Fifth Grade Curriculum

Wheat Farming and Climate Science in the Inland Pacific Northwest

REACCH
Regional Approaches to Climate Change – PACIFIC NORTHWEST AGRICULTURE

www.reacchpna.org

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The REACCH project is an interdisciplinary research effort that was developed across three states (Oregon, Washington, and Idaho), and among four institutions—the University of Idaho, Oregon State University, Washington State University, and the USDA Agricultural Research Service (USDA ARS). More information at **www.reacchpna.org**

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"If your plan is for one year, plant rice. If your plan is for ten years, plant trees. If your plan is for 100 years, educate children." –Confucius

Dear Educator:

The Regional Approaches to Climate Change for Pacific Northwest Agriculture (REACCH) project was designed to enhance the sustainability of cereal production systems in the inland Pacific Northwest. This multi-state project is unique in how it has engaged scientists, farmers, and educators in addressing the complex problem of sustainable cereal production in a changing climate. REACCH is more broadly and deeply integrated and more comprehensively coordinated than previous research projects of its kind, bringing together climate, cropping systems, economic models, agricultural economics, rural sociology, agronomy, soil science, crop protection and other disciplines in an integrated, transdisciplinary manner.

You are receiving this curriculum as a fifth-grade teacher in one of the three participating states; Idaho, Washington, and Oregon. A goal of this project was to develop free, useful, high-quality curricula. We are pleased to give the final product to you and your students. The curriculum was pilot tested by the developer, and a video presentation from the students in that class is available on the REACCH website.

The following principles guided the development of this curriculum:

- Accurate and current scientific content
- Age-appropriate dissemination of content
- Active teaching approach that considers differing learning styles
- Additional resources and/or activities for enhancing or differentiating content
- Incorporation of the Next Generation Science Standards and Common Core State Standards for math and English language arts and literacy

A main goal of the REACCH project is to prepare scientists and educators to create and promote practical, science-based agricultural approaches to climate change adaptation and mitigation. The REACCH education team has developed innovative approaches to incorporating agriculture and climate change topics into K–12 curricula in order to prepare citizens and professionals for the climate- and agriculture-related challenges they will face in the future. As the Greek philosopher Diogenes once said, "The foundation of every state is the education of its youth."

For further information on content, student work examples, case study videos and image galleries, please visit our website **www.reacchpna.org**. This website has extensive information relating to the research conducted during the six-year project. Additional resources to enhance the curriculum and inform your instruction are also available under the Education tab.

We hope to update and improve this curriculum over time, and look forward to receiving your comments, corrections, and suggestions. Please send them to Kattlyn Wolf at kwolf@uidaho.edu. Please share this curriculum with others in your school, middle school teachers, Scouts, 4-H, etc. If you do not want this printed curriculum, kindly return it to Kattlyn Wolf, University of Idaho, 875 Perimeter Drive MS 2040, Moscow, ID 83844-2040.

Introduction

Curriculum Overview

This curriculum is designed to assist fourth- through sixth-grade teachers in incorporating agriculture and climate change science into their classrooms. The curriculum is specifically designed to meet fifth-grade standards for science (Next Generation Science Standards and Idaho state) and English language arts and literacy Common Core standards for Oregon, Washington, and Idaho. (Note: one lesson also hits a Common Core math standard.)

Although the curriculum is designed for four weeks, five days a week, two hours a day, teachers will find that they can modify it to meet their specific needs regarding implementation timing. This curriculum is designed to be place-based (inland Pacific Northwest) and scientifically sound, based on current research conducted by REACCH scientists.

All lessons are designed to be hands-on, inquiry-based, and standards-based to actively engage students in successful learning. While most texts are designed to be in the fourth- to sixth-grade Lexile range (as defined by Common Core State Standards), other texts are intentionally more difficult in order to provide opportunities for reading and comprehension of complex texts. Below is an overview of the major topics covered in the four-week curriculum and an overview of individual lesson plan components.

Major topics

Week 1: How Do Wheat Plants Grow?

The lessons cover these topics: what plants need to grow, photosynthesis, water cycle and role of plants, wheat plant structures and functions, wheat life cycle, wheat plant systems model (end of week assessment).

Week 2: How Is Wheat Farming in the Inland Pacific Northwest Impacted by Climate Change?

The lessons cover these topics: history of wheat farming in the inland Pacific Northwest, inputs and outputs of a wheat farm, global climate change (carbon dioxide, temperature, greenhouse effect), climate change (temperature and precipitation) in the inland Pacific Northwest, how climate change is influencing wheat agriculture in the region, wheat farm system model (end of week assessment).

Week 3: What Is Happening on My Wheat Farm?

Students will be divided into groups, and each group will receive one of three scenarios. They will analyze data to discover what is happening on their farm, and then spend the week learning about potential solutions to address the problems they are facing on their farm. The topics of the three scenarios are:

- Scenario 1: Aphids on a Wheat Farm in Moscow, Idaho
- Scenario 2: Hotter, Drier Summers on a Wheat Farm in Pendleton, Oregon
- Scenario 3: Wetter, Warmer Winters on a Wheat Farm in Walla Walla, Washington

Week 4: What Will I Do? Evidence-Based Opinion Essays and Formal Presentation

Students will spend the week writing opinion essays about what they think is needed to address the problems they are facing on their farm. Students will cite textual evidence from their research to support their thesis statements and all supporting opinions and claims. At the end of the week, students will present their cases and proposed solutions to their class. The REACCH education team encourages teachers using this curriculum to have students make formal presentations to a group of local farmers and/or scientists. Research has shown that student work and interaction in real-world contexts enhances student motivation, engagement, and learning.

Lesson Plan Components

Detailed lesson plans for each day are provided. Each lesson plan includes the following:

- Lesson overview
- Alignment to fifth-grade ELA Common Core and Science standards (for Oregon, Washington, and Idaho)
- Learning targets for the lesson, aligned to specific standards
- List of materials needed
- Complete lesson descriptions (All lessons are designed to be hands-on, inquiry-based, standards-based, place-based, and scientifically sound.)
- List of resources used in lesson development (Some lessons also include additional resources or recommendations for extension activities.)
- Handouts, graphic organizers, and supplementary materials (unless otherwise noted and attached as separate documents)

Introduction to Wheat and Plant Growth

Week 1 – Day 1

Lesson Overview

The purpose of this lesson is to introduce students to the topics of wheat and what plants need to grow. This lesson briefly covers the role of wheat in the global food system, wheat production in the inland Pacific Northwest, food and non-food products that contain wheat, and the basic components necessary for plant growth (i.e., water, sun, air, and soil). This lesson includes an overview of what students will be learning throughout the four-week curriculum and sets them up for learning more about photosynthesis, the water cycle, and specific structures and functions of wheat plants during the rest of the week.

Lesson Vocabulary

wheat, global staple foods, inland Pacific Northwest, Jan Baptist van Helmont, air, water, soil, and sunlight

Standards and Learning Targets for Lesson
Learning Targets • I can describe the basic components that plants need for growth.
<u>Next Generation Science Standards</u> • 5-LS1-1 – Molecule to Organisms - Support an argument that plants get the materials they need for growth chiefly from air and water.
<u>Idaho Science Standards</u> • 5.S.3.2.1 – Goal 3.2 Biology - Communicate how plants convert energy from the sun through photosynthesis.
<u>Common Core ELA Standards</u> • W.5.10 – Writing - Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Materials

- About 20 products that do and do not contain wheat (Use the graphic organizer “Is It Made with Wheat?” to gather items, or use the images in the PowerPoint slides.)
- PowerPoint slides (W1D1_Introduction Presentation.pptx) to use in place of the collected items (if desired) and for the mini-lesson on wheat in the global food system
- Graphic organizer “Is It Made with Wheat?”
- Graphic organizer “Is It Made with Wheat? TEACHER KEY” (This version is the answer key.)
- Graphic organizer “Was van Helmont Right?”

- Graphic organizer "Jan Baptiste van Helmont's Science Notebook"
- Graphic organizer "What Plants Need to Grow"
- Transpiration demonstration setup materials: one baggie and one twist tie for each student pair/group and indoor or outdoor plants in sun and shade (Read setup instructions below for more details.)

Lesson Duration

Approximately 2 hours

Lesson Description

Part 1: Wheat in the World and the Inland Pacific Northwest –Short Lesson Introduction (30 minutes)

- Place about 20 products (some that do and some that do not contain wheat) on a table. Use the graphic organizer to gather products, or show students the product images provided in the PowerPoint slides. Have students gather around the table (or watch slides one at a time) and use the graphic organizer "Is it Made with Wheat?" to add each product to one of two columns (contains wheat or does not contain wheat).
- Discussion: Hold up one product at a time (or show product slides) and ask students whether they think it contains wheat or not. Ask students to explain their thinking. Share details about the products, highlighting surprising examples and the diverse uses of wheat in our daily life.
- Use the PowerPoint slides beginning with "Wheat in the Global Food Supply" to engage the class in a short discussion and highlight the main points on each slide.
- Tell the class about what they will learn in the next four weeks:
    - How plants grow and how wheat grows
    - What wheat farms in the inland Pacific Northwest look like
    - How weather and climate patterns influence wheat
    - You will get to pretend you are a wheat farmer facing a certain problem and you will work in groups to find solutions.
    - You will each write an essay about how to solve the farm's problem and make a presentation (maybe to local farmers and/or scientists).

Part 2: What Plants Need to Grow – Engage, Explore, Explain, Elaborate, and Evaluate (5E) Lesson Structure (80 minutes)

Engage

- Distribute the graphic organizer "Jan Baptiste van Helmont's Science Notebook" to each student. Read the text aloud while students follow along.
- Read the text a second time aloud, pausing frequently so students can draw the experiment based on what you read.
- Instruct students to use the information in the text to draw two colored lines on the graph (one green line showing the increase in plant mass and one brown line showing the maintenance of soil mass) in order to summarize van Helmont's findings.

- Select a couple of students to share their plots and thinking.
- Clarify what the two lines should look like by drawing them on the board. Have students make any corrections needed to their own plots. Ask students to clarify what van Helmont's main conclusions were (i.e., the weight of the soil remained the same [200 pounds], but the weight of the tree increased by 164 pounds).

Explore

- Distribute the graphic organizer "Was van Helmont Right?" to each student.
- Have students answer the following questions in their groups (Be sure to have them write down their responses in the first column as they will be using them again later in the lesson.):
    - *Do you think van Helmont was right? Why or why not?*
    - *What other possible explanations for the tree's growth are there?*
- Ask groups to share their answers to these questions.
- Let students know that the rest of today's lesson will be about what plants need to grow.
- Unpack the learning target: *I can describe the basic components that plants need for growth*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- Distribute the graphic organizer "What Plants Need to Grow." Have students work in groups to discuss their answers to the questions and fill out the graphic organizer, recording their answers on their own papers. Another option is to cut the graphic organizer into four parts (water, soil, sun, and air) with one part at each of the four stations around the room. Have students move to each of the four stations to answer the questions on the graphic organizer, taping each piece into their notebooks as they move.
- Circulate around to help groups as they work through the questions. Stop the class as needed to clarify points along the way (i.e., catch and release).

Explain

- Whole-class discussion about what plants need to grow: work through the graphic organizer, asking each group to share their responses to a question.
- Throughout the discussion, you can take notes to create an anchor chart highlighting what plants need to grow. Clarify the basic processes in which plants use these components to grow.
    - Water: hydrates
    - Soil: provides structure to hold the roots, holds and stores water, and is the source of most nutrients required by plants
    - Sun: provides light, a necessary component for plants to make their own food
    - Air: contains gases like carbon dioxide
- If needed, review the basics of elements and matter.
- Let students know that we will explore how plants use these components to grow throughout the rest of the week.

Elaborate

- Have students return to the original questions and their responses:
    - *Do you think van Helmont was right? Why or why not?*

- *What other possible explanations are there for why the tree grew?*
- Have students work in groups to answer these questions again, record their answers in the second column of their graphic organizers, and assess how their thinking has changed.

Evaluate

- Have students write one paragraph about the basic components plants need (i.e., water, sun, air, and soil) and how plants use each of them for growth.

Part 3: Set Up Transpiration Demonstration for Analysis on Day 3 of This Week – Set Up Only (10 minutes)

The purpose of this demonstration is to reiterate how plants contribute to the water cycle through transpiration. The results of this demonstration will be analyzed on Day 3 this week as an extension of water cycle knowledge and understanding. Teachers can decide whether to set up one demonstration for the whole class to look at together or to have student pairs/groups each set up their own demonstration. The latter option would be preferred to maximize student engagement, but it might not be possible for all classes due to time requirements or other constraints. The set-up instructions follow:

- Use either indoor or outdoor plants.
- In order to compare their transpiration rates, choose plants that receive either sunlight or shade for most/all of the day or place plants in those conditions.
- Divide students into eight groups, with four assigned to sun and four assigned to shade.
- Give each student group a baggie and a twist tie.
- Decide on a number of leaves to try to cover with the baggie so that all groups cover approximately the same number of leaves.
- Instruct the groups to find outside plants (or indoor plants) in either the sun or the shade (according to their assigned categories). Have them place their baggies over the determined number of leaves and seal tightly with the twist tie.
- Remind students not to harm the plants and to have as little impact on the plants as possible in this process.
- Have students draw the demonstration setup in their science notebooks and make a prediction about what they will be observing in two days when they look at it again.
- See "The Water Cycle" (week 1, day 3) for the analysis portion of the demonstration.

Resources Used in Lesson Development

David Hershey. (2003). *Misconceptions about Helmont's Willow Experiment*. Plant Science Bulletin. The Botanical Society of America. 49:3. [Text for van Helmont's science notebook activity was adapted from this source, which cites the original source as: Helmont, J.B. van. (1662). *Oriatrike or Physick Refined*. London: Lodowick Loyd. (translated by John Chandler).

Global Wheat Statistics. International Development Research Center, Canada. https://www.idrc.ca/en/article/facts-figures-food-and-biodiversity

U.S. Wheat Statistics. United State Department of Agriculture. Search for "U.S. wheat statistics" at this website: http://www.usda.gov/wps/portal/usda/usdahome

Map of Wheat Producing Regions of the World. University of Minnesota Institute on the Environment. Accessed from: https://en.wikipedia.org/wiki/International_wheat_production_statistics

Is it Made with Wheat?

	Yes	No
Bread		
Pretzels		
Pasta		
Flour Tortillas		
Trash Bags		
Ketchup		
Chewing Gum		
Metal		
Licorice		
Eggs		
Flavored Potato Chips		
Salad Dressing		
Soy Sauce		
Laundry Soap		
Canned Soup		
Popcorn		
Hot Dogs		
Paper		
Kitty Litter		
Housing Insulation		
Paste		
Play-Doh		
Golf Tees		
Cosmetics		
Pet, Livestock, & Fish Food		
Clothes		
Shampoo & Conditioner		
Sunscreen		
Pencils		
Hot Chocolate		
Vegetables		
Meat and Fish		

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Is It Made with Wheat? (TEACHER KEY)

	Yes	No
Bread	X	
Pretzels	X	
Pasta	X	
Flour Tortillas	X	
Trash Bags	X	
Ketchup	X	
Chewing Gum	X	
Metal		X
Licorice	X	
Eggs		X
Flavored Potato Chips	X	
Salad Dressing	X	
Soy Sauce	X	
Laundry Soap	X	
Canned Soup	X	
Popcorn		X
Hot Dogs	X	
Paper	X	
Kitty Litter	X	
Housing Insulation	X	
Paste	X	
Play-Doh	X	
Golf Tees	X	
Cosmetics	X	
Pet, Livestock, & Fish Food	X	
Clothes		X
Shampoo & Conditioner	X	
Sunscreen	X	
Pencils		X
Hot Chocolate	X	
Vegetables		X
Meat and Fish		X

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Was van Helmont Right?

My first response	My second response
Do you think Van Helmont was right? Why or why not?	Do you think Van Helmont was right? Why or why not?
What other possible explanations are there for why the tree grew?	What other possible explanations are there for why the tree grew? How did your thinking change between your two responses?

Jan Baptiste van Helmont's Science Notebook

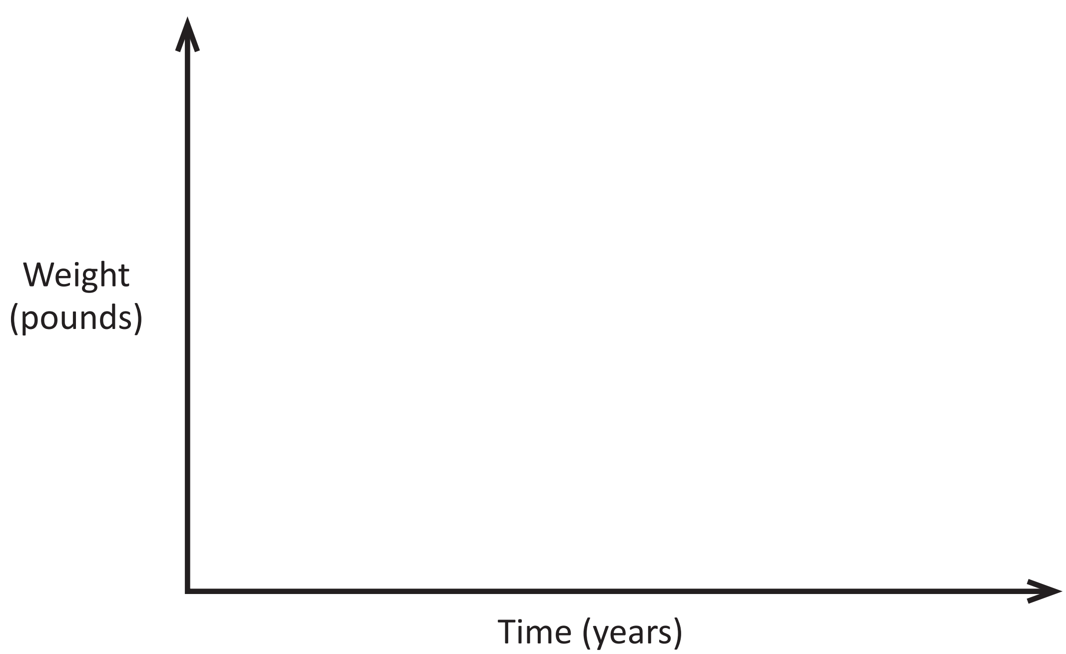
I have learned that all plants do grow from water only. In a clay vessel I put 200 pounds of soil that had been dried in a furnace. In that soil I planted a small willow tree weighing five pounds. I covered the soil with a tin plate full of holes to allow rainwater to enter. For five years I allowed rainwater to fall onto the soil and I also watered the tree myself. After five years, the tree weighed 169 pounds. However, I did not weigh the leaves that fell off the tree in the four autumns that passed. After drying the soil, I found that it weighed nearly the same 200 pounds as five years ago. Therefore, 164 pounds of wood, bark and roots arose out of water only.

Text adapted from: Helmont, J.B. van. (1662). *Oriatrike or Physick Refined*. London: Lodowick Loyd. (translated by John Chandler). Referenced in: David Hershey. (2003). *Misconceptions about Helmont's Willow Experiment*. Plant Science Bulletin. The Botanical Society of America. 49:3.

Based on this entry from van Helmont's science notebook, draw the following two lines on the graph below. Be sure to draw them in two different colors.

1. Plot the change in weight of the willow tree over the five years of his experiment.

2. Plot the change in weight of the soil over the five years of his experiment.



What Plants Need to Grow

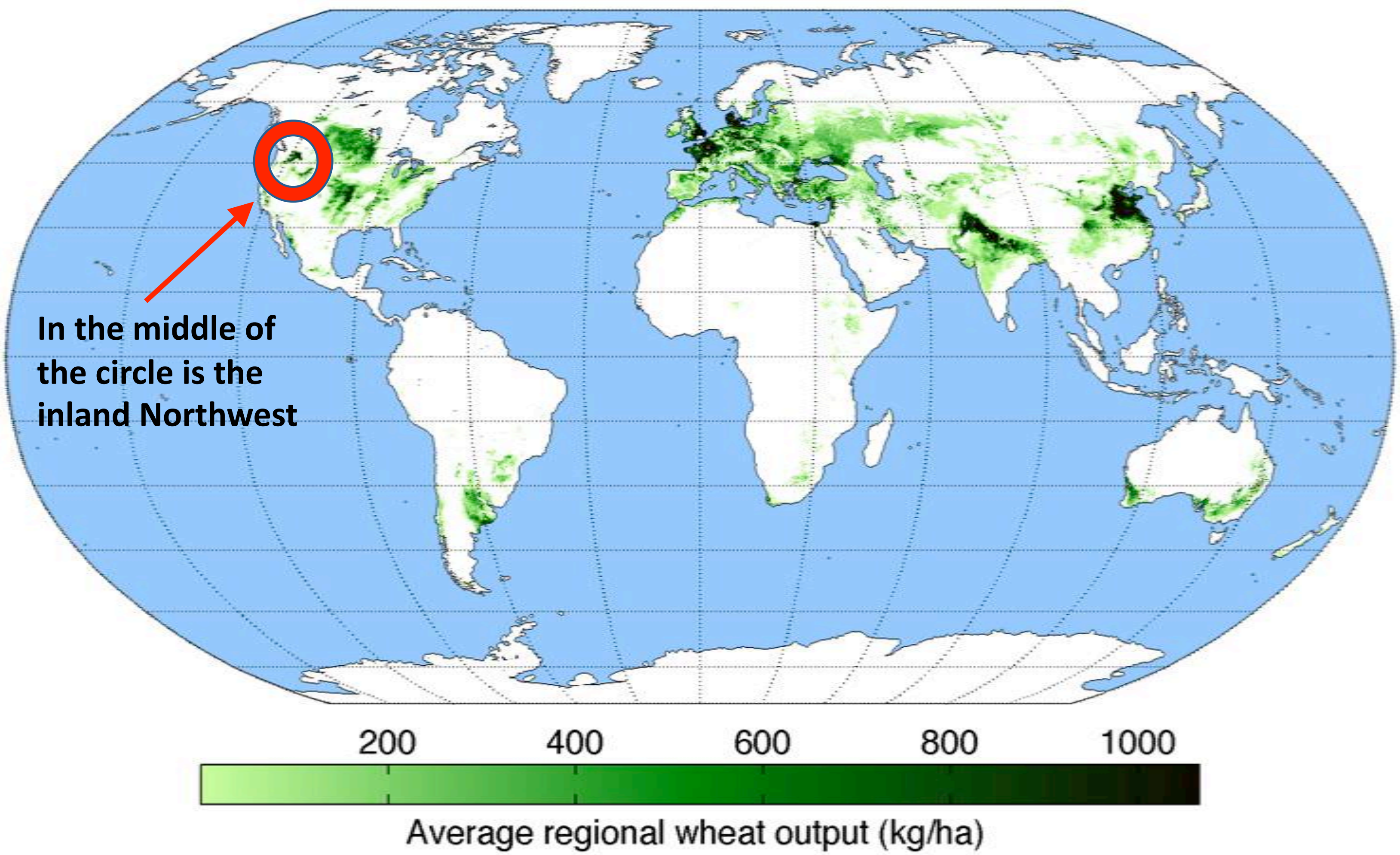
Water	Can you survive on water alone? Besides water, what else do you need to grow? Do you think that plants can survive on water alone? Where do you think the willow got its food?
Soil	Did soil contribute to the mass of the willow growth? Do you think the willow got its food from the soil? How do you know?
Sunlight	Do you think the willow got its food from sunlight? How do you think the sun helps plants grow?
Air	What is air made of? How do you think air helps plants grow?

The Global Food Supply

- The three major crops that feed the world are **wheat**, **rice**, and **corn**.
- In total, wheat, rice, and corn are the staple diet for more than 50% of the world's population (that's almost 4 billion people).
- According to the United States Department of Agriculture, the United States produces about 10% of the world's wheat supply.
- About 15% of all U.S. wheat comes from the inland Northwest.

Color images available for download at **reacchpna.org/education/elementary-curriculum**

Wheat Producing Regions in the World



Color images available for download at **reacchpna.org/education/elementary-curriculum**

Color images available for download at **reacchpna.org/education/elementary-curriculum**

Photosynthesis

Week 1 – Day 2

Lesson Overview

The purpose of this lesson is to teach students about photosynthesis and explore more deeply the components that plants need for growth introduced in the previous lesson.

Lesson Vocabulary

plants, photosynthesis, carbon dioxide, oxygen, glucose, chloroplast, and chlorophyll

Standards and Learning Targets for Lesson
Learning Targets • I can explain the process of photosynthesis.
<u>Next Generation Science Standards</u> • 5-LS1-1 – Molecules to Organisms - Support an argument that plants get the materials they need for growth chiefly from air and water.
<u>Idaho Science Standards</u> • 5.S.3.2.1 – Goal 3.2 Biology - Communicate how plants convert energy from the sun through photosynthesis.
<u>Common Core ELA Standards</u> • RI.5.1 – Reading Informational Text - Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

Materials

- Four jars labeled: (1) soil (add soil), (2) water (add water), (3) sunlight (leave empty), and (4) air (leave empty)
- Photosynthesis cards: one set per group of students
- Text "Photosynthesis: The Amazing Talent of Plants": one copy per student
- Graphic organizer "Photosynthesis Vocabulary": one copy per student
- Exit ticket: one copy per student
- Photosynthesis demonstration setup: clear cups or jars, leaves, and water
- Xylem demonstration setup: small cups or jars, celery, food coloring, and water
  (Note: demonstrations can be set up as one for the class or one per student group.)

Lesson Duration

Approximately 2 hours

Lesson Description

Engage (20 minutes)

- Start by asking students to remember the basic components that plants use for growth.
- Place jars labeled "sunlight," "air," "soil," and "water" on a table in the classroom. Ask students to consider that if these are the components that plants need for growth, then ask—can people grow with these same components? Ask for a volunteer who thinks they can make food with these components, and ask them to do it.
- Have students discuss in groups how they think plants use these materials to grow.
- Have groups share their thinking with the class. Reiterate that plants are amazing! They use sunlight and air to make food (sugars) that they use to grow.
- Ask if anyone knows what this process (photosynthesis) is called. Define photosynthesis on the board and unpack the word origin (Greek: *photo* means light and *synthesis* means putting together, so *photosynthesis* means putting things together using light).
- Unpack the learning target: *I can explain the process of photosynthesis*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- Explain that we will now set up two demonstrations. One we will observe at the end of the lesson today, and the other we will observe tomorrow.
- Set up two demonstrations (see the next two bullet points for instructions). You can decide whether to set up either one station for the whole class to observe or have student groups each set up their own demonstrations. Both demonstrations are simple, should not take much time to set up, and will be used in the Evaluate section of this lesson.
- **Photosynthesis demonstration setup** (this demonstration helps students see how the photosynthetic process creates oxygen):
    - Materials needed: clear cups or jars, leaves, water (Note: small clear cups work best so students can observe the top, bottom, and sides of the cups and leaves very easily.)
    - This demonstration can be set up as one for the class or one per student group.
    - Students (or groups) should remove two leaves from a plant and place each leaf in a clear cup of water—one in direct sunlight and one in a dark spot not receiving much light. After 1 to 2 hours, students can observe the leaves and will notice small bubbles, which is the oxygen released from the leaves through photosynthesis. They should see a difference in the amount of oxygen produced with and without direct sunlight. See the Resources list below for two websites that explain this classroom demonstration.
    - Have students record in their science notebooks the time the leaves were placed in the water and three initial observations (for both the leaves placed in the light and the leaves placed in the dark). Tell them we will come back to these later in the lesson today.
    - Have students draw the demonstration setup in their science notebooks and make a prediction about what they will be observing in 1.5 hours.
- **Xylem demonstration setup**: This demonstration helps students see how the plant roots take up water (and nutrients) from the soil and transport them through the stalk to the leaves. (Note: this demonstration will be left overnight and observed during tomorrow's lesson on the water cycle.)

- Materials needed: small cups or jars, celery stalks (preferably with leaves on the top), food coloring, and water
- This demonstration can be set up as one for the class or one per student group.
- Each student group should fill their cups about halfway with water and add about three drops of food coloring to each cup—one cup with red and one cup with blue.
- The instructor can provide one stalk of celery to each group. To prepare the celery, cut about ½ inch off the non-leaf end of the celery, then slice the stalk into two strips to about halfway up the stalk so the top half of the stalk remains connected.
- Students will place the cups next to each other and place one root end in the blue jar and the other in the red jar, making sure that the celery remains upright and balanced on the edge of the jars.
- Have students draw the demonstration setup in their science notebooks and make a prediction about what they will be observing tomorrow.

Explore (15 minutes)

- Distribute one set of photosynthesis cards to each group. Groups can be any size that works for your classroom.
- Have students work in groups to sort the cards to form the equation for photosynthesis—how plants use light to put things together and make food for growth.
- Instruct students to write down at least two questions they have in the process of organizing the cards.
- Once students have the cards organized into what they think is the equation for photosynthesis, instruct them to explain their thinking by completing this sentence: *We think this is the equation for photosynthesis because __________ .*
- Ask a few student volunteers to share their thinking to transition into the explanation of photosynthesis.

Explain (45 minutes)

- Distribute the photosynthesis text and graphic organizer to each student.
- Have students independently read the text. Have them underline key concepts and circle unknown vocabulary words while they read.
- Instruct students to fill out the graphic organizer table, listing unknown vocabulary words and completing the “what I think it means” section of the table.
- Have students use the graphic organizer to answer the question: *What is the equation for photosynthesis?* Ask them draw a picture of a plant and the process of photosynthesis.
- Give a 10-minute mini-lesson on photosynthesis. Facilitate a class discussion to write the equation on the board. Explain the process and clarify vocabulary. Have students write the definitions of any words they did not know in their graphic organizer.
- For fun practice, have students find partners and stand with one partner facing the board where the equation for photosynthesis is written and the other partner looking in the opposite direction. Have them practice reciting the equation for photosynthesis from memory several times, with feedback from the partner looking at the board. Switch off as many times as desired.

Elaborate (20 minutes)

- Instruct students to use their graphic organizers and mini-lesson notes to reevaluate their thinking from the card sort. Have them look at the equation for photosynthesis they wrote in their groups and at what they wrote about why they thought that was the equation. Have them critique their thinking by asking, *What were you right about?* and *What were you wrong about?* Have them write a few sentences.
- Use a think-pair-share protocol. Have students work independently first, then share their thinking with their groups, then with the whole class.
- Have students go look at the photosynthesis demonstration they set up at the beginning of class. Have students observe the leaves, record the time (to calculate how much time has passed during the experiment), record two or three observations, and include a proposed explanation for each observation.
- Have students share their new observations and proposed explanations. Focus on the air bubbles.
- Instruct students to use their knowledge of photosynthesis to explain the bubbles. They can use a format like this: *I observe ___________. Based on what I know about photosynthesis, I think this is because ___________.*
- Clarify that the bubbles are oxygen produced in photosynthesis. Reiterate that plants make the oxygen that animals need to breathe, including us! We cannot survive without plants!

Evaluate (20 minutes)

- Have the class circle up. Allow them a minute of silence to reflect on this phrase and how they would complete it: *I used to think ___________, but now I know ___________.*
- Have students share their phrases.
- Celebrate what they have learned and how their thinking has changed throughout the lesson.
- Use the exit ticket: have students go back to their seats and independently draw a diagram or model from memory showing the process of photosynthesis. Use this as a formative assessment.

Resources Used in Lesson Development

NSTA Science 101. How Does Photosynthesis Work? Found at http://science.nsta.org/enewsletter/2007-05/sc0704_60.pdf

Photosynthesis demonstration found at:

http://education.seattlepi.com/photosynthesis-experiments-kids-6302.html

http://www.kids-fun-science.com/plant-experiments.html

Photosynthesis Cards

Carbon Dioxide	CO_2
Water	H_2O
Glucose	$C_6H_{12}O_6$
Oxygen	O_2
Stomata	Photon (light)
Chloroplast	=
+	+
+	+

Photosynthesis: The Amazing Talent of Plants

What does photosynthesis mean? Since we know *photo* means *light* and *synthesis* means *putting together*, we can start to understand that photosynthesis is a process of putting things together using light. Photosynthesis is the process by which plants (and other organisms like algae and bacteria) use the energy of sunlight to make food.

In photosynthesis, plants use carbon dioxide (CO_2) and water to make sugar and oxygen (O_2). Photosynthesis takes place in plant structures called chloroplasts. Chloroplasts have a pigment called chlorophyll that makes plants look green. When chlorophyll absorbs particles of light called photons, the photosynthesis reaction begins.

Here's how it works. Plants take in carbon dioxide from the air by opening tiny holes on the underside of their leaves called stomata. Plants take in water from the soil through their roots. When sunlight stimulates the chlorophyll, a chemical reaction occurs. Carbon dioxide and water are converted into a sugar called glucose and oxygen. The oxygen is released through the stomata into the air we breathe. The plant then uses the glucose as food. Plants use sugar as a source of energy for growth and living just like you and me!

So you see, photosynthesis is pretty cool! Plants use sunlight to make the food they need to grow. In the process they make the oxygen we breathe every minute of every day. Plus, we rely on plants as food for the energy we need to grow and live. Without photosynthesis, we could not survive! So be sure to share your thanks every day for all the hard work plants do for you and all of the creatures on our planet!

Fifth Grade Curriculum:
Wheat Farming and Climate Change in the Inland Pacific Northwest

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Photosynthesis Vocabulary

Vocabulary word	What I think it means	What it really means

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Exit Ticket

Name: ____

What is the equation for photosynthesis?

Based on the text and your equation above, draw a picture of a plant and the process of photosynthesis.

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The Water Cycle

Week 1 – Day 3

Lesson Overview

The purpose of this lesson is to teach students about the water cycle and highlight the role of plants in the water cycle. This lesson explores more deeply the role of water as a component that plants need for growth introduced in the previous lessons.

Lesson Vocabulary

water cycle, transpiration, evaporation, condensation, precipitation, plants, roots, xylem, and stomata

Standards and Learning Targets for Lesson
Learning Targets • I can describe the major components of the water cycle. • I can explain the role of plants in the water cycle.
Next Generation Science Standards • 5-ESS2 -1 – Earth's Systems - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
Idaho Science Standards • 5.S.4.1.1 – Earth and Space Systems - Describe the interactions among the solid earth, oceans, and atmosphere. • 5.S.1.6.4 – Understand Scientific Inquiry and Develop Critical Thinking Skills - Use evidence to analyze descriptions, explanations, predictions, and models.
Common Core ELA Standards • W.5.7 – Writing - Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

Materials

- Jar of water (You can use the same jar from Day 1 of this week.)
- Water Cycle Game supplies:
  - Signs (Print one copy, cut out the signs, and hang one at each of nine stations.)
  - Station cards (Print, cut out, and place at each station. Tip: print two or three copies. It will be easier for students to read and move quickly with multiple copies at each station.)
  - Dice: two or three dice at each of nine stations
  - Blank paper: one sheet for each student to draw their journey through the water cycle

- U.S. Geological Survey (USGS) water cycle diagram: regular and kid versions as PDFs (See websites in Resources section below for other downloadable and online interactive versions.)
- Computer and projector for showing water cycle diagram
- Transpiration demonstration: set up on Day 1 of this week
- Xylem demonstration: set up on Day 2 of this week

Lesson Duration

Approximately 2 hours

Lesson Description

Engage (10 minutes)

- Hold up a jar of water in front of the class. Tell them that you just filled it from the sink this morning (or two days ago) and ask the students, *How old is this water?*
  - Have students write their answers in their science notebooks and explain their answers. Once they have finished writing their responses, let them know that we will revisit their responses at the end of today's lesson.
- Have students work in groups to make a list of all the places in the world where water exists. Ask for a few examples to get them started (i.e., lake, rain, ocean, etc.).
  - Ask a few students to share an example of where water exists, and let them know that today we are going to learn about the water cycle on Earth.
  - Tell them that there are nine main places where water can be found in the water cycle. Have them compare their lists to the nine stations in the game.
  - As you go through this with the students, hang the Water Cycle Game station signs at each station and place the station cards and dice at each station.
- Unpack the learning targets: (1) *I can describe the major components of the water cycle*; and (2) *I can explain the role of plants in the water cycle*. Write the learning targets on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.

Explore (30 minutes)

- Introduce the Water Cycle Game. Let the students know that they will each be a drop of water traveling through the Earth's water cycle. As they travel through the water cycle, they will create a picture of their journey that shows all the places they traveled to and how they got to each place.
- Place this statement about the water cycle on the board (from the USGS website https://water.usgs.gov/edu/watercycle.html) and briefly discuss it before and after playing the game: "Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor (gas), and ice (solid), with these processes happening in the blink of an eye and over millions of years."

- Explain the instructions clearly:
  - You will start at one of the nine stations, and I will tell you which one before we get started.
  - At each station, you will read about where you are and add to your drawing.
  - When you hear the bell ring, each student will roll the dice and read the key on the card at your station to tell you where to go next based on the number you rolled. (Teachers can model this for the students as an example to show them how the key works.)
  - Before you move to the next station, you will draw an arrow to show where you are now and where you are traveling to. You will also carefully read about what is happening to get you from one place to another and write down key words or phrases on your diagram. (Teachers can also model an example of reading and drawing on the board.)
  - I will ring the bell again to tell you when to move to your next station. When you get to your next station, you will read the text about your new location and record major vocabulary words and processes on your diagram.
- The process will continue for several rounds until students have mapped out most or all of the water cycle on their drawings.
- Remind students that there are nine stations, so they should think about this when they start using the space on their paper. They might need to use the back or a second paper along the way.
- Distribute blank pieces of paper to each student to draw their journey as a drop of water.
- Evenly distribute the students at all the stations and start the game.
- You might let students move through the game at their own pace, or you might find it best to ring a bell (or make another noise) when it is time for each group to roll the dice AND when it is time to move to their next station.
- Monitor how much time is needed for students to draw most of the water cycle on their diagrams. It is okay if students do not get to hit every station and get every part of the water cycle, as they can fill in what they are missing during the Explain phase of the lesson.

Explain (30 minutes)

- Have students circle up and have each share one thing that they learned by playing this game.
- Give a mini-lesson on the water cycle using the USGS water cycle diagram. Review the major parts of the water cycle—sublimation, evaporation, condensation, precipitation, and transpiration. Highlight the role of plants in transpiration, and how plants take up water from the soil through their roots.
- Keep the USGS diagram projected and have students compare their own diagrams to the USGS diagram. Instruct students to make any corrections or adjustments on their diagrams. Make sure they have correctly labeled the key pieces that were just covered in the mini-lesson.
- Revisit the USGS quotation from the beginning of the lesson and ask students to reflect on how their thinking has changed through the lesson.
- The Resources section below includes a link to the USGS website with an online interactive version of the USGS water cycle diagram and a link to the online Project WET water cycle

game. One extension or alternative option for this lesson is to have students use those online interactive versions to further their understanding and improve their hand-drawn diagrams.

Elaborate (30 minutes)

- Have students look at the transpiration demonstration that was set up on Day 1 of this week and the xylem demonstration that was set up on Day 2. You may choose to have two different stations and divide the class in half, with one group at each station.
- At each station have students record their observations in their science notebooks. Instruct them to use what they know about plants, photosynthesis, and the water cycle to write explanations for their observations.
- **For the transpiration demonstration:**
    - First have the students make a data chart in their science notebooks. The chart should have cells to record eight observations of the number of water droplets in the bags, four of sun plants and four of shade plants (see example below).
    - Have students make observations of all eight plants and record their observations in their science notebooks.
    - You can make a class data chart on the wall (see example below) and have each student record their eight observations on the class chart. Students can then take averages (with the level of support that teachers decide is appropriate).

Example Data Chart for Transpiration Demonstration (individual student science notebooks)

Location	Plant #1	Plant #2	Plant #3	Plant #4
Sun				
Shade				

Example Class Data Chart for Transpiration Demonstration

Location	Plant #1	Plant #2	Plant #3	Plant #4
Sun	For each cell, all students record #s in cell, with + signs in between. Then, teacher shows how to calculate average by taking sum and dividing by number of observations.			
Shade				

- Conduct a class discussion based on the class data analysis. Ask students what was similar and what was different between the plants in the sun and the shade. Ask students to think about where the water droplets in the plastic bag could have come from. Ask them to consider what they know about leaves and water. Ask them how the amount of light influenced the amount of water, and why they think this is the case. Also, ask the students how their observations compare to the predictions they made when they set up the demonstration.

• **For the xylem demonstration*:***
    - Have the students (or help them) cut the celery into cross sections so they can observe the colored dots the whole way up the celery stalk.
    - Prompt students to think about what they know about photosynthesis and water (i.e., plants need water for the reaction). Then ask them to consider where plants get water (i.e., from the soil via their roots).
    - Ask them to think about what they can observe in the celery about how plants take water from the soil and get it to the leaves for use in photosynthesis.

• With the whole class, review the major conclusions from the two demonstrations. Through this discussion give a mini-lesson to clarify the concepts of transpiration and xylem. Make sure to reinforce key vocabulary words on the board with class definitions of transpiration, stomata, roots, and xylem. Leave time between explanations for students to record the main points of each demonstration in their science notebooks.
    - For transpiration: ask students to share their thinking on how plants transpire water. Clarify that plants lose water through their stomata (when they open for taking in carbon dioxide and giving off oxygen in photosynthesis). Ask students to consider what factors

might influence how much water a plant loses through its stomata (Hint: *What happens to you when you get hot? What escapes the pores of your skin?*).

- For xylem: ask students to share their thinking on how plants take up water from the soil and get it to the chloroplasts in the leaves for use in photosynthesis. Ask students to consider what factors might influence how much water a plant can take up from the soil (Hints: *What would happen if it rained less? What would happen if soil were dry and not moist? What would happen to plants without water?*).

Evaluate (20 minutes)

- Without using their notes, have students work individually to draw a diagram of a plant in the water cycle. Provide the following vocabulary words for students to include in their diagrams: accumulation, evaporation, transpiration, condensation, precipitation, xylem, roots, leaves, and stomata.
- In the last five minutes of class revisit the question about the jar of water: *How old is this water?* Have students go back to their initial answers in their notebooks and decide if their thinking has changed. Ask them, *Based on what you know about the water cycle now, how old do you think this water is?*
- Ask students to share their thinking. Clarify that the Earth is over 4 billion years old and the molecules of water in this jar have been moving through the water cycle for at least 4 billion years!

Resources Used in Lesson Development

U.S. Geological Survey (USGS) water cycle website. http://water.usgs.gov/edu/watercycle.html. This website has a section specifically for educators, including a kid-friendly version of the water cycle diagram and an interactive diagram (http://water.usgs.gov/edu/watercycle-kids-adv.html) that kids can click on to read more. Water cycle diagrams and summaries are also available in many different languages.

Project WET Foundation, 2011. http://www.discoverwater.org/blue-traveler/ The water cycle game in this lesson is designed similarly to this web-based game. Students can also utilize this website as an additional exercise to supplement this lesson.

Water Cycle Game—Station Signs

Plant	**River**	**Glacier**
Animal	**Lake**	**Groundwater**
Soil	**Cloud**	**Ocean**

Water Cycle Game—Station Cards

OCEAN

An ocean is a body of salt water. Oceans cover about three-fourths of the Earth's surface and about 96% of all the water on Earth is in the oceans.

If you rolled a …	You now travel to the …
1 or 2	**Ocean**—You stayed in the ocean!
3, 4, 5, or 6	**Cloud**—You experienced **evaporation** and **condensation**! Due to the sun's heat on the ocean surface, you **evaporated**, or changed from a liquid to a gas called water vapor. Then as invisible water vapor, you floated up into the sky, cooled, and **condensed**, or turned into tiny liquid water drops called a cloud.

CLOUD

Clouds are formed when tiny invisible droplets of water vapor rise into the atmosphere, cool, and condense into a liquid or solid form of water.

If you rolled a …	You now travel to the …
1 or 2	**Ocean**—You experienced **precipitation** and fell as rain into the ocean! As water vapor continued to condense and your cloud became heavier, it could no longer float in the air, so it started to rain. Rain is a form of **precipitation**.
3	**Cloud**—You stayed in a cloud!
4	**Glacier**—You experienced **precipitation** and fell as snow onto a glacier! As water vapor continued to condense and your cloud became heavier, it could no longer float in the air, so it started to snow. Snow is a form of **precipitation**.
5	**Soil**—You experienced **precipitation** and fell as rain onto soil! As water vapor continued to condense and your cloud became heavier, it could no longer float in the air, so it started to rain. Rain is a form of **precipitation**.
6	**Lake**—You experienced **precipitation** and fell as rain into a lake! As water vapor continued to condense and your cloud became heavier, it could no longer float in the air, so it started to rain. Rain is a form of **precipitation**.

SOIL

Water is stored in soil and used by plants for making food to grow.

If you rolled a …	You now travel to the …
1 or 2	**Cloud**—You experienced **evaporation** and **condensation**! Due to the sun's heat on the soil surface, you **evaporated**, or changed from a liquid to a gas called water vapor. Then as invisible water vapor, you floated up into the sky, cooled and **condensed**, or turned into tiny liquid water drops called a cloud.
3	**Soil**—You stayed in the soil!
4	**Groundwater**—With the help of gravity, you soaked into the underground space between rocks and soil.
5	**River**—Because the soil was saturated (fully soaked, or already holding as much water as it could hold), you ran along the soil surface and into a river.
6	**Plant**—You were absorbed through the roots of a plant.

RIVER

Rivers are large streams of water that flow into a lake, ocean, or another river. Rivers carry water from one place to another on the Earth's surface.

If you rolled a …	You now travel to the …
1	**Lake**—You flowed down the river into a lake.
2	**Ocean**—You flowed down the river into an ocean.
3	**Groundwater**—With the help of gravity, you soaked into the underground space between rocks and soil.
4	**Animal**—An animal (human or non-human) consumed you as they drank water from the river.
5	**Cloud**—You experienced **evaporation** and **condensation**! Due to the sun's heat on the river's surface, you **evaporated**, or changed from a liquid to a gas called water vapor. Then as invisible water vapor, you floated up into the sky, cooled, and **condensed**, or turned into tiny liquid water drops called a cloud.
6	**River**—You kept on flowing down the river!

LAKE

A lake is a body of water surrounded by land.

If you rolled a ...	You now travel to the ...
1	**Groundwater**—With the help of gravity, you soaked into the underground space between rocks and soil.
2	**River**—You flowed out of the lake and into a river.
3	**Cloud**—You experienced **evaporation** and **condensation**! Due to the sun's heat on the lake surface, you **evaporated**, or changed from a liquid to a gas called water vapor. Then as invisible water vapor, you floated up into the sky, cooled, and **condensed**, or turned into tiny liquid water drops called a cloud.
4	**Animal**—An animal (human or non-human) consumed you as they drank water from the lake.
5 or 6	**Lake**—You stayed in the lake!

GROUNDWATER

Groundwater is the water found underground in the spaces or cracks between rocks and soil.

If you rolled a ...	You now travel to the ...
1 or 2	**Lake**—You filtered through several layers of rock and soil under the Earth's surface and into a lake.
3	**River**—You filtered through several layers of rock and soil under the Earth's surface and into a flowing river.
4, 5, or 6	**Groundwater**—You stayed underground.

GLACIER

Glaciers are large bodies of dense ice. Glaciers form when snow accumulates in one location and over many years compresses into large, thick ice masses.

If you rolled a …	You now travel to the …
1	**Cloud**—You experienced **sublimation**! With the sun's heat on the glacier surface, you transformed from ice (solid form of water) to water vapor (gas form of water). Then as invisible water vapor, you floated up into the sky, cooled, and **condensed**, or turned into tiny liquid water drops called a cloud.
2	**Groundwater**—As you melted, gravity helped you soak into the under-ground space between rocks and soil.
3, 4, or 5	**Glacier**—You stayed frozen in the glacier.
6	**River**—You melted and flowed into a river.

PLANT

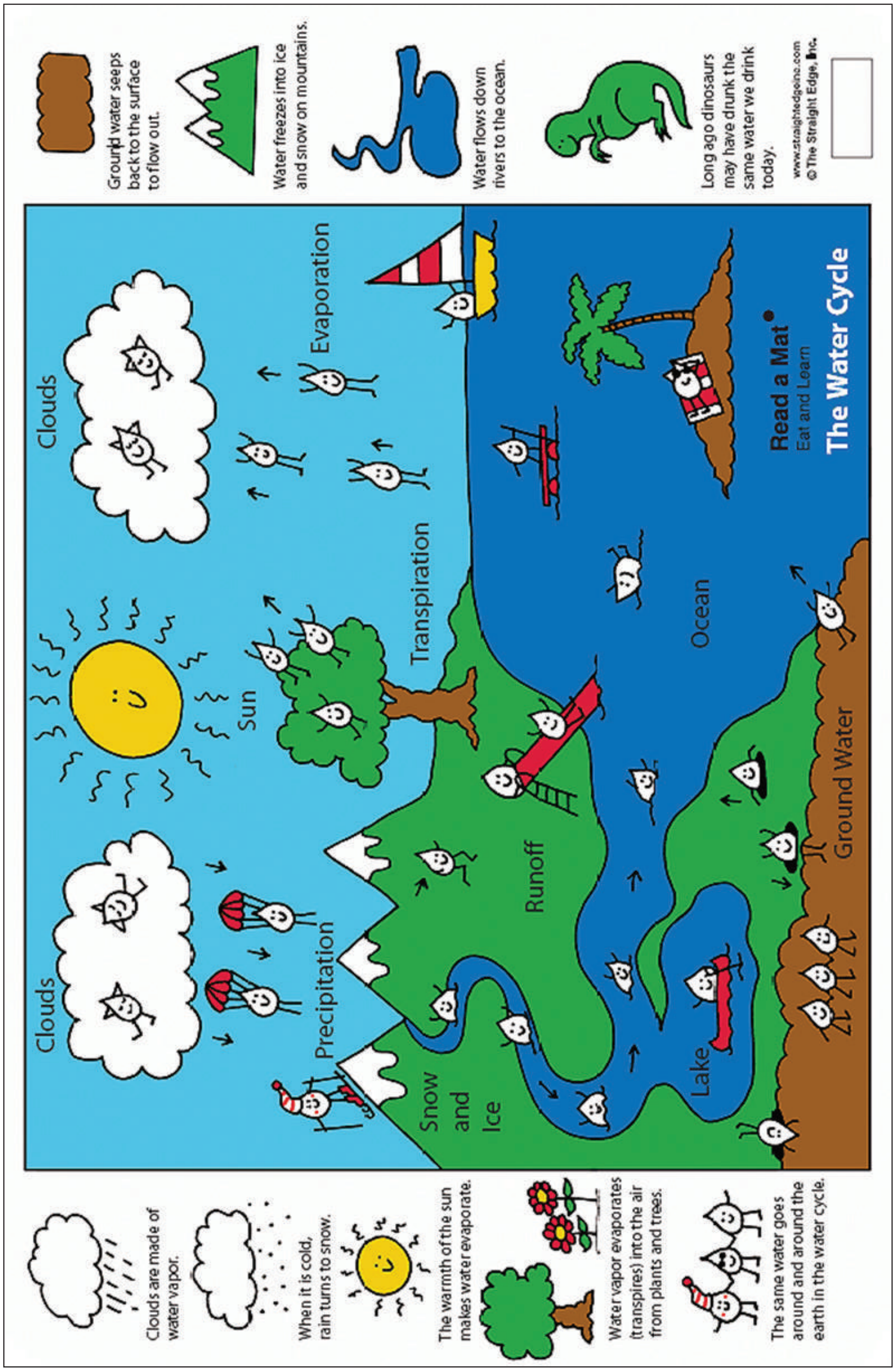
Plants get water and nutrients from the soil through their roots. Water travels up the stem to the leaves where it is used for making food in a process called photosynthesis. Some water vapor escapes through small leaf pores called stomata and is released into the air. This process, called **transpiration,** is an important part of the water cycle.

If you rolled a …	You now travel to the …
1, 2, 3, or 4	**Cloud**—You experienced **transpiration** and **condensation**! In the process of transpiration you exited the plant through an open stoma on the leaf and transformed from a liquid to a gas called water vapor. Then as invisible water vapor you floated up into the sky, cooled, and **condensed**, or turned into tiny liquid water drops called a cloud.
5 or 6	**Plant**—You stayed in the plant!

ANIMAL

All animals, including you, play a role in the water cycle.

If you rolled a ...	You now travel to the ...
1	**Animal**—You were incorporated into the body of an animal. Did you know that more than 60% of your body is water, and you can survive only for about three days without water? So be sure to drink plenty of water and stay hydrated!
2, 3, or 4	**Cloud**—You were released from the animal's body through sweat or breathing (also called respiration).
5 or 6	**Soil**—You were excreted from the animal's body as either feces or urine. You might think yuck! BUT did you know that animal feces actually acts as fertilizer, adding essential nutrients back into the soil?



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The Wheat Plant and Its Life Cycle

Week 1 – Day 4

Lesson Overview

The purpose of this lesson is to introduce students to the specific structures and functions of a wheat plant as well as to the wheat life cycle. This lesson builds on the previous three lessons about what plants need to grow and prepares students to apply the concepts of photosynthesis and the water cycle specifically to the wheat plant in the next day's assessment using a systems model of a growing wheat plant.

Lesson Vocabulary

wheat, structure, function, life cycle, tillering, stem extension, heading, ripening, head, kernel, stem, xylem, phloem, leaf, chloroplast, stomata, roots, and root hairs

Standards and Learning Targets for Lesson
Learning Targets • I can describe the major structures and functions of a wheat plant. • I can explain the life cycle of a wheat plant.
<u>Next Generation Science Standards</u> • 5-LS1-1 – Molecules to Organisms   - Support an argument that plants get the materials they need for growth chiefly from air and water.
<u>Idaho Science Standards</u> • 5.S1.5.1 – Goal 1.5 Understand Concepts of Form and Function   - Explain how the shape or form of an object or system is frequently related to its use or function.
<u>Common Core ELA Standards</u> • RI.5.9 – Reading Informational Text   - Integrate information from several texts on the same topic in order to write or speak about the subject knowledgably.

Materials

- Wheat life cycle cards (Print one set per student group and cut into 12 cards so life cycle names, explanatory text, and pictures are each on a separate card.)
- Wheat plant structure and function station cards (Print one set per station, more if needed.)
- Graphic organizer "Wheat Structures and Functions" (Print one copy per student.)
- Living and/or or dried wheat plants at any stages of the life cycle, as available (Plants that show stem extension and heading stages on the same plant are great. Mature, dried plants for

students to pick apart the head and discover the kernels are also an excellent resource. A bag of wheat kernels makes it fun, too.)

Lesson Duration

Approximately 1.5 to 2 hours (See possible extension activity in Evaluate.)

Lesson Description

Engage (10 minutes)

- Students work in groups to organize the wheat life cycle cards with life cycle stage names, explanatory text, and illustrations matched up and in chronological order.
- Ask for student volunteers to show their work, and clarify the correct order of the life cycle.
- Show wheat plants and kernels, if available. Discuss life stages and major uses of kernels (e.g., grind up for wheat flour, plant as seed, etc.)

Explore (10 minutes)

- Ask the class for definitions of “structure” and “function.” (Structure = parts of a plant; function = what those parts do.)
- Have students work in groups to use what they know so far about plants, specifically the wheat plant. Make a two-column table with columns labeled “structure” and “function” and write as many structures and associated functions as they can.

Explain (10 minutes)

- Have students share some structures and functions they have in their list, and use the discussion to lead into a mini-lesson to clarify the major structures and functions of a wheat plant.
- Unpack the learning targets: (1) *I can describe the major structures and functions of a wheat plant*; and (2) *I can explain the life cycle of a wheat plant*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- This discussion will transition into the Elaborate section of the lesson below.

Elaborate (40 minutes)

- Let students know that they will be moving around to different stations to learn about the major structures and functions of the wheat plant. Introduce the stations and explain the instructions. Students will read about each structure and function, draw a picture of each structure, and write down the major function of each structure.
- Distribute the graphic organizer “Wheat Structures and Functions,” one copy to each student.
- Students will rotate through four stations (head, stem, leaves, and roots). Having two of each station is recommended to keep group sizes low. Plan for 10 minutes at each station.

- Circulate to clarify questions and engage students at each station. Catch and release as necessary to clarify questions and misconceptions.
- Have a short whole-class discussion to clarify any questions.

Evaluate (20 to 50 minutes)

- Write key vocabulary words on the board: tillering, stem extension, heading, ripening, head, kernel, stem, xylem, phloem, leaf, chloroplast, stomata, roots, and root hairs.
- Have students use the provided vocabulary words to draw and label a wheat plant in a life stage of the student's choice.
- Another possible extension activity is to have students form groups and develop skits to act out the life of a wheat plant. Have the groups perform for each other.

Resources Used in Lesson Development

http://www.californiawheat.org/consumers/educational-materials/feekes-scale-of-wheat-development/

http://www.californiawheat.org/uploads/resources/362/feekes-scale.pdf

http://www.clover.okstate.edu/fourh/aitc/lessons/primary/wheat2.pdf

http://www.extension.umn.edu/agriculture/small-grains/growth-and-development/spring-barley/

http://prairiecalifornian.com/wheat-growth-stages/

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Wheat Life Cycle Cards

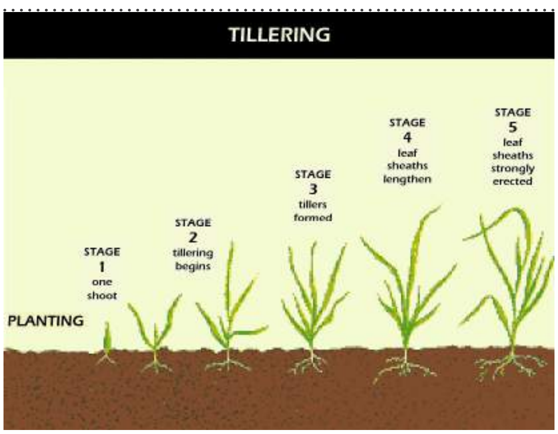
Color images available for download at **reacchpna.org/education/elementary-curriculum**

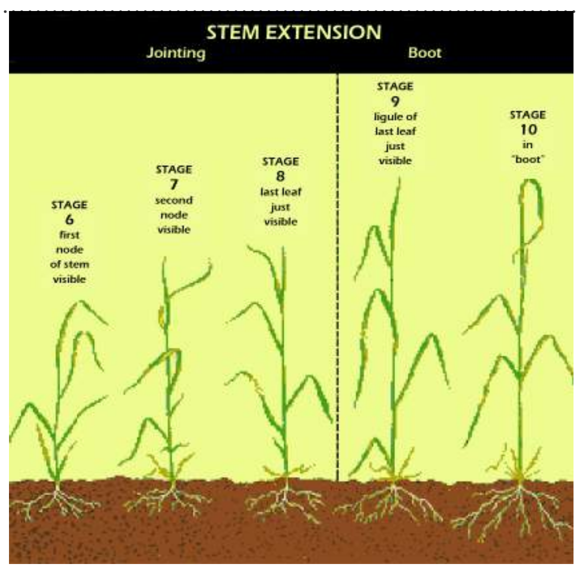
Tillering

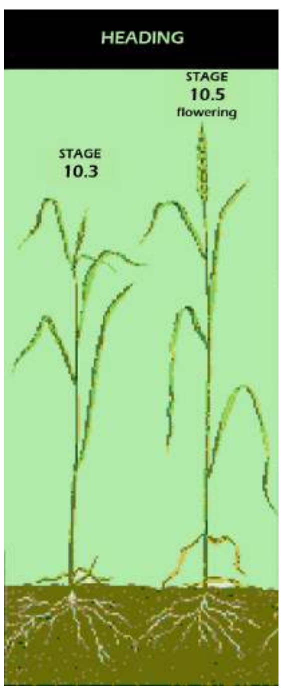
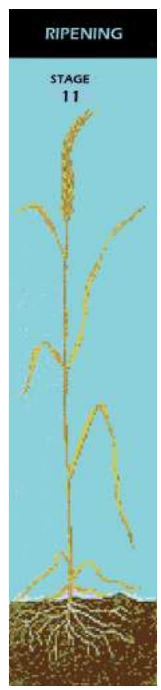
Stem Extension

During this stage of wheat plant growth the planted seed germinates, which means that the seed has started to grow and has broken the seed coat. Roots form and the first shoot, also called a tiller, grows up from the ground.

This stage of growth has two parts, jointing and booting. During jointing the shoots continue to grow forming nodes and eventually leaves. During booting the head of the wheat plant grows from the top of the stem and has the last leaf wrapped around it.





Heading	Ripening
During this stage the head of the wheat plant continues to grow upward until the last leaf unwraps from around it.	During this stage of growth the wheat plant is full-grown but ripens from the color green to a golden color. Once the wheat plant is ripe, it is ready to be harvested.
	

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Wheat Plant Structure and Function Station Cards

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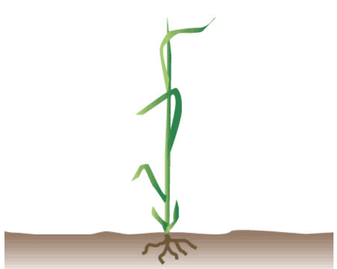
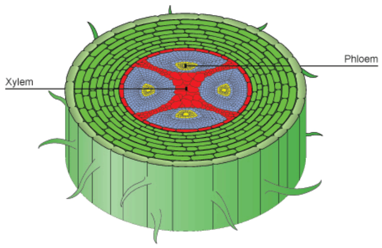
Head 	The head is the part of the wheat plant that contains the wheat kernels.
Wheat Kernel 	The wheat kernel is also the seed of the plant and is found in the head. The kernel is the part of the plant that is ground to make flour.
Stem 	The stem supports the head of the plant and transports nutrients and materials within the plant.

Xylem & Phloem (Vascular System)

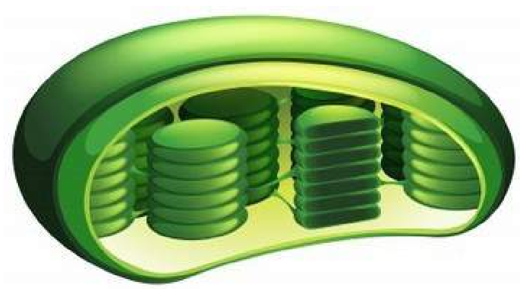


The xylem and phloem are both found in the stem of the plant and make up the vascular system. The xylem moves water up the stem, and the phloem moves sugars down the stem.

Leaf

The leaf is where the plant makes its food.

Chloroplast



Chloroplasts are found in the leaf and contain chlorophyll, which gives the leaf its green color and conducts photosynthesis when stimulated by sunlight.

Stomata

Stomata are small pores or openings on the underside of the leaf that open and close to let plants absorb CO_2 and re-lease water (transpiration) and oxygen.

Roots 	Roots hold the plant in the soil, transport materials from the soil to the stem, and store food and water for the plant.
Root Hairs 	Root hairs are small hairs on the roots of the plant that absorb water and nutrients from the soil for the plant to use.

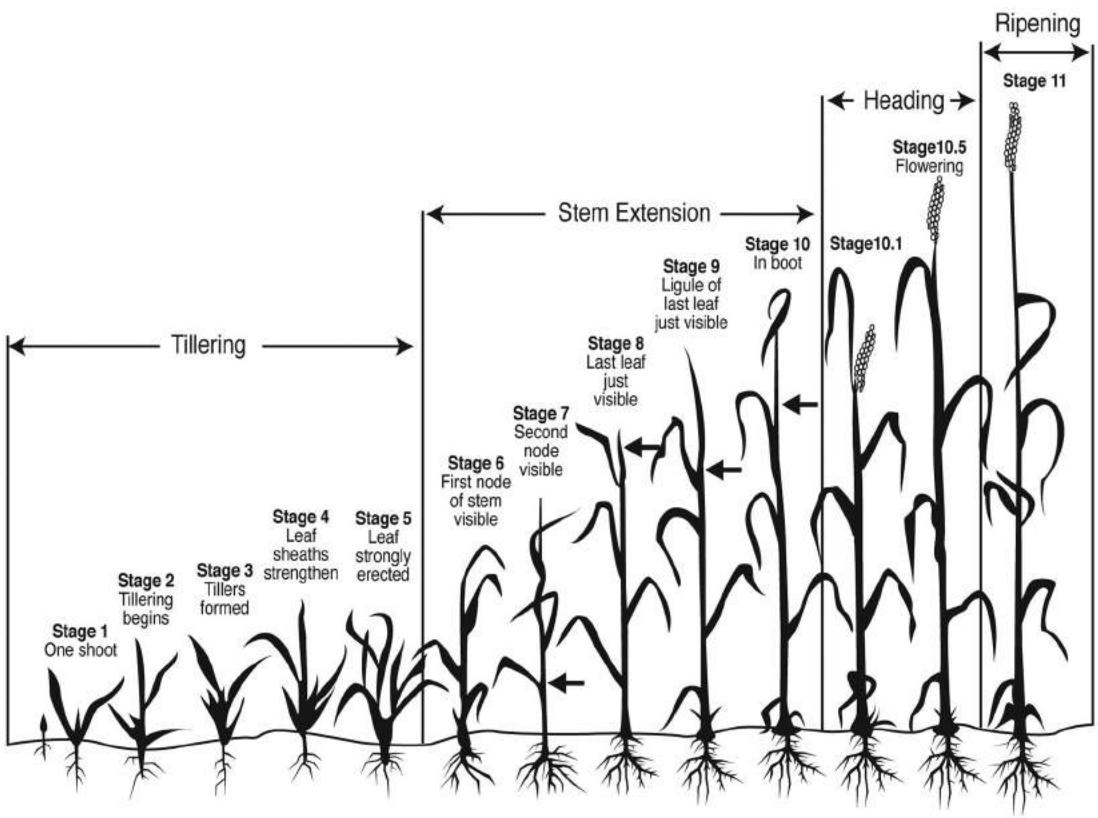
Wheat Structures and Functions

Structure	Function	Drawing of Structure
Head: Wheat Kernel		
Stem: Xylem Phloem		
Leaves: Chloroplast Stomata		
Roots: Root Hairs		

Wheat Growth Stages: Teacher's Key

From: http://prairiecalifornian.com/wheat-growth-stages/

Wheat growth can be broadly divided into several different stages: germination/emergence, tillering, stem elongation, boot, heading/flowering, and grain-fill/ripening. Several different systems have been developed to identify wheat growth stages; the two most popular are called the Feekes scale and the Zadoks scale. Recognizing the stage of your wheat crop is vital to producing a good crop of wheat. Wheat responds best to certain inputs at certain stages of development.



Germination/Seedling Stage

During the germination stage, adequate temperature and moisture are needed for wheat seeds to germinate. Wheat seeds enjoy an optimum temperature between 54° and 77°F. Under favorable conditions, seedling emergence usually occurs within seven days. Until the first leaf becomes functional the seedling will depend on energy and nutrients stored in the seed.

Tillering and Stem Extension

The next stage is tillering. Tillering usually starts when the plant has three or four leaves. After the wheat plant finishes forming tillers it begins elongation of its internodes, or the stem extension stage of growth. Most short-season wheat will typically produce seven or eight leaves on the main stem before stem elongation occurs. The boot stage begins when the head begins to form inside the flag leaf.

Heading and Flowering (Pollination)

The next stage is heading where the head will fully emerge from the stem. After this takes place the plant starts reproductive growth, or flowering. Pollination is normally very quick lasting only about three to five days. Wheat is self-pollinated and it is during this time that kernels per head are determined by the number of flowers that are pollinated. High temperatures and drought stress during heading and flowering can reduce kernel numbers or yield.

Ripening and Maturity

After pollination, the ripening stage begins. Ripening is divided into four levels of maturity: milk, soft dough, hard dough and mature. It is during this time that the wheat plant turns to a straw color and the kernel becomes very hard. The kernel becomes difficult to divide with a thumbnail, cannot be crushed between fingernails, and can no longer be dented by a thumbnail. Harvest can begin when the grain has reached a suitable moisture level. Many farmers can tell maturity by chewing on a kernel to determine hardness and approximate moisture level.

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System Model of a Wheat Plant

Week 1 – Day 5

Lesson Overview

The purpose of this lesson is to assess student learning about the previous four lessons—the major components that plants need to grow, photosynthesis, the role of plants in the Earth's water cycle, and the specific structures and functions of a wheat plant. The Assessment will entail having students individually draw a system model of a growing wheat plant, followed by developing and performing skits in groups.

Lesson Vocabulary

system, model, wheat, and plant growth

Standards and Learning Targets for Lesson
Learning Targets • I can use a criteria list to draw and label a system model of a wheat plant.
Next Generation Science Standards • 5-ESS2-1 – Earth's Systems - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. - Systems and system models – A system can be described in terms of its components and their interactions.
Idaho Science Standards • 5.S.1.5.1 – Goal 1.5 Understand Concepts of Form and Function - Explain how the shape or form of an object or system is frequently related to its use or function. • 5.S.3.2.1 – Goal 3.2 Understand the Relationship between Matter and Energy in Living Systems - Communicate how plants convert energy from the sun through photosynthesis.
Common Core ELA Standards • LS.5.6 – Language - Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal contrast, addition, and other logical relationships.

Materials

- Wheat plant system model examples (provided)
- Large pieces of blank paper: one for each student to draw a model
- Writing and art supplies: pencils, colored pencils, markers, protractors, rulers, etc.

- High-quality system model criteria list
- Anchor chart paper or board

Lesson Duration

Approximately 2 hours

Lesson Description

Review

- Let students know that today they will be drawing a model of the wheat plant that includes all the components needed for plant growth and survival:
  - Water: taken up through roots, transported to leaves through the xylem, required for photosynthesis, and transpired through stomata in leaves
  - Soil: contains water and nutrients which plants take up through roots
  - Air: exchange of gases in photosynthesis (plants use carbon dioxide, and make oxygen)
  - Sunlight: required for photosynthesis, and photons stimulate chlorophyll in the chloroplast
- Allow them to ask questions to clarify any misconceptions they may have prior to the assessment.

Unpack the Learning Target

- Write the learning target on the board or on chart paper: *I can use a criteria list to draw and label a system model of a wheat plant*.
- Discuss the meaning of key words.
- Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.

Assessment

- Provide students with an example of a model (See the wheat plant system model examples provided.)
- Distribute the criteria checklist for system model assessment and instruct students to include all the components on the checklist.
- Distribute a large blank piece of paper to each student. Have students use pencil to draft their systems model and then complete it with colored markers.

Sharing

- When students are finished with their posters, have them share them in student groups or with the whole class.
- Have each student share with the whole group one thing that surprised them about plants or wheat this week.

Reinforcement activity

- Divide students into groups. Give them time to develop a skit about a wheat plant that incorporates the major components needed for plant growth. Encourage them to be creative about the plot of their skit but to include basic structures of a wheat plant and elements of photosynthesis, the water cycle, and the wheat plant life cycle.
- You can provide students with a list of required vocabulary and concepts to include in their skits.

High-Quality System Model Criteria Checklist

High-quality posters will include:

____ A realistic drawing of a wheat plant (both above and below ground)

____ All major structures of the wheat plant with labels

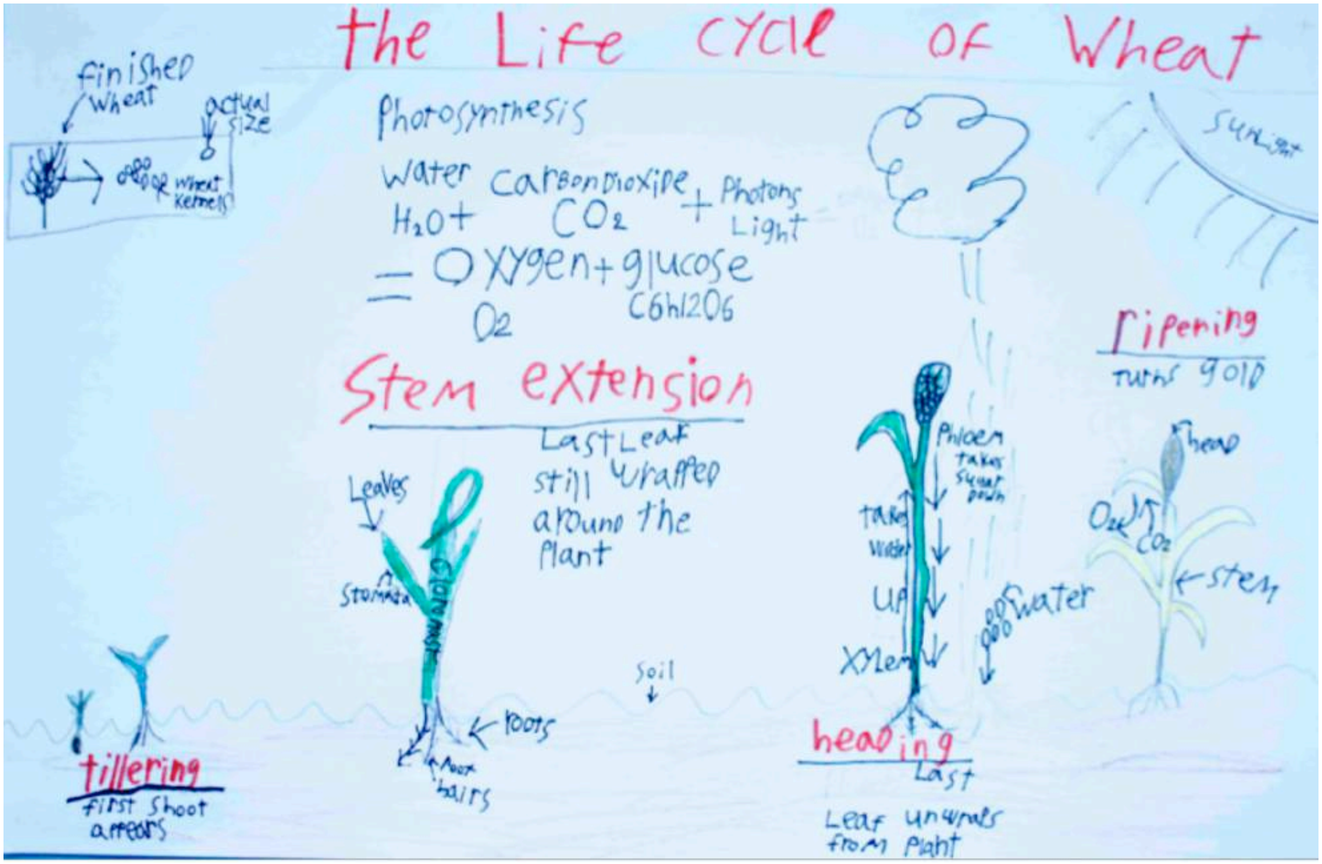
____ What a wheat plant needs to grow (air, soil, sunlight, and water)

____ Photosynthesis (where the process is occurring)

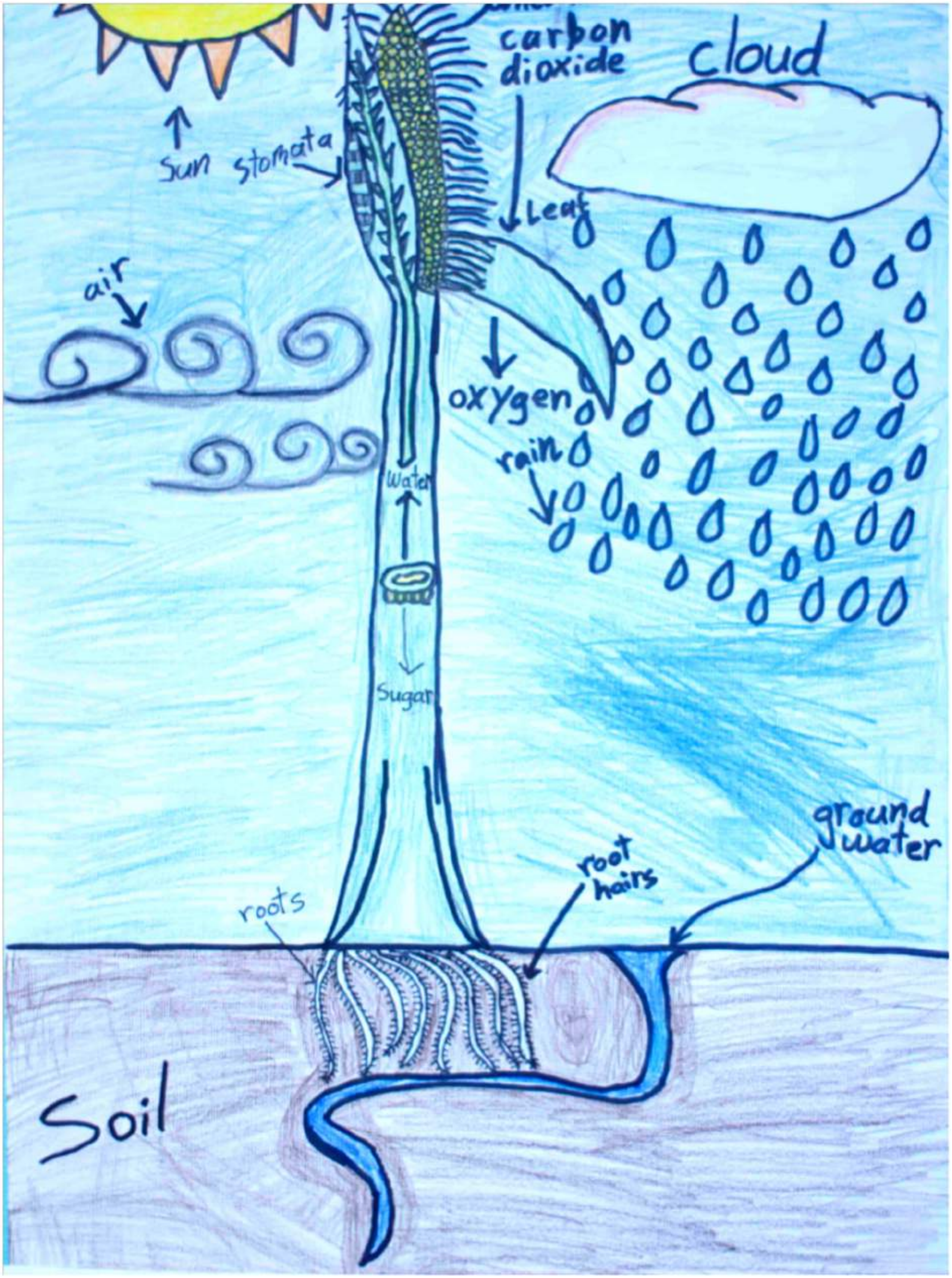
____ The parts of the wheat plant that are in the water cycle (water uptake through roots and transpiration through the stomata)

____ Optional: the life cycle stages of a wheat plant

Wheat Plant System Models - Examples



Color images available for download at **reacchpna.org/education/elementary-curriculum**


carbon
dioxide
cloud
sun
stomata
Leaf
air
oxygen
rain
Water
Sugar
ground
water
root
hairs
roots
Soil

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Wheat Agriculture: From Past to Present

Week 2 – Day 1

Lesson Overview

The purpose of this lesson is to begin shifting students away from thinking about plants in isolation and toward thinking about plants in an agricultural context. Students will develop knowledge by exploring the history of agriculture and highlighting major events and innovations that have shaped wheat farming in the inland Pacific Northwest.

Lesson Vocabulary

Homestead Act, settlers/settlement, harvest, header, export, combine, plow, harrow, threshers, weeder, drill, rotary, grain elevator, and furrow

Standards and Learning Targets for Lesson
Learning Targets • I can create a timeline of the major innovations and events in inland Pacific Northwest wheat farming.
<u>Next Generation Science Standards</u> • 5-ESS3-1.C – Earth and Human Activity - Obtain and combine information about the ways individual communities use science ideas to protect the Earth's resources and environment. - Human Impacts on Earth Systems
<u>Idaho Science Standards</u> • 5.S.5.1.1 – Personal and Social Perspectives - Identify issues for environmental studies.
<u>Common Core ELA Standards</u> • RI.5.5 – Reading Informational Text - Compare and contrast the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in two or more texts.

Materials

- "Timeline Text and Photos" (Make one copy of the timeline for student cards and one copy to use as a key. For the student cards, cut and separate the descriptions from the photos with dates.)
- Graphic organizer "Weighing the Evidence"

Lesson Duration

Approximately 2 hours

Lesson Description

Engage (10 minutes)

- Students gather into groups of four or five.
- Give each student a photograph (or more depending on class size) and conduct the 4Ws protocol (who, what, where, and when).
  - In this protocol, students will analyze the photo and using evidence from the photograph, determine who is in it, what they are doing/using or what is happening, where the photo was taken, and when the photo was taken.
- Following the 4Ws protocol, ask each student to share her/his thinking with their group.

Expand (30 minutes)

- Pass out photo descriptions to each group (be sure to give the correct four or five descriptions to each group, but keep them random within each group).
- Ask students to collaborate as they use textual and photographic evidence to match each description with its corresponding photo. Note: if there are more students than photos, have several students work with partners.
- Have students fill out the "Weighing the Evidence" graphic organizer.

Explain (10 to 30 minutes)

- Now the entire class will collaborate to create a timeline of photographs and descriptions.
- Unpack the learning target: *I can create a timeline of the major innovations and events in inland Pacific Northwest wheat farming*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- Your primary role is to facilitate the process and ensure that student thinking is driving the discussion AND that in the end photographs are in the correct sequence. You should print an extra copy of the timeline as a reference to help facilitate this process.
- Have the students work as a whole class to post the correct sequence of historical photos on the wall or on the floor (or wherever works).
- You can choose whether to keep dates attached to the photos or to separate them, as the former option will allow students to focus on the skill of organizing chronologically based on dates, and the latter option will make this activity more challenging and time-consuming, with the focus on technological developments over time.

Elaborate (30 to 60 minutes)

- After the class has accurately sequenced all the photos, ask each student to read aloud the text to the original photo they were assigned. This way the entire timeline will be read in sequence for the entire class.
- This section of the lesson is also meant to provide an opportunity for students to discuss important historical events shaping agriculture in the inland Pacific Northwest.

Evaluate (5 to 10 minutes)

- As an exit ticket, have students write one paragraph (three to five sentences) about the importance of their originally assigned photo(s) in the history of wheat farming in the inland Pacific Northwest.
- Display the timeline on the wall for future reference.

Photo Sources

Steamboat:
https://oregonhistoryproject.org/articles/historical-records/steamboats-on-the-columbia-river-at-cascade-locks/#.V7jxWj4rK8o

Farming:
http://www.threevillagehistoricalsociety.org

Settlers in Shelter:
http://rushcanvas.pbworks.com/w/page/62732245/Settlement%20of%20the%20West

Ritzville:
https://www.sos.wa.gov/legacy/cities_detail.aspx?i=39

Wheat Production Shifting:
https://commons.wikimedia.org/wiki/File:PSM_V77_D523_Annual_average_usa_wheat_production_1890-1908.jpg

Dust Storm:
https://charmstrongbooks.com/2016/04/14/black-sunday-the-storm-that-gave-the-dust-bowl-its-name/

Rural Electricity:
http://americanhistory.si.edu/blog/rural-electrification

Gas Powered Trucks:
https://www.kshs.org/exhibits/wheat/harvestales/southcent/stumps1.gif

Modern Combine:
http://www.bluebird-electric.net/oceanography/ocean_pictures/Combine_Harvester_Tractor_Grain_Collector_Ocean_Barges.jpg

No Till:
https://dl.sciencesocieties.org/publications/aj/articles/100/Supplement_3/S-166

Wheat Exports:
http://idahowheatcommission.blogspot.com/

Fertilizer:
http://www.newtoncrouch.com/images/history/sprayer-and-newton-sr-small.png

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Weighing the Evidence

Year	Important phrase or sentence from text	Why is this piece of evidence important in the history of wheat farming?

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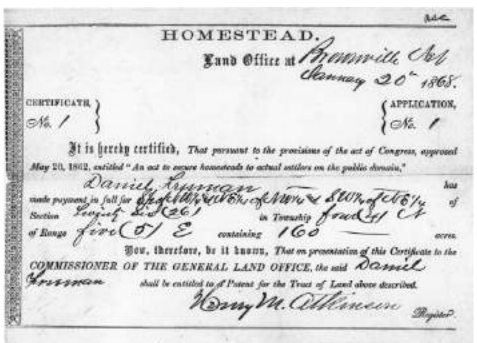
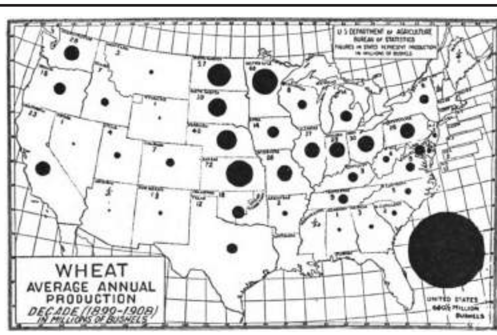
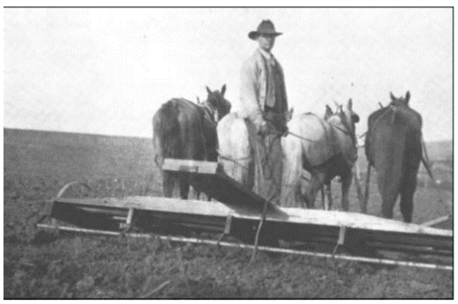
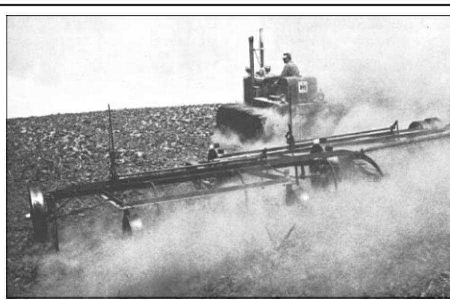
Timeline Text and Photos

One copy for student cards, one copy for teacher key. Available for download at **reacchpna.org**

Date	Photograph	Year/Event
1602		Wheat was grown for the first time in what is now the United States on an island off the coast of Massachusetts.
1862	 HOMESTEAD. Land Office at Brownville Neb January 20th 1868. CERTIFICATE, No. 1 — APPLICATION, No. 1 It is hereby certified, That pursuant to the provisions of the act of Congress, approved May 20, 1862, entitled "An act to secure homesteads to actual settlers on the public domain," Daniel Freeman has made payment in full for ... of Section ... (26) in Township four (4) N of Range five (5) E containing 160 acres. Now, therefore, be it known, That on presentation of this Certificate to the COMMISSIONER OF THE GENERAL LAND OFFICE, the said Daniel Freeman shall be entitled to a Patent for the Tract of Land above described. Henry M. Atkinson Register.	The Homestead Act promised 160 acres of government land to each family or person over 21 who successfully claimed it. To claim land they had to file a claim, pay a $15 fee, and then live on and farm the property for a certain number of years.
1870		Pioneers realized that they could make money in the West by growing wheat for sale. The first wheat farmers arrived by wagon and began to clear bunchgrass and sagebrush from the land so they could plant crops.
1878		A small group of immigrants settled in Ritzville, Washington after all the best land for wheat cultivation had already been claimed. Although they lost their first wheat crop to ground squirrels, their second crop was very successful. Their success convinced other settlers that wheat production was possible in drier climates where land was still available.

1880		Settlers lived in wagons, tents, or shelters made in the sides of hills. The first shelter they built was usually a barn for their horses. They began farming, planting wheat each spring.
1882		Using boats to transport wheat along the Columbia River helped create a boom in farming and wheat exports.
1884		The railroad was completed and took the place of wagon trains. Trains were able to carry not only people, but household goods, farm machinery, and livestock.
1890		The inland Pacific Northwest replaced California as the most important wheat-producing area in the far West.

1898		Combines were introduced making it much quicker and easier to harvest wheat. Early combines were pulled by horses.
Early 1900s		New and up-to-date farming equipment such as plows, harrows, stationary threshers, steam engines, rod weeders, drills, wagons, and combines were being brought to the inland Pacific Northwest.
1906		Major dust storms occurred lasting up to three days at a time. Each storm caused up to six inches of soil loss.
1907		The rotary rod weeder was invented in Cheney, Washington and became an essential tool for controlling weeds.
1920s		Farmers began to transport wheat in trucks, which was much more efficient than relying on livestock. A truck could make six trips, carrying 25 sacks of wheat on each trip, in the same amount of time that a wagon pulled by a team of mules could make one trip with 70 sacks of wheat.

Mid-1930s	 	Farmers no longer had to put wheat in sacks because they could haul it to storage elevators in trucks. Handling grain in this way made farming easier.
Late 1940s		Electricity was made available in rural areas, which made farm life easier.
1950s		Self-propelled combines replaced older machinery that had to be pulled by livestock. The new machines meant that only two or three people were needed to harvest a wheat crop.
1950s		Nitrogen fertilizer became available and affordable to farmers in the West. Using fertilizer helped increase wheat yield (the amount of wheat grown) by putting more nutrients in the soil.

1960s	 	Farms increased in average size from 1,250 to 1,600 acres. Most farms were still managed by a single family with a few additional people hired during harvest. The deep-furrow split-packer drill was also invented. The drill let farmers plant winter wheat seeds in the late summer seven inches deep so the seeds could reach the water they needed to sprout.
1980s		The "no-till" farming technique was developed. This technique leaves the stubble of wheat plants behind in the ground when the grain is harvested. The stubble reduces erosion and improves soil health and fertility.
Today		Farms have become larger, ranging in size from 1,500 to more than 15,000 acres. The farm equipment used is among the largest in the world.
Today		Wheat is carried by barge down the Snake and Columbia rivers to Portland, Oregon where it is loaded on ships for export to countries around the world.

The Inputs and Outputs of a Wheat Farm

Week 2 – Day 2

Lesson Overview

The purpose of this lesson is to teach students about the basic inputs and outputs of a wheat farm in the inland Pacific Northwest. This lesson explores more deeply the concepts that students explored in the agricultural timeline exercise.

Lesson Vocabulary

input, output, nitrogen fertilizer, soil moisture, cost, yield, drill, tractor, harvest, combine, grain elevator, kernel, and bushel

Standards and Learning Targets for Lesson

Learning Targets

- I can describe the major inputs and outputs of a wheat farm in the inland Pacific Northwest.

Next Generation Science Standards

- 5-LS2-1 – Ecosystems: Interactions, Energy, and Dynamics
  - Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. A system can be described in terms of its components and their interactions.

Idaho Science Standards

- 5.S.1.3.1 – Understand Constancy, Change, and Measurement
  - Analyze changes that occur in and among systems.

Common Core ELA Standards

- RI.5.1 – Reading Informational Text
  - Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

Materials

- Map for projecting in the Engage portion of the lesson
- Computer and projector for displaying map
- Text “The Ins and Outs of a Wheat Farm” (Print one copy for each student.)
- Graphic organizer “Inputs and Outputs of a Wheat Farm” (Print one copy for each student.)

Lesson Duration

Approximately 2 hours

Lesson Description

This workshop lesson is a text-based model designed to assess students on both science content and on literacy skills related to quoting and citing textual evidence. Students will be able to clearly articulate the major inputs and outputs of a wheat farm and cite source material.

Engage (5 minutes)

- Project the map:
  https://www.nass.usda.gov/Charts_and_Maps/graphics/WW-PR-RGBChor.pdf
- Ask students to look at the map and try to figure out what it is saying.
- Ask students to share their inferences. Clarify that the map shows where wheat is planted throughout the inland Pacific Northwest.

Initial Reading (25 minutes)

- Have students independently grapple with the text "The Ins and Outs of a Wheat Farm" and conduct a close-reading protocol:
  - All students will underline important details, circle unknown or interesting vocabulary, write the gist of each paragraph in the margin, and write down one question about the text.
  - Option: for the first read, students can read aloud with a partner or small group, switching off readers every paragraph.

Discussion (20 minutes)

- Have students get into small groups and discuss the following focusing question (5 minutes): *What are the major aspects of a wheat farm*?
- After the small group discussion, have all the students circle up for a whole-class discussion of the focusing question (10 to 15 minutes).
- Have students bring their text on a clipboard and a pencil to the circle.

Focus (20 minutes)

- Introduce and unpack the vocabulary of the learning target.
- Unpack the learning target: *I can describe the major inputs and outputs of a wheat farm in the inland Pacific Northwest*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- In this mini-lesson, explain the major inputs and outputs of a wheat farm and clarify new vocabulary that students identified in the Initial Reading portion of the lesson.
- Pass out the graphic organizer "Inputs and Outputs of a Wheat Farm" and explain the directions for the Application portion of the lesson; rereading the text and using the graphic organizer to cite evidence from the text.

Application (30 minutes)

- Ask students to go back to the text and work through the graphic organizer.
- Monitor student progress and engagement. Note: the major inputs are seeds, soil moisture, nitrogen fertilizer, drill, tractor, combine, and grain elevator. The major outputs are wheat (kernels, and bushels), wheat products (bread, pasta, etc.), income for farmers/families, and jobs.

Synthesis (10 minutes)

- Whole-class discussion and debrief: have students circle up and have each one share their thinking on the reflection question at the bottom of the graphic organizer.

Exit Ticket/Assessment (10 minutes)

- Ask students to write a response to the following prompt: *What are the major inputs and outputs of a wheat farm in the inland Pacific Northwest?*
- Ask them to cite at least three pieces of evidence from the text and use their graphic organizers to guide their writing.

Extension Activity Ideas

- This would be a great spot for a guest to visit the class to share pictures and stories about wheat farming.
- Field work visits to a local wheat farm would be another excellent addition to this lesson.

Resources Used in Lesson Development

https://www.nass.usda.gov/Charts_and_Maps/graphics/WW-PR-RGBChor.pdf

https://www.nass.usda.gov/Charts_and_Maps/graphics/SW-PR-RGBChor.pdf

http://www.wheatworld.org/wheat-info/producing-wheat/

http://wagrains.org/all-about-wheat/varieties-of-wheat/types-of-wheat/

http://idahowheat.org/

http://www.wheatfoods.org/sites/default/files/atachments/agriculture.pdf

The Ins and Outs of a Wheat Farm

Wheat is an important ingredient in many foods. Wheat is grown around the world and the United States is one of the top wheat-producing countries. Wheat is grown in 42 of the 50 states on approximately 64 million acres of land. Many inputs go into growing this important food source. Inputs are all the things that farmers need to grow wheat, and outputs are all the things that farms produce.

Wheat farmers are busy year-round. There is always something to be done around the farm even when it isn't the growing season. Before the wheat seed is planted there is work to be done to prepare the fields. Farmers have to make sure the fields have the proper soil moisture content because if the soil is too wet the seeds will rot and if the soil is too dry the seeds will not germinate. This requires farmers to get their timing for planting seeds just right. Farmers also make sure that the soil contains enough of the nutrients plants require to grow such as nitrogen. In some instances, farmers may have to apply nitrogen fertilizer before they plant the seeds.

Farmers have a few different methods to use when it comes time to plant the seeds. The most commonly used method is drilling. Farmers use a drill machine attached to a tractor to place the seeds in the ground and cover them with soil.

Two main kinds of wheat are grown in the inland Pacific Northwest—winter wheat and spring wheat. If the farm is growing winter wheat, the seed is planted and germinates in the fall, the wheat is dormant through the winter, and then it continues to grow in the spring and is harvested in the summer. If the farm is growing spring wheat, the wheat seed is planted in the spring and it continues to grow for weeks until it is harvested in the summer.

After the seed is planted there is still work to be done on the farm. Farmers check the fields for weeds, pests, or any diseases that could possibly affect their wheat yield. Farmers also apply nitrogen fertilizer while the wheat is growing and make sure that all their equipment is in perfect condition for the next time they need to use it. Checking equipment is very important because if something breaks while in the field it can stop the entire wheat-producing process until it is fixed.

After the wheat has gone through its entire life cycle, it is ready to be harvested. The total amount of wheat that a farm produces is called the yield and is measured in bushels per acre of land. Wheat farmers harvest their crop with a combine. A combine is a very large machine that cuts the wheat from the field, separates the kernels from the head of the wheat plant, and stores them in a storage container on the machine. Once the storage container on the machine is full, it is unloaded into a truck that drives the wheat kernels to a grain elevator where they are stored. This process is repeated until all the wheat in the field is harvested. Combines are amazing pieces of farm equipment because they can harvest up to 1,000 bushels of wheat per hour. If 1 bushel of wheat weighs about 60 pounds how many pounds of wheat can be harvested each hour?

When the wheat arrives at a grain elevator it goes through a process of drying, cleaning, and blending before it is stored. Once stored, the wheat awaits transport to a port or a processor. At a port, the wheat will be loaded onto a cargo ship and exported around the world. At a processor, the wheat will be milled into flour and then turned into the many different products that we get from wheat such as bread and pasta.

You can see that farmers put a lot of hard work into producing wheat! They help produce food for the world to eat, make money to support themselves and their families, and help the economy by providing jobs to people who help them in every step of the process.

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Inputs and Outputs of a Wheat Farm

Name: ____ **Date:** _____________________

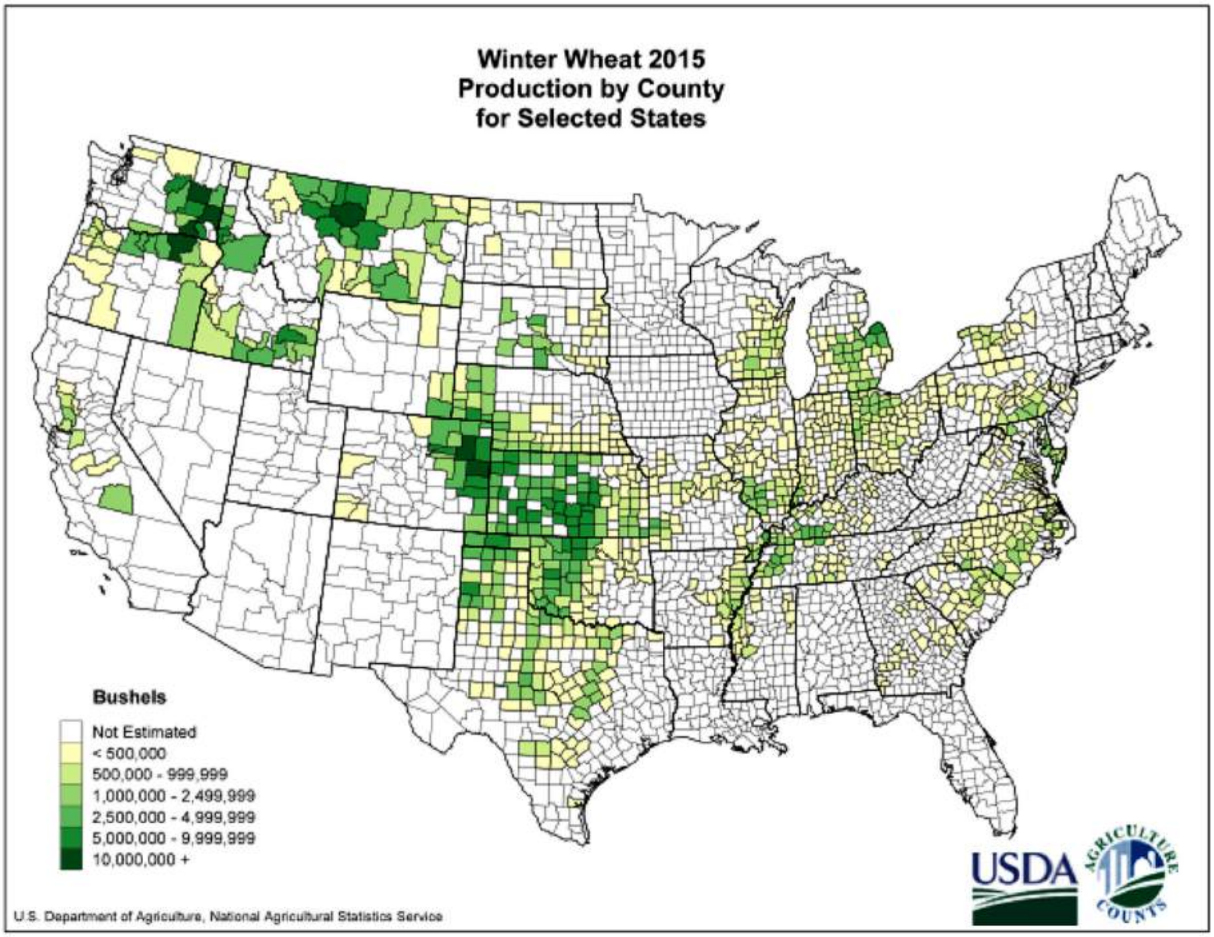
Learning Target: *I can describe the major inputs and outputs of a wheat farm in the inland Pacific Northwest.*

Directions: Reread the text "The Ins and Outs of a Wheat Farm" and select words or phrases that describe the major inputs and outputs of a wheat farm. Add each piece of evidence to this graphic organizer and cite it by paragraph number (¶ #). Afterward, think about and answer the reflection question.

Major Inputs	Citation (¶ #)	Major Outputs	Citation (¶ #)

Reflection question: Based on the inputs and outputs of a wheat farm, what do you think would be the greatest challenges of farming wheat when weather patterns are unpredictable?

Map for Engage portion of lesson



Color images available for download at **reacchpna.org/education/elementary-curriculum**

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Global Climate Change

Week 2 – Day 3

Lesson Overview

The purpose of this lesson is to begin to lay out the complexities of wheat farming in the context of global climate change. Students will explore and learn about global climate change by looking at data published by NASA (National Aeronautics and Space Administration) and NOAA (National Oceanic and Atmospheric Administration). Students will analyze data, read an article, participate in a greenhouse effect game, and make inferences and predictions based on data analysis.

Lesson Vocabulary

climate, weather, climate temperature, anomaly, CO_2, Mauna Loa, greenhouse effect, and climate change

Standards and Learning Targets for Lessons
Learning Targets • I can explain how the greenhouse effect contributes to global climate change.
Next Generation Science Standards • 5-ESS2 – Earth's Systems - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
Idaho Science Standards • 5.S.1.2.1 – Goal 1.2 Understand Concepts and Processes of Evidence, Models, and Explanations - Use observations and data as evidence on which to base scientific explanations and predictions.
Common Core ELA Standards • RI.5.3 – Reading Informational Text - Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

Materials

- Computer
- Projector
- "Mauna Loa Data" (Print one copy for each student.)
- Text "Global Climate Change" (Print one copy for each student.)

- NASA global temperature anomaly animation (https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4419)
- Exit ticket (Print one copy for each student.)

Lesson Duration

Approximately 2 hours

Lesson Description

Engage (5 minutes)

- Project the NASA global temperature anomalies animation (https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4419).
- Have students watch the video and make predictions as to what they think is causing the changes in temperature anomalies.

Explore (15 minutes)

- Ask students to analyze the Mauna Loa global CO_2 data and write down their thinking around the following questions:
  - *Why do you think CO_2 increases and decreases within each year?*
  - *Why do you think global CO_2 is increasing each consecutive year?*
  - *What do you think is the link between the CO_2 data and the NASA temperature anomaly data?*
- Next, ask students to get into small groups and share their responses to the three questions. (3–5 minutes)

Explain (30 minutes)

- Unpack the learning target: *I can explain how the greenhouse effect contributes to global climate change*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson. (15-minute mini-lesson)
- Ask student groups to collaboratively read the short text on global climate change and revise their thinking around the questions from Explore. (15 minutes)

Elaborate (30 minutes)

- Have students play the Greenhouse Effect Game:
  - Select one student to be “heat” and three students to be CO_2. The idea of the game is to have the “heat” run past the CO_2, touch an object or wall designated as the surface of the Earth and try to run back past the $C0_2$ (make sure the CO_2 lets the heat run to the object or wall first before trying to stop them).
  - Play the game in rounds and after each round add three more CO_2 players. (As time progresses, there will be more and more CO_2 and the “heat” will have a harder and harder time getting out.)

  - After each round all students will collect data on how easily the "heat" left the "atmosphere."
  - The game will be over once all students have been added to the "atmosphere."
- Greenhouse Effect Game debrief: have students plot their data on how much CO_2 was in the atmosphere and compare that to how easy or difficult it was for "heat" to be trapped in the atmosphere.

Evaluate (20 minutes)

- Have students independently complete the exit ticket (intended for use as a formative assessment).

Extension Ideas

- Do the 30-minute activity to visualize the concept of the greenhouse gas effect http://www.education.com/activity/article/Observe_Greenhouse_Effect/
- Students can watch the CO_2 animation "History of Atmospheric Carbon Dioxide from 800,000 Years Ago until January, 2016" http://www.esrl.noaa.gov/gmd/ccgg/trends/history.html

Resources Used in Lesson Development

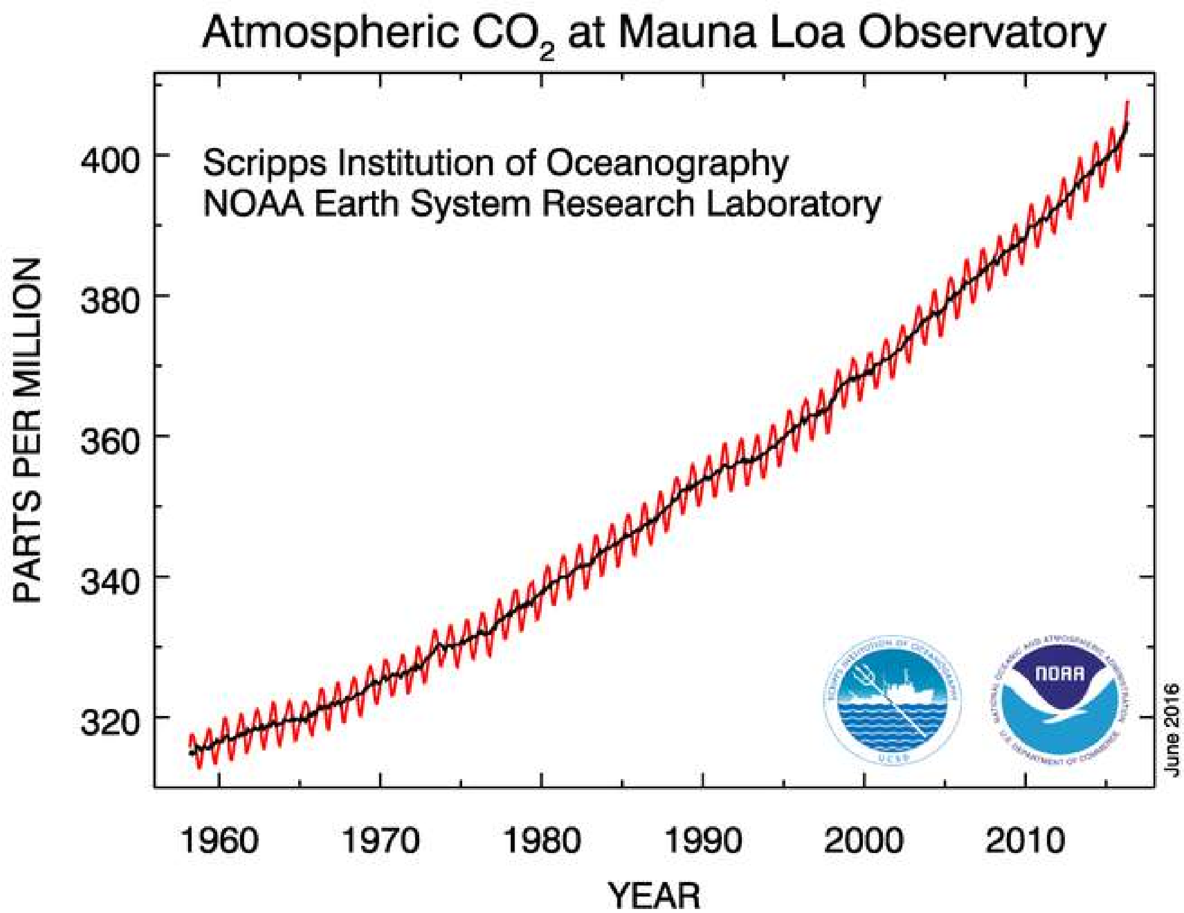
https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4419

http://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

http://climatekids.nasa.gov/menu/weather-and-climate/

https://www3.epa.gov/climatechange/kids/index.html

Mauna Loa Data



1. Why do you think the CO_2 increases and decreases within each year?

2. Why do you think global CO_2 is increasing each consecutive year?

3. What do you think is the link between the CO_2 data and the NASA temperature anomaly data?

Global Climate Change

If you were packing your bags to leave tomorrow for a weeklong trip to New York City, how would you decide what clothes to bring? One piece of information that will help you is the weather forecast. Weather scientists, called meteorologists, use technology to predict what the weather is likely to look like in one hour, tomorrow, and over the next few days. **Weather** is a specific event or condition that happens over a period of hours or days. For example, a thunderstorm, a snowstorm, and today's temperature all describe the weather. So you could read a weather report to see if it is likely to be rainy, snowy, windy, sunny, hot, or cold next week in New York City. The weather report can help you decide what clothes to pack for your trip next week.

But what if you were packing your bags today for a trip you will take to New York City to celebrate YOUR fortieth birthday? That's a trip you will take thirty years from now. How could you decide what clothes to pack? Information about the climate will help you much more than next week's weather report. **Climate** refers to the average weather conditions in a place over many years (usually at least 30 years). For example, the climate in New York City is cold and snowy in the winter and hot and humid in the summer. So you could use your knowledge of the general climate patterns in New York City to plan for your trip in thirty years, but it's very hard to predict the actual weather you will encounter when you get there.

Weather conditions can change from one year to the next. New York City might have a warmer winter one year and a much colder winter the next year. This kind of change is normal. But when the average pattern of weather over many years changes the result is **climate change**. Our world is always changing. Look out your window long enough and you might see the weather change. Look even longer and you'll see the seasons change. The Earth's climate is changing too, but in ways that you can't always see by looking out your window.

Global climate is the average climate over the entire planet. Global climate is a measure of the planet's health. Think about it this way: when a doctor or nurse takes your pulse and your temperature, she or he is "checking your vital signs." These measurements are called "vital" because they are very important signs of your health. The same is true of our planet. Two "vital" signs for the health of our planet Earth are global average temperature and the composition of the Earth's atmosphere. Let's talk about why these measurements are so important in understanding how our planet is doing.

The first vital sign, **global average temperature,** combines the temperatures of all the hot, warm, and cold places on Earth. It is a very important measure of changes happening on Earth. A rise of just one degree Fahrenheit (°F) on a sunny day where you live might have little effect. But over the whole Earth a rise of 1°F makes a big difference. Just think, normally, water at 32°F is solid ice. But water at 33°F is liquid water. Even a small rise in Earth's global temperature means melting ice at the North and South poles. It means rising seas. It means flooding in some places and drought in others. It means that some plants and animals thrive while others starve. It can mean big changes for humans too. And that's why this number is a very big deal.

The second vital sign, the **composition of the Earth's atmosphere,** is causing the global temperature to rise. The Earth's atmosphere is the thin layer of gases that surrounds the Earth and is the air we breathe. The Earth's atmosphere is made up of 78% nitrogen, 21% oxygen, 0.9% argon, 0.03% carbon dioxide, and small amounts of other gases. All of these gases exist naturally in the atmosphere and they help keep the Earth warm enough for plants and animals to live. This is called the **greenhouse effect** because the Earth is like a greenhouse.

A greenhouse is a house made of glass or plastic where people can grow plants all year long. Sunlight shines in and warms the plants and air inside. The heat is trapped and can't escape. So a greenhouse stays warm inside even during winter. **Earth's atmosphere does the same thing as a greenhouse.** Gases in the atmosphere such as carbon dioxide do what the roof of a greenhouse does. During the day, the sun shines through the atmosphere and the Earth's surface warms up. At night the Earth's surface cools as the heat is released back into the atmosphere. But some of the heat is trapped by the greenhouse gases in the atmosphere, keeping our Earth warm.

The greenhouse effect of Earth's atmosphere keeps some of the Sun's energy from escaping back into space at night. However, if the greenhouse effect is too strong Earth gets warmer and warmer. This is what is happening now. Too much carbon dioxide and other greenhouse gases in the air are making the greenhouse effect stronger. The Earth is getting warmer because we are adding heat-trapping gases, called **greenhouse gases,** to the atmosphere (see three figures below). These extra gases are causing the Earth to get warmer, setting off all sorts of other changes around the world—on land, in the oceans, and in the atmosphere. These changes affect people, plants, and animals in many ways.

More than 100 years ago people around the world started burning large amounts of coal, oil, and natural gas to power their homes, factories, and vehicles. Today most of the world relies on these **fossil fuels** for their energy needs. Burning fossil fuels releases carbon dioxide, a heat-trapping gas, into the atmosphere which is the main reason why the climate is changing. People produce more carbon dioxide than any other greenhouse gas and it is responsible for most of the Earth's warming that is happening now. Carbon dioxide and other greenhouse gases are changing the Earth's climate.

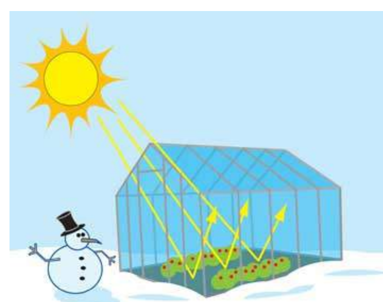
How do we know the amount of greenhouse gases in the atmosphere is increasing?

Scientists measure the amount of greenhouse gases in the atmosphere in several ways. They use satellites and other instruments to measure the amount of greenhouse gases in the air all around the world. They also collect samples of air and then analyze these samples in a laboratory.

The Earth also gives us clues about the levels of greenhouse gases that existed in the past. For example, ancient air bubbles trapped deep in the ice of Greenland and Antarctica reveal how much carbon dioxide was present long ago.

Scientists have carefully examined all this evidence and made a startling discovery. There is more carbon dioxide in the atmosphere now than at any other time in at least 650,000 years! The amount of carbon dioxide and other greenhouse gases is continuing to increase.

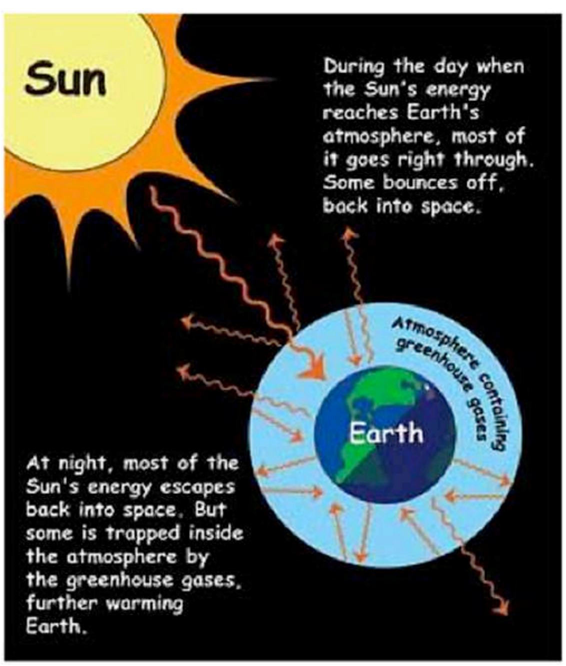
Scientists, and folks like you and me, are concerned because the Earth's global climate is changing. The planet is warming up fast—faster than at any time scientists know about from their studies of Earth's entire history. The Earth's climate has changed before, but this time is different. Scientists have discovered that human-made greenhouse gases are the leading cause of the observed warming on planet Earth. People are causing these changes, which are bigger and happening faster than any climate changes that modern society has ever seen before.

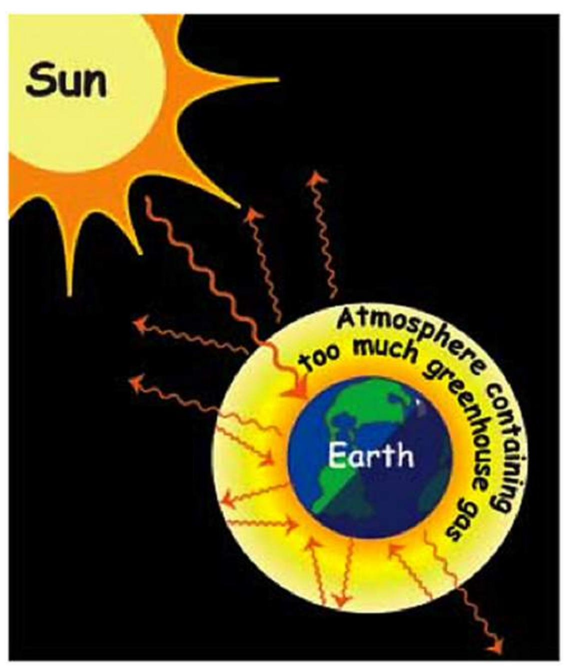


Text adapted from the following sources:

http://climatekids.nasa.gov/menu/weather-and-climate/

https://www3.epa.gov/climatechange/kids/index.html





Exit Ticket

Name: ____

What is the greenhouse effect?

Draw a diagram of the greenhouse effect.

Describe HOW the greenhouse effect is influencing global climate change.

Fifth Grade Curriculum:
Wheat Farming and Climate Change in the Inland Pacific Northwest

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Climate Change in the Inland Pacific Northwest

Week 2 – Day 4

Lesson Overview

The purpose of this lesson is for students to apply and extend their previous knowledge of global climate change to a regional context. Students will gain an understanding of what the impacts of climate change look like in the inland Pacific Northwest and how those impacts will influence wheat farming.

Lesson Vocabulary

temperature, precipitation, climate, seasons, region, and climate change

Standards and Learning Targets for Lessons
Learning Targets • I can describe how the climate is changing in the inland Pacific Northwest. • I can explain several ways that climate change is impacting wheat farms in the inland Pacific Northwest.
<u>Next Generation Science Standards</u> • 5-ESS2-1 – Earth's Systems - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
<u>Idaho Science Standards</u> • 5.S.1.2.1 – Goal 1.2 Understand Concepts and Processes of Evidence, Models, and Explanations - Use observations and data as evidence on which to base scientific explanations and predictions.
<u>Common Core ELA Standards</u> • RI.5.2 – Reading Informational Text - Determine two or more main ideas of a text and explain how they are supported by details; summarize the text.

Materials

- Text "Regional Climate Change and Agriculture in the Inland Pacific Northwest" (Print one copy for each student.)
- "Regional Temperature Data" (Print one copy for each student.)
- "Evidence-Based Reading and Writing: Text Reduction Protocol Recording Form" (Print one copy for each student.)
- Exit ticket (Print one copy per student.)

Lesson Duration

Approximately 2 hours

Lesson Description

Engage (5 minutes)

- Begin this lesson by accessing prior student knowledge.
- Have students get into partner groups and discuss the following questions: *What is the greenhouse effect?*; and *What is climate change?* (2 minutes)
- Select several students to share their group's thinking. (2 minutes)

Explore (30 minutes)

- Give each student a copy of the regional temperature data (graph) and have them independently grapple with the graph to identify patterns. (5 minutes)
- During this time, write the discussion questions below on the board.
- After the students have independently spent time analyzing the data, have them work in small groups to analyze the data and answer the following discussion questions:
  - *What are three patterns that you notice in the data?*
  - *What differences do you see between the high-temperature spikes in our time right now and those in the 2090s?*
  - *How do you think this warming pattern will impact wheat farmers?*

  *Note for teacher: this graph was plotted using a model to predict inland Paci*fic Northwest regional temperature from 2005 to 2099. The major trends to highlight are that the lowest temperatures each year are expected to increase (i.e., winters will get warmer) and the highest temperatures each year are expected to increase (i.e., hotter summers).

Explain (15 minutes)

- Unpack the learning targets: (1) *I can describe how the climate is changing in the inland Pacific Northwest*; and (2) *I can explain several ways that climate change is impacting wheat farms in the inland Pacific Northwest*. Write the learning targets on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
  - Clarify the term "climate" and the concept "climate change" for the first learning target.
  - Clarify that the expectation of the second learning target is for students to articulate multiple ways that climate change is impacting wheat farming and that the evidence students use will be based on data and cited directly from the text.

Elaborate (45 minutes)

- Pass out "Evidence-Based Reading and Writing: Text Reduction Protocol Recording Form." Read instructions together and clarify any questions.
- Have students conduct the text reduction protocol in small groups.

Evaluate (20 minutes)

- Begin by having a debrief on the text reduction protocol. Have the whole class circle up. Each student will share her/his significant word that addresses the question, *How are changing temperature and precipitation impacting wheat crops in the inland Pacific Northwest?*
- After the students have shared their thinking, ask each student to complete the exit ticket.

Regional Climate Change and Agriculture in the Inland Pacific Northwest

Scientists at the University of Idaho in Moscow, Idaho study temperature, precipitation (rain and snow), and climate patterns in the inland Pacific Northwest. They have collected data showing that the climate is changing in the region. The average temperature of the region has increased by nearly 1.3°F over the past century. Summers have become warmer in the past ten years. Scientists have also observed changes in precipitation patterns throughout the region. Data show an increase in spring rain and a decrease in summer rain over the past fifty years.

Scientists also study how these changes in the region will continue into the future. They have gathered data showing that the regional climate will very likely change even more over the next one hundred years. Summers will become hotter and drier. Summer temperatures will increase about 9°F over the next one hundred years. High temperatures that used to be considered heat extremes will become more usual and eventually considered "normal." Summer precipitation is expected to decrease a lot. In addition, winters will become warmer and wetter. Warmer winter temperatures will result in less snowfall and more precipitation falling as rain. Winter rain is expected to increase by 1.5 to 3 inches over the next fifty to eighty years.

Scientists also study how these changes in climate will affect people living in the region. Warming temperatures present both opportunities and challenges for agriculture in the region. Warmer temperatures throughout the year are likely to increase the length of the growing season and/or the part of the year in which temperature and rainfall allow plants to grow. This could increase crop yield. However, warming of summer temperatures and less summer rain can also increase stress for crops. First, increased summer heat will result in increased transpiration and plants will lose more water through their stomata. Second, less summer rain will result in drier soils making it more difficult for plants to get the water they need. Both of these conditions will impact many agricultural crops.

Wheat is a main crop of the inland Pacific Northwest. Climate change is expected to have both positive and negative impacts on the region's wheat. Some wheat farmers will see higher yields with climate change. As atmospheric carbon dioxide (CO_2) increases from greenhouse gas emissions, plants will get more CO_2 in their leaves. Like many plants wheat will use this additional CO_2 to photosynthesize more, which means each plant will make more food and grow more. Another benefit of increasing CO_2 in the atmosphere is that plants will close their stomata more and lose less water. These responses to climate change have been well documented in the scientific literature and could increase wheat yield in the region.

In addition to these positive impacts climate change will have negative impacts on wheat in the region. High temperature during the flowering stage of plant growth can damage wheat.

For example, a few days with temperatures above 88°F can significantly reduce crop yield. In addition, increased winter rain can result in excess water for wheat crops. Plants need soil moisture for growth, but when soils have too much water their roots become damaged and the plants can die. Climate change can also increase weeds, insect pests, and diseases. All these pests cause decreased wheat yield. Farmers will also lose money as they spend more money on chemicals they will need to kill weeds and insects.

Farmers in the inland Pacific Northwest will continue to see changes in climate and the crops they grow. Wheat farmers are sensitive to the impacts of regional climate change. It is impossible to predict the exact impacts climate change will have on wheat farming. Scientists and farmers throughout the region are working together to help farmers be successful in a changing climate. They are constantly searching for new ways to adapt or adjust to climate changes so they can continue to produce wheat to feed people all over the world.

Text adapted from REACCH Annual Reports: https://www.reacchpna.org/reports

Evidence-Based Reading and Writing: Text Reduction Protocol Recording Form

Directions: Today you will collaborate with a group to read a text, annotate it, and capture evidence and reflections on the recording form on the next page.

Part 1: The protocol begins with a silent reading of "Regional Climate Change and Agriculture in the Inland Pacific Northwest."

Part 2: As a group reread the text out loud to answer the following questions, underlining or highlighting the information needed to support your answers.

How are temperature and precipitation changing in the inland Pacific Northwest?

How are changing temperature and precipitation impacting agriculture in the inland Pacific Northwest?

How are changing temperature and precipitation impacting wheat crops in the inland Pacific Northwest?

Evidence-Based Reading and Writing: Text Reduction Protocol Recording Form

PART 3: Independently (silently) organize your thinking in the table below.

Question	Significant sentence	Significant phrase	Significant word
How are temperature and precipitation changing in the inland Pacific Northwest?			
How are changing temperature and precipitation impacting agriculture in the inland Pacific Northwest?			
How are temperature and precipitation impacting wheat crops in the inland Pacific Northwest?			

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Exit Ticket

Name: ____

What do you think are several (three or four) challenges that wheat farmers will face in the future?

Note: use evidence from the text reduction protocol recording form from today and your prior knowledge around plants, photosynthesis, and the inputs and outputs of a wheat farm.

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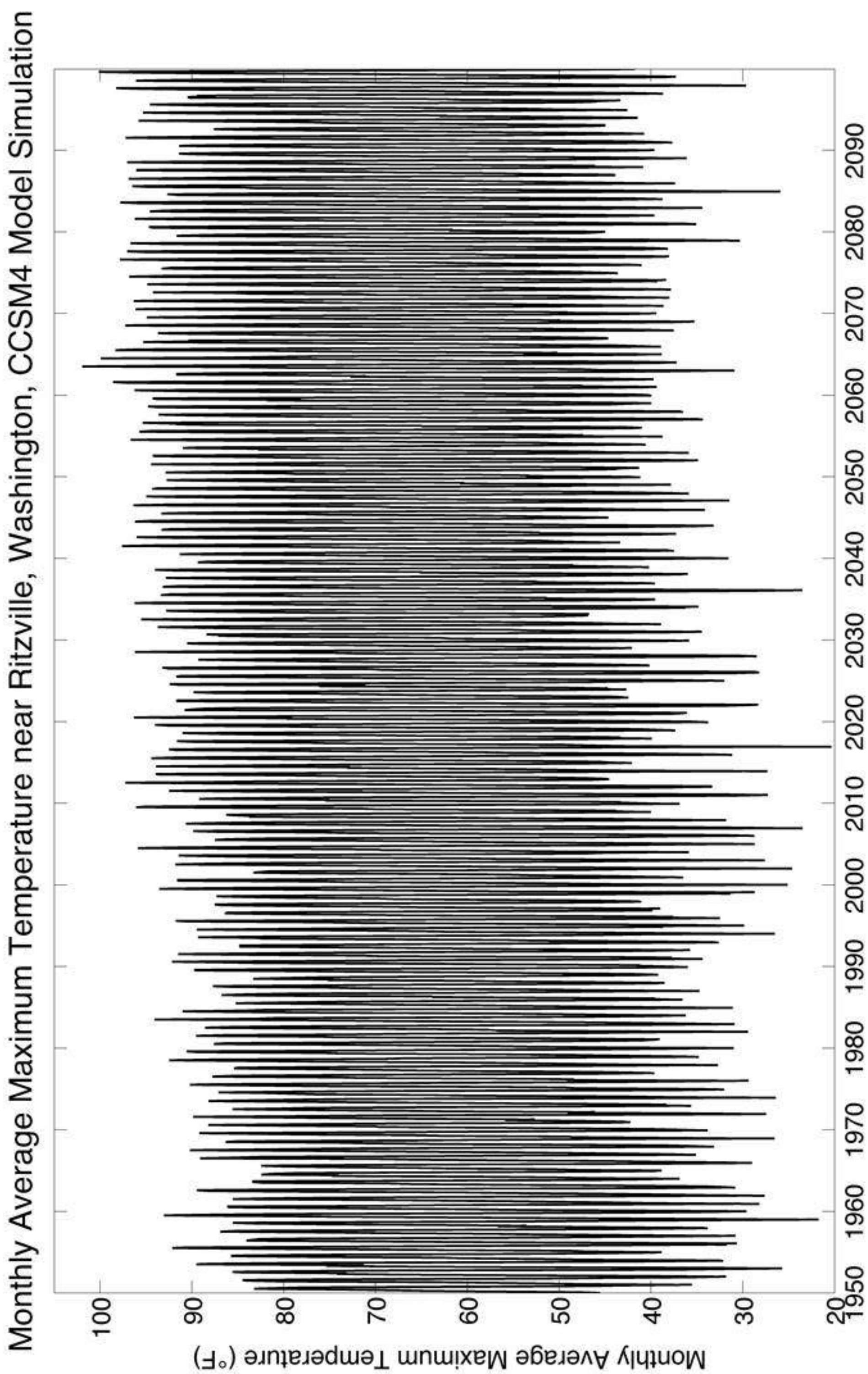
Regional Temperature Data



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Wheat Farming and Climate Change in the Inland Pacific Northwest

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System Model of a Wheat Farm in the Inland Pacific Northwest

Week 2 – Day 5

Lesson Overview

The purpose of this lesson is to provide students with an opportunity to synthesize their thinking around inland Pacific Northwest wheat farms and climate change. Students will craft a high-quality system model of a wheat farm in the inland Pacific Northwest. This model will include the major inputs and outputs of a wheat farm and the influences of climate change on that system. This lesson is intended to have a constructivist approach where students are synthesizing their own thinking around the evidence collected throughout the past week.

Lesson Vocabulary

system model

Standards and Learning Targets for Lessons
Learning Targets • I can craft and revise a high-quality system model of a wheat farm that includes the influences of regional climate change.
Next Generation Science Standards • 5-ESS2-1 – Earth's Systems - Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
Idaho Science Standards • 5.S.1.2.3 – Goal 1.2 Understand Concepts and Processes of Evidence, Models, and Explanations - Use models to explain or demonstrate a concept.
Common Core ELA Standards • RI.5.9 – Reading Informational Text - Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. • SL.5.1.a – Speaking and Listening - Engage effectively in a range of collaborative discussions with diverse partners on 5th grade topics and texts, building on others' ideas and expressing their own clearly.

Materials

- Large pieces of blank paper, one for each student to draw model.

- Writing and art supplies: pencils, colored pencils, markers, protractors, rulers, etc.
- Anchor chart paper or board

Lesson Duration

Approximately 2 hours

Lesson Description

This is an assessment activity where students will be synthesizing their thinking on the inputs, outputs, and influences of climate change on wheat production. The teacher should promote creativity, evidence-based thinking, and high-quality scientific, artistic, and written craftsmanship throughout the assessment.

Engage (20 minutes)

- Have the whole class circle up and introduce the learning target.
- Unpack the learning target: *I can craft and revise a high-quality system model of a wheat farm that includes the influences of climate change.* Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- To tap into student background knowledge, lead a brief discussion/reflection on the students' system models created at the end of Week 1.
- Ask students to turn to side-by-side partners and have a 2-minute discussion on what a high-quality system model should look like.
- After the side-by-side discussions have each group share its thinking.
- Create (and guide the development of) an anchor chart detailing the student-created criteria list for what a high-quality system model should include.
- The criteria list should include ideas around scientific accuracy, high-quality craftsmanship (neatness, spelling, conventions, use of color, organization, etc.) and evidence-based thinking.

Assessment (60 minutes)

- Ask students to independently craft high-quality system models.
- Monitor and provide support as needed.

Peer Critique and Feedback (15 minutes)

- In groups of three have students share their models.
- Have students use the criteria list to provide warm and cool feedback (things that worked, things that didn't work) to each member of the group.

Assessment Revision (10 minutes)

- Using peer feedback, have students revise their models.
- Have students submit their finished work to you for assessment.

Debrief (15 minutes)

- Have the whole class circle up.
- Have each student share his/her thinking on the following reflection question:
  I used to think_____________, but now I think_____________________ .

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Real-World Scenarios: What's Happening on My Wheat Farm?

Week 3 – Day 1

Lesson Overview

The purpose of this lesson is to provide student groups an opportunity to collaboratively build understanding around a real-world agricultural scenario. Students will be analyzing both text and data to gain an initial understanding. The text and data used during this lesson will be an abbreviated version of what students will be analyzing on Day 4. The overall objective is for students to effectively collaborate with a peer group to generate background knowledge on each scenario.

Lesson Vocabulary

data, plotting, graph, and inference

Standards and Learning Targets for Lesson
Learning Targets • I can summarize both text and data to gain a deeper understanding of the scenario. • I can effectively collaborate with my group to build background knowledge on my scenario. • I can plot *x* and *y* values on a graph.
Next Generation Science Standards • 5-ESS3-1.C – Earth and Human Activity - Obtain and combine information about the ways individual communities use science ideas to protect the Earth's resources and environment.
Idaho Science Standards • 5.S.5.1.1 – Personal and Social Perspectives - Identify issues for environmental studies.
Common Core ELA Standards • RI.5.9 – Reading Informational Text - Integrate information from multiple sources on the same topic in order to write or speak about the subject knowledgeably. • SL.5.1.a/b – Speaking and Listening - Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly. A. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion. B. Follow agreed-upon rules for discussions and carry out assigned roles.

Common Core Math Standards

- 5.G.2 – Geometry
  - Graph points on a coordinate plane to solve real-world and mathematical problems. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane and interpret coordinate values of points in the context of the situation.

Materials

- Copies of the three scenarios for student groups (Assign each scenario to one or more groups and give one scenario packet to each student.)
- Graphing paper
- Rulers
- Optional: Excel graphs with and without plotted lines to scaffold graph making as needed

Lesson Duration

Approximately 2 hours

Lesson Description

During this lesson students will read the text of their respective scenarios, analyze the accompanying data, participate in collaborative discussions, plot data, and generate initial thoughts on what is happening on their wheat farms.

Engage (10 minutes)

- Lead a recap discussion on the high-quality system models crafted on the previous day.
- After the discussion, introduce the week's objectives and present the learning targets for this lesson.
- Unpack the first two learning targets: (1) *I can summarize both text and data to gain a deeper understanding of my scenario*; and (2) *I can effectively collaborate with my group to build background knowledge on my scenario*. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.

Exploring the Text (30 minutes)

- Have students move into prearranged groups and receive their assigned scenario.
- Have students independently read the text, annotate the main ideas in the margins, and write down any questions or confusing statements. (15 minutes)
- After the initial reading each group will conduct the following sharing protocol:
  - Each student gets 2 minutes to present their thinking on the following points: (1) *What were some of the problems presented in the scenario*?*; and* (2) *What were some things you need clarification on*?

- After each student presents, give the group 1 minute to respond to the clarifying questions and the problems/solutions.

Analyzing the Data (40 minutes total)

- **Initial Observations (5 of 40 minutes)**
  - Groups will analyze the data for their scenario.
  - Each student will independently grapple with the data and make initial observations (5 minutes). This could be in the form of notice and wonder.
  - Choose a few students to share what they noticed and what they wonder about their data.

- **Mini-Lesson (15 of 40 minutes)**
  - During the mini-lesson explicitly teach how to plot ordered pairs in the first quadrant of a coordinate plane.
  - Present and unpack the last learning target: *I can plot* x *and* y *values on a graph*.

- **Mini-Lesson Expansion: Plotting and Analyzing Data (15 of 40 minutes)**
  - Have students get back into scenario groups and plot their data in a graph.
  - Monitor and assist as necessary.
  - Once students have plotted the data, ask groups to make two observations and one inference based on the graph.
  - Note: one option is to have students use the data tables to make their own graphs from scratch. Another option is to first provide students with the blank graphs so they can add the points and draw the trend line. Then provide students with the plotted graphs so they can compare their graphs to the actuals and discuss challenges and what they learned about graphing.

- **Scenario Partner Group Sharing (5 of 40 minutes)**
  - Ask different groups with the same scenario to combine.
  - Ask each group to present its plotted data, observations, and inferences.
  - After all the groups have presented, ask each group to determine one important observation and one important inference from the data.

Synthesis (20 minutes)

- Have students work independently to craft a summary of their text and data. They should answer the question: *What is happening on my wheat farm?*
- Summaries should incorporate both the textual evidence and the mathematical evidence.
- Monitor and provide assistance as needed.

Debrief (10 minutes)

- Have the whole class circle up.
- Lead a "fist to five" debrief on the learning targets:
  - State each learning target (one at a time) and have students self-assess on meeting the learning target. They will use their hand to show zero to five fingers (fist = 0 fingers) indicates "I did not come close to meeting the learning target" and 5 fingers indicate "I fully met the learning target."
  - This self-assessment is intended as a formative assessment strategy to identify where different students may need additional support and clarification.

Scenario 1

What's Happening on My Wheat Farm in Idaho?

It is the year 2025. You are a wheat farmer in the Palouse region of the inland Pacific Northwest of the United States. For over thirty years you have been managing your family farm a few miles south of Moscow, Idaho. In 2020 you started noticing that your wheat plants don't grow as much as they did in the past. You are concerned because you are seeing more aphid damage to your wheat plants. You have also noticed that the wheat leaves are more yellow with red stains near the top of each leaf. In December of 2020 you started collecting data in order to document patterns each year. For the past five years, during each of the four seasons, you have been counting the number of aphids on wheat plants scattered throughout your farm. The table below shows the average number of aphids per wheat plant every three months from December 2020 to September 2025.

Date	Number of aphids per plant
December 2020	0
March 2021	1
June 2021	4
September 2021	10
December 2021	0
March 2022	2
June 2022	7
September 2022	12
December 2022	0
March 2023	3
June 2023	11
September 2023	25
December 2023	0
March 2024	4
June 2024	15
September 2024	29
December 2024	0
March 2025	6
June 2025	19
September 2025	41

Make a graph with the date (months and year) on the *x* axis and the number of aphids per plant on the *y* axis. Plot this data on your graph. Draw a line to connect your data points.

1. What do you observe? What do see happening on your farm?

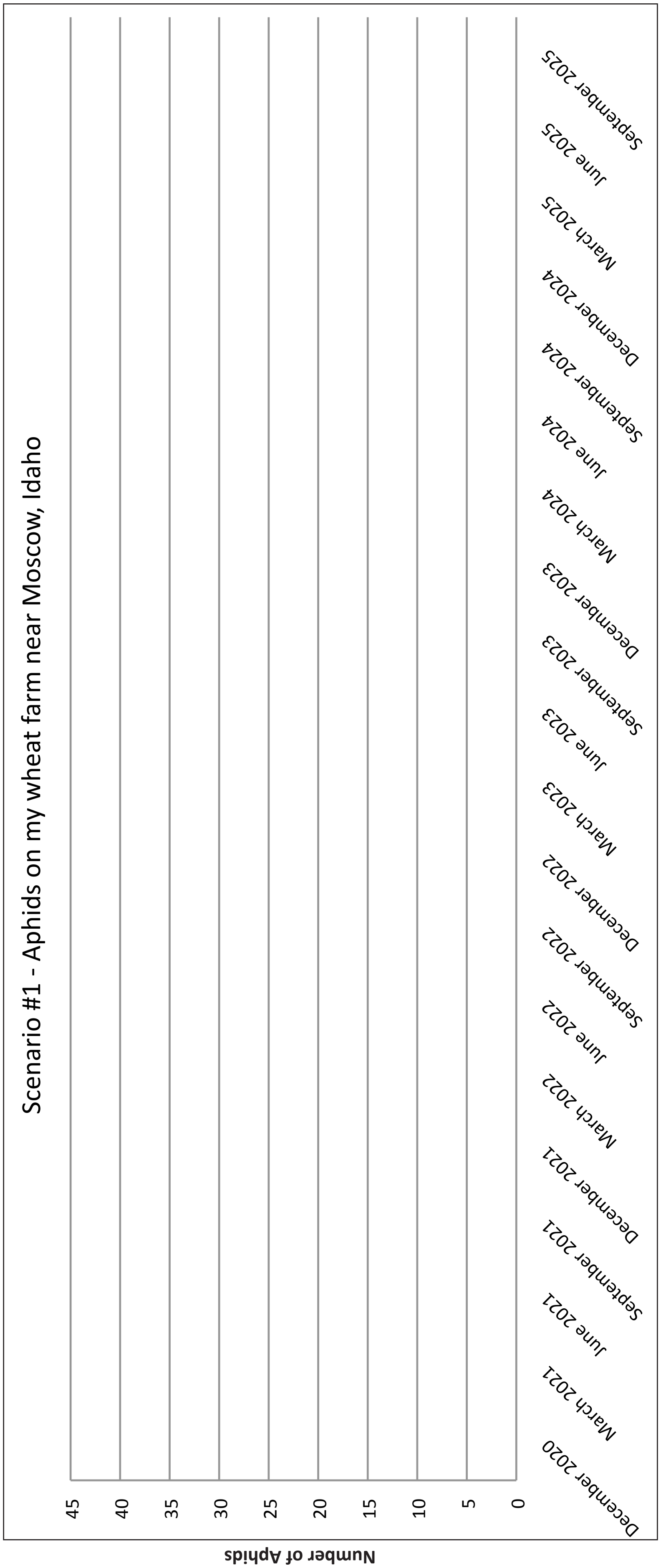
You also have the following yield data from each of these five years.

Date	Yield (bushels/acre)
September 2021	130
September 2022	127
September 2023	121
September 2024	116
September 2025	109

Draw a new *y* axis on the right side on your graph to show wheat yield (bushels/acre). Plot your wheat yield for each year. Use a differently colored marker to draw a line connecting your data points.

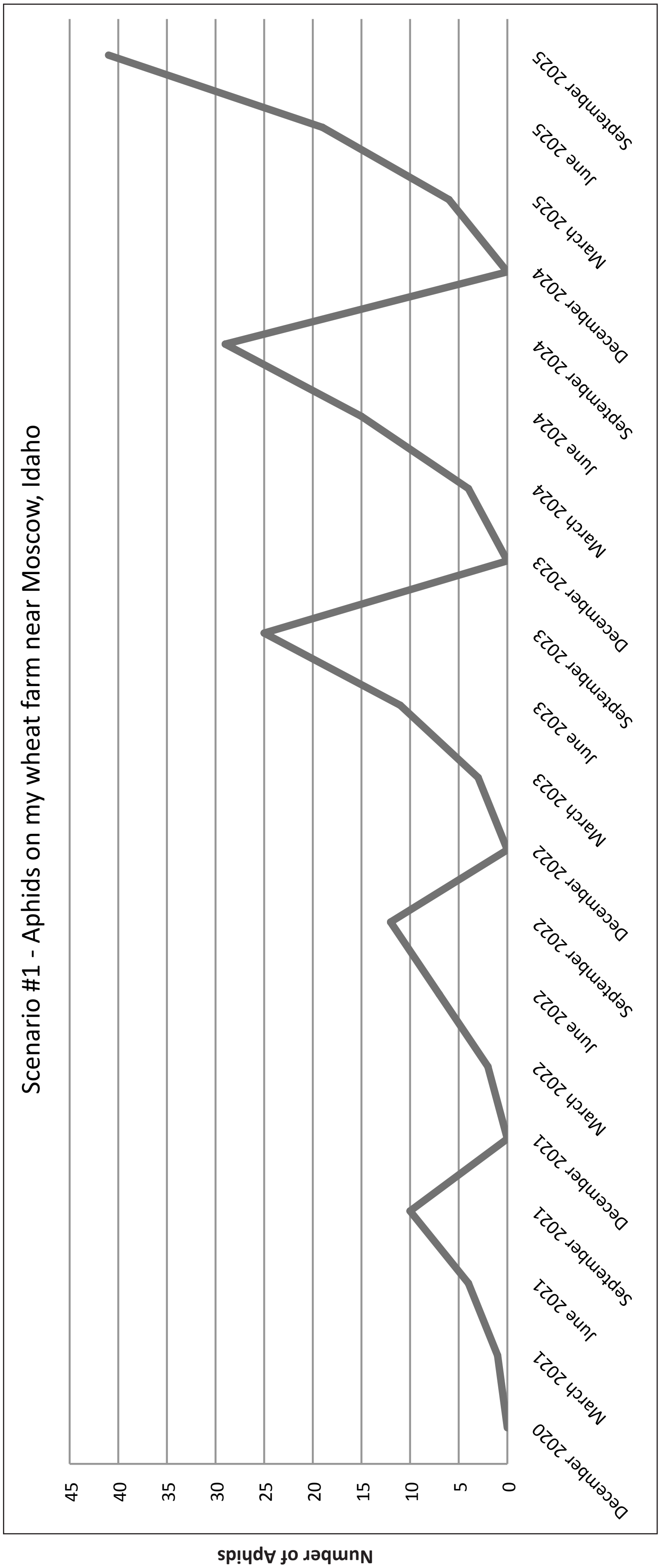
2. What do you observe from plotting this data? What do you see happening on your farm?

3. Why do you think you are seeing more aphids on your wheat?

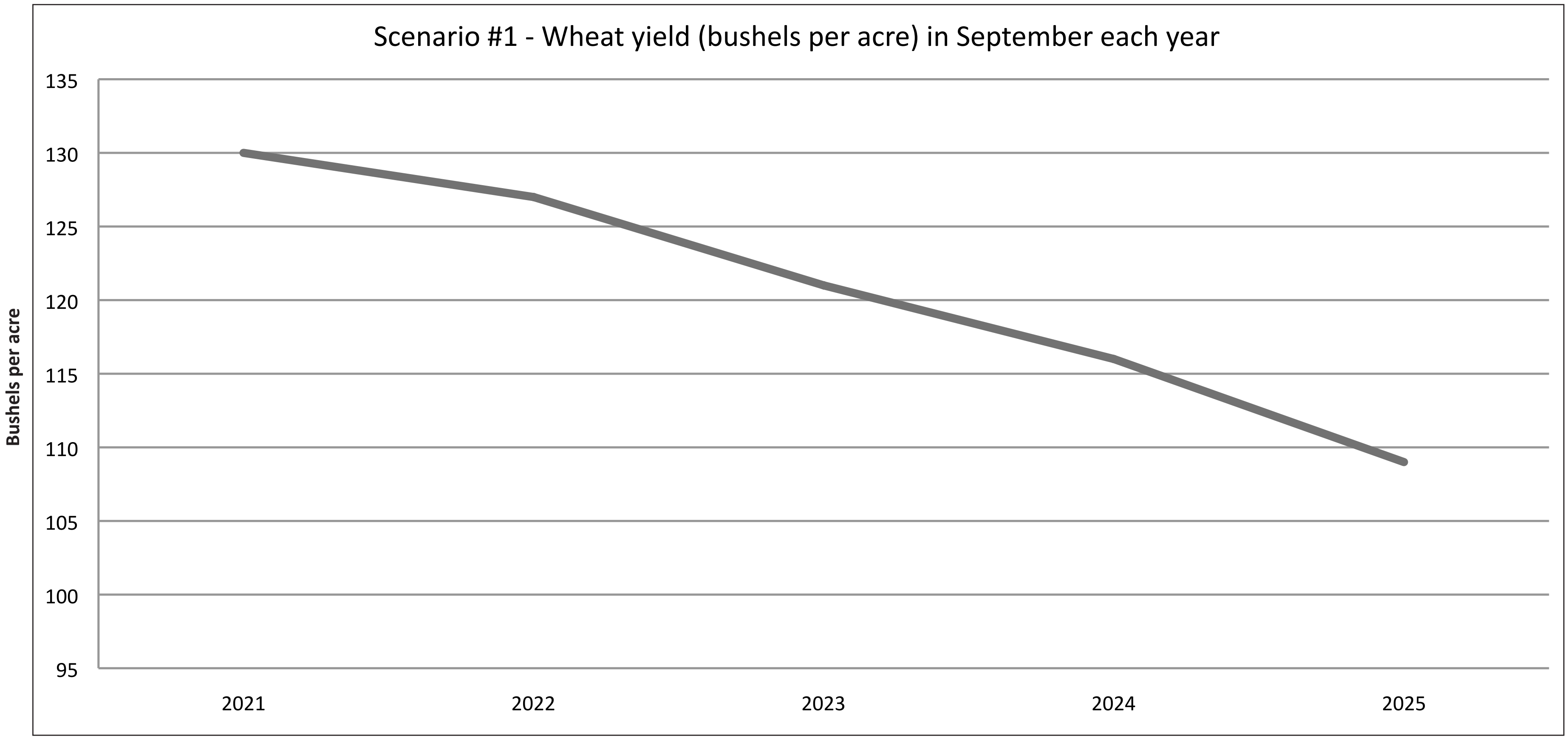

Scenario #1 - Aphids on my wheat farm near Moscow, Idaho
Number of Aphids
0
5
10
15
20
25
30
35
40
45
December 2020
March 2021
June 2021
September 2021
December 2021
March 2022
June 2022
September 2022
December 2022
March 2023
June 2023
September 2023
December 2023
March 2024
June 2024
September 2024
December 2024
March 2025
June 2025
September 2025


Scenario #1 - Wheat yield (bushels per acre) in September each year
Bushels per acre
135
130
125
120
115
110
105
100
95
2021
2022
2023
2024
2025

Teacher Key – Scenario 1



Teacher Key – Scenario 1



Scenario 2

What's Happening on My Wheat Farm in Oregon?

It is the year 2025. You are a wheat farmer in the inland Pacific Northwest region of the United States. For over thirty years you have been managing your family farm near Pendleton, Oregon. For the past several years you have noticed that your wheat plants don't grow as much as they used to and the soil seems very dry. You have also seen a consistent decline in yield (bushels per acre) each year. You have been working with scientists at Oregon State University to better understand what is happening on your farm and what you can do about it.

The table below shows two types of data that the Oregon State University scientists gave you. The middle column shows average high temperatures (in degrees Fahrenheit) during summer months (June to August) for every three years from 1998 to 2025. The right column shows the average potential evapotranspiration (in millimeters) during summer months (June to August) for every three years from 1998 to 2025. You were having a hard time understanding what "average potential evapotranspiration" means. The scientists explained to you that it is an estimate of how much water is lost from plants (through transpiration) and the soil (through evaporation) and that it depends on the weather conditions where the plant is growing.

Year	Average high temperature (°F) in summer (June–August)	Average potential evapotranspiration (mm) in summer (June–August)
1998	82	650
2001	84	716
2004	86	1007
2007	88	947
2010	86	1043
2013	87	1009
2016	88	1101
2019	93	1417
2022	90	1139
2025	91	1223

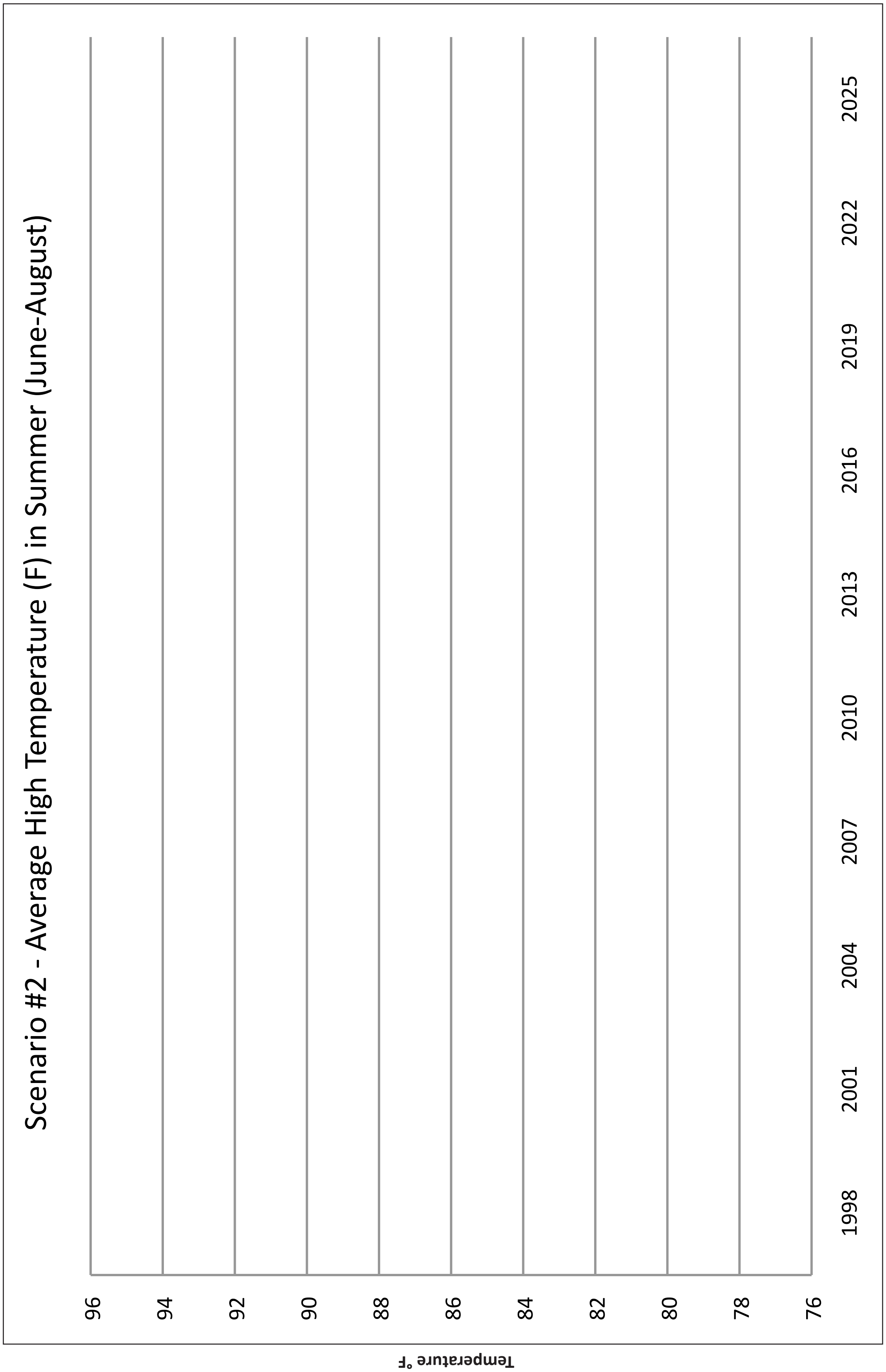
Make a graph with the date (months and year) on the *x* axis and the average high summer temperature on the *y* axis. Plot this data on your graph. Draw a line to connect your data points.

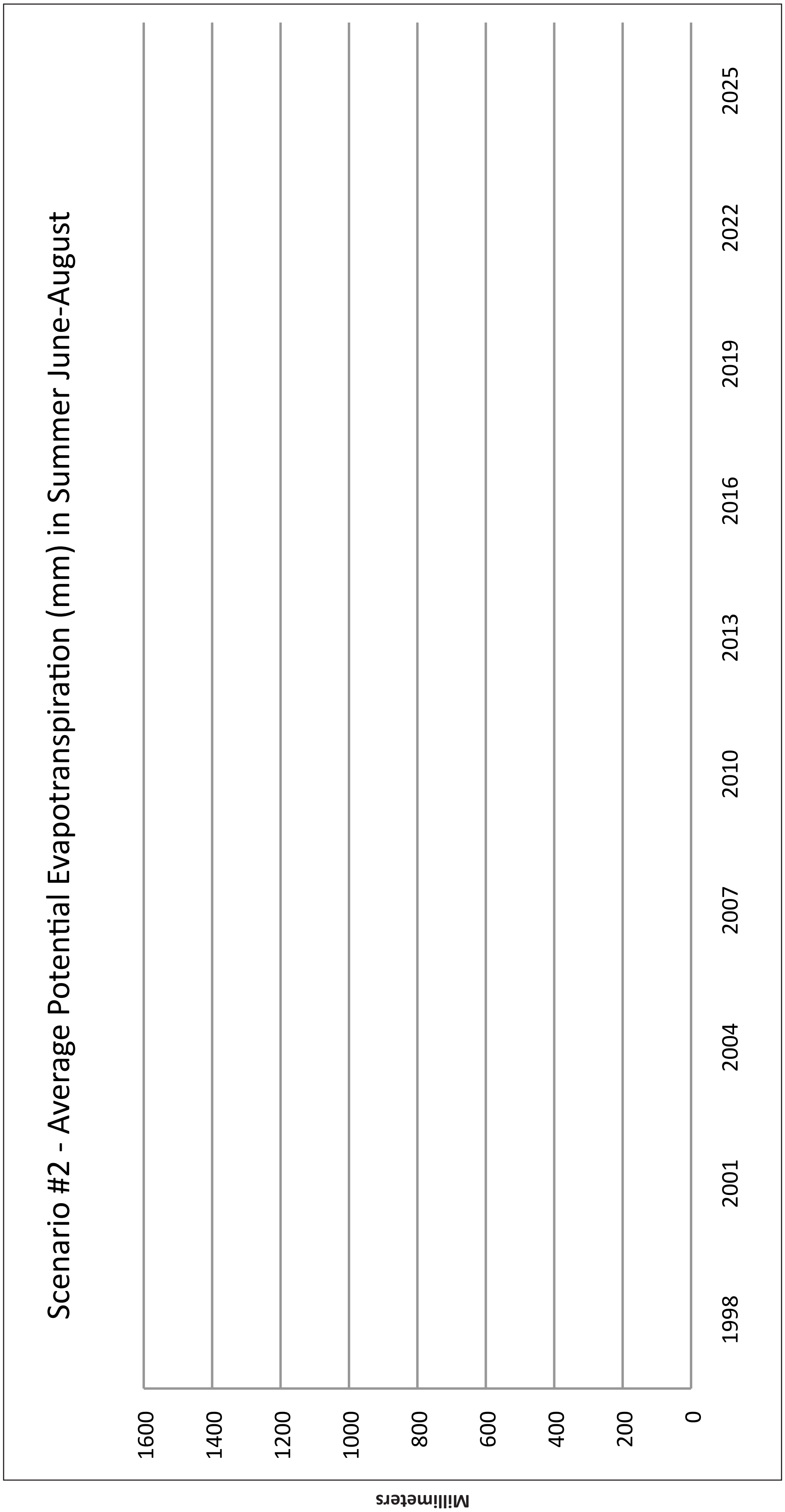
1. What do you observe? What do see happening on your farm?

Now draw a new *y* axis on the right side on your graph to show average potential evapotranspiration in millimeters. Plot your average potential evapotranspiration data. Use a differently colored marker to draw a line connecting your data points.

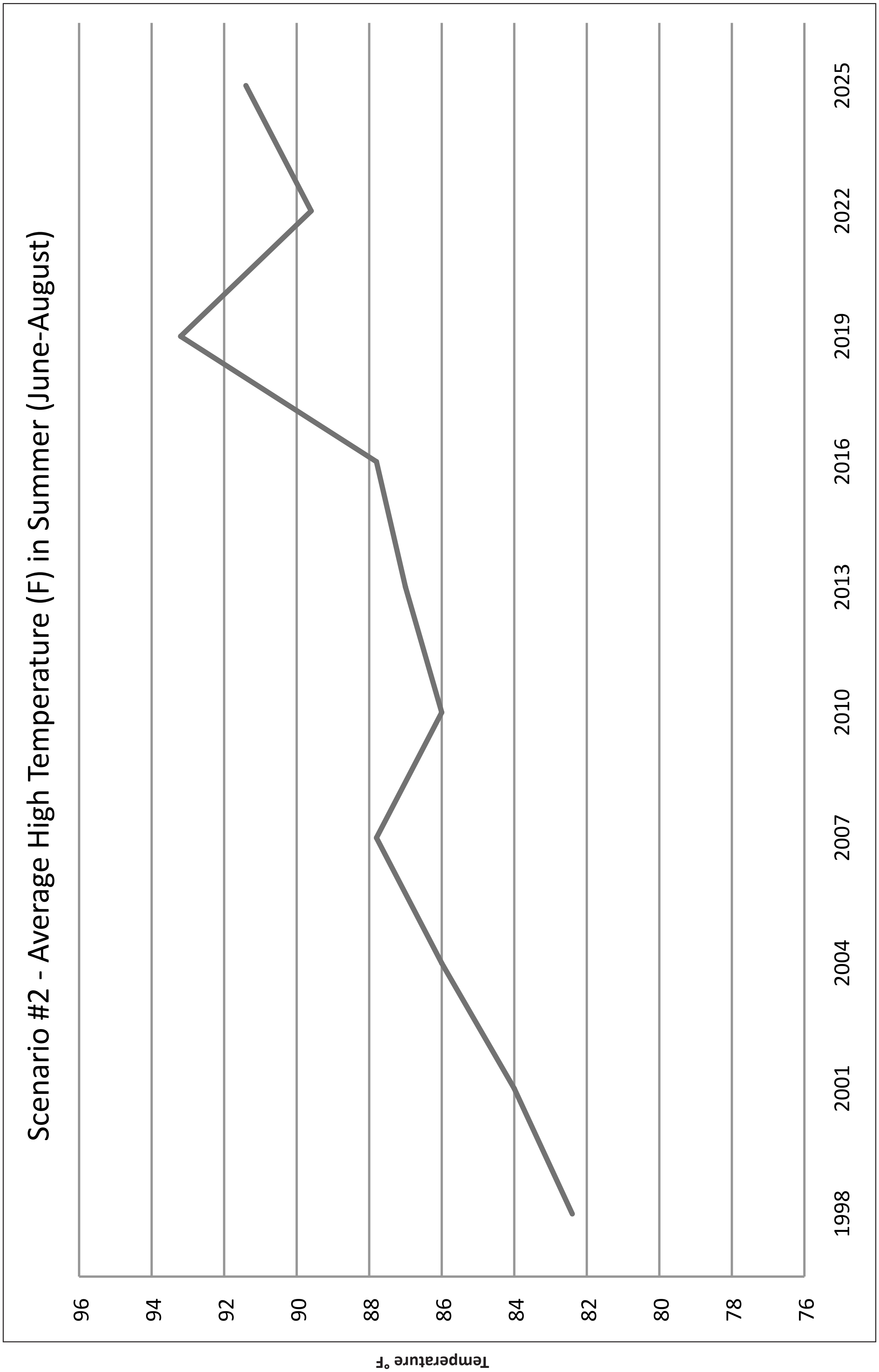
2. What do you observe from plotting this data? What do you see happening on your farm?

3. Why do you think your wheat has not been growing well?

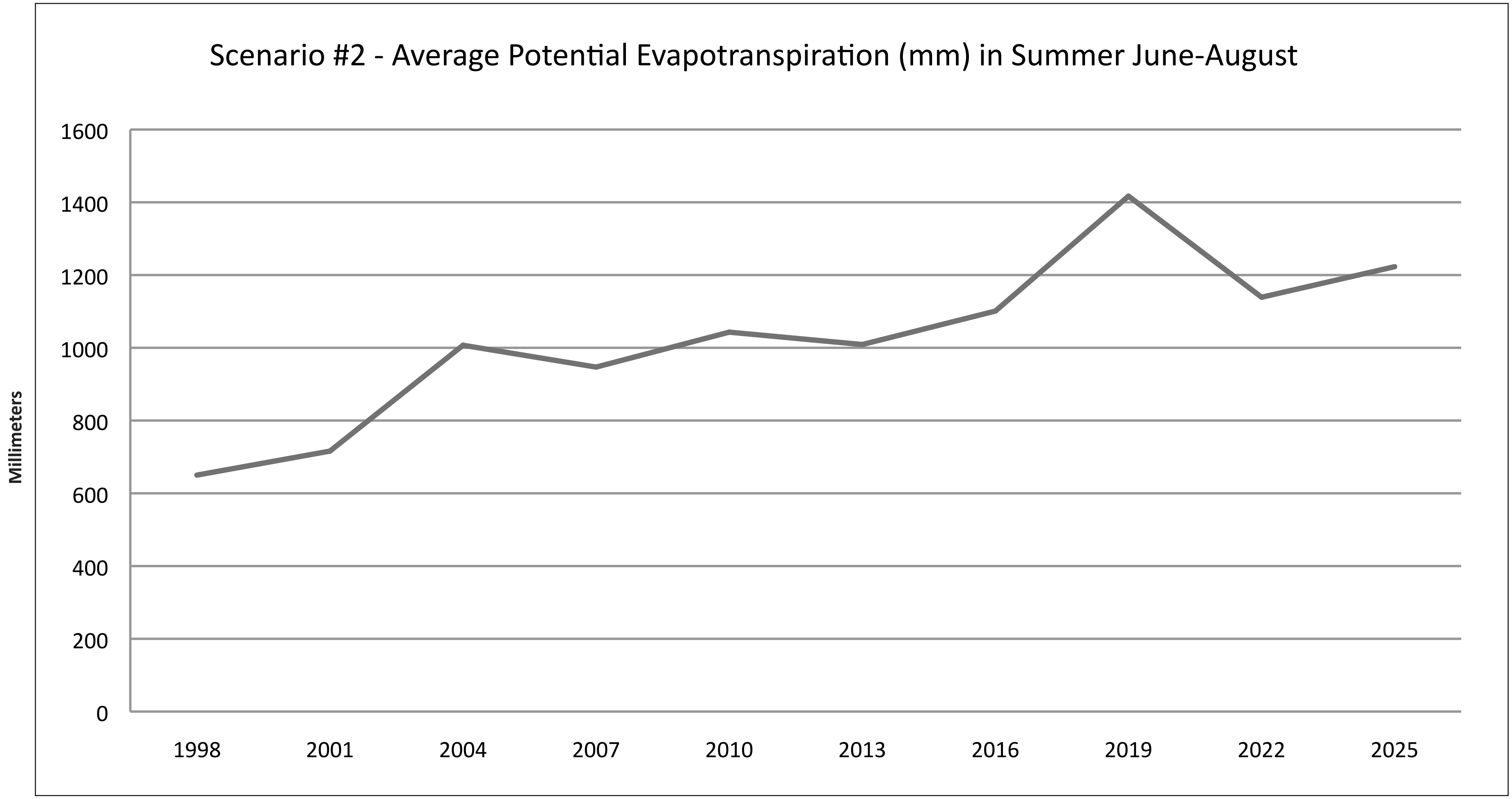

Scenario #2 - Average High Temperature (F) in Summer (June-August)
96
94
92
90
88
86
84
82
80
78
76
1998
2001
2004
2007
2010
2013
2016
2019
2022
2025
Temperature °F


Scenario #2 - Average Potential Evapotranspiration (mm) in Summer June-August
Millimeters
1600
1400
1200
1000
800
600
400
200
0
1998
2001
2004
2007
2010
2013
2016
2019
2022
2025

Teacher Key – Scenario 2



Teacher Key – Scenario 2



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Scenario 3

What's Happening on My Wheat Farm in Washington?

It is the year 2025. You are a wheat farmer in the inland Pacific Northwest region of the United States. For over thirty years you have been managing your family farm near Walla Walla, Washington. For the past several years you have noticed that your wheat plants don't grow as much as they used to and you have seen a consistent decline in yield (bushels per acre) each year. For several years you have been frustrated because the ground is too wet in early spring to plant your wheat. Your tractor and seed drill get stuck in the mud. By the time the ground is dry enough to drive your plow and pull the seed drill, it is too late in the planting season. You have been working with scientists at Washington State University to better understand what is happening on your farm and what you can do about it.

The table below shows two types of data that the Washington State University scientists gave you. The middle column shows average low temperatures (in degrees Fahrenheit) during winter months (December to February) for every three years from 1998 to 2025. The right column shows the average precipitation as rain (in millimeters) during winter months (December to February) for every three years from 1998 to 2025.

Year	Average low temperature (°F) in winter (December–February)	Average precipitation as rain (mm) in winter (December–February)
1998	28	89
2001	29	84
2004	30	94
2007	31	95
2010	32	103
2013	32	127
2016	32	119
2019	32	139
2022	33	122
2025	34	156

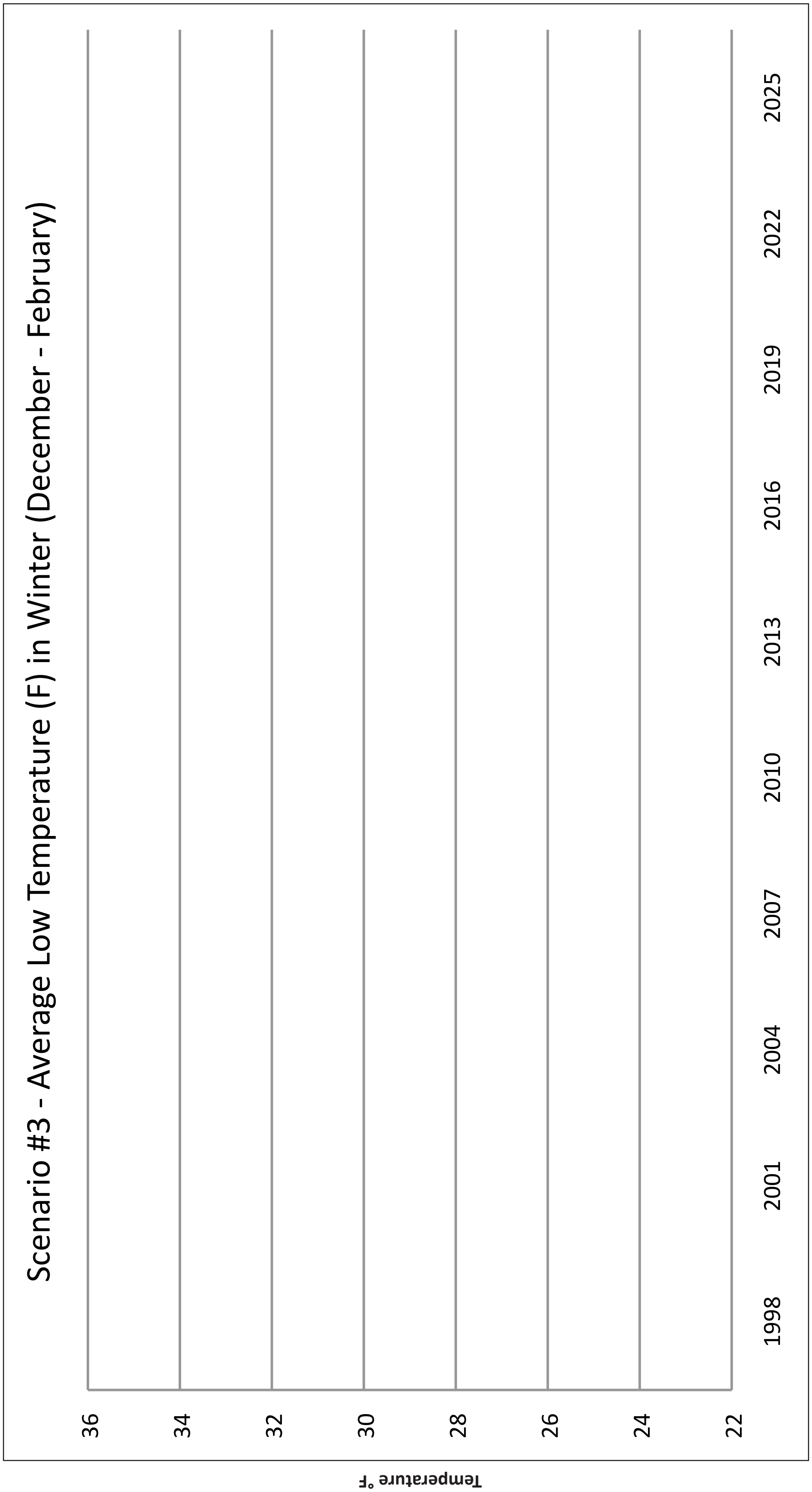
Make a graph with the date (months and year) on the *x* axis and the average low winter temperature on the *y* axis. Plot this data on your graph. Draw a line to connect your data points.

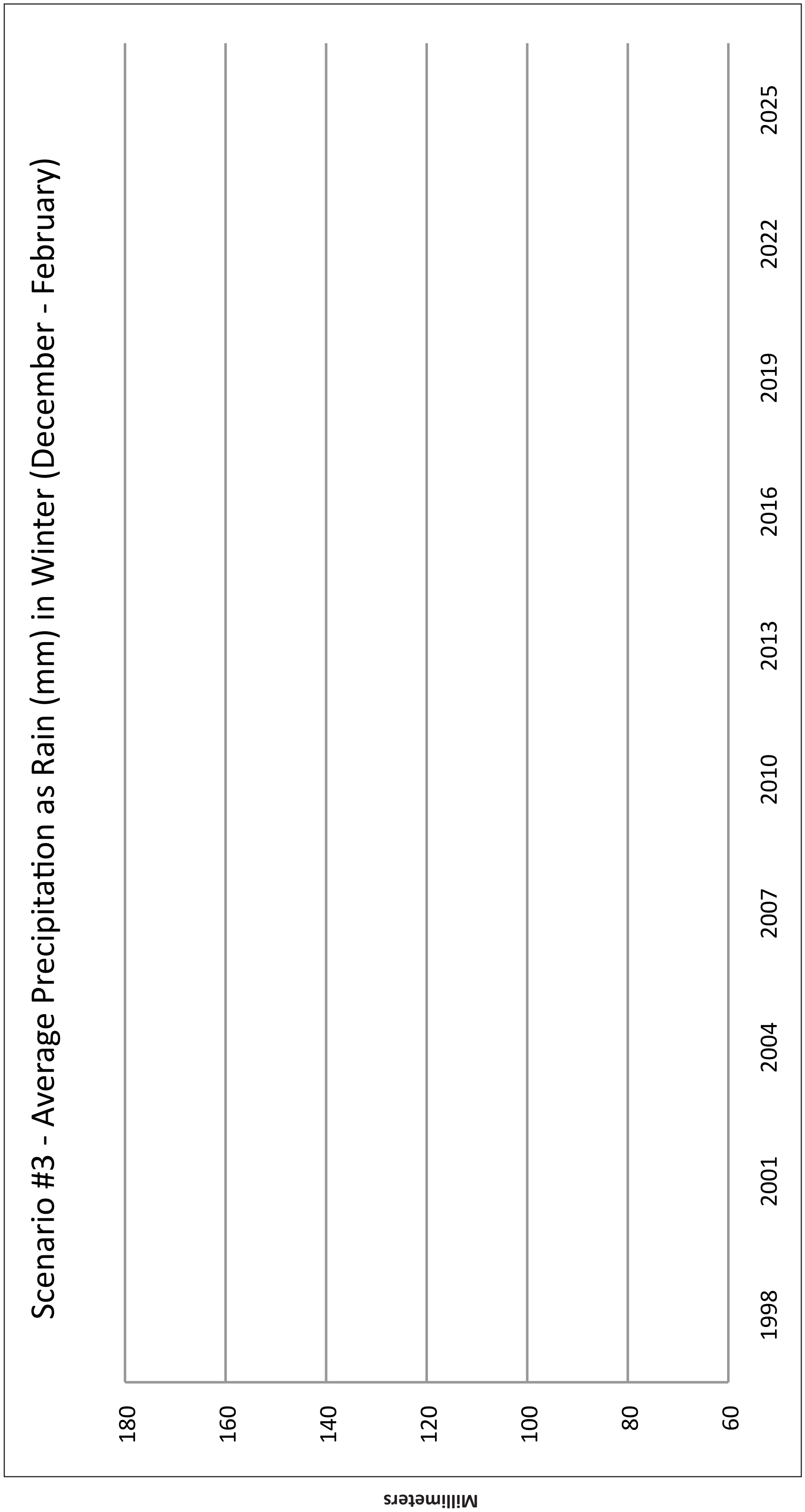
1. What do you observe? What do see happening on your farm?

Now draw a new *y* axis on the right side on your graph to show average precipitation as rain in millimeters. Plot your average precipitation as rain data. Use a differently colored marker to draw a line connecting your data points.

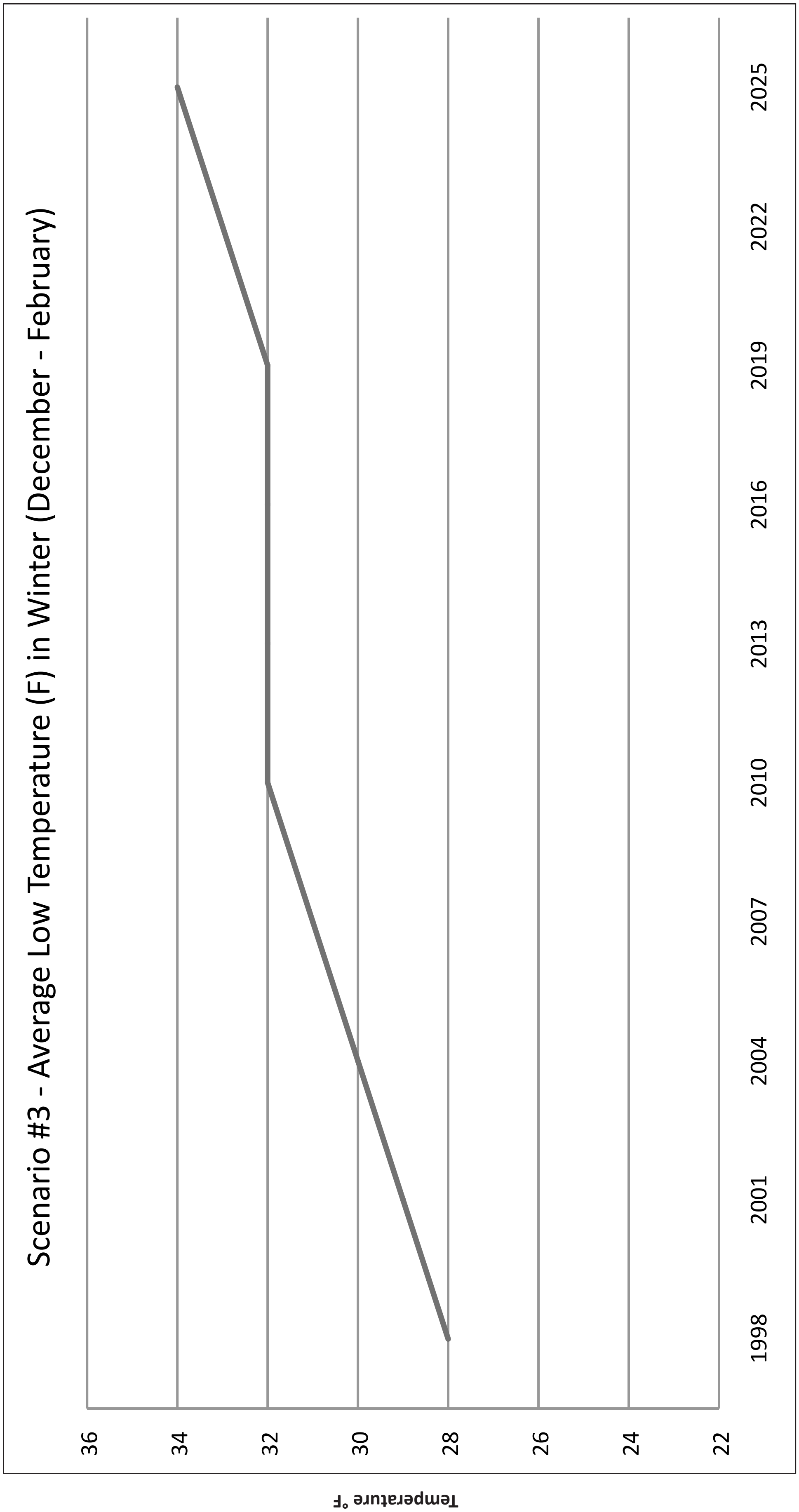
2. What do you observe from plotting this data? What do you see happening on your farm?

3. Why do you think the ground is too wet in early spring (April) to plant your wheat?

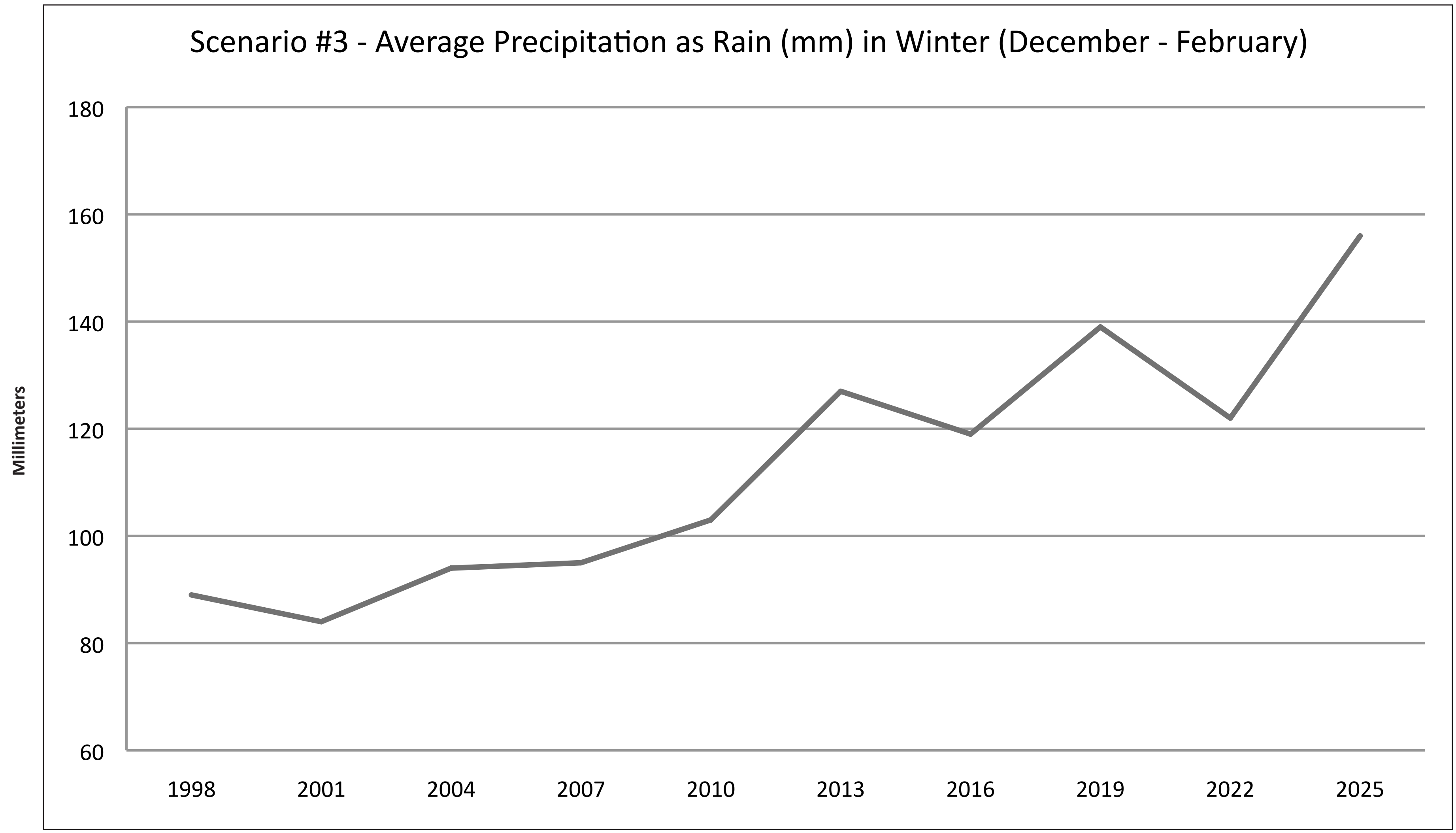

Scenario #3 - Average Low Temperature (F) in Winter (December - February)
Temperature °F
36
34
32
30
28
26
24
22
1998
2001
2004
2007
2010
2013
2016
2019
2022
2025


Scenario #3 - Average Precipitation as Rain (mm) in Winter (December - February)
Millimeters
180
160
140
120
100
80
60
1998
2001
2004
2007
2010
2013
2016
2019
2022
2025

Teacher Key – Scenario 3



Teacher Key – Scenario 3



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Poster Presentations of Real-World Scenarios

Week 3 – Day 2

Lesson Overview

This lesson will build on the previous day's work by engaging students in poster presentations of their group's scenario.

Lesson Vocabulary

high-quality and poster

Standards and Learning Targets for Lesson
Learning Targets • I can craft a high-quality poster to present my scenario to the class. • I can effectively collaborate with my group to both create and present the poster.
Next Generation Science Standards • 5-ESS3-1.C – Earth and Human Activity - Obtain and combine information about the ways individual communities use science ideas to protect the Earth's resources and environment.
Idaho Science Standards • 5.S.5.1.1 – Personal and Social Perspectives - Identify issues for environmental studies.
Common Core ELA Standards • SL.5.4 – Speaking and Listening - Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

Materials

- Anchor chart paper for high-quality criteria list
- Large paper for posters, one sheet per group
- Markers, colored pencils, and supplies for poster design
- Graphic organizer "Observations and Questions about Group Presentations", one copy per student

Lesson Duration

Approximately 2 hours

Lesson Description

During this activity, students will be collaborating with their scenario groups to craft a high-quality poster detailing their scenario.

Engage (15 minutes)

- Begin this lesson by introducing the activity and the learning targets.
- Unpack the learning targets: (1) *I can craft a high-quality poster to present my scenario to the class*; and (2) *I can effectively collaborate with my group to both create and present the poster*. Write the learning targets on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
- During the discussion around the first learning target, co-develop with the students a criteria list for what "high-quality poster" means. Examples from the pilot test are available at **www.reacchpna.org**.
- For the second learning target, draw on examples from the previous day's collaborative work to define what "effectively collaborate" means.

Poster Creation (55 minutes)

- Have students work in groups to create a poster explaining their scenario. They should include a problem statement and the data they analyzed to discover the problem.
- Monitor progress and provide assistance and guidance as necessary.

Presentation Practice (15 minutes)

- Give students 15 minutes to discuss and rehearse their presentations.
- Continue monitoring and providing assistance.

Group Presentations (25 minutes)

- Give each group 4 minutes to present its poster. (You can adjust this time to meet specific needs and time constraints.)
- While groups are presenting, have audience members use the graphic organizer to write down observations and questions about each group's scenario.

Debrief (10 minutes)

- Have the whole class circle up.
- Pose reflection questions: *What went well with your group work today? What could we improve upon next time*?

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Observations and Questions about Group Presentations

Group	Observation	Question

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Observations and Questions about Group Presentations

Group	Observation	Question

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Gathering and Evaluating Evidence

Week 3 – Day 3

Lesson Overview

During this lesson the teacher will be using a gradual release instructional model to scaffold literacy skills around acquiring, evaluating, and citing textual evidence. Students will be working primarily independently to gather and evaluate multiple pieces of evidence to support their final essays.

Lesson Vocabulary

textual evidence, quote, citation, and inference

Standards and Learning Targets for Lesson
Learning Targets • I can gather and evaluate textual evidence about potential solutions to my scenario.
Next Generation Science Standards • 5-ESS3-1.C – Earth and Human Activity - Obtain and combine information about the ways individual communities use science ideas to protect the Earth's resources and environment.
Idaho Science Standards • 5.S.5.1.1 – Personal and Social Perspectives - Identify issues for environmental studies.
Common Core ELA Standards • RI.5.1 – Reading Informational Text - Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

Materials

- Graphic organizer "Gathering Evidence", one copy for each student
- Scenario packet (scenario and articles) for each student, specific to his or her assigned scenario
- Graphic organizer "Problem and Solutions Statements", one copy for each student
- Computer and projector for projecting scenario text

Lesson Duration

Approximately 2 hours

Lesson Description

This lesson has two stages. The first stage of the lesson is a gradual release instructional model (i.e., I do, we do, you do) where the teacher explicitly teaches how to gather, evaluate, and cite textual evidence and students gradually transition into gathering evidence from text independently. The second stage of the lesson involves students working both independently and collaboratively to extract evidence from texts specific to their assigned scenarios. They will use this evidence to support their proposed solutions to their scenario as they write their essays next week.

Engage (10 minutes)

- Begin this activity by explaining the final assessment that the students will be working on over the course of the next week. Each student will be tasked with summarizing their scenario and offering evidence-based solutions to the problem. This will be done in a three- to five-paragraph essay next week. This week the class will continue gaining an understanding of the main problems in their scenarios and start looking for potential solutions in scientific and informational texts.
- Briefly introduce the final assessment learning target: *I can craft a high-quality, evidence-based written opinion piece that explains potential solutions to my scenario*, before explaining the daily learning target. You will briefly introduce this learning target to provide students with an understanding of how today's work will feed into the writing project for the next several days.

Mini-Lesson: "I do, we do, you do" format (40 minutes)

- Unpack today's learning target: *I can gather and evaluate textual evidence about potential solutions to my scenario*. (5 minutes)
  - Write the learning target on the board or on chart paper.
  - Discuss the meaning of key words.
  - Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.
  - Give each student a copy of the scenario packet for their group's scenario.

- Part 1 of Mini-Lesson—Gathering Evidence: I Do (10 minutes)
  - Read the directions to the graphic organizer and explain the central question.
  - Project the scenario 1 text and read a section aloud to the class.
  - Model gathering one piece of evidence from the text and evaluate how that piece of evidence addresses the central question.
  - Model how to cite the page and paragraph number of where the evidence came from.
  - Have students observe this entire process and ask clarifying questions.

- Part 2 of Mini-Lesson—Gathering Evidence: We Do (10 minutes)
  - Have students collaborate in pairs to gather one piece of evidence from their scenario and explain in writing why they chose it.
  - Ask each student pair to share with the class what evidence they chose and why, and to show that they cited the page and paragraph number.

- Part 3 of Mini-Lesson—Gathering Evidence: You Do (10 minutes)
  - Ask students to silently and independently gather one piece of evidence, write down the evaluation, and cite page and paragraph number.
  - Differentiate this process by working with any students who do not yet understand the process.

- Part 4 of Mini-Lesson: Debrief (5 minutes)
  - Ask students to self-assess on the learning target: *I can gather and evaluate textual evidence about potential solutions to my scenario*.
  - Conduct a fist to five self-assessment (for students below a three, provide additional support as necessary).

Independent Work (40 minutes)

- Students will independently gather evidence from their text and fill out the "Gathering Evidence" graphic organizer.

Summarizing (10 minutes)

- Give each student a copy of the "Problem and Solutions Statements" graphic organizer.
- Ask each student to use complete sentences to write a problem statement and two potential solutions they have identified in their reading today.

Debrief/Check-in (20 minutes)

- Ask the students in each group to check in with each other and discuss what evidence they have gathered and why.
- During this time, have a representative from each group schedule a 5-minute appointment with you to discuss what is going well with each member and what obstacles or challenges the group needs help overcoming.

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Gathering Evidence

Name ____

Scenario ____

Directions: As you read pull quotes/evidence directly from your text and into this graphic organizer. For each piece of evidence you collect you must also write down where you found the information (page and paragraph number (¶#) for articles, website addresses for online sources) and why you decided to collect each piece of evidence. You will use this information to write your final essay.

Central question: What are the major problems presented in this scenario and what are the potential solutions?

Quote/evidence	Why you chose this evidence (evaluation)	Citation (page# and ¶#, website)

Gathering Evidence, continued

Quote/evidence	Why you chose this evidence (evaluation)	Citation (page# and ¶#, website)

Gathering Evidence, continued

Quote/evidence	Why you chose this evidence (evaluation)	Citation (page# and ¶#, website)

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Gathering Evidence, continued

Quote/evidence	Why you chose this evidence (evaluation)	Citation (page# and ¶#, website)

Time for a thesis statement!

A thesis statement is a sentence that provides a reader with the author's main opinion in an essay. Your task now is to write <u>your</u> thesis statement for your essay. Reread all of the evidence you gathered, and in the space below, write the opinion you are going to back up with all of your evidence. If you are stuck, try using the thesis statement starter example to get you started.

Thesis Statement (starter model)

Wheat farmers should ____
____because ___________________________________
____.

Thesis Statement (independent model)

____
____
____
____.

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Problem and Solutions Statements

Wheat farmer's name ____

Scenario (# and brief description):

Problem Statement:

Potential Solution 1:

Potential Solution 2:

Scenario 1 – Searching for Solutions
Gathering and Evaluating Evidence

Review of What's Happening on Your Farm

You have several aphid species on your wheat crop. Many farmers across the inland Pacific Northwest region report problems with aphid pests. With increasing temperatures in the Palouse region of the inland Pacific Northwest, aphids have become more abundant. With the decrease in yield from 2021 to 2025, you estimate that you have lost about $315,000. Aphid pests appear to be playing a role in your decreased wheat yield. You are still doing research to understand exactly why and how the aphids are damaging your wheat crops.

Research You Have Done So Far

For several years with the help of scientists at the University of Idaho you have been doing research to find solutions to the problems you are facing on your farm. Below is information from three articles you have found. You have decided to summarize and evaluate the evidence you found so far and continue to do more current research. Your goal is to find a solution for the problems you are facing on your farm. After summarizing your research findings, you will write an evidence-based opinion piece to share your thoughts with the scientists. You will ask the scientists to critique your assessment of the problems you are having on your farm and your proposed solutions. Have fun!

Scenario 1—Article 1

Potential Effects of Climate Change on Insect Pest Dynamics

Authors: Sikha Deka, Sharmistha Barthakur, and Renu Pandey. From the National Research Centre on Plant Biotechnology, Pusa Campus and the Division of Plant Physiology, Indian Agricultural Research Institute, New Delhi, India. Article adapted from book chapter published in 2008.

http://www.academia.edu/3510694/POTENTIAL_EFFECTS_OF_CLIMATE_CHANGE_ON_INSECT_PEST_DYNAMICS

Introduction

Climate change is the most important, and the most complex, global environmental issue to date. Effects of greenhouse gases and climate changes are being observed in rising temperature and changes in rain and drought patterns. Global climate warming over the next one hundred years is expected to reduce crop harvest and global agricultural production.

Rising Temperature and Pest Population

Climate changes currently observed include increased temperature, changes in precipitation, and warmer and shorter winters. Climate factors like temperature and precipitation have a very strong influence on the development, reproduction, and survival of insect pests. Researchers have found that the numbers of leaf eating insects are likely to increase as a result of climate change. Climate change is expected to cause an increased frequency of pest outbreaks.

A key factor regulating the reproduction of insect pest is temperature. Because insects are cold-blooded organisms, the temperature of their bodies is approximately the same as that of the environment. Therefore, their growth and development is strongly influenced by temperature. Almost all insects will be affected by changes in global temperature. Scientific experiments show that agricultural pests are likely to respond to increased temperatures. Milder and shorter winters allow earlier reproduction of insects. With every degree rise in global temperature, the life cycle of insects will be shorter. Shorter life cycles will mean larger populations of pests.

Conclusions

The greatest challenge facing humans in the next one hundred years will be the need to double our global food production to feed the growing world population. Growing enough food will be difficult as high quality water and soil become more rare. Food crops will also face increasing insect damage as insect populations increase with temperature.

Scenario 1—Article 2

Aphids in the Inland Pacific Northwest Region

Article by Regional Approaches to Climate Change (REACCH)—Pacific Northwest Agriculture Scientists.

Many cereal crops, including wheat, are attacked each year by multiple insects. Aphids are one of the insects that cause direct damage to wheat plants. Scientists in Oregon, Washington, and Idaho have been monitoring aphids on farms across the region. These studies give us a better understanding of how aphids are affecting farms and what farmers can do to better manage these pests.

Scientists have found that some aphid species are highly affected by changes in the climate. Warmer temperatures in the region will cause some aphid populations to increase. Like many insects, aphids respond to weather patterns such as long-term trends in temperature and precipitation. The ongoing warming and reduced precipitation in summer will influence the number of aphids in the region. As aphids become more common, farmers will see them as pests on their wheat farms.

Aphids damage crops in two major ways. First, when aphids eat the sugar produced in wheat leaves through photosynthesis, the plant is left with less food. This results in less wheat growth and lower wheat yields. Second, aphids carry viruses that infect plants and reduce yields. Some aphid species transmit the *Barley yellow dwarf virus* (BYDV), which negatively affects grain quality and grain yield of cereals, including wheat.

Scenario 1—Article 3

Barley Yellow Dwarf Virus in Idaho Cereal Crops

Authors: Juliet M. Marshall and Arash Rashed. University of Idaho Extension. Article adapted for fifth-grade readers.

Introduction

Barley yellow dwarf virus (BYDV) is a serious and widely occurring viral disease of cereal crops and other grasses. It affects wheat, barley, oats, and occasionally rice and corn. BYDV is spread by aphids that colonize and reproduce on grassy host plants. BYDV is efficiently transmitted by different species of cereal aphids. Unusual weather conditions in 2012 contributed to the BYDV spread in wheat in Idaho. A long frost-free fall promoted large, healthy wheat growth. The warm winter weather was ideal for aphids. In late fall, large populations of aphids migrated from corn crops to wheat crops, bringing the infection to wheat. The extent and severity of the 2012 outbreak was unexpected and considered to be unusual for Idaho grains.

Symptoms and Impacts of BYDV

Symptoms of BYDV can vary widely. The most characteristic symptom is yellowing of leaves and reddening starting at leaf tips (Figure 1). Plants affected by BYDV have smaller leaves and roots. Affected plants have small irregular wheat heads and smaller seeds. Smaller grains and reduced grain production with BYDV result in reduced grain yields. Yield reductions with BYDV are common.

Winter wheat infected with BYDV in Idaho. Photo by Juliet Marshall. May 30, 2013.

Aphids and BYDV Spread

BYDV can be spread only by aphids. There is no evidence that the virus can spread through farm equipment or seeds. Several species of aphid can carry and transmit BYDV. Interestingly, aphid mothers do not pass BYDV to their young. Aphids get the virus when they eat infected plants, and the virus lives in their bodies for the rest of their lives. Then, when aphids eat other healthy plants, they pass the virus on to these plants and cause healthy plants to become infected. Aphids are attracted to wheat. Mild fall temperatures can lead to increases in aphid populations before freezing winter temperatures reduce aphid numbers and stop transmission of the virus. Corn is considered to be a "silent carrier" because corn carries the virus, but BYDV does not cause harm or symptoms of disease in corn as it does in wheat.

Control Recommendations

The most effective way to control BYDV would be to use resistant varieties of wheat that do not become infected with the virus. However, resistant varieties of Pacific Northwest wheat do not yet exist. The following recommendations have shown to be helpful in reducing the risk of BYDV infection:

- Avoid planting winter wheat varieties in the fall when aphids are at their highest numbers. Instead, plant spring wheat varieties so the plants will grow out of the most vulnerable seedling stage before aphids move into the crop. This would reduce the extent of damage since crops would be larger and more mature during summer aphid infestations. Aphids cause more damage to younger smaller plants. Large plants are less affected by the virus than small seedlings.

- Control aphid flights from other crops like corn. Spraying corn with insecticides will reduce aphid movement from corn to wheat crops. However, this option might be hard to do if the corn crops are not on your farm.

- Insecticide spray treatment may reduce the spread of BYDV in wheat and barley. However, apply treatment to seeds instead of to leaves. This is because spraying leaves may also kill ladybugs and wasps. Both ladybugs and wasps are natural predators of aphids. Applying insecticides to wheat leaves can reduce the populations of these natural predators, which could then cause an increase in aphid numbers.

Scenario 1—Article 4

Idaho Grain Growers Brace for Yellow Dwarf Problems

Author: John O'Connell. Published March 17, 2016, in the *Capital Press*. http://www.capitalpress.com/Idaho/20160317/idaho-grain-growers-brace-for-yellow-dwarf-problems. Article adapted for fifth-grade readers.

University of Idaho Extension cereal crop pathologist, Juliet Marshall, holds a sample of winter wheat infected with barley yellow dwarf virus. Growers from throughout Idaho have sent her samples of winter wheat infected with the virus. Marshall said that this sample did not have an insecticidal seed treatment, which is a recommendation for limiting damage. She warns growers to expect another tough year for diseases.

ABERDEEN, Idaho — Based on the amount of recent farmer complaints about barley yellow dwarf virus infections in winter wheat, University of Idaho Extension cereals pathologist Juliet Marshall said it's clear the disease will be aggressive again this season.

Last season Idaho grain growers coped with the most widespread Barley yellow dwarf virus outbreak they'd ever experienced. The virus is spread by aphids, causing yellowing of leaves and stunted plant roots.

Though an abnormally wet May helped plants grow out of their symptoms in 2015, many growers still experienced yield losses of up to 40 percent, Marshall said. Marshall fears the disease is at least as widespread as last year, and without a break from Mother Nature, yield losses could be greater.

Coupled with slumping grain prices, Marshall worries Idaho wheat and barley returns could suffer.

"It's going to be widespread again," Marshall said. "There are some growers who feel like it's going to be worse, but at this point, we can't tell."

Marshall said growers have brought half a dozen samples of infected plants to her office and she's been flooded with calls, confirming the disease is present in fields throughout Idaho. She said growers have found infected plants throughout fields often with the heaviest infections occurring along field edges.

"Barley yellow dwarf virus is going to be pretty visible here in the next several weeks," Marshall said.

Marshall believes barley yellow dwarf virus has been present in the region for a long time but said it first became a noticeable problem in 2008. She believes infection rates have risen as the state's corn acreage has increased. Corn supports aphids until fall grains sprout and lure them away.

Marshall advises farmers to use insecticidal seed treatments and delay planting fall grain as long as possible to reduce exposure to aphids before cold weather keeps them in check. Marshall said most of the reported infections were from early planted grain, but she acknowledges some growers wouldn't have enough time to plant if they delayed.

This spring Marshall advises growers to control potential sources of aphids and to plant spring grain as early as possible, allowing the plants to mature and be hardy when aphids arrive. She also advises growers to keep crops well watered and fertilized as the virus robs plants of the nutrients and moisture they need to grow.

UI agronomist Xi Liang is leading greenhouse and field studies to evaluate how sick plants absorb moisture. "We'll collect roots at the end of the study to see if the roots are affected by barley yellow dwarf virus and damage water uptake from the soil," Liang said.

Fifth Grade Curriculum:
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Scenario 2 – Searching for Solutions
Gathering and Evaluating Evidence

Review of What's Happening on Your Farm

With summer temperatures increasing, your wheat plants and the soil are losing a lot of water through evapotranspiration. Your soils are becoming drier every year and your wheat is not growing as well as it used to. Heat stress is affecting wheat throughout the inland Pacific Northwest region and many farmers are changing their practices to better fit the weather conditions they encounter each year.

Research You Have Done So Far

For several years with the help of scientists at Oregon State University, you have been doing research to find solutions to the problems you are facing on your farm. Below is information from three articles you found. You have decided to summarize and evaluate the evidence you have found so far and continue to do more current research. Your goal is to find a solution for the problems you are facing on your farm. After summarizing your research findings, you will write an evidence-based opinion piece to share your thoughts with the scientists. You will ask the scientists to critique your assessment of the problems you are having on your farm and your proposed solutions. Have fun!

Scenario 2—Article 1

Farmers Expect Low Yields for Wheat Harvest: Umatilla and Morrow County Farmers Can Expect Reduced Yields on Wheat Harvest Following a Dry Growing Season

Published June 23, 2015, in the *East Oregonian*. http://www.eastoregonian.com/eo/local-news/20150623/farmers-expect-low-yields-for-wheat-harvest. Article adapted for fifth-grade readers.

Standing in a field of golden wheat that reached barely up to his knees, Joe Rietmann said this year's abnormally short crop is clearly feeling the effects of drought.

"This is all typical drought stress," said Rietmann, owner of JDR Farms in Ione. "If you look over the expanse of the field and see the darker areas, that's where it's stunted."

Like most dryland farmers in eastern Oregon Rietmann expects the hot, dry weather will cut into his winter wheat harvest and lower yields by more than half in some areas. Ione's precipitation is three inches below normal dating back to September 2014 (winter wheat is usually planted in September). Upcoming weekend temperatures forecast well into the triple digits.

If it weren't for about an inch of rain that fell in May Rietmann said things would look even worse. As it is, he figures to harvest somewhere in the high-teens to mid-30s bushels per acre, depending on the location of the field.

"In an agricultural endeavor, you just have to roll with it and stay in business," he said.

This year actually marks the third straight year of below-average precipitation for the region's wheat farmers after a solid season in 2012. That's compounded the problem for growers like Rietmann who manage their fields in a wheat-fallow rotation to build up moisture deep in the soil.

Larry Lutcher, soil scientist with Oregon State University Extension Service in Morrow County, said the cumulation of three dry years in a row has left farmers with virtually no water left in storage. He predicted yields could be less than 10 bushels per acre on land that typically grows 35-40 bushels per acre.

"Even with crop insurance, it gets difficult to make ends meet," Lutcher said. "They'll get by, but they certainly won't make any money generating yields like this."

Umatilla and Morrow counties rank first and second by a wide margin in Oregon wheat production. Last year the two counties combined to harvest 17.8 million bushels of winter wheat on 357,000 acres, according to the National Agricultural Statistics Service.

In 2012 the counties harvested 21.7 million bushels thanks in part to higher rainfall. Precipitation in Ione averaged 12.23 inches between the months of September and June from 2010-2012, but just 7.5 inches from 2013-2015.

The timing of rains is also an important factor, said Jason Middleton, director of grain operations for Pendleton Grain Growers. Dryland farmers always need precipitation in May and June to finish a winter wheat crop, and precipitation has essentially shut off the past month, he said.

"I would expect (yields) to be down across the board this year," Middleton said.

Lower yields means more farmers could fall back on crop insurance to make them whole. Debbie Morrison, an agent with Wheatland Insurance in Pendleton, said she expects a lot of claims in the coming weeks.

"I don't think we'll have the high yields we were looking for," Morrison said. "As soon as they start harvesting, they'll call me and tell me if they're light."

Crop insurance provides coverage based on a field's production over the past 10 years, marking a guaranteed value that can be set either to yield or revenue. If harvest comes in below the guarantee, insurance pays the rest.

Farmers can only insure up to 85 percent of their crop, and the higher insured percentage, the higher the premium, Morrison said.

Don Wysocki, soil scientist with OSU Extension in Umatilla County, said this is the kind of year crop insurance is designed to protect. He said the best farmers can do now is hope for a burst of rain in August or September, which will allow for earlier planting of next year's crop.

Ione wheat farmer Joe Rietmann holds his hand out at the height his soft white winter wheat should be at this time of year with proper temperatures and moisture in one of his fields north of Ione.

"An inch of rain in early September would do a lot of good," Wysocki said. "Yield expectations would be better if you can plant during the optimal time period."

Early rains also allow farmers to spray for grassy weeds, such as cheatgrass and feral rye, before planting, which saves money on specialized herbicides they would otherwise have to use to kill the weeds while sparing wheat.

Growers certainly don't enjoy the dry years, Rietmann said, but they always plan for difficult conditions and aren't surprised when they happen. Dry periods are normal for the area, he said, and conditions always turn back around from year to year.

"There are worse things in life than a dry crop year," Rietmann said. "This is just part of farming ... I suspect somewhere on the other end of this, it will pick back up again."

Ione wheat farmer Joe Rietmann holds a malformed head of soft white winter wheat. Low moisture and hot temperature causes the heads of wheat to curl.

Thistles grow in a field of soft white winter wheat on Tuesday outside of Ione. Unusually high May temperatures and lower than normal spring precipitation has left a large amount of ground uncovered, giving the weeds a necessary foothold to grow.

Scenario 2—Article 2

No-Till Agriculture Offers Vast Sustainability Benefits. So Why Do Many Organic Farmers Reject It?

Author: Nicholas Staropoli. Published June 2, 2016, by the Genetic Literacy Project. https://geneticliteracyproject.org/2016/06/02/no-till-agriculture-offers-vast-sustainability-benefits-so-why-do-organic-farmers-reject-it/. Adapted for fifth-grade readers.

One of the main images most Americans have of farming is of a plow being pulled by a tractor (or in more antiquated images, livestock) turning the land. Technically speaking this act is referred to as tillage: the preparation of soil for planting by simply turning it over.

Today, most farmland is prepared in this way and has been for thousands of years, but tillage has many side effects that injure both farmland and the environment.

In the push to make farming more sustainable, an increasing number of farmers have turned to what is called no-till agriculture. However, the technique is not being embraced by all farmers. Organic farmers, the group one would think would be most embracing of this tool, are shunning it.

In contrast, farmers that are growing genetically modified crops are its biggest proponents and it's helped reduce the amount of greenhouse gases released from farm fields. How did this odd situation come about?

Tillage is primarily a form of weed control. When a farmer plows, depending on the crop, as much as a foot deep of soil is overturned, leading to a loss of 90 percent of the crop residue (the decomposing plant from the previous year) from the top soil. The benefit of this high turnover is that it kills weeds. The problem is that tillage takes a lot of work, a lot of fuel, and often a plot of land needs to be tilled several times before planting commences.

Tillage also damages the soil and leaves it exposed to erosion, particularly by wind and water. The damage of tillage was very bad during the Dust Bowl (1930 – 1939), a time in which crops and farms were ruined by severe windstorms and droughts combined with eroding topsoil. This period of hardship for many farmers has led some to rethink tillage-based farming.

How No-Till Works

No-till farming, a type of soil conservation farming, prepares the land for farming without disturbing the soil. The previous year's crops, referred to as the crop residue, are chopped off and left on the topsoil. A no-till planter then only slightly punctures the ground to insert a seed. To overcome the lost advantages in weed control that tillage brings, herbicides and pesticides are applied to the land before and after planting.

There are countless benefits to the land, the farmer, and the environment from adopting a no-till system. First and foremost, by leaving the soil mostly undisturbed and leaving high levels of crop residues behind, soil erosion is almost completely eliminated through no-till farming. The USDA's National Resources Inventory credits the 43 percent reduction in soil erosion in the United States between 1982 and 2003 to the increase in conservation tillage.

Using crop residues in no-till farming also increases the amount of soil moisture. This means there is less runoff of pesticide-polluted water, as well as a reduction in the amount of watering necessary for a given crop.

Some estimates suggest crop residues provide as much as 2 inches of additional water to crops in late summer. The Natural Resources Conservation Service states that no-till farmed soils have a water penetration rate of 5.6 inches per hour, twice as much as for conventionally tilled land. This makes no-till farming an excellent opportunity for drought-stricken areas like the dryland wheat farms around Morrow County, Oregon.

The farmer significantly benefits by the adoption of no-till farming, in particular through a reduction in labor and fuel cost. Conventional tillage practices requires as many as five passes over the land with a plow; however, no-till requires just a single pass to plant the seeds. An estimate by Purdue University calculates that a farmer will save 225 hours of labor per year for a 500-acre farm, the equivalent of four 60-hour work weeks saved a year. Another study estimated a reduction in labor by as much as 50 percent compared to tillage.

Climate Change Benefits

The benefits in reducing farming's global warming footprint are huge. One estimate suggests that no-till can reduce fuel usage by as much as 80 percent. In addition to the reduced carbon emissions from mechanical equipment used in no-till farming, there are several other benefits to the environment. No-till farming, often when paired with crop covering (a technique in which a crop is planted for the express purpose of soil health), reduces carbon emissions by holding carbon dioxide in the soil.

Carbon dioxide isn't the only greenhouse gas reduced by no-till; the release of nitrous oxide, a very dangerous greenhouse gas, is also reduced through no-till. As more nitrogen is immobilized in the soil, there is a reduced need for the application of nitrogen-rich manure.

Although there are benefits of no-till farming, there has yet to be widespread use of the technique. As of 2009, only 35 percent of U.S. farmland had at least some land dedicated to no-till practices. Furthermore, the USDA reports that no-till practices are increasing at just 1.5 percent and only 10 percent of farms are considered "continuously no-till."

Why haven't all farmers adopted it? No-till has some drawbacks.

For starters, some crops need to be planted on tilled lands, such as root crops (e.g., potatoes). There are also obstacles to adopting the practice, in particular start-up costs which include new no-till equipment (the planters) and chemical herbicides. A steep learning curve is also an obstacle as no-till practices can breed different pests, infections and weeds than those that are found in traditional tillage-based farming.

Despite the drawbacks of no-till farming, research into the technique continues and is expanding to many areas of the country. In Washington and Oregon, for example, where wheat is grown on fairly arid land, a study into farming of wheat there has shown that no-till matches (and possibly exceeds) yields compared to traditional tillage.

Although we may not be able to convert all cropland to no-till farming, the more we do the better it is for the environment, the farmer, and the land.

Scenario 2—Article 3

Study: Conserving Soil and Water in Dryland Wheat Region

Author: Sylvia Kantor, Washington State University, College of Agricultural, Human & Natural Resource Sciences. Published November 24, 2014. https://news.wsu.edu/2014/11/24/study-conserving-soil-and-water-in-dryland-wheat-region/. Adapted for fifth-grade readers.

In the world's driest rainfed wheat region, Washington State University researchers have identified new ways that can make all the difference for farmers, water, soil, and air quality.

Wheat growers in the Horse Heaven Hills of south-central Washington farm with an average of 6-8 inches of rain a year. Wind erosion has caused blowing dust that exceeded federal air quality standards 20 times in the past 10 years.

"Some of these events caused complete brown outs, zero visibility, closed freeways," said WSU research agronomist Bill Schillinger.

Harvesting hard red winter wheat at the western trial site in 2008 yielded 16 bushels per acre. Photo by Steve Schofstoll, WSU

He and WSU agricultural economist Doug Young compared three fallow management systems in the western part of the Horse Heaven Hills with 6 inches of annual rainfall and the same practices in the eastern part with 8 inches of rain. A fallow management system is a type of farming that has wheat growing one year and the soil recovering by having no crop on it the next year. Basically, it's one year on, one year off.

Timing to trap moisture

Farmers in the Horse Heaven Hills practice a winter wheat-summer fallow rotation where only one crop is grown every other year on a given piece of land.

Average yields can be as low as 18 bushels per acre – compared to upwards of 120 bushels per acre in the higher rainfall area of the Palouse in eastern Washington. With careful management, wheat farming in the Horse Heaven Hills can be profitable.

To get the highest yield, farmers need to plant winter wheat in late August or early September after a year of fallow. The fallow period allows enough moisture from winter and spring rains to accumulate in the soil for seeds to get established.

Alternating strips of undercutter tillage fallow and traditional tillage fallow in the eastern Horse Heaven Hills in 2009. *Photo by Bill Schillinger, WSU*

"In east-central Washington if you can't plant in late summer into deep seed-zone moisture in fallow, then you have to wait for fall rains in mid-October or later," Schillinger said.

The longer it takes to get winter wheat seedlings established the lower the potential for good yields.

To help ensure precious soil moisture remains in the seeding zone, farmers till the soil in the spring, which helps slow soil moisture evaporation in the seed zone during the hot, dry summer months.

But too much tillage can cause soil loss through wind erosion that feeds hazardous dust storms.

Undercutting

Compared to traditional tillage, Schillinger and Young found that undercutter tillage was the best option for fallow in the slightly moister eastern region of the Horse Heaven Hills, where late-August planting is possible and spring tillage helps hold summer soil moisture.

With wide, narrow-pitched, V-shaped blades, the undercutter slices beneath the soil surface without causing much disturbance of the soil surface.

Schillinger said scientists and farmers have conclusively shown that spring tillage with the undercutter effectively keeps seed-zone moisture.

An undercutter with V-shaped blades used for primary spring tillage with fertilizer injection during the fallow year. *Photo by Harry Schafer, Washington Association of Wheat Growers*

In the western region of the Horse Heaven Hills, the best option for controlling wind erosion was to practice no-till fallow, that is, to avoid tillage altogether. Most of the time rainfall in this area simply isn't enough to establish an early stand of winter wheat. "There's no reason to till the soil when you already know in the spring that it will be too dry to plant wheat in late August," Schillinger said.

Economist Young found that, despite the modest grain yield potential, wheat farming in this environment can be profitable – with enough acreage and careful use of inputs to manage costs. In fact, late-planted winter wheat on no-till fallow was just as profitable as traditional-tillage and undercutter-tillage fallow treatments in areas that receive far more rainfall.

Scenario 3 – Searching for Solutions
Gathering and Evaluating Evidence

Review of What's Happening on Your Farm

The climate has been changing over the course of the last 50 to 100 years. With winter temperatures increasing, winter precipitation falls more as rain and less as snow. You have been planting spring wheat for many years, a type of wheat that is planted in April (early spring). For the past few years the ground has been very wet in April after the winter rains. The soil is so wet that your tractor and seed drill get stuck in the mud. By the time the ground is dry enough to drive your plow and pull the seed drill, it is too late in the planting season and you lose an entire crop for the year. Many wheat farmers throughout the inland Pacific Northwest region are facing this same challenge planting wheat in the spring. Farmers are changing their practices in order to better fit the weather conditions they encounter each year.

Research You Have Done So Far

For several years with the help of scientists at Washington State University you have been doing research to find solutions to the problems you are facing on your farm. Below is information from three articles you found. You have decided to summarize and evaluate the evidence you have found so far and continue to do more current research. Your goal is to find a solution for the problems you are facing on your farm. After summarizing your research findings, you will write an evidence-based opinion piece to share your thoughts with the scientists. You will ask the scientists to critique your assessment of the problems you are having on your farm and your proposed solutions. Have fun!

Scenario 3—Article 1

Wetter Climate Influences Inland Northwest Wheat Growers

Article by Regional Approaches to Climate Change (REACCH)—Pacific Northwest Agriculture Scientists. Adapted for fifth-grade readers.

In the inland Pacific Northwest region, spring precipitation amounts have been increasing and are expected to increase by 5 to 15% more in the next 40 to 70 years. Wet springs are expected to become more common. The timing of heavier spring precipitation will impact spring crop plantings.

The eastern parts of the region have more winter rain and more clay in soils so soils often have excess water in the spring. Some fields are completely saturated for weeks during early spring months due to poor drainage through the clay soils. Excess springtime moisture can prevent farmers from planting seeds in the ground. When the ground is too wet plows and seed drills just sink in the mud and get stuck.

A few years ago an unusually wet spring prevented farmers from planting more than 122,000 acres in the inland Pacific Northwest region. After the latest possible planting day passed most farmers decided to leave their land in summer fallow, or without any crops growing on it. Bare soil without crops over the summer often results in soil erosion. Soil erosion is a process where the top layers of soil are carried away from the farm by wind or rain. Erosion leaves farms with less soil that plants need to grow. When erosion increases future yields and profits decrease because plants can't grow as well.

Farmers in the wetter regions of the inland Pacific Northwest must find ways to deal with wet soils during the early spring months.

One option for farmers is to plant wheat in the winter instead of the spring. Spring wheat is planted in the spring, grows throughout the spring and summer, and is harvested in late summer. Winter wheat is a different type of wheat that is planted in the fall, germinates in the fall, remains as a small plant in the ground throughout the winter, and continues to grow in the spring.

If the ground is too wet for farmers to plant spring wheat they could consider planting winter wheat. However, winter wheat should not be planted every year. Farmers only plant winter wheat every other year. They often plant a different crop in between the winter wheat years. This technique of switching off crops planted each year is called crop rotation. Crop rotation can help farmers improve soil health, prevent erosion, prevent weed growth, save water, and increase future wheat yields.

Some options for crop rotation with wheat in the inland Pacific Northwest region are peas, lentils, and canola. Research has shown that replacing fallow (bare land) with peas, lentils, or canola can help improve wheat yields the following year. This is because these crops improve soil health so the wheat can grow larger and stronger next year. Research has also shown that wheat grown after canola has higher grain yield compared to wheat grown after wheat. Rotating wheat with cover crops every other year is an exciting option that growers are beginning to adopt.

Scenario 3—Article 2

It's Time to Go Seeding, but Mother Nature Disagrees

Blogpost. May 8, 2014. A Year in the Life of a Farmer. https://southsaskfarmer.com/2014/05/08/its-time-to-go-seeding-but-mother-nature-disagrees/#comments

Tomorrow is the day. I hope.

It has been a whirlwind this spring, spinning us from hope, to frustration, to anxiety, and nearly to despair. Back in early April, for the first time in many years, it looked like seeding would begin early. Fields only had a light coating of snow and a long and brutal winter was finally drawing to a close. The days were growing warmer and the snow was finally beginning to melt. It appeared as though spring had arrived and the forecasts for May looked excellent, with cool but dry weather taking us through seeding, until a wetter June would arrive just in time to germinate crops and get everything growing. There were some real concerns about dryness, with fields looking almost alarmingly dry.

All of that has now changed.

In April through the first week of May, we received twice our normal rainfall (and snowfall!), coupled with far below normal temperatures. The ground went from dust to mud and the cold weather never even let the frost come out. The soil profile still has frost in it a few feet down and now every low spot is wet. We have reached the 8th of May with virtually no fieldwork happening in the entire region. In fact, until just recently, almost seeding all on the Canadian Prairies was stalled; few farmers could even get in the field to do rudimentary fieldwork.

This weather pattern has been frustratingly persistent. In 2009 there was a late start to seeding and it was a cool, wet year right through until harvest. Although seeding was difficult and harvest even more so, a year like that grows an amazing crop. The next year, 2010, was much worse, with snow arriving in late April, shutting us down for some time. We were unable to finish seeding that year and the crop was very poor, with saturated soil conditions killing much of our crops.

The year 2011 was the worst of them all, with seeding being virtually nonexistent. It was a tough year to be a farmer. Since 2011, we have had two great crops, but spring has still been difficult, with wet and cool weather plaguing us. Low spots are continually underwater despite our best efforts to look after them and our drills spend more time turning than they do in the ground.

We need a weather pattern change. We need to get to drier and warmer weather, or we again run the risk of not completing seeding. We get a very short window to get the crop in the ground here. Usually, seeding starts in late April and ends on June 15 before the Crop Insurance deadline. Lately, it starts in mid-May, and the Crop Insurance deadline is what it is. We are losing three weeks of normal seeding weather and this year will be no different.

Oddly enough, last year was in some ways more conducive for seeding than this year. Although we still had snow all over the place a year ago today, warm, bright, windy weather swooped in just in time at the beginning of May, melting the mountains of snow and getting us to the field surprisingly early. This year, we had very little snow, but cold weather has kept drying rates down to nothing. In reality this is simply one of the weirdest springs I can ever remember.

This is one of the most stressful times of the year for every farmer when frighteningly large sums of money are thrown into the soil and into Mother Nature's unreliable and often thrifty hands. The last question any farmer, especially this one, wants to ponder is, "Will I be able to get my crop seeded this year?" Unfortunately, I have been on the "no" side of that question before, and it is a terrible feeling. It is so frustrating to once again be faced with that question. Frighteningly, we are one large rain event away from being in real risk of not seeding this year. All we can do is hope that that rainfall event doesn't come, and that heat graces us over the next few weeks.

Scenario 3—Article 3

Oilseeds Successful Crop for Northwest Farmers

Author: Kristi Pihl, staff writer. Published January 23, 2013, in the *Tri-City Herald.* http://www.tri-cityherald.com/news/business/article32109417.html

Canola has been the successful result of some Washington and Idaho farmers' search for a more profitable crop.

Adams County farmer Curtis Hennings told about 225 people Tuesday that he has made more money on canola than wheat for the past several years.

He was speaking during the Washington State University (WSU) Oilseed Production and Marketing Conference at Kennewick's Three Rivers Convention Center.

Hennings of Ralston and other farmers explained the benefits they have found in growing oilseeds like canola, including improving soil quality and preventing erosion, during the event.

"It's a rotational crop with return," said Hal Johnson, who farms near Davenport.

Dan Bernardo, WSU's dean of the College of Agriculture, Human and Natural Resource Sciences and director of WSU Extension, said he sees a developing vibrant biofuels sector in Washington, from growing oilseeds like canola to crushing them and processing them into biofuels like biodiesel and aviation biofuel.

"We can grow biomass as well or better than anybody in the country because of our unique climatic conditions," he said.

There's a need for more oilseeds, said Mary Beth Lang, Washington State Department of Agriculture's bioenergy and special projects coordinator.

Washington has the infrastructure for biofuels production, she said. There are four biofuels plants, including one in Odessa in Lincoln County.

Lang said Washington saw a 40 percent increase in production last year from the previous year.

Washington's 14,500 acres of canola produced 27.6 million pounds of canola in 2012, according to the state.

Most of Washington's biodiesel has gone to Oregon and British Columbia, Lang said. Both have renewable fuel standards calling for such fuels in the marketplace.

In Canada, canola is more than a $15 billion industry, said Phil Thomas of Alberta, who has worked with canola and rapeseed for 51 years. Canada has about 20 million acres of canola.

In the '60s, Canadian scientists developed canola from rapeseed. The canola name comes from "Canadian oil, low acid."

Canola plants, which are related to mustard, Brussels sprouts and turnips, stand 3 to 5 feet tall. Its pods hold the seeds that are crushed for the oil, which then is used for cooking and biodiesel.

Canola is part of the diversity adding to the economics of a farm, Johnson said.

Newer combines and headers have made a huge difference, he said. The insurance programs have improved and the University of Idaho has developed varieties to withstand winter better.

Canola can be forgiving in some ways, said Scott McLeod, a farmer from Nezperce, Idaho. It is tough and will try to come back after it is hit by hail, while most other crops won't.

During harvest, it sounds like a thunderstorm because so much is coming in, he said.

"I like to grow canola because it's pretty," McLeod said.

People will stop and ask about the crop, which has yellow blooms. He said that is good for the farming industry.

For irrigated eastern Washington, which includes Benton and Franklin counties, adding canola into a crop rotation can help keep yields up and disease down for wheat, said Jenny Ringwood Connolly, WSU School of Economic Sciences associate in research.

Rotations that include canola see higher returns overall, she said.

In general, Connolly said researchers have found that while growing canola increased a farm's input costs, it results in higher profits. Canola may not be the most profitable crop in a year, but it complements other crops, she said.

She said WSU researchers are creating budgets for different growing regions that will be released online so farmers can adapt them to their specific circumstances.

The conference, which continues today, is meant to allow growers who have not grown oilseeds to interact with those who have, said Karen Sowers, WSU extension and outreach specialist for the Department of Crop & Soil Sciences.

“There is a real need to increase the knowledge base of both growers and the ag industry,” Sowers said.

Washington has taken a number of steps to encourage a biofuels industry in the state, including earmarking $1 million a year for WSU for research for bioenergy, including cropping systems, Lang said. While budget cuts have meant fewer dollars, the support remains.

The state Legislature also has asked state agencies to use biodiesel, she said. Washington ferries and ground vehicles are using some biodiesel.

Fifth Grade Curriculum:
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Gathering and Evaluating Evidence

Week 3 – Days 4 and 5

Lesson Overview

This activity is designed to be a two-day opportunity for students to independently gather, evaluate, and cite textual evidence from the resources provided in this curriculum and from additional digital or teacher-recommended resources.

Lesson Vocabulary

textual evidence, quote, citation, and inference

Standards and Learning Targets for Lesson
Learning Targets • I can gather and evaluate textual evidence about potential solutions to my scenario.
Next Generation Science Standards • 5-ESS3-1.C – Earth and Human Activity - Obtain and combine information about the ways individual communities use science ideas to protect the Earth's resources and environment.
Idaho Science Standards • 5.S.5.1.1 – Personal and Social Perspectives - Identify issues for environmental studies.
Common Core ELA Standards • RI.5.1 – Reading Informational Text - Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

Materials

- Graphic organizer "Gathering Evidence" from Day 3 for each student
- Searching for solutions articles from Day 3 for each student

Lesson Duration

Approximately 4 hours total (2 hours/day for 2 days)

Fifth Grade Curriculum:
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Lesson Description

During this activity, students will continue to gather and evaluate evidence from the text to support their essay on solutions to their scenario. This work will be mostly student driven; however, students/groups will need to schedule an appointment with the teacher to check in on progress and next steps.

Engage (15 minutes) – DAYS 4 and 5

- Have the whole class circle up and with your guidance create a list of behavior expectations for the long sections of independent work. The list of expectations should end up including several of the following criteria:
  - Appropriate use of technology
  - Reasonable voice volume for group collaboration
  - Responsible use of time
  - Clear, concise, and kind feedback on peer work
    (NOTE: on day 5, begin the day by facilitating a student discussion around expectations).

Independent Work/ Group Appointments (95 minutes) – DAY 4

- Have students continue to gather evidence from their texts.
- Have groups meet with you to discuss what is going well, obstacles, and next steps.

Debrief (10 minutes) – DAY 4

- Have the whole class circle up.
- Ask each student to respond to the following reflection question: *What are your next steps to accomplish the assessment learning target?*

Independent Work/ Group Appointments (95 minutes) – DAY 5

- Have students continue to gather, evaluate, and cite evidence from their texts and a variety of digital or teacher-provided sources.
- Have groups meet with you to discuss what is going well, obstacles, and next steps.

Debrief (10 minutes) – DAY 5

- Have the whole class circle up.
- Pose this reflection question: *During the past two days of work, what were your successes and what were your struggles?*
- Ask students to respond to these two questions using a fist to five scale: (1) *How prepared are you to begin writing your essay next week?*; and (2) *If you are not prepared, what can you do to prepare yourself to be successful when we start writing our essays?*

Fifth Grade Curriculum:
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Writing an Evidence-Based Opinion Essay

Week 4 – Days 1–5

Lesson Overview

This portion of the project will involve each student independently writing an opinion essay. The focus of this part of the curriculum should be on producing high-quality writing and providing clear, concise, and kind feedback that is directly tied to the revision checklists and rubric. This lesson plan is designed to encompass four, two-hour sessions.

Lesson Vocabulary

rubric, revision checklist, opinion-based essay, and textual evidence

Standards and Learning Targets for Lesson

Learning Targets

- I can craft a high-quality, evidence-based written opinion piece that explains potential solutions to my scenario.
- I can revise and edit my writing with the use of multiple revision checklists, rubrics, and feedback.
- I can provide clear, concise, and kind feedback to my peers by using a revision checklist and a rubric.

Next Generation Science Standards

- 5-ESS3-1.C – Earth and Human Activity
  - Obtain and combine information about the ways individual communities use science ideas to protect the Earth's resources and environment.

Idaho Science Standards

- 5.S.5.1.1 – Personal and Social Perspectives
  - Identify issues for environmental studies.

Common Core ELA Standards

- W.5.1a-d – Writing
  - Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
    a) Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.
    b) Provide logically ordered reasons that are supported by facts and details.
    c) Link opinion and reasons using words, phrases, and clauses (e.g., consequently, specifically).
    d) Provide a concluding statement or section related to the opinion presented.

Common Core ELA Standards, *continued*

- W.5.4 – Writing
  - Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
- W.5.5 – Writing
  - With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
- W.5.7 – Writing
  - Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- LS.5.2a-e – Language
  - Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
    a) Use punctuation to separate items in a series.
    b) Use a comma to separate an introductory element from the rest of the sentence.
    e) Spell grade-appropriate words correctly, consulting references as needed.

Materials

- Graphic organizer "'Gathering and Evaluating Evidence" (Students will need their work from week 3.)
- Revision checklists, one copy of each for each student (There are three revision checklists, one for each of three drafts, and each checklist should be provided at the corresponding stage of revision.)
- Rubric, one copy for each student

Lesson Duration

Approximately 2 hours per day for 5 days

Lesson Description

The work conducted by students during this week will be largely independent. Students are intended to use their "Gathering and Evaluating Evidence" graphic organizers to craft an opinion essay on their respective topics. To improve the quality of writing, each student will be engaged in an explicit revision and reflection process. (Note: a possible extension activity is to have students prepare to present their essays and opinions to a group of community members, including a group of scientists, farmers, or interested parties.)

Engage

- Unpack the three learning targets. Write the learning target on the board or on chart paper. Discuss the meaning of key words. Discuss the purpose of the lesson in terms of what students will be able to do by the end of the lesson.

- Assessment learning target: *I can craft a high-quality, evidence-based written opinion piece that explains potential solutions to my scenario.*
- *I can revise and edit my writing with the use of multiple revision checklists, rubrics, and feedback.*
- *I can provide clear, concise, and kind feedback to my peers by using a revision checklist and a rubric*.

- Pass out the first revision checklist (ideas and opinions) and the rubric to each student.
- Explain the process for using the revision checklists this week:
  - Each student writes the first draft of the essay.
  - Students partner up and go through the first revision checklist dealing with ideas and opinion. As a student is peer reviewing a partner's essay, he or she is marking "yes" or "no," indicating whether or not the essay is meeting the quality expectations. A student is allowed to move on to the next draft of his or her essay only if the revision checklist has all "yes" answers.
  - Moving on to the second draft (second revision checklist), the student will work to revise the essay to meet the expectations around organization, word choice, and sentence fluency. As with the first draft, when the student feels ready to get feedback, the student will work with a partner and the revision checklist. Once all criteria are marked "yes," the student may move on to final edits.
  - The final edits will be accomplished with the use of the third revision checklist. This portion of the checklist is solely focused on conventions and grammar.
  - Once the essay has gone through three revisions, it will be considered a high-quality piece of writing.

- Remind students to use the "Gathering and Evaluating Evidence" graphic organizer for both evidence and a thesis statement.

Let's Get Writing!

- Students will work independently.
- You will provide support as necessary.

Fifth Grade Curriculum:
Wheat Farming and Climate Change in the Inland Pacific Northwest

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Revision Checklists for Written Work – Solutions for Wheat Farming

Draft 1 Revision Checklist: Ideas and Opinion

Are there at least three paragraphs – introduction, evidence-based opinion (should include specific ideas and sources), and conclusion?	Y	N
Is there a thesis?	Y	N
Does all evidence support the thesis?	Y	N
Does the opinion take a stance and argue for an idea?	Y	N

If there are any NOs circled, then go back over your piece and revise until you have only YESs circled.

Reflection and Goals

Based on this revision checklist and the writing rubric, what are some things you did well and what are some things you need to improve?

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Draft 2 Revision Checklist: Organization, Word Choice, and Sentence Fluency

Read the piece out loud. Do the words have a flow that makes it easy to read?	Y	N
Is there a strong introduction and conclusion (use the rubric to determine if both the introduction and conclusion are at least accomplished)?	Y	N
Do all paragraphs have at least five sentences (count them)?	Y	N
Does the essay have at least three different sources (count them)?	Y	N
Does the essay frequently utilize academic and content vocabulary?	Y	N

If there are any NOs circled, then go back over your piece and revise until you have only YESs circled.

Reflection and Goals

Based on this revision checklist and the writing rubric, what are some things you did well and what are some things you need to improve?

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Draft 3 Revision Checklist: Conventions and Grammar

Does the essay have distinct paragraphs and indentations?	Y	N
Are there fewer than three spelling errors in the entire essay?	Y	N
Are there fewer than three punctuation errors in the entire essay?	Y	N
Are there fewer than three capitalization errors in the entire essay?	Y	N
Are evidence citations in parentheses at the end of the sentence and do they include the author's last name and year of publication?	Y	N

If there are any NOs circled, then go back over your piece and revise until you have only YESs circled.

Reflection and Goals

Based on this revision checklist and the writing rubric, what are some things you did well and what are some things you need to improve?

Rubric for Essay Scoring

Name______________________________ **Scenario** ________________________ **Draft#** ____________

(NOTE: any score in the Excellent category must also meet ALL criteria in the Accomplished category.)

	Beginning	**Developing**	**Accomplished**	**Excellent**
Ideas	• No clear topic • Limited or irrelevant information • Details are inaccurate.	• Topic is clear, but lacks purpose. • Details are present, but lack accuracy.	• Topic is clear and purposeful. • Supporting details are relevant and accurate.	• Insight goes beyond what sources explicitly state.
Opinion	• No opinion is present • No evidence • No thesis	• An opinion is present, but lacks supporting evidence and a thesis.	• The opinion is supported by a thesis. • Thesis is supported by relevant evidence that is cited from three different sources.	• The opinion is supported by a thesis and relevant evidence (five or more different sources).
Word Choice	• Words are non-specific. • Limited use of academic and content vocabulary	• Despite a few successes the writing is marked by everyday nouns and verbs. • Adjectives are mundane.	• Academic and content vocabulary are frequently and accurately used. • Nouns, verbs, and adjectives are colorful.	• Academic and content vocabulary have a professional quality. • Nouns, verbs, and adjectives are colorful and greatly enhance the essay's impact.

	Beginning	Developing	Accomplished	Excellent
Sentence Fluency	• The text does not invite expressive oral reading. • Endless connectives (and, and so, but then, and then) • Sentences are choppy.	• Parts of the essay invite expressive oral reading, but others are choppy. • Sentence beginnings are not ALL alike. • Sentences are constructed correctly.	• The writing has cadence (sound of words and meanings flows). • Three sentences in each paragraph have varied beginnings.	• Purposeful and varied sentence beginnings (five or more) • Creative and appropriate connectives show connections between ideas.
Organization	• No introduction • Conclusion is either absent or ineffective. • Sequence of ideas is confusing. • Body paragraphs do not support the thesis.	• Has a recognizable introduction and conclusion • Has recognizable body paragraphs that show some logic, but not enough to develop the main idea	• Has strong introduction and conclusion (catchy start, introduces main paragraph ideas, and has a thesis) • Body paragraphs are logical and support the claim. • At least five sentences in each paragraph.	• Thoughtful transition words and phrases connect ideas. • Sequence of ideas is highly effective.
Conventions	• Paragraphing is missing. • Spelling errors are frequent (more than five in each paragraph). •Punctuation is often missing or incorrect. • Capitalization is random. • Frequent grammar errors	• Spelling errors are infrequent (fewer than five in the essay). • End punctuation is usually correct. • Most words are capitalized correctly. • Paragraphing is attempted, but lacks accuracy.	• The essay contains fewer than three spelling errors, fewer than three punctuation errors, and fewer than three capitalization errors. • Citations are at the end of the sentence in parentheses and have author last name and year of publication.	• There are no errors in spelling, punctuation, capitalization, paragraphing, or grammar.

Notes

The REACCH project is designed to enhance the sustainability of cereal production systems in the inland Pacific Northwest under ongoing and projected climate change, while contributing to climate change mitigation by reducing emissions of greenhouse gases.

REACCH partners:

University of Idaho

Washington State University

Oregon State University

USDA United States Department of Agriculture

Agricultural Research Service

National Institute of Food and Agriculture

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