SOIL & SUSTAINABILITY (HS)

Cover crop design challenge

Focus questions	How might cover crops improve soil health? How might farmers benefit from the use of cover crops?
Learning target	Students will analyze characteristics of cover crops and apply them to state-specific scenarios to select a set of cover crops that will achieve specific soil regeneration goals.
Vocabulary	Cover crop, nitrogen fixation, erosion, water infiltration, ground cover, weed suppression, flood irrigation

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

Performance expectation HS-LS2-7	**Classroom connection:** Students will explore how agriculture has impacted natural soil ecosystems over time. Students will research the use of cover crops to determine their potential soil regenerative impact.

Science and engineering practices

Using Mathematics and Computational Thinking	**Classroom connection:** Students will complete practical math problems to determine the seeding amount for cover crops in their fields.
Constructing Explanations and Designing Solutions	**Classroom connection:** Students will select a set of cover crops as a regenerative soil solution for the different soil needs of farmers in different states.

Disciplinary core ideas

LS2.B Cycles of Matter and Energy Transfer in Ecosystems **LS4.D Biodiversity and Humans**	**Classroom connection:** Students will use their knowledge of the nitrogen and carbon cycles to choose their cover crops to improve soil health. Humans depend on soil to be able to grow food. Students will make the connection between the importance of biodiversity and soil ecosystem health. This lesson focuses on retaining and regenerating nutrients and organic matter in healthy soil ecosystems.

Cross-cutting concepts

Energy and Matter	**Classroom connection:** Students will observe and connect the cycling of matter in their soil regeneration experiments.

Background

Healthy soils are critical for plant growth. Soil acts as a natural filter for both air and water. Soil formation is a complex process that happens slowly over many decades.
Regenerative soil practices are actions that can help to restore soil and ecosystem health.

Cover crops are plants grown in an agricultural field primarily to benefit the soil ecosystem and retain nutrients, rather than for immediate harvest. They are referred to as cover crops because they “cover” the bare soil when the main crop is not actively growing. These crops play a critical role in sustainable agriculture by enhancing soil nutrient health, improving water retention, aiding in weed and pest control, contributing to organic material in the soil and increasing biodiversity. They are typically planted during the off-season when the main crops are not being cultivated. However, sometimes they can be planted in season with the crop when it is close to maturity. This allows the cover crop to germinate and begin growth before weather patterns change. Typical examples of cover crops include legumes, grasses, brassicas, and broadleaf plants. Overall, the strategic use of cover crops is a vital practice for promoting long-term agricultural sustainability and environmental stewardship.

Materials

- Copy of student handout for each student
- Two sets of state scenario cards to be used for the class
  (Groups will need one scenario card at a time and will trade with the teacher for a new one)
- A set of cover crop cards for each student group

Prior knowledge

Students will need to be familiar with the nitrogen and carbon cycles and the role plants play in those cycles. Students should also be familiar with modern and sustainable agricultural practices and the role they play in soil health and conservation.

Suggested timing

- Engage: 5–8 minutes
- Explore: 40–80 minutes
- Explain: 40–80 minutes
- Elaborate: 10–15 minutes
- Evaluate: 10 minutes

Teacher preparation

Print the appropriate materials listed above for the class.

Procedure

Activity 1: Engage

1. Assign students to work in groups of three.
2. Give the groups a few minutes to assess the two sets of statements about soil and determine which statement is incorrect. After a few minutes, have a short class discussion about each set of statements, discussing students' initial thoughts.

Activity 2: Explore

1. Students choose a set of cover crops for each state-specific scenario.
2. Each group will need a complete set of cover crop cards. Start each group with a random state scenario card. Using the cover crop deck, students will use the information on the scenario cards to choose three cover crops to help the farmer achieve their soil health goal. They will complete a table for each state scenario, providing their justifications in the table.
3. Once students complete one state, they will need to trade out the scenario card for another state.

Activity 3: Explain

1. Ask students to complete the questions with their group.
    - Questions 1 and 2 are specific to their choices in the Explore section. Discuss each state scenario and the students' selections for improvement.
    - Questions 3 and 4 introduce some math with dimensional analysis questions. All conversion factors are included within the questions. Work one or more problems together as a class to determine the amount of seed and cost needed. How might economics play a role in cover crop choice?
2. Students calculate the number of bags of cover crop seed the farmer will need to order to ensure proper seeding of his land. Show all work. Include units in the final answer.
3. Students calculate the number of seeds that will germinate once the farmer has seeded his land. Show all work. Include units in the final answer.
    - Questions 5 and 6 discuss alternative methods for soil health improvement. How might these additional options work cooperatively with cover crops to increase soil health?

