be analyzing pieces of data related to climate change, but that the data isn’t just numbers – it’s graphs, images, articles, and more.

Data Bank Items:

<table>
<thead>
<tr>
<th>Theme</th>
<th>Data</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carbon emissions and population growth (1751 – 2010)</td>
<td>Online data visualization</td>
</tr>
<tr>
<td></td>
<td>CO2 levels over the past 400,000 years</td>
<td>Line graph</td>
</tr>
<tr>
<td></td>
<td>Greenhouse gas emissions by type</td>
<td>Pie chart</td>
</tr>
<tr>
<td>Temperature Rise</td>
<td>Greenhouse effect</td>
<td>Visual diagram</td>
</tr>
<tr>
<td></td>
<td>Global temperature maps (1884 – 2015)</td>
<td>Time series maps</td>
</tr>
<tr>
<td></td>
<td>Climate change: Global Temperature (1880 – 2020)</td>
<td>Bar graph</td>
</tr>
<tr>
<td></td>
<td>Article: &quot;Earth is getting hotter, scientists say, pointing to 2014’s record warmth&quot;</td>
<td>Non-fiction article (adapted by Newsela)</td>
</tr>
<tr>
<td>Ice Melt*</td>
<td>Muir Glacier before (1941) and after (2004)</td>
<td>Photo image</td>
</tr>
<tr>
<td></td>
<td>Antarctica ice shelf time lapse</td>
<td>Online data visualization</td>
</tr>
<tr>
<td></td>
<td>Article: &quot;Greenland has lost vast amount of ice, and it’s melting faster, study finds&quot;</td>
<td>Nonfiction article (adapted by Newsela)</td>
</tr>
<tr>
<td>Sea Level Rise</td>
<td>US Sea level change (1960 – 2014)</td>
<td>Map</td>
</tr>
<tr>
<td></td>
<td>Flooding in Bangladesh</td>
<td>Photo image</td>
</tr>
<tr>
<td></td>
<td>Past and projected changes in global sea level rise (1800 – 2100)</td>
<td>Line graph</td>
</tr>
</tbody>
</table>

* The ice melt examined in this activity refers to land ice melt like glaciers and ice sheets that, when melted, contribute to sea level rise.

6. To begin, one person from each pair comes to the front of the room and picks a piece of data from the Bank. Don’t give the students guidance on what to pick first; the data should be chosen at random.
7. Each pair will work to complete the instructions and/or questions on their piece of data before going back to the Data Bank for another piece. Students should rotate who gets the data and keep all the pieces they’ve already analyzed at their desk.

   **Note:** For more monitoring, students could be required to bring each completed piece of evidence to the teacher for a quick check on understanding and completion before getting another piece.

8. Tell students that as they collect and analyze data, they should think about two things:

   a. Is this information communicating the same point as any other data I’ve already seen?
   b. Is this information related to any of the other information – either as a direct cause or direct effect?

   **Note:** All the information in the Data Bank can be grouped into four general themes, as indicated in the Data Bank Chart: 1. population growth and the rise of greenhouse gas emissions, 2. temperature rise, 3. land ice melt, and 4. sea level rise. There are several pieces of data for each theme – all of which represent the same general point, but through different methods (graph, data visualization, written article, image, etc.). Students might put the J-Curve graph of human population growth in its own group, and that’s okay.

9. Tell students that information representing the same idea should be grouped. Next, they should attach each piece of data (still in groups) to the butcher paper and connect correlative relationships between groups of data with arrows.

   **Answer:** In a basic sense, growing population → more greenhouse gases in the atmosphere → temperature rise → ice melt → sea level rise. However, depending on their climate background knowledge, students may be able to make more connections between these topics (e.g. ice melt leads to more greenhouse gas due to the release of methane).

### ALTERNATE PROCEDURES

1. For younger students, or to save time, divide the class into groups of four or five. Give each group the data pieces from only one theme. After groups have had time to analyze all of their information, each group shares with the class one sentence that summarizes what their data conveyed, what format (graphic, visual, etc.) they thought best represented that information and why. Next, ask students to determine how their group’s information relates to that of the other groups. Take time for each group to share and create a class web illustrating the connections that are discussed.

