Earth Systems in my Ahupua'a

NGSS Curriculum Unit
Hawaii DOE Standards for Grade 5

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Unit Overview and Alignment with Standards

Students learn about their ahupua'a from past to present as a system with interacting subsystems: the atmosphere, hydrosphere, geosphere and biosphere. The carbon cycle is used to illustrate how the spheres interact with each other. Only in the last few thousand years, humans have affected Earth systems in Hawaii. Polynesian/Hawaiians first introduced around 28 plants and 4 animals and transformed the landscape in sustainable social ecosystems based on ahupua'a land divisions. This system was changed after the arrival of Europeans who used local natural resources for extraction overseas and introduced hundreds of plants and animals. The system was further changed by human interference in the carbon cycle through use of fossil fuels. Students will use what they have learned about Earth Systems and the carbon cycle in their ahupua'a to design a plan to make their ahupua'a more sustainable.

Lessons 1-3. NGSS Standards.

Science & Engineering Practice	Disciplinary Core Ideas	Cross-Cutting Concept(s)
5-ESS2-1. **Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.** [Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.]		
Developing and Using Models Develop a model using an example to describe a scientific principle. (5-ESS2-1) **Obtaining, Evaluating and Communicating Information** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. **Using Mathematics and Computational Thinking** Use computation and mathematics to analyze data and compare alternative design solutions.(5-ESS2-2)	5-ESS2.A: **Earth Materials and Systems** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2, ESS3-1) **Energy and Matter** Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) **Patterns** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Lesson 4. NGSS Standards.

Science & Engineering Practice(s)	Disciplinary Core Ideas	Cross-Cutting Concept(s)
5-ESS3-1. **Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.**		
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5-ESS3-1)	**ESS3.C: Human Impacts on Earth Systems** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)	**Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2) **Connections to Nature of Science Science Addresses Questions About the Natural and Material World** Science findings are limited to questions that can be answered with empirical evidence. (5-ESS3-1) **Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1), (5-ESS3-1)

Lesson 5. NGSS Standards.

Science & Engineering Practice(s)	Disciplinary Core Ideas	Cross-Cutting Concept(s)
3-5-ETS1-1. **Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**		
Asking Questions and Defining Problems Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	**ETS1.A: Defining and Delimiting Engineering problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	**Influence of Science, Engineering, and Technology on Society and the Natural World** People's needs and wants change over time, as do their demands for new and improved technologies.

Building Toward Hawai'i Content & Performance Standard(s) III [HCPS III]
http://165.248.107.74/hcpsv3/

ENGLISH

Lesson 1, 2 & 4
CCSS.ELA-LITERACY.W.5.4 Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience. (Lesson 1,2,4) **CCSS.ELA-LITERACY.W.5.8** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (Lesson 2,4)
Lesson 2 & 4
CCSS.ELA-LITERACY.W.5.10 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. (2,4) **CCSS.ELA-LITERACY.W.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research.

MATH

Lesson 3
CCSS.MATH.5.OA.1 Use parentheses, brackets, or braces in numerical expressions and evaluate expressions with these symbols. CCSS.MATH.CONTENT.5.NBT.A.3 Read, write, and compare decimals to thousandths.
Lesson 3 & 5
CCSS.MATH.CONTENT.5.NBT.A.1 Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left. CCSS.MATH.CONTENT.5.NBT.A.4 Use place value understanding to round decimals to any place. CCSS.MATH.CONTENT.5.NBT.B.7 Add, subtract, multiply, and divide decimals to hundredths, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.

SOCIAL STUDIES

Lessons 1 - 5
Anchor Standard 13. Geographic Representations: Spatial Views of the World • Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions and their environmental characteristics. • Use maps of different scales to describe the locations of cultural and environmental characteristics.
Lesson 4 Social Studies Extension
Anchor Standard 14. Human-Environment Interaction: Place, Regions and Culture • Explain how the cultural and environmental characteristics of places change over time. **Anchor Standard 15. Human Population: Spatial Patterns and Movements** • Explain how human settlements and movements relate to the locations and use of various natural resources. **Anchor Standard 17. Change, Continuity and Context** • Compare life in specific historical time periods to life today.

Strengthening Nā Hopena Aʻo and ʻĀina Aloha Competencies

HĀ: BREATH
ʻĀina Aloha Competencies (OHE 2021).pdf

Sense of Belonging. As a result of learning more about the place in which they live and through an understanding of the lineage and connections to the past, present, and future, students stand firm in their space. Concepts of the water cycle and the four spheres in Earthʻs System are ever-repeating, just as the cycles and systems of the passing of knowledge. Through a deepened understanding of these cycles and systems, students are prepared to make responsible choices that respect and preserve culture and nature for future generations.

Sense of Responsibility. Students learn how their choices affect the environment around them now and how these choices affect the future.

Sense of Excellence. Students pursue the skills and knowledge that encourage them to reach their full potential through collaborative dialogue, project-based learning, and the stewardship of classroom, school, and community relationships.

Sense of Aloha. Students practice empathy, appreciation, and build trust for the symbiotic relationship between people and the natural world. Students care and respect for themselves, families, and communities as they learn about how the choices they and other humans make affect the environment in which they live.

Sense of Total Well-being. Students demonstrate principles of well-being and how to make
choices for the wellness of humans and their planet in terms of sustainability and pollution.
Sense of Hawaiʻi. As students learn about Hawai'i's unique features, a sense of Hawaiʻi is demonstrated through an appreciation for its rich history, diversity, language, and culture. Students will think critically about the resources of our island chain and how to best manage them through:

a. Use of ʻOlelo Hawaiʻi.
b. Place names, stories, special characteristics, and the importance of places in Hawaiʻi.
c. Hawaiian traditional world view and knowledge in contemporary settings.
d. Sharing of moʻolelo; histories, stories, cultures, and languages.
e. Compare and contrast different points of view and appreciate the cultural and scientific concepts unique to Hawaiʻi landscapes.

LESSON 1. What earth systems are present in my ahupua‘a?

Phenomenon: Something happens when you put hot water in a plastic bag.

Lesson components:

- Observe experiment that models the hydrosphere.
- Learn that scientists divide the earth into four connected systems.
- Identify and color the hydrosphere, geosphere, atmosphere and biosphere on a model.
- Record new vocabulary and concepts on worksheet.
- Optional - draw a model of the water cycle.

Student outcomes:

- Students identify the four earth systems in our ahupua‘a and in the world. Students observe how water changes form.