Activity 4: Elaborate

Students will need access to a device to watch two YouTube videos to observe industry experts discuss cover crops. They can either complete this section together in their small groups, or this section could be completed as a class with the teacher playing the videos for the class. Each short clip has a set of questions to complete with it. Questions are in order with the video clip. Answers are included on the key.

Activity 5: Evaluate

Students should write a multi-sentence paragraph describing how they could determine if their choices are successful. Answers should be specific. For example, if one of the goals was to increase nitrogen in the soil, they could perform soil tests and measure levels of nitrates in the soil.

Differentiation

Other ways to connect with students with various needs:

- **Local community:**
    - Bring in a local farmer that utilizes cover crops on his/her farm and/or a local agronomist. Have the students present their scenarios and solutions to them for feedback.
    - Take students to a local farm that utilizes cover crops along with a county extension agent. Ask the local farmer and extension agent to demonstrate how cover crops improve soil regeneration and look at the soil.
- **Students with special needs (language/reading/auditory/visual):** You could scaffold the activity by having students only complete the first three sections of the activity.
- **Extra support:** See above videos.
- **Extensions:** Students could create potential new scenario cards based upon current weather patterns or land use in your area.

Student handout

Activity 1: Engage

Two truths and a lie: Test your soil knowledge! For each of the two sets, do your best to guess the incorrect statement about soil. Which one is the lie?

Set 1

1. Soil acts as a natural filter for both air and water.
2. Soil formation is a simple process that happens relatively quickly.
3. Soil can help preserve archeological artifacts.

Set 2

1. Cover crops often are very susceptible to pests and increase pesticide use.
2. Cover crops help prevent the leaching of nutrients into local groundwater sources.
3. Cover crops are often used to help with soil erosion from seasonal storms.

Activity 2: Explore

1. In groups of three, obtain one state scenario card and a deck of cover crop cards.
2. Using the information provided on the scenario card, select three cover crops from the deck of cover crop cards to help the farmer with their soil needs. Record your choices along with your justification in the table below (provide a *minimum of two justifications* per cover crop).

Scenario 1

State: _____ Commodity crop: _____

Crop choice 1:	Crop choice 2:	Crop choice 3:
Justification:	Justification:	Justification:

Answers will vary by scenario and group choices. Refer to cover crop cards to verify student answers.

3. Return your scenario card and swap it for a different state. Repeat the decision-making process using the cover crop cards. Record your choices along with justification in the table below. *Note:* Information given on scenario cards assume normal weather conditions and planting patterns for the commodity crops. However, climates are shifting, so this isn't always the case for farmers, and they will need to adjust accordingly.

Scenario 2

State: _____ Commodity crop: _____

Crop choice 1:	Crop choice 2:	Crop choice 3:
Justification:	Justification:	Justification:

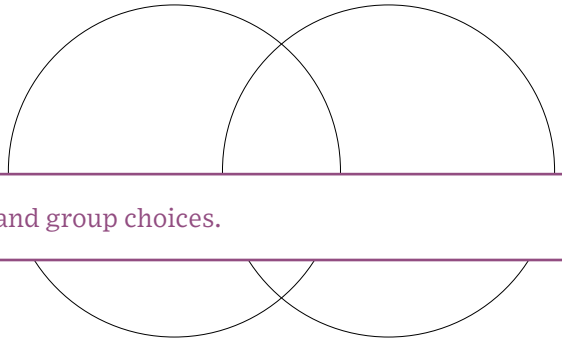
Student handout

Activity 3: Explain

1. Create a Venn diagram to compare and contrast your two scenarios. Include at least three items in each category.

State 1
State:

Goal:



State 2
State:

Goal:

Answers will vary by scenario and group choices.

2. Were the goals of each scenario similar or different? How did this impact your choices of cover crops?

Answers will vary by scenario and group choices.

3. A Nebraska corn farmer has a 410 acre farm. One of the cover crops they have chosen for their mix is sold in 50-pound bags, 4,100 seeds per pound. Based on their local conditions, they will need to use about 55 pounds per acre of seed of their chosen cover crop, but only want 30% coverage since they are using two other crops as well. Their seed bag tag indicates a germination percentage of 82%.
   a. **Calculate** the number of bags of cover crop seed the farmer will need to order to ensure proper seeding of his land. Show all work. Include units in the final answer.

$$410 \text{ acres} \times \frac{55 \text{ lbs}}{1 \text{ acre}} \times \frac{1 \text{ seed bag}}{50 \text{ lbs}} = 451 \text{ bags}$$

$$451 \text{ bags} \times 0.30 \text{ (30\% coverage)} = 135.3 \text{ bags}$$
(They will need to purchase 136 bags)

   b. **Calculate** the number of seeds that will germinate once the farmer has seeded his land. Show all work. Include units in the final answer.