2. Eliminate some of the data. Including only one or two pieces of information from each category would cut down on time and make it easier for younger students to draw connections.
DISCUSSION QUESTIONS

1. What piece of data did you find the most difficult to understand? Why do you think this is?

2. What form of information (visual, graphic, written) do you find the most effective? What are the benefits and drawbacks to each type of representation?

   Answers will vary. Students may feel that visual images are more powerful and interesting but lack in details, that data visualizations are easier to understand than line graphs, that line graphs best represent change over time, that articles have more information but take more time to process, etc. Some students may prefer to just look at numbers.

3. Temperature change, land ice melt, and the resulting rise in our seas all stem from the increase of greenhouse gases in our Earth’s atmosphere. How has population growth contributed to the rise in greenhouse gases?

   Fossil fuels power our lives. With more people, there are more cars on the road, more factories producing consumer goods, more food being processed, and more electricity being used. All of these human activities emit greenhouse gases and throw off Earth’s natural cycles.

4. Why do you think both population growth and CO2 emissions drastically increased in the 19th century?

   Both population and carbon emissions grew after the dawn of the Industrial Revolution when advances in medicine, technology, and sanitation led to longer life expectancy as well as higher demand for energy. Also, advances during the Industrial era allowed us to harness energy from fossil fuels in massive quantities like never before. An ever-growing and ever-consuming population meant continued increases in carbon use.

5. Are there any impacts of climate change that were not addressed in the Data Bank?

   Yes, there are many: coral bleaching, changes in weather patterns (more severe storms, extended droughts and shorter growing seasons), risks to wildlife health, changes in wildlife migration patterns, etc. All of these changes have far-reaching impacts on the well-being of both wildlife and humans.

6. What could be done to halt or slow the advance of climate change? Hint: think about the driving causes.

   Stabilizing population growth would be a good place to start. But it’s not only about our numbers – it’s also about how we use resources. Decreasing our dependency on fossil fuels and using more renewable energy sources like solar and wind can make a big impact. Individuals can play a part by driving less, buying fewer material goods, eating local and eating less meat, and spreading the word to others. In addition to emitting less, we can protect and plant trees which absorb CO2 from the atmosphere. Scientists and engineers are constantly brainstorming new technologies to help reverse Earth’s rise in temperature.
ASSESSMENT

Students complete the following statements, as they relate to interactions between the four themes of data:

I learned that: _______________________________________________________________________

I was surprised about: ___________________________________________________________________

I felt: _______________________________________________________________________________

FOLLOW-UP ACTIVITIES

1. Ask students to write a persuasive essay that would help convince a climate change skeptic that climate change is happening and is a result of human activities. Students could pick data from the lesson, or find other evidence to support their argument.

2. Have students find and analyze data on impacts of climate change that were not addressed in this lesson (changes in weather patterns, changes in wildlife migrations, etc.).
Go to www.WorldPopulationHistory.org. Click “Explore the Map” on the entrance screen. The yellow and red dots represent populations of 1 million.

Q1. How many dots are in South America? What was the population of South America in 1 C.E.?

_____________________________________________________

From the “Overlays” dropdown menu select “Fossil Fuel CO2 emissions.”

Q2. Next to the title, Fossil Fuel CO2 Emissions, is a date, 1751 – 2010. What do you think this means?

_____________________________________________________

Look at the “year” box at the top right of the screen. It should now show the year 1751.

Click the triangle play button on the bottom right of the screen to see how population and CO2 emissions change between 1751 and 2010.

Q4. What happens to population between 1751 and 2010?

_____________________________________________________

Q5. What happens to CO2 emissions between 1751 and 2010? How do you know?

_____________________________________________________

Q6. How are population and CO2 emissions related? Why do you think this is true?

_____________________________________________________


Q1. The graph starts in the year 1 C.E. How many years did it take for population to reach 1 billion people?

