Human Impact on Soil Case Study

Purpose of Activity: The purpose of this activity is to have students build science literacy through articles and news stories. Students are working collaboratively, such as scientists would, to analyze the information in the article and apply the information to real-life situations that are relevant to regenerative agriculture. The goal is to make connections on how soils are formed, the carbon cycle, and why that is important for agriculture. This activity relates to the following Essential Question and Student Learning Outcome:

• **Essential Question:** How is soil a valuable resource and what are humans doing to change soil quality.

• **Student Learning Outcome:** Assess the importance of soil as a renewable resource and create an action plan to reduce human impacts on soils

Directions for Teachers:

Print the article or have students be able to download the article into Notability (iPad) or some other app they can annotate, highlight, and answer the questions on. Have students read individually and use the following annotation and highlighting skills to analyze the text:

• Highlight new words you are unfamiliar with

• Put brackets [----] around sentences or paragraphs that confuse you

• Star sentences or paragraphs that help explain how soils, farming, and the carbon cycle are related. • Write comments in the margins to support or better explain the annotations used above Teachers should give examples of how to use the annotations. Perhaps read the first couple of paragraphs together and annotate together.

Once students have read the text, have them Think: Pair: Share with their table groups or partners. Have them compare annotations. Things to consider: Did they struggle with the same words, did the same parts confuse them, did they find the same connections of soil, farming and the carbon cycle? Have students share some of their group's conversation to the class. If multiple tables have the same confusions and struggles the teacher should address these before moving on.

Have students work with their groups or partners to answer the questions on pg 9. The last question has them practice Claim, Evidence, Reasoning writing, which may need to be taught prior or refreshed with students.

Important Note! The last question is the same as the Carbon in Soil Case Study - students should be able to answer the question more fully now and should not just reuse their answer from the Carbon in Soil Case Study

Useful Link:

link to the original article:
https://www.smithsonianmag.com/science-nature/scientists-say-nations-corn belt-has-lost-third-its-topsoil-180977485/

Human Impact on Soil Case Study

Student Direction:
Read the following article: highlight and annotate using the following annotation skills to analyze the text · Highlight new words you are unfamiliar with
· Put brackets [----] around sentences or paragraphs that confuse you
· Star sentences or paragraphs that help explain how soils, farming, and the carbon cycle are related. · Write comments in the margins to support or better explain the annotations used above When you are finished reading, share your annotation with a partner or your group. Compare annotations and notice if you all struggled on the same vocabulary words and concepts.
Pick concepts that your whole table struggled with to share with the class.
With your group answer the questions on pg 9 - work together to come up with a response to the last CER question.

The Nation's Corn Belt Has Lost a Third of Its Topsoil

smithsonianmag.com/science-nature/scientists-say-nations-corn-belt-has-lost-third-its-topsoil-180977485/ Becca Dzombak

Seth Watkins has been farming his family's land in southern Iowa for decades, growing pasture for his cows as well as corn and other row crops. His great-grandfather founded the farm in 1848. "He came in with one of John Deere's steel plows and pierced the prairie," Watkins recounted. With its rolling hills and neat lines of corn stretching to the horizon, broken by clumps of trees, it's a picturesque scene.

But centuries of farming those hills have taken their toll on the soil. Now, farmers like Watkins are facing widespread soil degradation that can lower their crop yields and incomes. "In 150 years or so, we've lost over half of that rich topsoil—if not all in some places."

Crops hunger for the carbon-packed composition of rich topsoil. They need the nutrients and water that it stores, unlike the compacted, infertile soils that decades of conventional farming create.

The baseline for soil in Iowa is visible on land owned by Jon Judson, a sustainable farmer and conservation advocate. His farm hosts a rare plot of original prairie grasses and wildflowers. Under the prairie, the soil is thick and dark, with feet of organic matter built up and plenty of moisture. The next field over is a recovering conventional field like Watkins' farm, and the effect of years of conventional practices is obvious. The soil is pale and compacted, with only a few inches of organic carbon, much less soil moisture, and a lot more clay.

Scientists and farmers know that agricultural soil erosion has been a problem for decades, but quantifying soil loss from a hundred years of farming and across multiple

states has proven difficult. Now a study led by geomorphologist Evan Thaler and published in *Proceedings of the National Academy of Science*s in February attempts to answer the elusive question of how much topsoil has been eroded in the Corn Belt, which stretches roughly from Ohio to Nebraska and produces 75 percent of the nation's corn. The study estimated that about 35 percent of the region has lost its topsoil completely, leaving carbon poor lower soil layers to do the work of supporting crops. Having thick, healthy topsoil means plants can grow faster and healthier, increasing crop yields and keeping the field's ecosystem running smoothly. Topsoil loss creates environmental problems, such as when eroded, nutrient-laden dirt degrades streams and rivers, and is estimated to cost the Midwest's agricultural industry almost $3 billion annually.