NGSS:
Performance Expectation: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
DCI: Earth Materials and Systems
CCCs: Systems and System Models; Energy and Matter
SEP: Developing and Using Models

Teacher Preparation

1. Earth systems explained with a Hawai‘i focus Appendix 2 (covers entire unit) https://docs.google.com/document/d/1-LJLwm234nDm5wCd9rFZYmztTs9Kx1-o4pCfxQy7Agg/edit?usp=sharing
2. Video detailing how to model the phenomena (2 min.) https://youtu.be/S1OzY6dBJ5w
3. NGSS video on system models (8 min.) https://www.youtube.com/watch?v=8kj__V8ehDU

Materials for Each Class

Large gallon size Ziplock bag or plastic wrap
Large clear glass container
Hot water – be mindful of student proximity for safety
Large piece(s) of ice
Baggie filled with dirt or sand
Computer with internet access
Projector to display computer screen

Materials for Each Student

Student Worksheet 1 - Earth Systems table
Student Model 1- Four Spheres
Student Model 2 - Water Cycle
Colored pencils or crayons

Preparation of Materials

Water should be heated before the experiment if the teacher does not have access to hot water in the classroom
Form dirt or sand in a plastic bag into a small hill against the side of the bowl

Learning Plan: 1.5 hours

Introduce Unit

Use Lesson 1 slides (modify as desired) or write phrases on a whiteboard or chart paper as you go through the lesson.
Say, "Today we are going to start learning about the Earth's systems. Review the term system. Review the term ahupua'a. Our Essential Question is: What earth systems are present in our ahupua'a? We will be able to: explain the four earth systems in our ahupua'a and in the world. It is important because: (ask for student answers) knowing about our ahupua'a helps us take care of where we live, so we can study where we live, so we can be scientists, so we can solve problems in our careers, etc."

Key terms

System. The universe is so big and complicated that scientists break it into smaller parts, called systems, to study. Systems have parts that interact together, and may have energy and matter coming into the system and going out of the system. Because of this, they may interact with other systems. An animal can be a system, a machine can be a system, or a galaxy can be a system (like the solar system).

Model. Scientists, engineers and mathematician use models to answer their questions/wonders. A model is a simplified representation of a system that can explain and help make predictions regarding phenomena. Scientific models can include diagrams, physical replicas, mathematical representations, analogies (like labs), and computer simulations. What models have you seen?

Ahupua'a. This is a traditional Hawaiian land division that usually runs from the mountain summits to the outer edge of the ocean reefs. Residents have rights to resources only within their own ahupua'a.

The hydrosphere is the ice, water vapor, and liquid water in the atmosphere, ocean, lakes, streams, soils, and groundwater.

The geosphere includes a very hot and mostly metallic inner core; a mantle of hot, soft, solid rock; and a crust of rock, soil, and sediments.

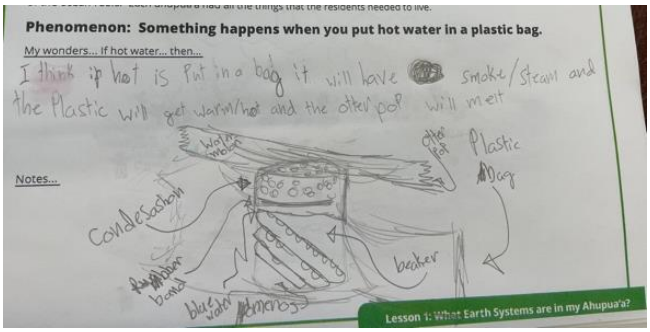
The atmosphere is the envelope of gas surrounding the planet.

The presence of living organisms of any type defines the biosphere; life can be found in many parts of the geosphere, hydrosphere, and atmosphere. Humans are of course part of the biosphere, and human activities have important impacts on all of Earth's systems.

Engage (Whole Group)

Phenomenon: Something happens when you put hot water in a plastic bag.

1. Tell the students that you have something to show them today and need their help to answer a question.
2. Show students your materials: see through glass bowl, hot water, ziplock bag, and bag of dirt/sand.
3. Ask: If I pour hot water in the bowl and seal the bowl in the plastic bag, then what do you think will happen?
4. Answers may be recorded on chart paper, whiteboard, or in student workbooks in response to the prompt: "I wonder…" Alternatively, they could make "if … then" prediction statements, if they have learned the scientific method.



Explore (Guided Instruction)

1. Press the bag of dirt/sand against one side of the bowl.
2. Pour the hot water in the bowl. All water evaporates, but hot water evaporates faster.
3. Cover the bowl with the plastic bag and seal it. (If you use plastic wrap instead, you will need a large rubber band or string to get a good seal.)
4. Put ice (or a frozen otterpop) in the center of the plastic covering. Have students observe what is happening and respond to the following or similar prompts:

https://youtu.be/S1OzY6dBJ5w

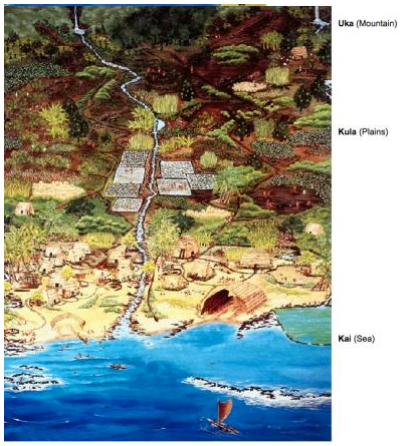
What do you notice?
What do you see?
What is the water doing?
What is happening inside the bag? Can you see clearly now? Why?
What do you think will happen next?
Do you notice any changes to the top of the plastic wrap?
What is happened to the water that has collected there?
Does this remind you of anything you know?
What happened to the dirt/sand? What does this remind you of in real life?
How is this experiment like a model of the earth?
If this was happening where our school is, what would each part of the model represent?

Students respond that the experiment is like the Earth because the water in the bowl was like the ocean, lakes, or rivers, and the steam that formed was like the beginning of clouds, and the droplets on the top of the plastic bag were like clouds before it rains, and the drops falling onto the dirt was like rain coming down. This is called the water cycle. It repeats over and over again continuously.