________________________________________________________________________________________

Q2. It took 123 years to grow from 1 billion to 2 billion people. How long did it take to get from 6 billion to 7 billion people? What does this mean about the rate of population growth?

________________________________________________________________________________________
Circle the title of the graph.

Q1. What type of greenhouse gas is the most prevalent worldwide?

Q2. What human activities contribute CO2 to the atmosphere (hint: look at the graph for clues)?

Q3. Is a pie graph a good way to represent this data? Why or why not?
Source: NASA

This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO2 has increased since the Industrial Revolution. (Credit: Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO2 record.)

Q1. Which greenhouse gas is being graphed?

Q2. What time period is represented by this graph?

Q3. What is the graph's main take-away?

Q4. Is this a compelling piece of information? Why or why not?

Q5. Give this graph a title.
The greenhouse effect is thrown out of balance by too much man-made carbon dioxide. (1) Some sunlight that hits the Earth is reflected. Some becomes heat. (2) CO2 and other greenhouse gases in the atmosphere trap heat, keeping the Earth warm.

Q1. Draw an arrow pointing to where greenhouse gases are located on the diagram.

Q2. Why is it called the Greenhouse Effect?

Q3. How does CO2 in the air contribute to Earth's warming? Use the diagram and the text below the diagram for reference.

Q4. What human activities do you know of that contribute CO2 to the atmosphere?
Q1. “Anomaly” means a departure from the long-term average. What do you think the 0 on the y-axis of the graph means?

Q2. What is the trend in global temperatures? Draw an extension of the red line to represent what you think will happen in the year 2020.
The time series below shows the five-year average variation of global surface temperatures from 1884 to 2015. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average.

Q1. What was the trend from 1884 – 1955?

Q2. What is the trend in the last 20 years of data?

Q3. What color do you think will be most represented on the map in 20 years?

Q4. What benefits are there to viewing temperature data in this format? What are the drawbacks?

Q5. How else could this data be portrayed?
Earth is getting hotter, scientists say, pointing to 2014's record warmth

By Los Angeles Times, adapted by Newlea staff

01.22.15

Please read the printed article that your teacher has provided.

Q1. What point is the article's author making?

Q2. Circle the paragraph that, in your opinion, is the most persuasive in expressing the author's point.
MUIR GLACIER, ALASKA

September 2, 1892          August 11, 2005

A pair of northeast looking photographs, both taken from the same location on the west shoreline of Muir Inlet, Glacier Bay National Park and Preserve, Alaska showing the changes that have occurred to Muir Glacier between September 2, 1892 and August 11, 2005.

Q1. How many years passed between the first and the second picture?

Q2. What do you think is causing the glacier to retreat so rapidly?

Q3. Give this set of images a catchy title.

Click on “Antarctica.”

Click the red dot representing the Larsen B ice shelf and click the play arrow to watch what happens to Larson B. Then click on the dot for the Wilkins ice shelf and click “play.”

Q1. What do these visualizations show?

____________________________________________________________________________________

____________________________________________________________________________________

Q2. What questions do you still have?

____________________________________________________________________________________

____________________________________________________________________________________
Greenland has lost vast amount of ice and it’s melting faster, study find

By Washington Post, adapted by Newlea staff
01.05.16

A melting iceberg floats along a fjord leading away from the edge of the Greeland ice sheet near Nuuk, Greenland. July 26 2011. Photo: AP/Brennan Linsley

Please read the printed article that your teacher has provided.

Q1. Circle the sentence that best summarizes the main point of the article.
This map shows total changes in sea level from 1960 to 2014 at tide gauge stations along U.S. coasts. Relative sea level reflects changes in sea level as well as land elevation.

**NOTES:** After a period of approximately 2,000 years of little change (not shown here), global average sea level rose throughout the 20th century, and the rate of change has accelerated in recent years. When averaged over all the world’s oceans, absolute sea level increased at an average rate of 0.06 inches per year from 1880 to 2013. Since 1993, however, average sea level has risen at a rate of 0.11 to 0.14 inches per year—roughly twice as fast as the long-term trend. Source: EPA

Q1. What is this map showing?

