

CALIFORNIA'S CLIMATE-SMART FARMS

# WHEAT, SOIL, AND CLIMATE CHANGE



## OVERVIEW

In these three activities, students explore the relationship between soil and climate change, focusing on wheat. Each activity in the set is designed to stand alone. The activities may also be combined to make a more complex learning progression.

**GRADE LEVEL: 6-8**



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**CALIFORNIA FOOD**  
FOR CALIFORNIA KIDS®

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# WHEAT, SOIL, AND CLIMATE CHANGE

## Summary of Activities

ACTIVITY	TIME	MATERIALS
<p><b>How Are Soil and Climate Change Connected?</b></p> <p>Students analyze a diagram to identify connections between soil and climate change.</p>	<ul style="list-style-type: none"> <li>One 50-minute period</li> </ul>	<ul style="list-style-type: none"> <li>Copies of student pages</li> <li>Access to internet (optional)</li> </ul>
<p><b>How Do Soil Organisms Contribute to Healthy Soil?</b></p> <p>Students collect soil samples and use a Berlese funnel (also called a Tullgren funnel) to observe soil organisms in soil.</p>	<ul style="list-style-type: none"> <li>One 50-minute period to set up, plus time to analyze results</li> </ul>	<ul style="list-style-type: none"> <li>Copies of student pages</li> <li>Access to internet (optional)</li> <li>Materials for Investigation: clear drinking glass; funnel; 2" square of gauze, screen, or needlepoint backing; measuring cup; 1 cup of soil (from top layer of soil); desk lamp or other lamp with shade; hand lens of microscope (optional)</li> </ul>
<p><b>How Can People Nurture Soil Health as a Response to Climate Change?</b></p> <p>Students read a profile of Full Belly Farm to learn what farmers are doing to reduce climate change impacts of growing wheat, particularly in terms of soil. They also identify steps individuals can take.</p>	<ul style="list-style-type: none"> <li>One 50-minute period</li> </ul>	<ul style="list-style-type: none"> <li>Copies of student pages</li> <li>Access to internet (optional)</li> </ul>

## Background

When you think of California agriculture, you may not picture “amber waves of grain.” But, wheat is both a primary crop for many California farmers and a valuable rotational crop, helping to improve the condition of the soil and prevent soil diseases.

California’s sunny, warm, and dry climate produces nutritious and tasty wheat, with big, plump wheat kernels, low moisture content, and consistent sizes. California wheat is also less susceptible to diseases that are more common in other areas of the U.S. and in countries with wetter climates.

Like other crops, wheat depends on healthy soils, which are also a vital element of Earth’s climate system. Soils are a significant reservoir for carbon, storing approximately 2,500 billion tons of carbon worldwide. When managed sustainably, soils can play a critical role in mitigating and adapting to climate change by holding carbon and decreasing greenhouse gas emissions in the atmosphere. If managed poorly, carbon from the soil can be released into the atmosphere in the form of carbon dioxide (CO<sup>2</sup>), and can contribute to climate change.

With rising global temperatures, soil erosion from extreme precipitation and drought are expected to become more prevalent. One way that more and more farmers are adapting to a changing climate is to focus on their soils. Practices such as composting, crop rotation, and planting cover crops between seasons replenish and protect the soil. Low-till farming (which means reducing the extent soil is ploughed) helps to retain organic matter within the soil, which reduces the amount of carbon dioxide that is released into the atmosphere. These practices also help to attract and retain water, ensuring proper hydration for plants and soil organisms even during dry periods.