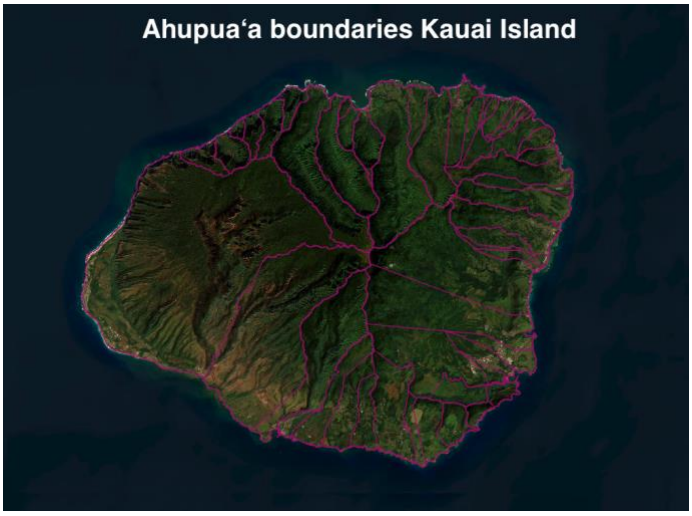
Tell students: Particles that make up water vapor can't be seen, but combine to form things we can see. What particles couldn't be seen in this investigation? Were they there? (Yes.) How do you know? (We could see clouds forming. The air got obscured. Water vapor [gas] formed into condensation on the plastic.)

Ask students: Why is the water flowing downward on the bag of dirt (mountains) to the water in the bowl (ocean)? (The gravitational force exerted by Earth on the water pulls the water downward toward Earth's center or the lowest point in the land. The flow creates rivers and streams. Where water collects if it does not make it to the ocean creates lakes, ponds, and reservoirs).

How has water affected where people have settled? Show maps of differently shaped ahupua'a and note they all have water sources from mountain watersheds and ocean access. Note how Hawaiians used the effect of gravity on water for their irrigation systems. This ties to **5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.**

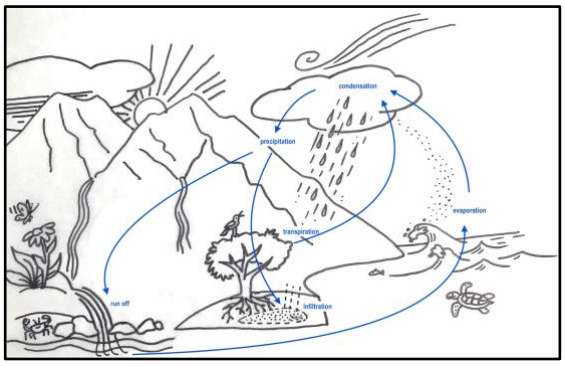


https://sites.google.com/site/mrmartinson7ss/the-ahupua-a



OPTIONAL

Possible expansion to cover **5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen but even then the matter still exists and can be detected by other means.** The NGSS standards to teach the water cycle fall in 6th grade, so teachers can choose to skip unfamiliar vocabulary and the details of the water cycle. Or, to cover 5-PS1-1 teachers can expand on this experiment and teach the water cycle**.** Two optional worksheets for a model of the water cycle are provided.



The previous demonstration is missing first-hand observation of infiltration which can be shown outside by pouring a glass of water onto the ground. Also missing is a first-hand observation of transpiration which can be seen by putting a plastic bag in advance over a leaf near the classroom, and then going to observe the water droplets formed on the inside of the bag. Use a pencil to complete *Model 2 Water Cycle*. Label evaporation, condensation, precipitation, runoff, groundwater infiltration and transpiration. Draw arrows showing the direction of the cycle. Two options of the worksheet are provided, one is blank while the other has boxes for labels and has lines that just need an arrow head to indicate direction. The cut out in the drawing showing an underground water reservoir may need clarification. Additional materials to cover **5-PS1-1** can be found at this link:

https://www.acs.org/content/acs/en/education/resources/k-8/inquiryinaction/fifth-grade/chapter-1-investigating-matter-at-the-particle-level/lesson-1-4--the-water-cycle.html

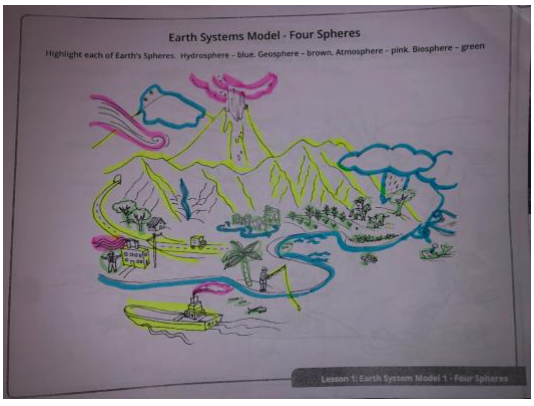
Explain (Guided Instruction)

1. **HYDROSPHERE.** Tell students that all the water on earth, in all of its forms, is called the hydrosphere. State the objective: we are going to learn about the hydrosphere and make a map of the names of the parts of the hydrosphere where we live. They learn the vocabulary for the hydrosphere and take notes on *Worksheet 1*.

Earth Systems Worksheet #1

System	Hydrosphere	Geosphere	Atmosphere	Biosphere
Meaning	water	earth	air	life
Scientist	hydrologist	geologist	aerologist	biologist
What it is made of	Water, snow, ice, water vapor	Molten and hard minerals - rocks and metals	Nitrogen 78%, Oxygen 21%, Argon 1%, Carbon dioxide 0.4%, trace gases	Plants, animals, bacteria, fungi
Where it is found	On the surface (lakes, rivers, ocean), underground (reservoirs), in the air	In the hot, liquid core, the hot soft mantle and the cool hard crust	6,000 miles above earth towards space	Sky, on the surface in the dirt or in the ocean
Characteristics of the system	Less than 3% is fresh water - 2/3 of that is in glaciers. Living things need water. Person = 66%. Tomato = 95%. Fixed amount of water cycles. - evaporation (ocean to sky) - condensation (clouds) - precipitation (rain) - surface run off (river to wetland / ocean) the rest is trapped by forests - infiltration (into the ground and creates ground water) - Transpiration (plants to the atmosphere - one tree 70 gallons/day. takes energy which is why it feels cool in a forest.) Water that percolates through soil and rock goes into an aquifer underground.	Includes solid rocks that make mountains on the earths hard outer crust and the hot molten liquid rock (magma) under the crust in the earth's core and mantle. Minerals are the building blocks for rocks and metals like iron, aluminum, copper, gold, lead, silver, zinc. Small amounts of these minerals are important for the health of plants and animals. Fossil fuels were created millions of years ago when living things got trapped under soil or water and pressured and heated. Plants turned to coal and marine plankton turned to oil and gas. They are called fossil fuels.	The atmosphere protects the earth from solar UV radiation and asteroids. Some trace gases and water vapor are called greenhouse gases because they absorb and emit heat radiation. This makes it warm enough on earth for living things. All weather happens in the atmosphere. When air is heated or cooled, it moves as wind. Air is polluted by natural sources like volcanoes or fires and human sources like burning fossil fuels. Polluted air harms animals and plants.	Includes living and dead plants and animals on land, in soil and in ocean. Small life (plankton, bacteria and fungi) play important roles in food webs and food chains. Organisms have roles as producer, consumer or decomposer. When living things have decomposed or burned (combusted) they are no longer part of the biosphere. Living things that arrived before humans are native. Many evolved in isolation to be new endemic species.