$$136 \text{ bags} \times \frac{50 \text{ lbs}}{1 \text{ bag}} \times \frac{4{,}100 \text{ seeds}}{1 \text{ lb}} = 27{,}880{,}000 \text{ seeds} \times 0.82 \text{ (82\% germination)} = 22{,}861{,}600 \text{ seeds}$$

Student handout

4. Often farmers will look at the cost per pound of seed, much as consumers might do for products while grocery shopping. However, taking into account the number of seeds per pound, as well as the planting rate (how many pounds per acre they will need to use with a specific planting method), to determine cost per acre gives the farmer a different picture of their cost. Company A offers their crimson clover seed at $1.80/lb. There are 140,000 seed per pound and a planting rate of 25 pounds per acre with Company A. Company B offers their balansa clover seed at $2.60/lb. There are 480,000 seeds per pound and a planting rate of 10 pounds per acre with Company B. Both companies are using the same planting method. **Calculate** the cost per acre for each company. Show all work. Include units in the final answers. Which company should the farmer purchase their seed from? Why?

Company A

$$\frac{\$1.80}{1\text{ lb}} \times \frac{25\text{ lbs}}{1\text{ acre}} = \$45/\text{acre}$$

Company B

$$\frac{\$1.80}{1\text{ lb}} \times \frac{25\text{ lbs}}{1\text{ acre}} = \$26/\text{acre}$$

5. **Describe** one additional method farmers can use to improve the health of their soil aside from cover crops.

Options include a description (not just an ID) of one of the following:

- Crop rotation
- Green manure
- No-till/low-till agriculture
- Composting organic waste
- Agroforestry
- Rotational grazing (managed grazing)

6. **Propose** a reason why a farmer might be hesitant to plant cover crops in their fields.

- Cost of cover crop seed
- Possible introduction of unintended pests
- Lack of knowledge about cover crops
- Management resources: there is more to manage with additional cover crops planted
- Time constraints depending on weather

7. **Research:** What are typical crops for your state? Find at least three examples. Is the distribution of the crops the same statewide; why or why not? How has the production of these crops impacted the soil health in your state? How can cover crops and other best practices improve or help to mitigate human impact on soils?

Initial answers are state-dependent, but generally, crop distribution is not uniformly distributed across most states. Many states are composed of multiple ecoregions which support different plant life.

Student handout

Activity 4: Elaborate

Video 1

Watch this video from **Natural Resources Defense Council (NRDC): youtu.be/3j5MRJeCoYs**.

1. What are three major benefits from the use of cover crops on the Lehmans' farm that are discussed?

Increasing organic matter, less fertilizer use, protects soil from erosion during heavy rains, water filtration

2. How can we encourage farmers to use cover crops?

Give good stewardship discounts for use of cover crops when purchasing crop insurance.

3. What is the common misconception about the use of cover crops?

It will reduce the yield of the cash/commodity crop.

Video 2

Watch this video from **SARE Outreach (Sustainable Agriculture Research and Education): youtu.be/PrQ_wu67ItM**.

1. When are cover crop benefits more pronounced?

When they are used in combination with reduced tillage practices

2. When should legumes be planted as cover crops?

Before heavy feeder crops, to introduce nitrogen to the soil

3. Describe the benefits of cover crop residues adding organic matter to the soil.

Adds organic matter to the soil, which results in better water holding capacity, which can help crops during hot dry years. Adding organic matter also helps with better water infiltration and better soil aeration.

4. How does a cover crop residue reduce herbicide costs?

The residue creates a mat that smothers weeds, reducing the need/cost of herbicides.

Activity 5: Evaluate

How would you be able to tell if your choice of cover crops were successful in achieving your goal? Write a thoughtful multi-sentence answer and be specific.

Answers will vary by choice, but should be specific. For example, if one of the goals was to increase nitrogen in the soil, they could perform soil tests and measure levels of nitrates in the soil.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Using Mathematics and Computational Thinking	Student puts in the correct data and units to solve the problem, but did not solve the problem correctly.	Student solves the problem correctly, but did not show their work.	Student solves the problem correctly and shows their work displaying the correct units.
Constructing Explanations and Designing Solutions	Student includes incomplete justifications for their cover crop design challenge and does not provide a correct solution to the farmer's request.	Student provides correct justifications and solutions for their cover crop design challenge.	Student provides well-reasoned justifications and in depth solutions for each soil design challenge.
Evaluating and critiquing	Student can identify the expense of cover crops for a farmer.	Student can compare the cost of cover crops to the cost of crop production.	Student can evaluate the cost of cover crops to their benefit for future soil health and crop production for a farmer.

Rubric for self-assessment

Skill	Yes	No	Unsure
I can describe the soil health benefits of cover crops.			
I can identify why farms may be hesitant to use cover crops.			
I can describe how cover crops are involved in biogeochemical (nitrogen, carbon) cycles.			