"I think it's probably an underestimate," says Thaler, a graduate student at the University of Massachusetts–Amherst. "There are areas where there's probably a centimeter of topsoil left."

Thaler and colleagues used soil color from satellite imagery to track which areas of Corn Belt fields were lighter or darker. Darker soils have more organic carbon, which is a good indicator that the topsoil is present. Further down in soil, less organic carbon builds up, so once those layers are exposed, the surface looks lighter. Thaler then connected a color map he created to high-resolution topographic data, which told him where slopes were steep and whether hilltops were curved in or out. When he compared soil color to hills' shapes, the map confirmed what he and countless farmers have noticed: the tops of hills are light, and their bases are dark. Plowing and precipitation lead rich topsoil to slowly creep downhill, leaving thin, carbon-poor soil uphill. Thaler found that highly curved hilltops are more likely to have eroded topsoil. That relationship drives his general finding of highly eroded soils in the Corn Belt, but it has been missing from erosion research until now.

Lighter soil at the top of hills indicates that darker topsoil has eroded downhill. (Evan Thaler)

In 2019 using on-the-ground soil surveys, the United States Department of Agriculture (USDA) estimated that none of those same fields had complete topsoil removal. Those determinations were based on small-scale examinations of soil that were assumed to reflect larger areas. But a single sampling site may not accurately reflect topsoil across an entire field: if scientists happened to sample the bottom of a hill, they might underestimate topsoil erosion for the whole field. Another issue, Thaler says, is estimating nationwide erosion. The

USDA can't sample soil from every corner of the country, so it relies on computer models to fill in the gaps. Because the equations those models use don't take hillslopes into account, like Thaler's study does, soil erosion is underestimated there, too.

Rick Cruse, an agronomy professor at Iowa State University whose research on soil erosion includes remote sensing and satellite imagery, found Thaler's results to be reasonable. "The technologies they used have been in the literature and have been developed for decades," he says. "When I look at the landscape where they're making

these estimates, and look at the economic estimates they've generated, I have no pushback on what's been done here."

Andrea Basche, an agronomy professor at the University of Nebraska who has used aerial imagery of fields at smaller scales, says the 35 percent estimate may be a little high and that verifying modeling results on the ground by surveying soils in person is important. But she says the study is a unique use of geospatial data to address a difficult problem, and that could help raise the profile of erosion as a pressing environmental issue. "Evidence of soil degradation and erosion from more intensive agriculture is ubiquitous," she says. "I think the study matters for elevating the conversation around this really critical issue."

Thaler's study shows the magnitude of soil erosion, but it is not able to say whether the erosion is due to current farmers' practices or the long culmination of a field's agricultural history. The Corn Belt and other agricultural regions in the United States have been heavily farmed for hundreds of years, during which both climate and agricultural methods changed. If a field has been farmed nearly continuously for such a long period of time, it's difficult to tell whether that topsoil was lost steadily over the last 200 years or in recent spurts of erosion.

"It's not a critique of the study, but what they did was a snapshot," says Hannah Birgé, a soil scientist at The Nature Conservancy–Nebraska. "I know Nebraska farmers would say, 'It probably did happen—we did major soil refining from the 1920s to '40s. But we don't do that anymore, so what you're seeing is old [erosion].'"

A clump of healthy topsoil sits in stark contrast to a light-hued hilltop that has lost much of its carbon-rich topsoil. (Evan Thaler)

The evolution of farming equipment and practices have affected the magnitude of erosion in the U.S. for hundreds of years. Settlers began systemically clearing the Great Plains prairie in the early 1800s as the John Deere plow became a staple of conventional tilling, which is the practice of digging up the topsoil to plant seeds. Later, gas-powered tractors made ripping up fields even easier. Aggressive plowing and monoculture planting led to unprecedented topsoil loss during the Dust Bowl. In 1935, in the wake of staggering soil and economic loss, Congress created the Soil Conservation Service (now known as the Natural Resources Conservation Service) to encourage more sustainable farming. The organization encouraged no-till planting, which conserves topsoil by not churning it up as intensely as conventional tilling, and cover crops, which help hold soil in place and replenish its nutrients, in the mid- to late-1900s. Today, such sustainable practices are beginning to spread as awareness of soil spreads too, but fewer than a quarter of fields nationally are farmed with no-till practices. Soil erosion is a slow, hard-to-spot problem, and financial pressures can keep farmers working fields even if they suspect they shouldn’t.

The slow timelines for erosion and changes in soil health are one reason it can be difficult to motivate farmers to adopt conservation practices. “It's hard not only for

farmers, but also for natural resources professionals and policymakers, to address things that change over such a slow period of time," Birgé says. "The risk is that the feedback will be slow, and then suddenly you have these nonlinear responses. Take, for example, the Dust Bowl. There were decades of slow change, then boom—30 years of mismanagement manifested in disaster."