Worksheet 1 – details up to teacher



Model 1 – student work

Students identify the parts of the hydrosphere in *Model 1 Four Spheres* and highlight them with a blue crayon. This could be done when you get to “where is it found” on the worksheet.

Underline “Hydrosphere” on *Worksheet 1* with your blue crayon. Review some facts about the Hydrosphere. If it has already been taught, you can refer to what was learned in **5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.** Less than 3% is fresh water - 2/3 of that is frozen in glaciers. Living things need water. People are 66% water and tomatoes are 95% water. Since the earth was formed, no new water has been created and no water has been lost. It just changes form as it goes through the water cycle: water vapor, clouds, rain, run off to the ocean, and water stored underground.

2. **GEOSPHERE.** Tell students: The surface the water is flowing on is part of another sphere, and we are going to see how it is formed in Hawai‘i. Show dramatic video (less than 2 minutes) of recent Hawai‘i volcanic eruption.
https://www.usgs.gov/media/videos/kilauea-volcano-morning-overflight-june-19-2018

Ask students: How does what you saw in the video relate to the formation of the Hawaiian Islands? The islands were formed by a “hot spot” under the ocean floor which created one island at a time through volcanic eruptions as the Earth’s crust moved over that spot.

Tell students: The geosphere is another earth system which includes the hot mantle where the lava comes from and the hard outer-crust of the earth that we usually see. They review that the prefix *geo-* means *earth*. They learn the vocabulary for the geosphere and take notes on *Worksheet 1*. Identify the parts of the geosphere in *Model 1 Four Spheres* and highlight them with a brown crayon. Underline “Geosphere” on *Worksheet 1* with your brown crayon.

How does the way Hawai‘i was formed affect the geosphere here? Other places have many types of rock and metals, Hawai‘i is mostly basalt rock made from lava. This type of rock is also what we see in black sand beaches. There are some cliffs near shorelines that are made of limestone formed from the ocean floor. These same materials that are in limestone - broken up shells and coral - form our white sand beaches. The very liquid lava here also formed our sloped (not steep) volcanoes. The geosphere can change quickly with a volcanic eruption, but it mostly changes slowly due to interaction with the hydrosphere.

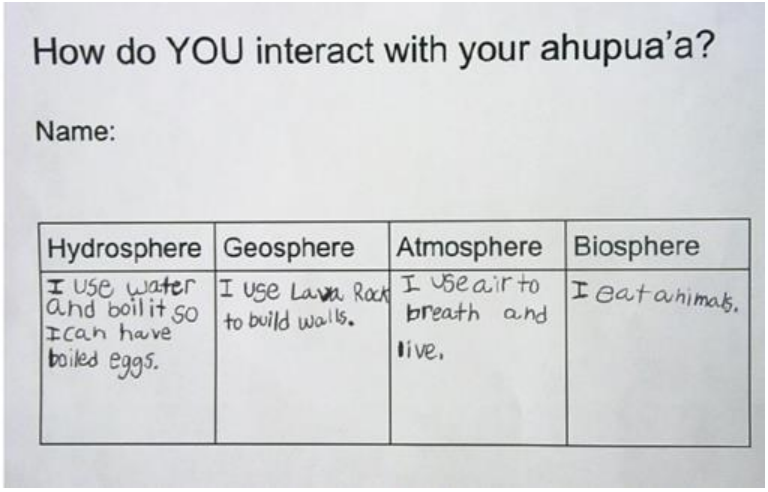
Because the continents were formed from different processes, by the crust getting pushed up along fault lines, and they were formed much earlier than Hawai‘i, they have different substances in their geosphere. They have metals like iron, aluminum, copper, gold, lead, silver, zinc. Small amounts of these minerals are important for the health of plants and animals. They also have fossil fuels were created millions of years ago when living things got trapped under soil or water and then pressured and heated. Plants turned to coal and marine plankton turned to oil and gas. They are called fossil fuels. Because they do not exist in the Hawai‘i geosphere, we import some stone to build with, metals and fossil fuels.

Ask students: How does the hydrosphere interact with the geosphere landforms around us? The water creates mountains, valleys, deltas...through **erosion** and **weathering**. You may review the concepts of erosion and weathering taught in 4th grade.

3. **ATMOSPHERE**. Tell the students they are going to do something to figure out what the next sphere is. Ask them to blow on their hands. Did you see anything on their hand when your blew? No. Did you feel anything on your hand? Yes. Explain that even though air is made of gases that are made of particles too small to be seen, we know it is there because we can feel it. The gases that make up air are held to earth by gravity and protect us from sun's UV radiation and keeps the earth from being as cold as outer space by trapping some of the heat radiation created when the sunlight hits the surface of the earth. Most of the gases are within 10 miles of the earth's surface, though the official boundary to space is defined often as 62 miles high. Does anyone know what this layer of air is called? They learn the vocabulary for the atmosphere and take notes on *Worksheet 1*. Identify the parts of the atmosphere in *Model 1 Four Spheres* and highlight them with a purple crayon. Underline "Atmosphere" on worksheet 1 with your purple crayon.

4. **BIOSPHERE.** Ask the students: Which sphere do you think has not been highlighted yet on our model? Animals and plants. The biosphere is all living things, including plants, animals, bacteria and fungi no matter where they are found - in the air, on land, in the soil or in the water. Even when they die they are part of the biosphere until they decompose or are burned. Make connections to the food web If you have taught **5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.** They learn the vocabulary for the biosphere and take notes on *Worksheet 1*. Identify the parts of the biosphere in *Model 1 Four Spheres* and highlight them with a green crayon. Underline "Biosphere" on *Worksheet 1* with your green crayon.

OPTIONAL Assessment



How do YOU interact with your ahupua'a?

Name:

Hydrosphere	Geosphere	Atmosphere	Biosphere
I use water and boil it so I can have boiled eggs.	I use Lava Rock to build walls.	I use air to breath and live.	I eat animals.

