PART 2: COMPARING THE ENVIRONMENTAL IMPACTS OF DIFFERENT PROTEINS

PROCEDURE

1. Draw three columns on the whiteboard, and label the columns with "Water," "Greenhouse Gas," and "Land." Explain that you will be examining the environmental footprints of four different types of protein: three types of meat (poultry, pork, and beef) and one plant-based protein (soy).

2. Ask students for ideas on how water is used to produce meat or to grow soy. Write student ideas in the "Water" column. Ask for ways meat production and soy farming contribute to greenhouse gas emissions. Add ideas to the "Greenhouse Gas" column. Ask for ways in which land is needed for meat production and soy farming. Add ideas to the "Land" column. If students struggle to generate ideas, use some of the ideas below to encourage brainstorming.

Water	Greenhouse Gas	Land
• Water for animals to drink • Water to irrigate soy • Water to clean farm equipment or barns • Water to irrigate crops for animal feed • Water used in the factories to process and package meat and soy	• Methane from animals burping and flatulence • Methane from rotting manure • Emissions from gas used in farm vehicles and to transport animals and crops to processing plants • Emissions from electricity needed on the farm, to keep meat chilled during transportation, and in the factories that process soy and meat • Nitrogen from fertilizer on soy and on animal feed • Carbon released when trees are cleared to make more pasture or crop land	• Space to grow soy • Space for animals to graze, barns, pastures • Space to grow crops used for animal feed

3. Divide students into groups of four. You may want to combine sets of pairs from Part 1.

4. 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, which contains:
      - 60 blue bingo chips
      - 80 red bingo chips
      - 90 green bingo chips (only 17 will be used on the grids)

   Note: The number of bingo chips does not need to be exact, as long as students have more chips than they need to complete the activity. There will only be space for 17 green chips to be used between all four grids. If using markers, distribute one blue, red, and green marker to each group.

5. Explain to students that they are going to examine how much water is used, how much greenhouse gas is emitted, and how much land is needed to produce one pound of beef, pork, poultry, and soy. Students will use bingo chips placed on a grid to visualize the size of water, greenhouse gas, and land footprints. If using markers rather than bingo chips, students will color in grid squares using the appropriate color. Each group member is responsible for completing an Environmental Impact Grid on one of the four types of protein.

6. Allow time for groups to determine which student will be responsible for which protein.

7. From the Teacher Environmental Impact Sheet, read aloud the Water Footprint statistics. Each student listens for the amount of water needed to produce their protein, and adds the appropriate number of blue "water" chips to their grid.

8. Repeat the process for the Greenhouse Gas Footprint and Land Footprint statistics. Note that students will not have enough grid squares to represent the entire land footprint of beef.

9. Allow students a few minutes to discuss their observations within their group.

DISCUSSION QUESTIONS

1. How do the water, greenhouse gas, and land footprints compare among the four types of protein? Why do you think some footprints are larger and some are smaller?

Soy has a much smaller environmental footprint than the animal proteins. Poultry is the next biggest, followed by pork. Beef has the biggest footprint. For example, beef's greenhouse gas footprint is 20 times larger than soy's. Pork's greenhouse gas footprint is 2.5 bigger than soy's, and poultry's is 2 times bigger than soy's.

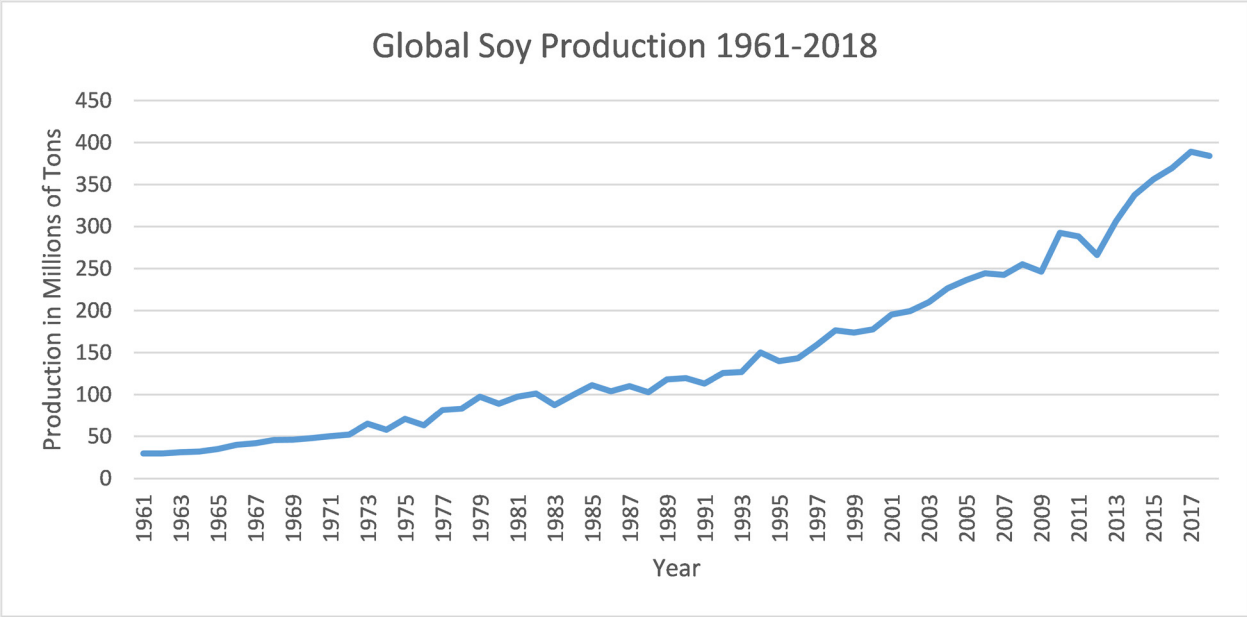
Cows are larger animals than pigs or chickens, and they live longer. They need significantly more food and water over the course of their lives, and they create more manure. Cows have larger land, water, and greenhouse gas footprints. Soy does not emit greenhouse gases through digestion like animals do, so its greenhouse gas footprint is less than an animal's.