Q2. What do you think relative sea level change means?

Q3. Underline the sentence in the “NOTES” that most helps you understand this image.
A Bangladeshi woman walks to another village to find drinking water after the well in her village flooded. Bangladesh is low-lying and densely populated, making it one of the most vulnerable countries to sea level rise from climate change.

Q1. How does this image make you feel?

Q2. What are benefits of getting information in this format? What are drawbacks?

Q3. Have you heard of other low-lying areas that will be impacted by sea level rise? Where?
Q1. What unit of measurement is used for tracking sea level rise in this graph?

Q2. Why do you think the orange bar shows such a wide range of potential sea level rise?
WHAT'S UP IN THE AIR?

INTRODUCTION

Clean air is necessary for the survival and health of human beings and the Earth. Yet in many parts of the world, especially in large cities in less developed countries, the air is far from clean. Created mostly by people, air pollution is considered any substance that humans introduce into the atmosphere that has negative effects on living things and the environment. Air pollution takes many forms but most commonly comes from the burning of fossil fuels such as coal and natural gas, and emissions from factories, cars, agriculture, and power plants. These emissions threaten public health and release greenhouse gases which trap heat in the atmosphere. In the United States, governmental agencies and systems are in place to help keep harmful levels of chemicals and gases out of our air, but this isn’t the case all over the world. As our global population grows, we are likely to increase the amount of fossil fuel emissions. There are things we can do on a personal level, such as driving less and recycling for example, to reduce our impact on the air. However, large-scale changes, such as government limits on emissions of harmful chemicals and gases, are also necessary.

MATERIALS

• Student Worksheets 1 & 2
• Story: “Donora Death Fog” (provided)
• Donora Photo Bank (provided)
• Multiple computers/tablets with internet access

PART 1: THE DONORA DEATH FOG

PROCEDURE

Donora, Pennsylvania was the site of the Donora Death Fog, which killed 20 people in 1948 and was the first major air pollution incident in the United States. The events that took place in Donora helped spur national concern over the state of our air.

CONCEPT

Human activities contribute to air pollution, which has negative impacts on the environment and public health.

OBJECTIVES

Students will be able to:
• Interpret information from photographs.
• Identify cause-and-effect relationships between air pollution and its impacts on human health and the environment.
• Distinguish between ozone and particle pollution and identify specific causes of air pollution.
• Consider solutions to reduce human impact on air quality.

SUBJECTS

Science (Earth and environmental), social studies (geography, history, civics)

SKILLS

Analyzing and interpreting visual sources, researching, listening comprehension, critical thinking

METHOD

Students interpret photos, along with historical accounts and online research, to deduce what human activities contribute to air pollution and suggest possible solutions.
1. Before class, hang a sign at the entry of the classroom that reads, “The year is 1948 and the air quality index of this classroom is rated hazardous.”

2. Start a discussion on air pollution with your students by asking the following questions:
   
   a. Why is the air so important to us?
      
      Answer: Air contains oxygen which is essential to life.
   
   b. What do you think of when you hear the words air quality and air pollution?
   
   c. What do you think the sign at the entry-way means?
   
   d. What do you think the air quality index is?
      
      Answers will vary. But be sure to tell students that the AQI is an index for reporting daily air quality. It tells us how clean or polluted the air is, and what associated health effects might be a concern. The higher the AQI value, the greater the level of air pollution and the greater the health concern.
   
   e. What do you think the air quality is in the place where you live? How can you tell? Has the air always been this way?

3. Tell your students that they will be going through a set of questions (Student Worksheet 1) using the Think-Pair-Share strategy. Your students will be using three photos from Donora, PA as clues to determine what happened in the town and to ultimately understand the importance of clean air for both people and the environment.