Next Lesson...Where we're going

We will explore a map of our ahupua'a and elements of the geosphere, hydrosphere and biosphere. We will see the relationship between the watershed(s) and boundaries of our ahupua'a. We will learn the names of the rains and the winds in our ahupua'a.

LESSON 2. What can I learn about my ahupua‘a from GIS maps, and from Hawaiian names of places, rains and winds?

Phenomenon: Maps showed the world from above, even when people could only see the world from the ground.

Lesson components:

- Explore GIS map to identify my ahupua‘a and elements of the geosphere, hydrosphere and biosphere in it
- Complete Worksheet #2
- Identify Hawaiian place names and landforms in the my ahupua‘a
- Mo’olelo about place names

Student outcomes:

- Students interpret layers on a GIS map.
- Students know the meanings of Hawaiian names connected to their ahupua’a.

NGSS:
Performance Expectation: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
DCI: Earth Materials and Systems
CCCs: Patterns
SEP: Obtaining, Evaluating and Communicating Information

Teacher Preparation

Before class, explore the GIS maps and layers at http://arcg.is/1Tnzr4

Identify resources or gather information on local place, rain and wind names, and mo’olelo.

Place names:

- Background information about place names https://www.papahanaumokuakea.gov/heritage/kapainoa.html
- Place Names of Hawai‘I by Mary Kawena Pukui, Samuel H. Elbert, & Esther T. Mookini. http://ulukau.org/elib/collect/pepn/index/assoc/D0.dir/book.pdf

Rain and wind names:

- Winds and Rains of Hawai‘iWebquest (full document) http://www.webquest.hawaii.edu/kahihi/webquests/topical/energy/SC6.6.2wind/extras/HawaiiWind&Rain.pdf
- Hanai Ka Ua: Hawaiian Rain Names by Collette Leimomi Akana with Kiele Gonzalez, Kamehameha Publishing.

http://www.ksbe.edu/imua/article/haanau-ka-ua-hawaiian-rain-names-educates-and-inspires/

Mo'olelo:

- No ka wai o ka Puna Hou (How Punahou Got its Name) Full text / illustrations http://www.ulukau.org/elib/collect/punahou2/index/assoc/D0.dir/book.pdf
- Mo'olelo for different ahupua'a, all islands: https://blogs.ksbe.edu/alohaainaproject/mo'olelo/

Ahupua'a:

- From the Mountains to the Sea: Early Hawaiian Life by Julie Stewart Williams, illustrated by Robin Yolo Racoma. Chapter "Umi Divides the Land" pp. 9-28 http://ulukau.org/elib/collect/english/index/assoc/D0.dir/doc28.pdf
- Kumukahi website: http://www.kumukahi.org/units/ka_honua/onaepuni/ahupua'a

Materials for Each Class

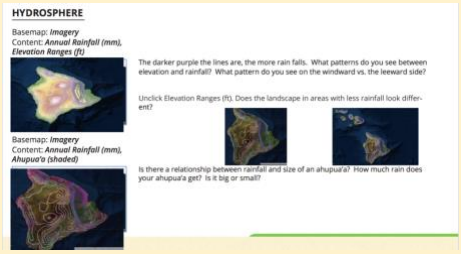
Equipment to view GIS maps – iPads are easier than computers
Internet connection
References for Hawaiian names and mo'olelo

Materials for Each Student

Worksheet 2 - My Ahupua'a

Preparation of Materials

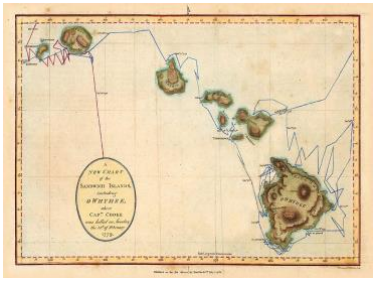
Adapt the worksheet to your ahupua'a by selecting the correct layers and taking screenshots, then pasting them over the island / ahupua'a image as needed. Sample teacher made for Hawai'i island shown here.
Research Hawaiian place names and mo'olelo for your ahupua'a to share with students.



Learning Plan: 2 hours 15 minutes

Use Lesson 2 slides (modify as desired) or write phrases on a whiteboard or chart paper as you go through the lesson.

Engage (Whole Group)



Phenomenon: Maps showed the world from above, even when people could only see the world from the ground.
http://www.printsellers.com/images/1784-harrison-sandwich_lg.jpg

Ask students what they wonder about the perspective of the old map, made before people started flying.
Answers may be recorded on chart paper, white board, or in student workbooks.

Tell the students: Now that we have learned what the earth systems are, we are going to look at our own ahupua‘a to learn what earth systems are here and how they help define the shape of our ahupua‘a. Maps are models of the earth’s surface that help us “see” patterns in data. **(**Looking from above from a distance allows us to see patterns better.) We are going to use a Geographical Information Systems (GIS) map. Geographical means physical features of an area. The GIS lets us observe and analyze different types of data collected on the physical features of an area.

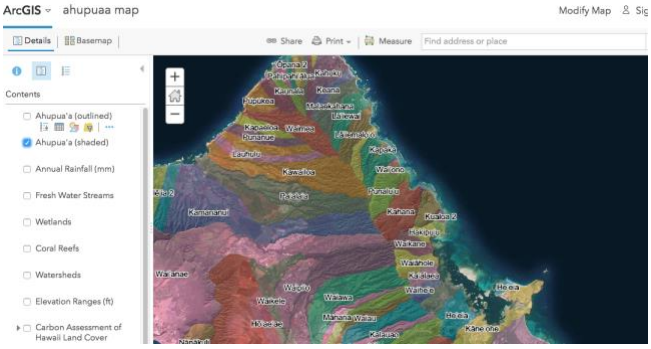
Explore

This lesson can take a long time and a class full of students doing the lesson at the same time may cause layers to load slowly. With good internet connection, all should load with no lag except the land cover layer which will load slowly once zoomed in sufficiently. Some students may have trouble navigating the unfamiliar technology. Some may want to spend time looking for their house, etc. Tablets are easier for students to use than laptops.