2. Look at your global meat production graph alongside the Environmental Impact Grids for poultry, pork, and beef. The global meat production graph looks at the total amount of each meat produced in the world. The Environmental Impact Grids show the impact of a small amount (one pound) of each type of meat. Looking at these data sets side-by-side, which meat do you think will have the biggest environmental impact in the world in the next ten years? Why?

Answers will vary. Beef has the largest environmental footprint per pound, but there's currently less of it raised than pork and poultry. Some students may point out that the demand for poultry seems to be growing fastest, and in ten years, there may be much more poultry production than beef or pork production. Alternatively, students may conclude that because the beef footprint is so much larger than poultry or pork, that beef will have the biggest impact in ten years, even if it isn't the most-produced meat.

3. 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.[4] The graph below shows historic global soy production. What is the trend for global soy production: is it growing, shrinking, or staying steady? What might this graph tell you about the need for farmland?

   Overall, soy production has increased from 1961 to 2018, even if it has shrunk for a year or two along the way. The graph tells us that we will most likely need more farmland in the future to keep up with the growing demand for soy products.



Source: Food and Agriculture Organization of the United Nations

4. Global meat and soy production will most likely continue to rise. What challenges does this present for the environment? For the global community?

   Environmental problems may include: land degradation caused by intensive livestock farming and overgrazing, deforestation in order to grow more soy or create grazing pastures, surface and groundwater contamination from animal wastes and farming pesticides and fertilizers, increases in greenhouse gases leading to climate change. Social problems may include: health and obesity problems from high meat consumption, the threat of antibiotic resistance, the inhumane treatment of animals in concentrated animal feeding operations (CAFOs).

5. What are some things that farmers and ranchers are doing, or can do, to lower the environmental impacts from producing beef, pork, poultry, and soy?

   Beef farmers can graze their cattle on pasture, rather than feeding them soy and other grains, in order to lower the land and water footprint. When farmers choose grains for feed, they can choose grains that have less impact on the environment. Some grains even limit the amount of methane cows produce. Livestock farmers can redesign how they capture and store manure to reduce greenhouse gas emissions. Farmers can buy livestock feed from places that use sustainable agricultural practices like reducing the use of fertilizers and chemicals and using crop covers to control erosion and restore soil health. Soy farmers can use different kinds of fertilizers, lower amounts of fertilizers, or apply fertilizers at different times in order to reduce the impact to water and the greenhouse gas emissions from nitrogen.

6. What can individuals do to lower the environmental impacts of protein in their diets?

   People can choose to eat fewer or no meat products, or go meatless on certain days of the week. Aside from soy, people can eat other plant-based proteins like beans, peas, nuts, and seeds. Individuals can also choose to eat poultry rather than beef to lower their impact on the environment. They can purchase meat products from local farms to reduce greenhouse gas emissions from shipping meat. Or they can purchase meat from farms that use sustainable agricultural practices, like crop and livestock integration, to improve the health of soils and the environment. Unfortunately, sustainably and locally sourced meats can be more expensive than their conventional counterparts. 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.

7. What can governments or organizations do to lower the impacts from producing beef, pork, poultry, and soy?

   Governments can help farmers pay for some of the expensive changes they might want to make to lower the environmental impacts of their farm. Organizations can encourage people to eat less meat. Countries can protect wild places at risk from expanding farmland.

ASSESSMENT

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

FOLLOW-UP ACTIVITY

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 students reflect on their experience in this activity by creating a poster or brochure to educate the public about the environmental impacts of meat consumption.