4. Distribute Student Worksheet 1 and ask your students to get into pairs.

5. Display the three photos found in Donora Photo Bank. Do not give your students any other information. Explain to students that using these photos as clues, it is their job to answer the following question: “What happened in the town of Donora, Pennsylvania?” For each photo, students should think to themselves about what they are seeing and then discuss their thoughts in their pairs, using Student Worksheet 1 to help guide their thinking and note their thoughts. Then, with their partner, they should write a one sentence caption for each of the photos.

6. As a class, go over Student Worksheet 1. How did students caption the photos and what do they think happened in Donora? What clues led them to their conclusions?

7. Read the story “Donora Death Fog” aloud to the class. Alternatively, you can have the students round-robin read but in that case, cover, white out, or cut out the questions/answers within the story.

   Note: For more background on the Donora Death Fog – Play NPR’s ‘Smog Deaths In 1948 Led To Clean Air Laws’ (Optional)
Answers to Student Worksheet 1
Possible photo captions. Student answers will vary.
Photo 1 - Donora Zinc Works of the U.S. Steel Corporation is dimly seen through fume-laden smoke and fog.
Photo 2 - Noontime smog on a street in Donora during the Donora Death Smog, 1948.
Photo 3 - Patient resting in an oxygen tent Donora, PA, 1948.

PART 2:
AIR POLLUTION: A GLOBAL PROBLEM

Large cities in less developed countries tend to have higher levels of air pollution than large cities in developed countries. According to the World Health Organization, some of the world’s most polluted cities are: Karachi, Pakistan; New Delhi, India; Beijing, China; Lima, Peru; Cairo, Egypt; Los Angeles, California.

PROCEDURE

1. Instruct your students to form their pairs from earlier and find a computer.

2. Distribute Student Worksheet 2 to each pair. If printing in black and white, it may be helpful to project the photos found in Student Worksheet 2 so students are better able to recognize them. Students could also visit the source link to get more information.

3. Students will complete Worksheet 2 by looking at photographs and conducting online research around different sources of air pollution.

4. As students complete their Worksheets, ask some of them to share what they came up with for captions and what they thought the photos were showing. Then go through the Discussion Questions as a class.

Answers to Student Worksheet 2

Photo 1 – Delhi, India
Possible photo caption: Burning garbage piles contribute to air pollution in Delhi.
1. Burning garbage. As our population increases so does the amount of waste produced.
2. Both. Burning trash emits carbon dioxide (ozone pollution) and particulate matter.
3. Carbon dioxide
4. Carbon dioxide is a greenhouse gas and a major driver of climate change. Fine particulate matter, tiny particles 2.5 micrometers in diameter or smaller, can harm human lungs and lead to respiratory issues and in some cases lung cancer.
5. Answers will vary.

Photo 2 – Lima, Peru
Possible photo caption: Commuters in Lima are affected by automobile emissions.
1. Automobiles. Growing population leads to an increased need for transportation. This comes in the form of both personal vehicles and public transportation, both of which burn fossil fuels and contribute to air pollution.
2. Ozone pollution
3. Nitrogen oxides such as nitric oxide or nitrogen dioxide, or volatile organic compounds (VOCs) which are emitted as gases from certain solids or liquids.
4. Ozone can irritate the respiratory system (coughing, throat irritation) and reduce lung function. The more pollution a person breathes, the more permanent damage it can cause.
5. Answers will vary.

Photo 3 – Beijing, China
Possible photo caption: Cooling towers of a coal-fired power plant emit harmful pollution into the air in Beijing.
1. Coal burning. This is a coal-fired power plant. The demand for energy will increase as more people are added to the population and require energy to heat and cool their homes, cook, and keep the lights on.
2. Ozone pollution
3. Same answer as Photo 2.
4. Same answer as Photo 2.
5. Answers will vary.

DISCUSSION QUESTIONS

1. What do all three of these activities have in common?
   They are all creating air pollution and are all human-driven activities.

2. What effect does the growing human population have on air quality?
   As more people are added to the planet their activities, such as driving and heating their homes, contribute to fossil fuel use and the emission of CO₂ into the air.