Strategies to reduce time and/or internet load:

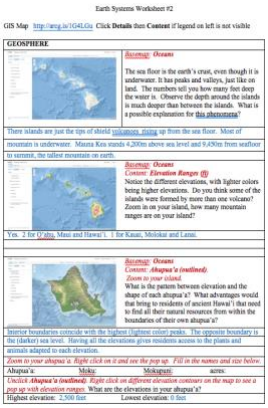
- Teacher shows the students the layers and what they mean, and then provides link for students to play with the layers at home the day before the lesson.
- Teacher projects their screen of the GIS map layers for students to view while they: fill out their worksheet independently, in groups or through class discussion.
- Teacher uses a smartboard to write directly on the maps.
- Groups complete entire worksheet.
- Groups are assigned a section of the worksheet to share out with the rest of the class after.
- Have stations with some students working on the maps while others work on other subjects so the internet is not overloaded.
- Do the first page as a class, then the rest on their own.
- Skip the worksheet for the Biosphere and/or place names.

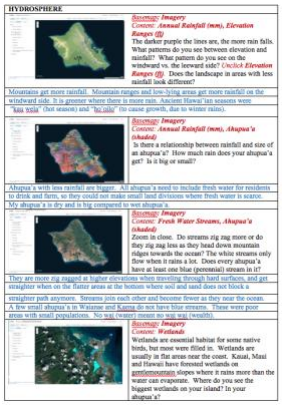
1.Open the GIS map.

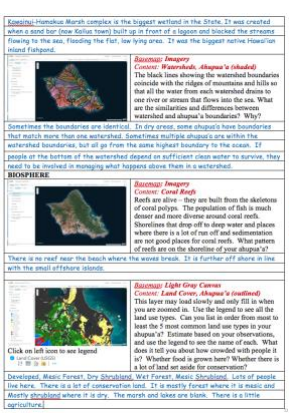


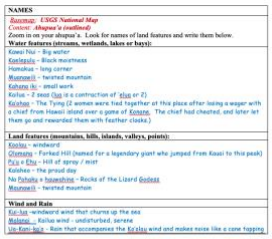
GIS MAP with Hawai‘i ahupua‘a and layers representing different Earth spheres.
Note: Click ‘Content’ (the square highlighted in blue) after the document opens.
http://arcg.is/1Tnzr4

2. Ask the students what they notice about the map. Students should say it is of Hawai‘i. It has their island and ahupua‘a, and there are different layers. Students should make the connection that the different layers represent different parts of spheres that are present in the ahupua‘a where they live. In this way, they connect science and culture. All layers are available for all islands with the exception of the shaded version of the ahupua‘a which is only available for Oahu.









Follow instructions on *Earth Systems Worksheet 2*. Review how to use the layers and then walk around to each student / group to make sure they understand. Students will look at the geosphere from ocean floor to mountain top. They will look at rainfall, streams, wetlands and watershed boundaries of the hydrosphere. They will look at landscape and coral reefs of the biosphere. For all spheres, they consider what is present in their ahupua‘a and how the spheres helped define the boundaries. Finally, they look for names of geographical features in their ahupua‘a.

Explain (Guided Instruction)

Go through worksheet questions orally together asking students to volunteer insights they wrote down. Add additional insights / information as needed. Students can make additions or changes to their worksheets.

Elaborate

The fourth page of the worksheet focuses on the names of the places, landforms, wind and rain in our ahupua’a. If you have a Kupuna Program at your school, consider involving

them is this part of the lesson. If possible, research and add the Hawaiian names for the winds, rains, landforms, and bodies of water in your ahupua‘a and include the names on your worksheet.

Share this ‘Olelo No‘eau with students:

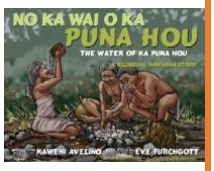
I Kama‘āina I Nā Makani A Me Nā Ua:
One is seen as a local native by one's knowledge of the winds and rains.

Question: Why do you think the early Hawaiians had so many names for different rains and winds. What is the significance of the Hawaiian names of places?

Answer: In old Hawai‘i the rains and winds were vitally important for survival. People were scientific observers of their environment and noticed the different features of rains and winds in different locations and the effects of these rains and winds. Many place names described important elements of the place that they were identifying, providing scientific and/or cultural information about that place. (Instead of being named after a famous person, etc.) If they did not know the winds and rains of their ahupua‘a they were considered a stranger (malihini) not a local (kama‘aina).

OPTIONAL

Mo‘olelo



Read short mo‘olelo about a place in the student’s ahupua‘a or island and how it got its name. A mo‘olelo, No Ka Wai O Ka Puna Hou/The Water of Ka Puna Hou, is provided for the ahupua‘a of Waikiki on Oahu if you are not able to find one for your ahupua‘a.

English extension - Opinion writing – 1 hour
Was the ahupua‘a system a good way to divide and manage the land? Why or why not? Use text evidence to support your opinion (informational text for article citation can be found in the sources listed above or another source). Write a multi-paragraph essay with an introduction paragraph, body paragraphs, and conclusion. Use a Thinking Map, Power Outline, or other graphic organizer to organize your ideas before you write. Edit and revise your work before submitting it.

More information about Standards Based Opinion Writing, as well as anchor papers can be found at:

https://portal.smarterbalanced.org/library/en/ela-g5-service-animals-annotations.pdf
https://portal.smarterbalanced.org/library/en/performance-task-writing-rubric-opinion.pdf
https://portal.smarterbalanced.org/library/en/g5-ela-practice-test-pt-scoring-guide.pdf

Next Lesson...Where we’re going
We will learn about the carbon cycle, including sources of carbon and carbon sinks.

LESSON 3. How do earth's systems interact in my ahupua'a?

Phenomenon: It is wetter on the windward side of all the islands.

Lesson components:

- Wind patterns and rainfall – video clips of Hawai'i winds
- Video on carbon cycle
- Complete Model 3 - Carbon Cycle
- Identify carbon sources and sinks in my ahupua'a
- Interactive carbon cycle activity
- Optional Math extension

Student outcomes:

- Students know a physical interaction between spheres.
- Students know a chemical interaction between spheres.
- Students make a model of the carbon cycle.
- Students identify carbon sources and carbon sinks in their ahupua'a.

NGSS:
Performance Expectation: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
DCI: Earth Materials and Systems
CCCs: Systems and System Models; Energy and Matter; Cause and Effect; Patterns

- SEP: Developing and Using Models; Using Mathematics and Computational Thinking

Teacher Preparation

- Earth systems explained with a Hawai'i focus Appendix 2 (covers entire unit) https://docs.google.com/document/d/1-LJLwm234nDm5wCd9rFZYmztTs9Kx1-o4pCfxQy7Agg/edit?usp=sharing
- This (former) EPA video explains the carbon cycle. 4.22 minutes. https://archive.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html
- Watch video of enactment. Read through the instructions.