3. Have students research specific agricultural technologies or innovations that lower environmental footprints.

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[1] Food and Agriculture Organization of the United Nations. (2012). *Livestock and Landscapes*. Retrieved from http://www.fao.org/3/ar591e/ar591e.pdf

[2] Ritchie, H., Roser, M. (2019, November). *Meat and Dairy Production*, Our World In Data. Retrieved from https://ourworldindata.org/meat-production

[3] OECD-FAO Agricultural Outlook 2018-2017. doi: https://dx.doi.org/10.1787/agr-outl-data-en

[4] "Soy: The Biggest Food Crop We Never Talk About." WWF. Winter 2015.

[5] Mekonnen M. M., Hoekstra A. Y. 2010. The green, blue and grey water footprint of farm animals and animal products. Value of Water Res. Rep. Ser. No. 48. UNESCO-IHE, Delft, the Netherlands. Retrieved from https://waterfootprint.org/media/downloads/Report-48-WaterFootprint-AnimalProducts-Vol1_1.pdf

[6,7] Poore, J., Nemecek, T. (2018). 'Reducing food's environmental impacts through producers and consumers,' American Association for the Advancement of Science, 360 (6392), pp. 987-992. doi: 10.1126/science.aaq0216.

[8] Food and Agriculture Organization of the United Nations. FAOSTAT Statistical Database. [Rome]; FAO, 2020.

TEACHER ENVIRONMENTAL IMPACT SHEET

Water Footprint[5]: 1 blue chip = 60 gallons of water

Soy: It takes approximately **300 gallons** of water to produce 1 pound of soybeans. Place **5 blue chips** on your grid.

Poultry: It takes approximately **540 gallons** of water to produce 1 pound of poultry. Place **9 blue chips** on your grid.

Pork: It takes approximately **720 gallons** of water to produce 1 pound of pork. Place **12 blue chips** on your grid.

Beef: It takes approximately **1,860 gallons** of water to produce 1 pound of beef. Place **31 blue chips** on your grid.

Greenhouse Gas Footprint[6]: 1 red chip = 1 pound of carbon dioxide equivalent (CO_2 eq)*

Soy: Approximately **3 pounds** of CO_2 eq are emitted to produce and transport 1 pound of soybeans. Place **3 red chips** on your grid.

Poultry: Approximately **6 pounds** of CO_2 eq are emitted to produce and transport 1 pound of poultry. Place **6 red chips** on your grid.

Pork: Approximately **7 pounds** of CO_2 eq are emitted to produce and transport 1 pound of pork. Place **7 red chips** on your grid.

Beef: Approximately **60 pounds** of CO_2 eq are emitted to produce and transport 1 pound of beef. Place **60 red chips** on your grid.

Land Footprint[7]: 1 green chip = 20 square feet of land

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

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

Pork: Approximately **80 square feet** of land are needed to produce 1 pound of pork. Place **4 green chips** on your grid.

Beef: Approximately **1,600 square feet** of land are needed to produce 1 pound of beef. Place **80 green chips** on your grid.

*A **carbon dioxide equivalent** (**CO_2 eq**) is a measurement used to compare the emissions from various greenhouse gases based on their potential to warm the planet. The measurement converts methane and nitrous oxide to the equivalent amount of carbon dioxide with the same global warming potential.

MEAT OF THE MATTER

STUDENT WORKSHEET

Name: _____ Date: _____

Directions: Work with your partner to graph and label the data provided below. Discuss what observations you can make from the graph.

	1964	1973	1982	1991	2000	2009	2018
Poultry	11.2	19.4	31.4	48.3	75.6	104.4	140.3
Pork	31.6	44.6	58.6	78.6	99.1	117.0	133.2
Beef	34.5	42.8	50.6	59.0	61.5	69.0	74.2

Millions of Tons of Meat Produced[8]

MEAT OF THE MATTER

ENVIRONMENTAL IMPACT GRID 1: BEEF


Water Footprint: 1 blue chip = 60 gallons of water

CO2 Footprint: 1 red chip = 1 pound of carbon dioxide equivalent (CO2 eq)


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

MEAT OF THE MATTER

ENVIRONMENTAL IMPACT GRID 2: PORK

Water Footprint: 1 blue chip = 60 gallons of water

CO_2 Footprint: 1 red chip = 1 pound of carbon dioxide equivalent (CO_2 eq)

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

MEAT OF THE MATTER

ENVIRONMENTAL IMPACT GRID 3: POULTRY


Water Footprint: 1 blue chip = 60 gallons of water

CO2 Footprint: 1 red chip = 1 pound of carbon dioxide equivalent (CO2 eq)


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

MEAT OF THE MATTER

ENVIRONMENTAL IMPACT GRID 4: SOY


Water Footprint: 1 blue chip = 60 gallons of water

CO2 Footprint: 1 red chip = 1 pound of carbon dioxide equivalent (CO2 eq)


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