3. Where does our pollution come from?
   Answers may include: exhaust fumes from cars, emissions from factories, agricultural practices, mining operations, fires or burning trash, and other human actions.

4. Does the quality of our air matter? Is clean air important?
   Yes, polluted air can cause serious environmental problems such as ozone depletion, acid rain, and global warming. It can also have negative effects on public health, especially vulnerable populations, such as reducing lung function, aggravating asthma and irritating the respiratory system.

5. What could happen if you breathe polluted air?
   Polluted air can cause itchy eyes, coughing, asthma, and other illnesses. Prolonged exposure can have serious health impacts and even lead to death.

6. How can historic events, such as the Donora Death Smog, help us tackle environmental issues we face today?
   A historical event like the Donora Death Smog tell us how and why things happened in the past. These accounts are valuable to us as we move forward to try and protect and prevent the damage of our natural resources such as air, water, and land.
ASSESSMENT

Review answers to Student Worksheet 2 to assess understanding.

FOLLOW-UP ACTIVITIES

1. Using the information collected on Student Worksheet 2, have your students choose one of the three countries. They will then write a letter to a government official of that country persuading them to take action on air pollution. Students should look into the environmental agency for the country and research what is already being done. Encourage your students to come up with ways the country’s citizens and government can take action on air pollution.

2. Have students write a short journal entry describing how the Donora Death Smog helped pave the way for modern air quality laws in the U.S. Entries should include the following: how the citizens of Donora advocated for their right to clean air, and the outcome in regards to both the industry (what happened to the power plants?) and government policies (were any enacted as a result?).
STORY: DONORA DEATH FOG

In late October, 1948 the town of Donora, Pennsylvania was the site of a lethal air pollution disaster unprecedented in American history. The skies over Donora turned black with pollution and for five straight days the people of Donora endured a thick fog that cloaked the town in a toxic cloud of carbon monoxide, sulfur dioxide, and metal dust pollution.

Donora was home to the U.S. Steel Corporation’s Donora Zinc Works and American Steel and Wire Company, both of which constantly emitted streams of unregulated toxic smoke. The citizens of Donora were accustomed to the clouds of smog that often hung around until late morning.

- **What is smog?**
  
  *Answer: Fog or haze combined with smoke and other atmospheric pollutants.*

- **Can you name any other air pollutants and their sources?**
  
  *Answers may include: carbon dioxide (CO2) from burning fossil fuels such as gas from cars, cigarette smoke, and methane from agricultural processes.*

- **Are there any local sources of pollution near you?**

However, the Donora Death Smog was unlike anything Donora’s citizens had ever seen before. On October 27, 1948 the pollution from both the zinc and steel factories combined with a temperature inversion (a naturally occurring weather event in which air stops circulating and is trapped close to the ground) to create the deadly smog that claimed the lives of 20 people (mostly elderly with respiratory illnesses) and hospitalized over half of the town. After five days the lethal smog began to scatter thanks to the zinc and steel mill temporarily shutting down and to rain showers. In the coming years, this event would set the stage for substantial changes in how we manage our air.

- **Who or what was responsible for the deadly smog?**
  
  *Answers may include: people, industry, the zinc and steel mill, the temperature inversion.*

Following the deadly episode, Donora residents began to advocate for clean air and demanded that the zinc and steel factories shut down. In fact, the residents of Donora sued American Steel & Wire, and in June 1962 the steel mill closed permanently. This tragic disaster helped persuade members of the scientific and medical communities, as well as the public, that air pollution is a major threat to human health and can result in death. The events that took place in Donora have been credited for the adoption of air quality regulations and modern air pollution laws in the United States.