Materials for Each Class

Video of wind patterns
Hawai'i sphere cards - found in Appendix p 46-49 or at this link:
http://healthyclimatecommunities.org/wp-content/uploads/2018/10/Sphere-sorting-cards.pdf
3 different sized containers (buckets or boxes?)
25+ balls or other small classroom object like markers, erasers, paper balls

Materials for Each Student

Model 3 – Carbon Cycle
Worksheet 3 – Carbon Flux and Storage

Preparation of Materials

Print and cut Hawai‘i sphere cards
Get wind and carbon video links and images ready for projection
Gather the balls or other plentiful objects in a clear bag
Label the containers with images or words: smallest – Forests; medium - Coral & Shells; biggest - fossil fuels & limestone

Learning Plan: 2 hours

Engage

Print and cut Hawai‘i sphere cards. Label each corner of the classroom with one sphere. Give each student (or pair) a card. Ask students to go to the corner their image represents. If they are not sure, they should go to the middle of the classroom. Alternatively the teacher can project one image at a time and all students can walk to the label where they think it belongs.

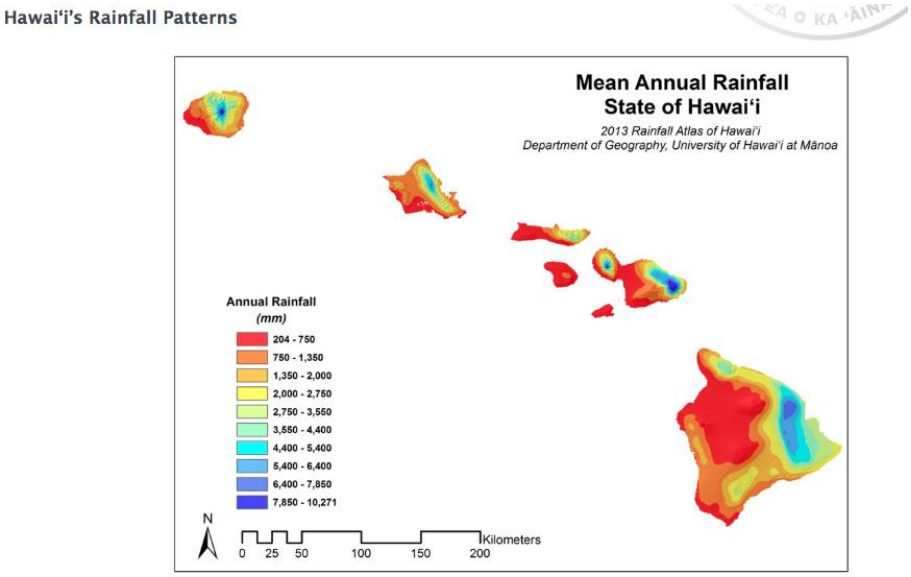
Alternatively have groups arrange a set of cards at a table.

Is more than one sphere present in the images of those on the middle? Why is it hard to capture images of just each sphere by itself?

Each of the 4 spheres is a system that interacts with all the other spheres. Examples already covered:
The geosphere channels the flow of precipitation from the hydrosphere and that flow in turn slowly re-shapes the geosphere.
Plants from the biosphere take in water from the hydrosphere through their roots and release it to the air as water vapor through transpiration.

Use Lesson 3 slides (modify as desired) or write phrases on a whiteboard or chart paper as you go through the lesson.
Say, “Today we are going to learn interaction between Earth’s systems. Our Essential Question is: How do earth’s systems interact in our ahupua‘a? We will be able to: explain a physical way the spheres interact to form our weather, and a chemical way they interact to support life in our ahupua‘a.

Phenomenon: It is wetter on the windward side of all the islands.
Show students picture of the Mean Annual Rainfall in Hawai‘i.



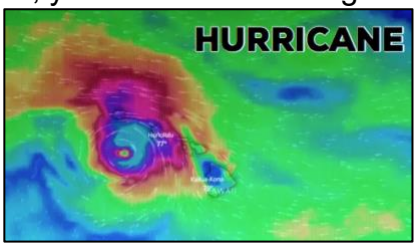
Map of Average Yearly Rainfall:
Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013: Online Rainfall Atlas of Hawai‘i. *Bull. Amer. Meteor. Soc.* 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1.
http://rainfall.geography.hawaii.edu/rainfall.html

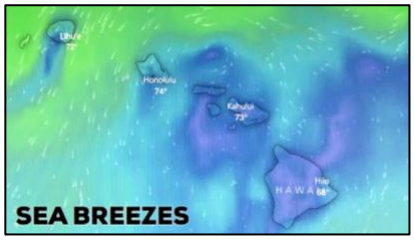
What do you notice? What questions do you have about the phenomenon? Answers may be recorded on chart paper, white board, or in student workbooks.

Explore

Question: How do the atmosphere, the hydrosphere and the geosphere interact to make it wetter on the windward side?

In the GIS maps there were no layers that represented the atmosphere. These models represent more than one point in time, and they track patterns of air moving (wind) which allows us to “see” the atmosphere.
Look at 30 second video
https://www.youtube.com/watch?v=Sd7WIf1vJ0o&feature=youtu.be
of three different wind patterns (source windy.com). Which pattern do you think we are experiencing today? Go to windy.com (if internet is available) to check.
*Blue is still, green is usual wind, yellow to red is stronger winds.





Explain

The most common wind pattern in Hawai‘i is trade winds. We call them “trade winds” because trading vessels used to rely on them to sail their routes. The trade winds are caused by a consistent circular pattern of air (atmospheric eddy) to the northeast of Hawaii, called the North Pacific High. The North Pacific High moves north in the summer making the trade winds stronger and more persistent that time of year. In the winter when it moves south, trade winds may be interrupted and we get light sea breezes or southwest “Kona” winds.

Ask them to recall what they learned about the water cycle and to think how the trade winds (atmosphere), and the mountains (geosphere) might cause the rain pattern (hydrosphere) we saw on the GIS map:

1. Evaporation forms water vapor over the ocean.
2. The water vapor is carried by wind over the land.
3. When the warm, moist air lifts over the windward coasts and slopes it cools.
4. Since cool air can hold less moisture, it condenses, forming clouds and rain.
5. When the air goes down the mountain on the Leeward side, it tends to be dry.

Explain that these are physical interactions between the spheres that we can see and feel. However, there are also important interactions where matter passes between the spheres and transforms in ways we can’t see or feel.