For farmers who own, rather than rent, their land, a long-term approach to managing their farm's ecosystem can be guided and encouraged by federal agencies like the Natural Resources Conservation Service, which helps agricultural landowners work sustainably and efficiently. The Conservation Reserve Program, officially established by the 1985 Farm Bill, pays farmers to stop farming ecologically sensitive land for 10 to 15 years. Birgé says farmers jump at the opportunity, with more people signing up than the program can pay.

"The program has been hugely successful," she says. "Ten years is a long time in the policy world, but it's the blink of an eye when you think about soil erosion. It's transformed the landscape in really important ways. But now it's at the point where it could use more funding and some improvement."

Cruse agrees that such economic incentive programs are essential to treating soil erosion.

"It's really challenging to make things happen because we're a capitalist society, and people make money by farming," Cruse says. "There can be a resistance in the farming population to manage fields sustainably. We need a government program that would pay farmers *not* to farm. We need incentives and regulation."

A dearth of economic incentives to pursue sustainable farming remains one of the main hurdles in agricultural soil conservation. While programs like the Conservation Reserve Program are successful, they are still limited in scope and funding. Other federal agriculture programs can emphasize income over environment. Crop insurance, which was created to protect farmers against sudden financial ruin if a crop fails, guarantees a set payment for a planted crop—whether or not it's in at-risk soil that may not be able to support a successful crop.

"Most people want to take care of the land," says Judson, of modern farmers. "But if implementing conservation changes aren't going to show a positive benefit to them in the near future, they may be less likely to implement practices because they can't really see value in it."

Native plants on an original prairie plot help rich topsoil develop and stay in place. (Jon Judson)

Some farmers, though, are motivated to make a change for the better and adopt a long-term mindset. Without a direct economic incentive, Watkins decided to switch from conventional farming practices to conservation-focused ones, like planting a diverse array of native grasses, beginning in the early 1990s. In the early 2000s, he decided to add cover crops, like clover and alfalfa, which decreased soil erosion and increased his soil quality without relying on fertilizers. Even though he was already practicing no-till farming because of how steep his fields were, “My ‘no-till’ never quite worked until I added cover crops,” he says.

Farming practices that decrease erosion and increase crop yields are good for the environment in other ways. Soils store a huge amount of carbon—more than any other part of an ecosystem on land. Implementing conservation practices like cover crops can lower a farmer’s carbon footprint and reduce reliance on chemical additions to soil. “But they don’t really talk about those things in farmer meetings,” Watkins says. “The main message you get as a farmer is that it’s your job to produce and not to worry about those things.”

“The argument is that we’ve got to feed nine billion people by 2050, and that seems to give me carte blanche to do whatever I want with the land, if I’ll produce corn,” Watkins says. “I think it’s more important to build up a bank of healthy, fertile soil for when our

population grows, instead of depleting it now.”

Despite the efforts of farmers like Watkins and Judson, the vast majority of the Corn Belt remains conventionally tilled. Economic incentives and risks, as well as social norms, still push many farmers to focus on yearly yield rather than long-term conservation. And as Watkins and Judson noted, simply changing one practice may not be enough to stop soil erosion. No quick, easy fixes exist to solve the problem. But focusing on the long-term and increasing funding for programs like the Conservation Reserve Program are important places to start.

After adding cover crops, Watkins continued converting his conventional farm into a sustainable practice by planting native prairie grasses and trees to improve the soil and biodiversity. He also began using geospatial data tied to financial predictions to decide which parts of a field to plant. “I started doing those things and not only did they improve my bottom line,” he says, “but I’ve also watched them improve the quality of my soil and wildlife.”

Analysis Questions

Directions: Answer the following questions with your group

1. Is the article a reliable source of information? Provide 2 pieces of evidence that supports this article is reliable.
    a. use the link to the original article: https://www.smithsonianmag.com/science-nature/scientists-say-nations-corn-belt-has-lost-third-its-topsoil-180977485/

2. Based on the article and what you have learned in class, why is soil health important in growing crops?

3. What is the impact of soil degradation on crop yields?

4. How is prairie soil different than soil under a crop field?

5. Is soil erosion the only form of soil degradation? How else are agricultural practices changing soil health?

6. What is one practice that farmers are implementing to restore soil health?

7. What technologies have been developed in order to assess soil erosion issues on farms?

8. What are the long term benefits of thinking about soil health?

9. Starkey Farms is a farm in Indiana that is employing methods to restore soil health for long term benefits. Copy and paste the link into your Internet browser. Explore the website and describe two restoration methods that Starkey is employing on his farm.

a. https://www.starkeyfarmspartnership.com/farming-methods

10. There is a farmer in your town that has been tilling his lands every year before planting. His soil is bare with no cover crops and is susceptible to wind and water erosion. Over the past couple of years, the farmer has noticed that his crop yields have declined and he is losing money.
    a. Write this farmer a letter explaining the issues of his farming practices and suggest what he might do to increase his crop yields and his income. Make a claim for what this farmer needs to do, back it up with evidence from the lesson and the article, then explain the reason WHY your evidence is good and WHY he should change his practices.