*Example of low-till fields with harvest residue between the rows*

## Resources

- **“Reforming Farming to Fight Climate Change: An Interview with Michael Pollan.”** Center for Ecoliteracy. Author and journalist Michael Pollan suggests agricultural strategies to mitigate climate change, including soil carbon storage.  
<https://www.ecoliteracy.org/article/reforming-farming-fight-climate-change-interview-michael-pollan>
- **Stop Treating Our Soil Like Dirt!** TED Talks. In this 8.5-minute video, farm manager Karen Wynne explains the connections among healthy soil, water, food, and climate change.  
<https://www.youtube.com/watch?v=27NUR7XnlhY>
- **Soil and Climate Change.** European Environment Agency. An overview of the relationship between soil and climate change.  
<https://www.eea.europa.eu/signals/signals-2015/articles/soil-and-climate-change>
- **Learn about California Wheat.** California Wheat Commission. Information about wheat production in California, including where the growing regions are, and the classes of wheat grown in California.  
<http://californiawheat.org/california-wheat/>

## Extension Ideas

- Share with students **“Soil Strategies: The Role of Cover Crops”** in Center for Ecoliteracy’s **Understanding Food and Climate Change: An Interactive Guide**. Lead a discussion about cover crops with questions such as: What are cover crops? Why are they important? How do cover crops help keep soils healthy?  
[https://foodandclimate.ecoliteracy.org/interactive-guide/page\\_0019.xhtml](https://foodandclimate.ecoliteracy.org/interactive-guide/page_0019.xhtml)
- Encourage students to conduct additional investigations for soil organisms using a Berlese funnel. See **A Community Underfoot: Density and Diversity of Invertebrates in Soil or Ground Cover** from the National Association of Biology Teachers.  
[https://nabt.org/files/galleries/5\\_Density1.pdf](https://nabt.org/files/galleries/5_Density1.pdf)
- Use John Steinbeck’s novels, the ballads of Woodie Guthrie, and WPA photographs to introduce the Dust Bowl. Have students research America’s famous drought, investigating questions such as: What was the environmental impact on the Great Plains? What happened to the topsoil? What happened to the people who lived there? Could the Dust Bowl happen again? What impact would this have on the global food system?
- Challenge students to explore California’s official state soil and why it is important. For more information, see The San Juaquin Series: **California State Soil** from the Soil Science Society of America.  
<https://www.soils4teachers.org/files/s4t/k12outreach/ca-state-soil-booklet.pdf>
- Invite students to share family recipes or personal stories related to wheat. For information about the history of wheat, see the book *Amber Waves: The Extraordinary Biography of Wheat, from Wild Grass to World Megacrop* by Catherine Zabinski.

- Encourage students to apply what they have learned in the activities by developing a plan to enhance the soil in your school garden or a community garden. What actions do they recommend and why?

**Note:** Complete activity sets for all the *California's Climate-Smart Farms* lessons are available at: <https://www.ecoliteracy.org/download/climate-smart-lessons>

WHEAT, SOIL, AND CLIMATE CHANGE

# ACTIVITY 1

## How Are Soil and Climate Change Connected?

Students analyze a diagram to identify connections between soil and climate change.

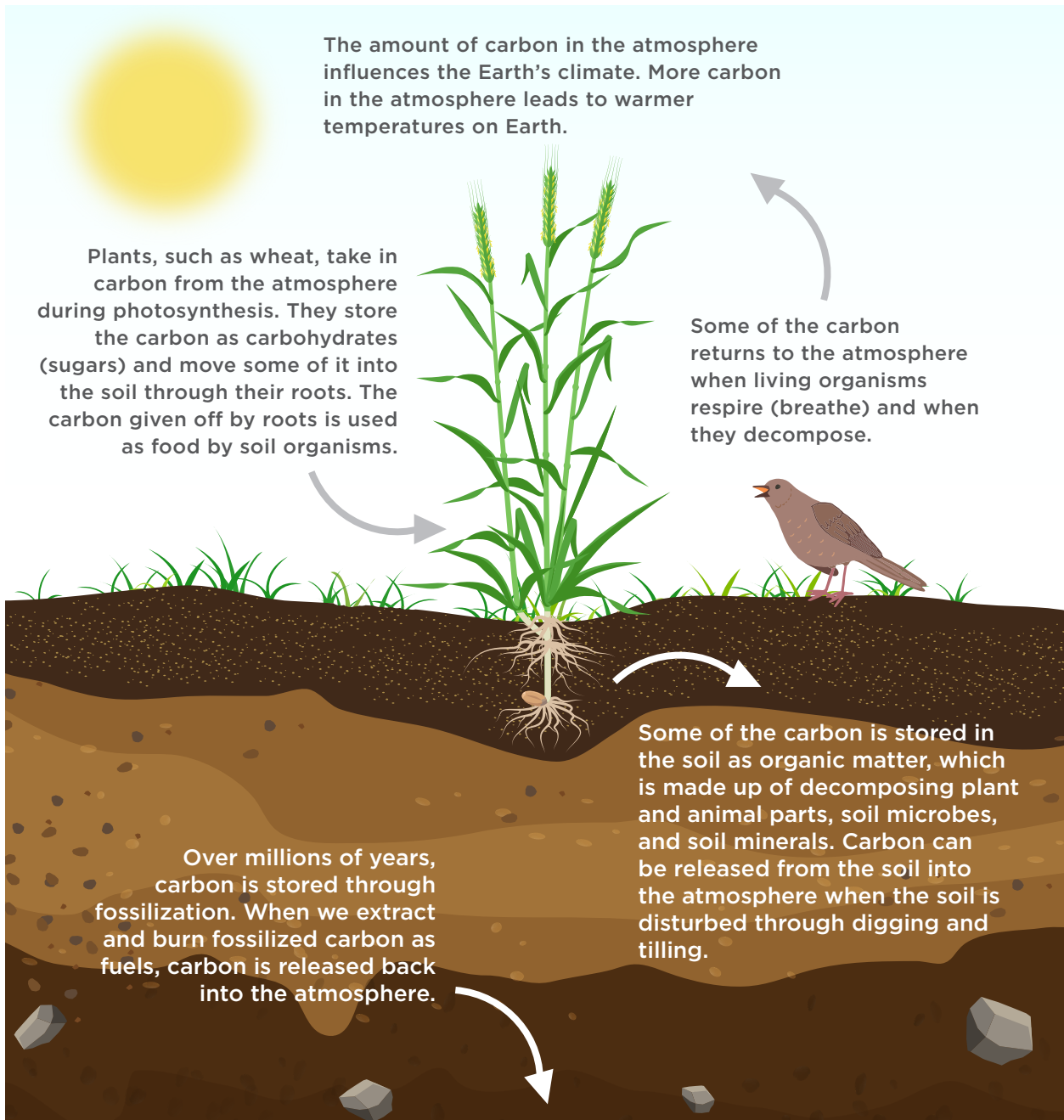


# How Are Soil and Climate Change Connected?

## Evidence

Carbon is an essential component for all living organisms. The amount of Earth's carbon is always the same, but it moves to different places through the carbon cycle. Soil plays an important role in the carbon cycle.

### SOIL AND THE CARBON CYCLE



## ACTIVITY 1, PAGE 2

Figures on carbon stores from **Soil as Carbon Storehouse: New Weapon in Climate Fight?** Judith D. Schwartz. Yale Environment 360. March 4, 2014.

[https://e360.yale.edu/features/soil\\_as\\_carbon\\_storehouse\\_new\\_weapon\\_in\\_climate\\_fight#:~:text=Scientists%20say%20that%20more%20carbon,in%20plant%20and%20animal%20life](https://e360.yale.edu/features/soil_as_carbon_storehouse_new_weapon_in_climate_fight#:~:text=Scientists%20say%20that%20more%20carbon,in%20plant%20and%20animal%20life)

## GLOSSARY TERMS

**Carbon (noun)** An element and essential component for all living organisms.

**Carbohydrate (noun)** A molecule made up of carbon, hydrogen, and oxygen that can be broken down by organisms to release energy.

**Carbon cycle (noun)** The process by which carbon atoms are exchanged among the Earth's air, soil, living organisms, and in modern times, the burning of fossil fuels.

**Decompose (verb)** To rot or decay. When decomposing, dead organisms are broken down into smaller components.

**Microbe (noun)** A microorganism that causes disease or fermentation.

**Photosynthesis (noun)** The chemical process by which plants make their food using energy from the sun to turn water and carbon dioxide into carbohydrates.

**Soil organic matter (noun)** The living or once-living part of soil, including small bits of fresh plants, microbes, and decomposing plant and animal remains.

## **Guiding Question:** How Are Soil and Climate Change Connected?

### **POSSIBLE ANSWERS**

Look at the evidence from the preceding pages. **What possible answers to the question are presented?**

### **DIGGING DEEPER**

Research to find out more about the connections between soil and carbon. Places to start:

- Watch a 3½-minute video, **The Soil Story**, that explains the relationship between carbon and soil and describes how carbon farming can help build healthy soil while reducing carbon in the atmosphere.  
<https://www.youtube.com/watch?v=08T11RKj54g&feature=youtu.be>
- Read the article **Soil & Carbon: Soil Solutions to Climate Problems**, which explains connections between soil and carbon and offers possible solutions.  
[https://www.centerforfoodsafety.org/files/soil-carbon-pamphlet\\_finalv2\\_88688.pdf](https://www.centerforfoodsafety.org/files/soil-carbon-pamphlet_finalv2_88688.pdf)
- Read one author's perspective on why people should focus on soil in order to tackle climate change: **Restoring Soil Can Help Address Climate Change** by David R. Montgomery.  
<https://theconversation.com/restoring-soil-can-help-address-climate-change-121733>

**Summarize what you learned:**

**WHAT DO YOU THINK?**

Using the evidence from the preceding pages and your additional research, explain your answer or solution to the question.

**Claim:** Write a sentence stating your answer.

**EVIDENCE**

**Data:** Include data that supports your claim.

**REASONING**

**Explanation:** Share how your evidence supports your claim.

WHEAT, SOIL, AND CLIMATE CHANGE

# ACTIVITY 2

## How Do Soil Organisms Contribute to Healthy Soil?

Students collect soil samples and use a Berlese funnel (also called a Tullgren funnel) to observe soil organisms in soil.

# How Do Soil Organisms Contribute to Healthy Soil?

## Evidence

Healthy soil is not just dirt. It contains lots of different living organisms as well as dead plant and animal matter. The following chart shows how many organisms may live in just one teaspoon of healthy farm soil.

SOIL ORGANISMS IN HEALTHY SOIL		
BACTERIA	Per teaspoon of soil (one gram dry)	
FUNGI		
PROTOZOA		
NEMATODES		
ANTHROPODS	Per square foot	
EARTHWORMS		

Plan and conduct an investigation, such as the following, to investigate some of the organisms that live in soil. The example uses a Berlese [bur-LAY-zee] funnel to remove living organisms from a soil sample. The light above the funnel causes soil organisms to move away from it and into the trap below.

**EXAMPLE INVESTIGATION**

1. Place a funnel in a clear water glass or glass vase. As an alternative, you can make a Berlese funnel from an empty plastic beverage bottle. See: <chrome-extension://efaidnbnmnnibpcajpcglclefindmkaj/https://arboretum.harvard.edu/wp-content/uploads/2020/07/berlese-funnel-how-to.pdf>
2. Place a piece of gauze or screen in the neck of the funnel to prevent soil from falling to the bottom. Use a hole punch or cut a couple of slits in the gauze or screen to allow larger organisms to pass through it.



*Example of setup with glass, funnel, paper towel, and screen with holes punched in it*



*Glass, funnel, paper towel, and screen assembled with soil in funnel*

3. Moisten a paper towel and place it in the bottom of the glass.
4. Use a measuring cup to collect 1 cup of soil from the garden or other location.
5. Gently put the soil into the funnel, being careful not to move the gauze or screen.
6. Place the funnel under a desk lamp or other lamp.
  - o What do you think will happen?

**ACTIVITY 2, PAGE 3**

7. Check the paper towel every day for at least three days. Observe any organisms that collect in the bottom.
  - o How many kinds of organisms did you observe? (Look closely. Some of them may be smaller than the period of this sentence.) If you can, look at them with a magnifying lens or microscope.
  - o What else did you notice?

**GLOSSARY TERMS**

**Arthropod (noun)** An animal without a backbone that has a hard, outer skeleton and three or more pairs of legs that can bend. Insects and spiders are examples of arthropods.

**Bacteria (noun)** Microscopic, single-celled organisms.

**Fungi (noun)** A group of organisms that includes yeasts, molds, and mushrooms.

**Nematode (noun)** A roundworm.

**Organism (noun)** An individual animal, plant, or single-celled life form.

**Protozoan (noun)** A single-celled organism. Plural is protozoa.



## Guiding Question: How Do Soil Organisms Contribute to Healthy Soil?

### POSSIBLE ANSWERS

Look at the evidence from the previous page. **What possible answers to the question are presented?**

### DIGGING DEEPER

Research to find out more about the connections between soil and carbon. Places to start:

- Compare your soil sample with a sample from a different location. You may share your results with fellow students to compare findings.
- Watch a 3-minute video, **The Living Soil Beneath Our Feet**, for an up-close look at the ants, amoebas, and bacteria that maintain healthy soil.  
<https://www.calacademy.org/educators/the-living-soil-beneath-our-feet>
- Watch a 6-minute video, **What is the Soil Food Web?** to learn how soil organisms contribute to healthy soil. The video features a leading soil organism scientist, Dr. Elaine R. Ingham.  
<https://www.youtube.com/watch?v=uAMniWJm2vo>

**Summarize what you learned:**

### WHAT DO YOU THINK?

Using the evidence from the previous page and your additional research, explain your answer or solution to the question.

**Claim:** Write a sentence stating your answer.

**EVIDENCE**

**Data:** Include data that supports your claim.

**REASONING**

**Explanation:** Share how your evidence supports your claim.

# ACTIVITY 3

## How Can People Nurture Soil Health as a Response to Climate Change?

Students read a profile of Full Belly Farm to learn what farmers are doing to reduce climate change impacts of growing wheat, particularly in terms of soil. They also identify steps individuals can take.



## How Can People Nurture Soil Health as a Response to Climate Change?

### Evidence

Full Belly Farm is a certified organic farm located in the beautiful Capay Valley of Northern California. With help from about 80 employees, the farm produces an amazing diversity of vegetables, herbs, nuts, flowers, fruits, and grains—including wheat. The farm also has a flock of chickens and sheep, a tribe of goats, and several cows.

Full Belly grows heirloom varieties of wheat, which make unusually delicious breads and pastas. In growing wheat and other crops, the farm adopts a whole-system approach in which every action is made with purpose and consideration of the impact it will have on the long-term sustainability of the farm.

“There are many ways that farms can mitigate the impacts of climate change,” says Full Belly farmer Judith Redmond. “We are looking at new farming patterns that minimize moisture loss, maximize living roots in the soil, and gather and sequester more carbon,” adds fellow farmer Paul Muller. “We want to put carbon in the soil, where it becomes key to the soil food web.”

Wheat is an important part of the farm’s soil health program because it allows the soil to rest and dry out completely, maintaining a beneficial balance of microbes. To replace soil nutrients, Full Belly uses cover crops—which are plants grown in the off-season to protect and enhance the soil—and harvests them by a herd of sheep. Full Belly also applies compost to their fields and reduces the tillage or plowing they do.

These practices help to maintain soil health and maximize carbon soil. They also increase disease resistance, the capacity of the soil to hold water, and how much crop is produced (the crop yield).

Full Belly Farm:

<https://fullbellyfarm.com/>



*Staff and family gathering at Full Belly Farm*



## GLOSSARY TERMS

**Cover crop (noun)** Plants grown to protect and enrich the soil.

**Crop yield (noun)** The amount of crop grown per unit area of land.

**Heirloom (noun)** A variety of a fruit, vegetable, or grain that was saved for its flavor or other qualities and passed down from one generation to the next.

**Microbe (noun)** A microorganism that causes disease or fermentation.

**Organic (adjective)** Grown according to USDA organic standards that address, among many factors, soil quality, animal raising practices, pest and weed control, and use of additives.

**Sequester (verb)** To collect and store carbon dioxide to keep it from entering the atmosphere.

**Tillage (noun)** The preparation of soil for planting by digging, stirring, or overturning it.

## **Guiding Question:** How Can People Nurture Soil Health as a Response to Climate Change?

### **Possible Answers**

Look at the evidence from the preceding pages. **What possible answers to the question are presented?**

### **DIGGING DEEPER**

Research to find out more about what farmers and individuals can do. Places to start:

- Watch a video on “**Soil Strategies**” in Understanding Food and Climate Change: An Interactive Guide. What happens when soil is damaged? How do soils lose carbon? What strategies can be used to increase the carbon in soil?  
[https://foodandclimate.ecoliteracy.org/interactive-guide/page\\_0019.xhtml](https://foodandclimate.ecoliteracy.org/interactive-guide/page_0019.xhtml)
- View the infographic **Soil’s Carbon Storage Capabilities Can Help Fight Climate Change**, which describes farming techniques that increase the amount of carbon stored in soil.  
<https://insideclimatenews.org/infographics/infographic-how-soil-carbon-storage-can-help-fight-climate-change/>
- Read about **5 Things Everyone Can Do to Protect the Planet’s Soil**.  
<https://www.treehugger.com/things-everyone-protect-soil-4855245>

**Summarize what you learned. What positive and negative effects could these actions have?**

### **WHAT DO YOU THINK?**

Using the evidence from the preceding pages and your additional research, explain your answer or solution to the question.

**Claim:** Write a sentence stating your answer.

**EVIDENCE**

**Data:** Include data that supports your claim.

**REASONING**

**Explanation:** Share how your evidence supports your claim.



## ABOUT THE CENTER FOR ECOLITERACY

The Center for Ecoliteracy is an internationally recognized leader in education for the sustainability of people and the planet. Since 1995, the Center has engaged with thousands of educators from across the United States and six continents. The Center offers publications, seminars, coaching for teaching and learning, in-depth curriculum development, keynote presentations, and technical assistance. Our California Food for California Kids® initiative connects public school districts as they advance their work in providing students with fresh, locally-grown food and reinforcing connections between the classroom, cafeteria, and garden. With a network of over 100 public school districts across the state, California Food for California Kids helps districts share the knowledge, experience, and caring of its participants to advance practical solutions that transform school food systems and how students learn about the food they eat.

## CREDITS

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## PHOTOS

**Full Belly Farm** Photos courtesy Full Belly Farm

**Student activities** Karen Brown

**Stock photos** butterfly: [iStock.com/Antagain](https://www.iStock.com/Antagain); soil layers: [iStock.com/BSVIT](https://www.iStock.com/BSVIT); wheat: [iStock.com/Rorygez Fresh](https://www.iStock.com/Rorygez Fresh); bird: [iStock.com/GooseFrol](https://www.iStock.com/GooseFrol); wheat: [iStock.com/Bezvershenko](https://www.iStock.com/Bezvershenko); field: NRCS/USDA

Our deepest gratitude to Full Belly Farm, who shared their stories, knowledge, and photos in the development of this lesson. Their generosity and wisdom will help students understand and adapt to the challenges they may face in the future of agriculture.