- **Did your predictions match this account? Now that you have this information, do the three photos make more sense?**

- **Do we have any agencies in the U.S. dedicated to the protection of human health and the environment?**
  
  *Answer: Yes, the Environmental Protection Agency.*

- **Are there any laws in place to protect our shared resources and environment? Do you know of any environmental laws or governmental agencies that we have in the U.S. to help protect our environment?**
  
  *Answers may include: Clean Air Act, Clean Water Act, and the EPA*
Today, air quality is much better in the United States. After the events in Donora came several important policies such as The Air Pollution Control Act of 1955 which was the first piece of federal legislation involving air pollution. Next came the U.S. Clean Air Act of 1963 which, for the first time, aimed to control air pollution. This was followed by the Air Quality Act of 1967 which enabled the federal government to investigate and enforce interstate air pollution transport, and, for the first time, to carry out far-reaching ambient monitoring studies and stationary source inspections.

- What is meant by interstate air pollution transport?
  Answer: Also referred to as air transport, this is the transport of air pollution across state boundaries.

- What is a stationary source of pollution?
  Answer: A fixed, non-moving emitter of air pollution. For example, factories, power plants, food processing plants, etc.

Then in 1970, the Clean Air Act was established to set regulations to limit emissions from both stationary and mobile sources such as factories and power plants or cars, trucks, and buses. In order to implement the various requirements of all of these acts, the U.S. Environmental Protection Agency (EPA) was established in 1970. These laws helped to drastically improve air quality in the U.S. However, air pollution still exists and not just in the U.S., but all over the world and is a very real threat. The World Health Organization estimates that outdoor air pollution in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012.¹

WHAT'S UP IN THE AIR?
STUDENT WORKSHEET 1

Name: _______________________________ Date: ____________________

Use the questions below to help you figure out what happened in the town of Donora. Then come up with a one sentence caption for each photo.

1. What is happening in these photos?

2. What do you see that makes you say that?

3. What more can you tell from these photos?

4. What/who do you think caused what is happening in these photos?

5. Are there any indications in each photo that something good or bad is happening? If so, is it good or bad for humans? The environment? Why?

Photo 1 Caption:

________________________________________________________________________

________________________________________________________________________

Photo 2 Caption:

________________________________________________________________________

________________________________________________________________________

Photo 3 Caption:

________________________________________________________________________

________________________________________________________________________
WHAT'S UP IN THE AIR?
STUDENT WORKSHEET 2

Name: ____________________________________________ Date: ______________________

For each photo, come up with a descriptive caption and answer the questions that follow. To answer the questions, go to: www.AirNow.gov and scroll down to the bottom of the homepage. You'll find the Health, Ozone, and Particle Pollution links helpful.

Photo 1: Delhi, India

Caption:

1. Identify the activity that is causing air pollution in this photo. How is this activity influenced by population growth? __________________________

2. Is this an example of particle pollution, ozone pollution, or both? __________________________

3. Name at least one harmful chemical or gas that is released into the air through this activity. __________

4. What impacts does this form of pollution (from question #3) have on human health and the environment? __________________________

5. What can the people and government of India do to prevent this form of pollution? __________
WHAT'S UP IN THE AIR?
STUDENT WORKSHEET 2 - PAGE 2

Photo 2: Lima, Peru

Caption:
______________________________________________________________

1. Identify the activity that is causing air pollution in this photo. How is this activity influenced by population growth? ________________________________________________

2. Is this an example of particle pollution, ozone pollution, or both? ________________________________________________

3. Name at least one harmful chemical or gas that is released into the air through this activity. ________

4. What impacts does this form of pollution (from question #3) have on human health and the environment? ________________________________________________

5. What can the people and government of Peru do to prevent this form of pollution? ______________________

______________________________________________________________

______________________________________________________________
WHAT’S UP IN THE AIR?
STUDENT WORKSHEET 2 - PAGE 3

Photo 3: Beijing, China

Caption:

1. Identify the activity that is causing air pollution in this photo. How is this activity influenced by population growth? ________________________________

2. Is this an example of particle pollution, ozone pollution, or both? ________________________________

3. Name at least one harmful chemical or gas that is released into the air through this activity. ____________

4. What impacts does this form of pollution (from question #3) have on human health and the environment? ________________________________

5. What can the people and government of China do to prevent this form of pollution? ________________
WHAT'S UP IN THE AIR?
DONORA PHOTO BANK

Photo 1:

Photo 2:

Photo 3: