POPULATIONS (HS)

The challenge of modern farming

Focus questions	How many people farm in the United States today? What are the methods and technologies employed by modern farmers in the United States?
Learning target	Students participate in a simulation of a modern American farmer utilizing the advanced technologies of modernized equipment and biotechnology.
Vocabulary	Precision technology, infrastructure, commodity farming, climate change, yield, organic, hybrid, genetically modified organism (GMO), Roundup Ready, *Bacillus thuringiensis (Bt)*

HS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Performance expectation HS-LS2–7	**Classroom connection:** Students engage in a modern farming simulation. Upon completion of the simulation, students evaluate and refine solutions for addressing problems encountered using these methods.

Science and engineering practices

Constructing Explanations and Designing Solutions	**Classroom connection:** Following the simulation, students will design a solution that involves reducing the negative effects of human activities on environment and biodiversity, and that relates to scientific knowledge of the factors affecting changes and stability in biodiversity.

Disciplinary core ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience	**Classroom connection:** Students develop solutions that help modern farmers become more efficient and productive, while exploring the effects of food production on the environment.
ETS1.B: Developing Possible Solutions	**Classroom connection:** Students evaluate the cost, safety, reliability, and the social, cultural and environmental impacts of the proposed solution for a select human activity that is harmful to an ecosystem.

Cross-cutting concepts

Stability and Change	**Classroom connection:** Students refine the proposed solutions by prioritizing the criteria and making tradeoffs as necessary to further reduce environmental impact and loss of biodiversity while addressing human needs. Students evaluate difficulties with the modernized farming model and barriers to improvements.

Background

Roughly 25% of the world's labor force is employed in agricultural food production, but in the United States this drops significantly, to only 2% of its labor force. How can we account for this diminishment in labor required for food production in the US? Infrastructure, mechanization, and technology have accounted for much of the change in the United States, altering farming from a more labor-intensive practice to what we see today.

Modern American farming is a blend of tradition and innovation, requiring farmers to be skilled in science, economics, and technology while adapting to changing environmental and market conditions. Farmers make strategic decisions to maximize productivity while ensuring sustainability and profitability. They choose crops and livestock based on market demand, soil conditions, climate, and government policies. Farmers must decide whether to sell their crops at harvest or to store them to contract sell at a later date. Modern farms use GPS-guided equipment, drones, and data analytics to optimize planting, spraying and harvest. Farmers make financial decisions on equipment purchases, land investments, and crop insurance to protect against unpredictable weather. Do these farming innovations make food production easier or not?

Students will engage in this simulation and see the differences that exist in commodity farming within the United States depending upon the biotechnology and precision agricultural practices employed by the farmer. They will collect data about input prices and crop yields and calculate revenue while determining which production practices have the greatest impact on the environment. Students will work individually in their groups as either a farmer or a sales agronomist to complete this simulation.

Materials

- Student worksheet
- Event cards
- Products and services cards
- Six-sided die
- Coins

Suggested timing

90 minutes or 2 class periods

Prior knowledge

Students should have an understanding of what a plant needs to be planted, grow to maturity, and be harvested in the United States. They should understand that modern farming in the United States is technologically advanced and has specialized seed genetics, fertilizers to support crop growth, and pesticides to help prevent competition and precision equipment driven by GPS.

Teacher preparation

1. Make copies of the materials needed for student groups. Each student group should have a set of event cards, products and services cards, student worksheets, and 1 die.
2. Ask students to brainstorm what modern agricultural methods are utilized in the United States. How do farmers select, plant, and harvest commodity crops? What crops are grown here and what food categories do they support? Does the crop go to feed livestock or humans, to produce bioproducts or biofuels? Allow time for students to discuss and research modern agricultural practices and methodologies for the simulation.
3. Review the rules for play and the procedure with the students before the simulation. After the simulation is complete, ask students to reflect with their group on the guiding questions below.

Rules for play

- **Players:**
  - 1 Sales agronomist starts with 35 coins.
  - 3–5 Farmers: Each farmer starts with 30 coins and 3 fields.
- **Decision-making per round:**
  - All farmers make decisions simultaneously during the agricultural decisions phase, but they roll dice individually.
- **Starting player rotation:**
  - If you want to rotate turns, the first buyer changes each round for fairness (optional).
- **Negotiation allowed:**
  - Farmers can discuss strategies and sales agronomist can make deals (e.g., discounts for buying in bulk).
- **Buying fields:**
  - Farmers can expand their farms by spending 8 coins per field during the End of Round phase.
- **Event card rules:**
  - Event effects apply before farmers roll dice.

