PACIFIC EDUCATION INSTITUTE

"Solutions-Oriented Learning" Storyline

HS-Regenerative Agriculture (Western Washington)

Storyline introduction and overview:

Students learn about the practices of regenerative agriculture and how regenerative agriculture is a solution to climate change. Embedded in the storyline are scientific concepts relating to carbon cycling and soil microbial activity. The storyline culminates with students creating an infographic that is intended for educating the community about regenerative agricultural practices.

NGSS Learning Progression for this Storyline: The high school storyline is part of a larger learning progression that includes students mastering standards pre-K to 12th grade. Take a look at how the high school performance expectations fit in a continuum of learning for your students.

Placemaking:	**Anchoring phenomena:**	**Drawdown:**
The Pacific Northwest is home to dozens of tribal Nations that harvest plants and animals from the land and water. Growers and producers of berries, corn, carrots, cattle, herbs, mushrooms, eggs, cherries and more support the Washington State economy. Agriculture is a principle source of economic stability for rural communities and the state as a whole.	Show samples of soil from different fields OR, use images from A Closer Look: Regenerative Agriculture Post the statement: Soils from fields that use different agricultural practices have a different impact on climate change. * *Students may be confused at this point about how soil emits carbon dioxide AND is also a solution for climate change. Soil is a critical part of the carbon cycle.	Regenerative Annual Cropping Nutrient Management Conservation Agriculture Composting
Indigenous and other relevant cultural connections: Food is essential for survival, and many Indigenous cultures (including the Coast Salish peoples) value food as the center of their culture. A revival of traditional practices is reconnecting people to the first foods of their ancestors. The influence of these practices and beliefs should not be overlooked when considering regenerative agricultural practices, which are gaining traction as practices which will support drawdown of carbon and resiliency of people and land.	**NGSS PEs (progress towards):** HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity	

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Estimated time required to implement this storyline: 3 to 4 weeks

NGSS PEs:

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HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
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Science & Engineering Practice (SEP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles and theories. Design or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**For HS-ESS3-4** **ETS1.B: Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system.
Using Mathematical and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use mathematical representations of phenomena or design solutions to support claims.	**For HS-LS2-4.** **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems.** Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	**Energy and Matter** Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9– 12 builds on K–8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Use a computational representation of phenomena or design solutions to	**For HS-ESS3-6** **ESS3.D: Global Climate Change** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

describe and/or support claims and/or explanations.		

Learning Session:	Materials List
2	Soil samples
5	Bromothymol Blue Berlese Funnel Lab: ● 1 2-L plastic soda bottle ● 1 pair scissors ● 1 10-cm2 square of 1/4 or 1/8-inch mesh hardware cloth or plastic needlepoint backing ● 1 pair tin snips ● 1 pair pliers ● 1 10 x 10 x 5-cm soil-surface sample ● 1 trowel or pancake turner ● 1 pair of gloves ● 1 3.8-L (1-gallon) sealable, plastic bag ● 50.0 mL ethanol ● 1 500-mL glass jar with 7.5-cm diameter opening and tight lid ● 1 piece of newspaper ● 1 9-watt colorless light bulb & a socket in a string of holiday lights or 25-watt shielded light ● 1 10-cm2 ● square of aluminum foil or dark paper You will need the following for each group of two students in a class of 24: ● 3 2-L plastic soda bottles ● 1 pair scissors ● 3 10 x 10 x 5-cm soil-surface samples

1.	Grounding Native Ways of Knowing	Estimated time: One to Two 50-minute Periods
	Show Robin Kimmerer's Ted Talk about how Indigenous people treat the harvesting of food [Reclaiming the Honorable Harvest] You can support this video with the content at Burke Museum, "[Reviving traditional Coast Salish food knowledge]", which is more regionally specific. The core values listed in this resource are: - Food is the center of culture, - Honor the food chain, - Eat with the seasons, and - Eat a variety of foods.	

	"Native Plants Journal" specifically speaks to one food species popular among Indigenous peoples in the Pacific Northwest: camas. It includes 9 management practices which can support understanding of Indigenous agricultural practices. We also recommend researching your nearest tribe and the approaches to food and agriculture in the past, present, and future. Locate resources such as sustainability plans, climate adaptation plans, etc. to support your learning. Additional resources on working with Indigenous students and tribes: To access information on how to reach out and build relationships with local tribes, visit the OSPI Office of Native Education: Partnering with Tribes, and contact your district's tribal liaison/Title VI coordinator. To learn more about respecting and building upon Indigenous Peoples' Rights visit the Learning in Places website, a project led by Dr. Megan Bang then read Practice Brief #10: Teaching STEM In Ways that Respect and Build Upon Indigenous Peoples' Rights and Practice Brief #11: Implementing Meaningful STEM Education with Indigenous Students & Families published on the University of Washington's STEM Teaching Tools website.

2.	**Examine phenomena: Soils from fields that use different agricultural practices have a different impact on climate change.**	Estimated time: 30 minutes
	Show samples of soil from different fields OR use A Closer Look: Regenerative Agriculture. Students may be confused at this point about how soil emits carbon dioxide AND is also a solution for climate change through carbon storage.	

3.	**Pre Assessment:**	Estimated time: 30 minutes
	HS-Regenerative Ag (Western WA) Pre-Assessment **HS-Regenerative Ag (Western WA) Assessment Rubric**	

4.	**Guiding question: What does agriculture look like in Washington state and how has it changed over time?**	Estimated time: Two to three 50-minute periods
	1. List all the food that you eat and place them (or their ingredients) into categories. For example: plants and animals. Students highlight their favorite food on their list and trace back to the sources of that food. (For example, if a students' favorite food is pizza, they may say that the olive oil is from Italy or the tomatoes are from Mexico, while the cheese is from cows in California.) Guide the discussion to local crops and the kind of	

food that is made from those crops. Ask students to, on the same piece of paper, write down as many crops grown in Washington as they can; this is a fun activity to do as a timed brainstorm. After, you may choose to show the Washington State Agriculture video (YouTube) and have students check off the crops they listed as they see them on the screen. Finally, show and discuss the Washington state infographic on crops.

2. What was the land like before agriculture; pre-pioneer? Although Indigenous peoples in the West did not practice Western agriculture, their practices did care for the land that produced the food they gathered. Give students a copy of the Traditional Coast Salish Foods list from Burke Museum. Compare this list with the Washington State infographic on crops from Part 1. Facilitate a discussion comparing the foods on the commodities infographic to the list of Coast Salish foods.

3. The tribes in the northeastern part of the US did practice traditional agriculture. Students read Native American Culture of the Northeast to discover what agriculture looked like pre-pioneer. Students explore WHY the “three sister” farming of squash, beans, and corn makes so much sense from a biological standpoint by reading How do the “three sister” plants work together? You may want to ask students to create a sketch or model to help them understand the relationships described in the article, in small groups or individually as it will support further understanding of the role that crop biodiversity plays in soil health

   Additional three sister resources:
   - GENERATION NEXT: Honoring the past, creating the future
   - Living Soil begin at 41:30 stop again at 47:30

4. In this part, students will be comparing and evaluating technological solutions for providing food for people with a graphic organizer. They will use this organizer once again later in the learning sessions. It is suggested that this be a work of collaboration, where students pick one practice in either industrial or Indigenous agriculture and work together as a class or in teams to complete the graphic organizer. Below, we’ve included some resources to help students explore industrial agricultural practices and Indigenous practices. These resources should help support students in completing the graphic organizer, but are by no means the only resources available. You may also want students to build a timeline of events during the history of agriculture if you are integrating content areas or working with social studies courses.
   - Graphic Organizer: Exploring Agriculture Practices

     Industrial Practice Resource:

     The Industrialization of Agriculture
     Sustainable Agriculture vs. Industrial Agriculture

	Indigenous Practices Resource: Indigenous Agriculture and Sustainable Foods Indigenous Food Harvesting Reviving Traditional Coast Salish Food Knowledge Regenerative Practices Resource: 10 Regenerative Practices Every Grower Should Know The future of food and agriculture: Trends and Challenges, Figure 14.1 and Challenge 1 on page 135

5.	**Guiding question: What is the role of soil in agriculture?**	Estimated time: Four 50-minute period **(The labs can take up to 9 days to perform but do not necessarily need to be revisited every day)**

1. Discuss the term “ecosystem services” while showing Forests and Family Farms infographic. Then, direct students to Soils and Biodiversity infographic. Using these two resources, students list the ecosystem benefits that a field of ____________ (name a local crop) provide. Be sure that students consider the soil in the ecosystem services.
2. Students bring in soil samples and set up a closed system with a carbon dioxide indicator (Bromothymol Blue). Based on the color change of the indicator, students will make a claim about the living component of the soil. Use the protocol in Soil Microbial Lab (Soil Respiration). This lab requires a 24-hour period. The background information is a good introduction for students.
3. Students perform the lab in #2 again using different kinds of soil that the students bring in. Students collect data on the different rates of soil respiration and graph the results. Students make a claim about the amount of carbon in the soil using the data on soil respiration. Soil Respiration from Science Direct has a graphic that shows the relationship between carbon and respiration rate.
4. Students complete a Berlese Funnel Lab (soil trap lab) that can be completed in 8 days. Teacher can customize the lab for their classroom needs.
5. Facilitate a discussion about the role of biodiversity in soils in the ability for that soil to act as a carbon sink (calling attention to the entire biological diversity of the system, plant and micro/macro-organisms).

6.	**Guiding question: How does increasing soil health pose solutions to climate change?**	Estimated time: Three 50-minute periods

	1. Students complete the Earth Lab: Soil Carbon. Students watch short videos throughout the lab and discuss the information in small groups. Students learn how farmers can build carbon rich soil and how these practices connect to climate change. Review the Carbon cycle and the role of photosynthesis using the REACCH ppt Ecological Cycles, Carbon cycle, Photosynthesis, and Respiration ppt, or use carbon cycle curriculum from your own content. 2. Students explore the difference between carbon store, carbon sequestration, and carbon emission. Students go to an area outside and sketch what they see. They then label their sketch with; a. C = carbon store b. S = carbon sequestration c. E = carbon emitting 3. Students design a lab that evaluates the impact of monoculture farming versus polyculture farming practices on soil carbon storage. 4. If there is time, students can use Top Crop Interactive game (National Geographic) to explore how farming decisions impact the health of the soil and therefore the crops. To engage the students, make the game a competition and post the top scores.	

7.	**Guiding question: What is regenerative ag and how is it a solution to climate change?**	Estimated time: Two 50-minute periods
	Students begin to collect information for their Infographic at this point in the storyline. 1. Students read Project Drawdown: Reg ag 2. Chose videos of regenerative agriculture practices that best suits your location: • Living Soil stop at 16:30 and begin again at 41:30 stop again at 47:30 • 21 Acres Farm Virtual Tours (Teacher can choose the video/clip that best suits their classroom needs). • Composting and Regenerative Agriculture (Video from Lopez Island Farms that showcases how the farm utilizes compost in their regenerative agriculture practices). 3. Students read Kiss the Ground Regenerative Agriculture and define the term “regenerative”. ◦ NOTE: This website does portray Industrialized farming in an extremely negative	

	light, which is not the intent of the exercise or to focus of the content presented here. Please read over the materials you are sharing with students prior to sharing with them. 4. Students research the 5 principles of regenerative agriculture using the resource Regen Ag: Solid Principles, Extraordinary Claims ○ McGuire presents an argument that Brown’s (Kiss the Ground) data is extraordinary. Based on the argument, students make a claim either refuting or supporting Brown’s data. Research current regenerative ag studies to find evidence to support the students’ claim. Use the Regen AG Practices in W.WA. examples to support student claims. 5. This is an excellent place in the unit to arrange a local farm tour or to have an agriculture professional come to your class to speak about the new technologies 6. Students revisit the phenomenon and explain how soils from different fields that have been farmed with different practices can have a different impact on climate change through carbon storage. 7. This would be a point to have students revisit their graphic organizer. Are there practices or items that can be added to the students’ graphic organizer?

8.	**Guiding question: What can I do to show how regenerative agriculture is a solution to climate change?**	Estimated time: 70 minutes
	Final Cumulative Project Students create an infographic to inform the local community about the importance of regenerative agriculture practices in sequestering and storing carbon in the soil. The infographic will include the following information: ● The role of soil in carbon storage ● The practices of regenerative agriculture ● A description of how each practice increases the carbon stored in the soil ● A description of how Indigenous people care and have always cared for the land ● Incorporate data/observations gathered during the storyline. ● Career opportunities in Agriculture and Natural Resources (another resource for career options: Career Seeker) The link Infographics as a Creative Assessment provides students with samples, online tutorials, and the steps to create an infographic.	

9.	**Possible next steps/off-ramps/actions:**	Estimated time:
	• Students explore career opportunities in Careers in Agriculture and Natural Resources • Future of Agriculture resource focuses on new careers in agriculture • Soil microbes plating in a starch medium using iodine to observe the microbe activity • Calculate the carbon sequestration capabilities through sampling a soil and measuring the soil organic carbon concentration. A soil carbon measurement can be performed through soil burning. See this video for an example methodology: Soil Science 3. Measuring Soil Moisture and Organic Content. NOTE: This is a very high-level data simulation and lab exercise.	

10.	**Post Assessment:**	Estimated time: 50 minutes
	HS-Regenerative Ag (Western WA) Post Assessment **HS-Regenerative Ag (Western WA) Assessment Rubric**	

Teacher Resources

HS-Regenerative Ag (Western WA) OER Tracker

Pacific Education Institute would like to acknowledge and thank the writing team for their work. The team included Megan Rivard, Madison Crow, Chris Stone and Michelle Townshend. In you have comments or questions please contact info@pacificeducationinstitute.org

Funds for this project were provided by the Washington Office of Superintendent of Public Instruction (OSPI).