Procedure

Students should work together in groups of 4–6 to complete the simulation. Each round represents a growing season with these steps:

1. **Event card**
   - The sales agronomist draws an event card and reads it aloud.
2. **Farming decisions**
   - Farmers make decisions and purchase seeds for planting.
   - Farmers record products on chart.
3. **Ag products and service decisions**
   - Sales agronomist meets with farmers to discuss products or services for farmers to buy to increase yield.
   - Farmers decide to purchase or not purchase products or services.
   - Farmers record products or services purchased on chart.
   - Sales agronomist records sales on chart.
4. **Harvest time**
   - Farmers roll a die for each field to see if their crops are successful.
     - Roll a 1 or 2 : The field/crop fails due to drought.
     - Roll a 3, 4, 5, or 6: The field/crop is successful.
5. **End of round**
   - Farmers calculate income and decide about future actions:

        - Whether to expand by buying another field for 8 coins.
        - Whether to purchase product and/or services.
    - Optional: Rotate the starting position for decision-making.
6. **Scoring**
    - At the end of each round, farmers calculate coins as follows:
        - 0 coins earned for failed field.
        - +2 coins for each successful field.
        - −1 to −5 coins for products or services purchased.
        - −8 coins if they buy an extra field.
        - Optional penalty: If you use basic fertilizer in the same field for 3 years in a row you are penalized (−1) coin per round for water quality pollution!
        - Optional penalty: If you use regular irrigation for 3 years in a row you are penalized (−2) coins for high volume water usage!
        - Optional bonus: Farmers who use eco-friendly products (natural fertilizer, biological pest control, cover crops) get +1 bonus coins for 2 or more products used per round!
    - Sales agronomist calculates coins as follows:
        - +1 coin profit for each product sold.
        - −2 coins loss for each crop insurance payout.
        - −1 coin loss for each free product (event card).
        - −5 coins loss for not meeting quota of 12 products or services sold per round.
7. **Success or loss**
    - Farmers are successful if they have 15 coins and 5 fields by the end of the 5th round.
    - Sales agronomist is successful if they have 40 coins at the end of the 5th round.

Differentiation

Other ways to connect with students with various needs:

- **Local community:** Students may investigate the farming methods used in their community on a class field trip to a local farm and explore modern farming practices and ask questions about food production.
- **Students with special needs (language/reading/auditory/visual):** Students who may not be interested in working in groups or who are motivated by video games may play Farming Simulator (`farming-simulator.com`) to see how successful they might be in this simulation.
- **Extra support:** Pair students that require extra support with a group leader that can lead them through each round of the game. This leader can help them to understand their products and services purchases and calculate their revenue and total profits.
- **Extensions:**
    - Students can compare modern farming with traditional farming methods still employed by groups (e.g., Amish/Mennonite populations) living in the United States.
    - Play additional rounds each day during your agricultural unit.

Student handout

Reflection

1. How successful were you at growing commodity crops on your farm? Were you able to increase your fields from 3 to 5 total fields?

Answers will vary depending on student purchase choices and roll of the die.

2. How is this simulation realistic? Not realistic?

This simulation helps students to understand some of the complications of modern farming (e.g., purchases, weather events, market prices, etc.), but does not include equipment and additional infrastructure costs or accurately predict weather and/or pest events that may impact yield, etc.

3. Describe 3 specific differences between this farming simulation and subsistence farming as practiced in small groups within the United States or abroad.

Answer may vary but some potential answers may include:

- Modern farming is done on a much larger scale than traditional farming on over thousands of acres often specializing in a few crops.
- Modern farming may produce food that does not enter the human food stream immediately after harvest.
- Modern farming employs large, mechanized equipment.
- Modern farming employs GPS technology to autosteer equipment to make it more efficient.
- Modern farming is specialized to use several inputs for specific outcomes (seeds, fertilizers, etc.).
- Traditional farming is mostly subsistence-based farming and consequently more difficult to be successful.
- Traditional farming may cause more soil disturbance and/or erosion due to less advanced tillage implements.

4. How do stability and change within farming practices play a role in modern farming within the US?

Answers will vary but may include:

- Modern farming allows for more stability within the food production system, creating more global food security.
- Modern farming is more efficient, taking up less land space to produce a crop for human use.
- Modern farming is specialized, including specific equipment and products for success. This economic investment can lead to financial problems if fields are not successful.
- Farming methods (traditional and modern) have brought about great change in natural ecosystems. This change has led to climate change in land areas as soil systems dry out and natural biodiversity is lost.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade-off considerations.	Student participated in the modern farming simulation; solution to modern farming as a method to produce food is vague or missing.	Student participated in the modern farming simulation; a specific solution or set of solutions that will lessen the impact of modern farming and increase food production efficiency is/are included.	Student participated in the modern farming simulation; a specific set of solutions that will lessen the impact of modern farming and increase food production efficiency with priorities for implementation and consideration of barriers to implementation is/are included.

Rubric for self-assessment

Skill	Yes	No	Unsure
I participated in the farming simulation with my group and collected data on field success and loss.			
I can suggest a solution for lessening the impact of modern farming on the environment.			
I can suggest a solution for increasing food production efficiency.			
I can prioritize the solution and predict the barriers to implementing my solutions.			