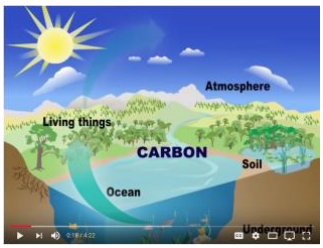
Guided instruction

Question: How do the spheres interact in a way that we can’t see?

1. Explain. These are chemical reactions between substances in the spheres. Bonds between tiny molecules are rearranged to make new bonds that result in different molecules. (Ex. the gases H and O combine to form H_2O = water)

   We are going to learn about Carbon (C), which is the main ingredient of all living things. Similar to water, when the earth was formed there was a certain amount of carbon and no new carbon has ever been created and none has ever been lost. It goes in a cycle. As carbon goes through its cycle, it combines and separates from other substances through chemical reactions we can’t see.

   Each molecule of carbon is so tiny you can't see it. When a lot of carbon is together, we can see it. One example of this is graphite (pencil led), or when the graphite is compressed a LOT by nature, it becomes diamonds. Most of the time, carbon combines with other types of molecules and turns into completely different substances.

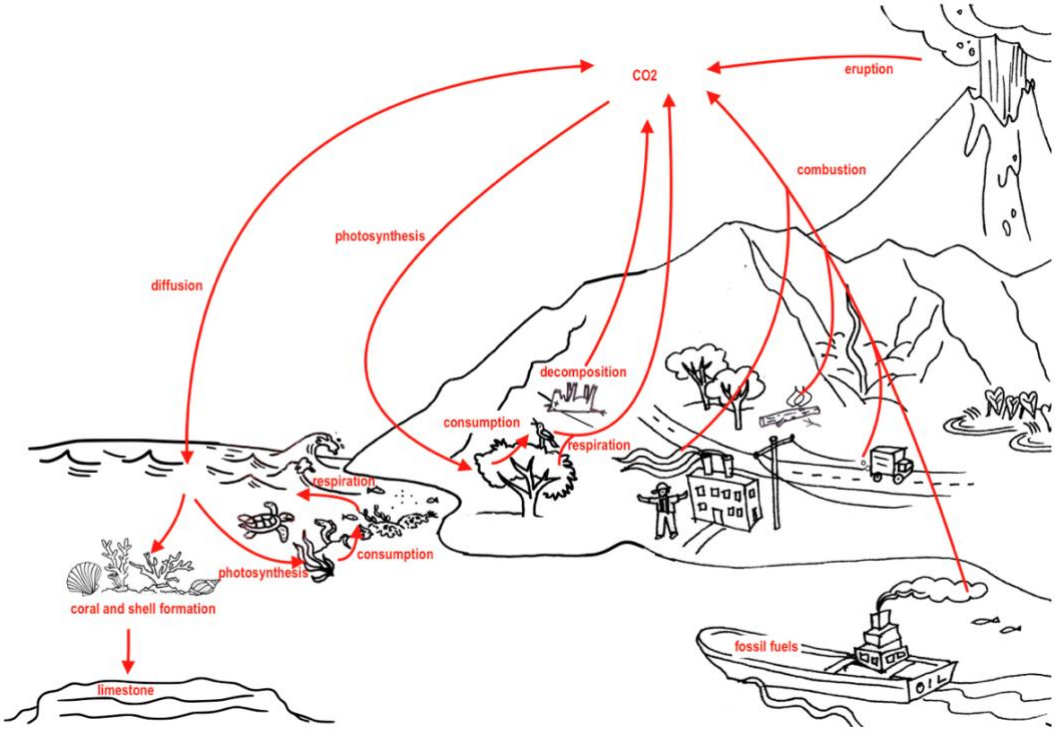


2. Watch video on the carbon cycle 4.5 minutes. It is a lot of information, but it will be reviewed again in the teacher-led discussion while filling in the model, and in the carbon cycle activity. https://youtu.be/vrDekmRbBVk

3. Take out the *Model 3 Carbon Cycle.* Tell the students you are going to go over the information about the carbon cycle from the video again together, and you are going to identify the ways it cycles through our ahupua‘a together as we discuss it and draw it

on our worksheets. Options of the worksheet are provided: blank, with boxes for labels, with lines or arrows. The students can write in the word or the number or glue on a printed label. A poster size model can printed and filled out together, then left up in the classroom for reference. Arrows can be color coded to indicate carbon being sequestered vs. emitted, or land vs. ocean cycles.

Draw a big CO2 in the atmosphere in the middle/ top of the page. This is where all your arrows of carbon emissions will come to.



BIOSPHERE. Carbon is the main ingredient in all living things when it mixes with Oxygen (O), Hydrogen (H) or Nitrogen (N). If you take the water out of us, we are 50% carbon (C), and plants are more. How do living things get C in them? Plants combine energy from the sun with water and **CO2** to make glucose, or sugar, which is food. This is called **photosynthesis.** Animals get the C in the glucose from eating plants or eating other animals that eat plants - **consumption**. When living things die, they store the carbon in the dirt. When they rot **(decomposition)** or are burned (**combustion**), they release the carbon back into the air. [all together deep breath in / out] We just breathed in air and took the O out and put it into our bloodstream, then combined it there with C from our food, and breathed it out as CO2, another way C gets back into the air. That is called **respiration**.

- Draw labels and arrows to show photosynthesis, consumption, decomposition, combustion and respiration of living things on land.

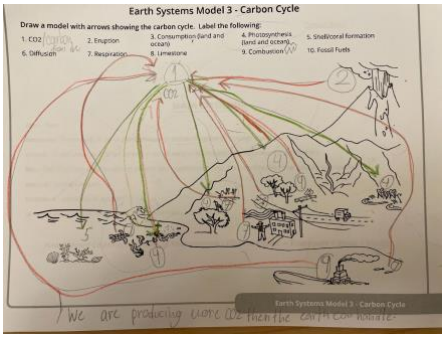
HYDROSPHERE. Carbon is in the ocean. How do you think it gets into the ocean? CO2 from the atmosphere **diffuses** back and forth between the air and the surface layer (2% of the carbon in the ocean), but some of it goes into the deep layer where it is more concentrated and stays a long time (98% of the carbon). Algae and marine plants get CO2 that is dissolved in the water to do **photosynthesis**. It is in their bodies, then other marine life eats them and it gets in *their* bodies (**consumption**) and when they die and **decompose** it ends up in marine deposits on the bottom. They may become limestone rock or fossil fuels (part of geosphere). Some animals get carbon from the water to **make**

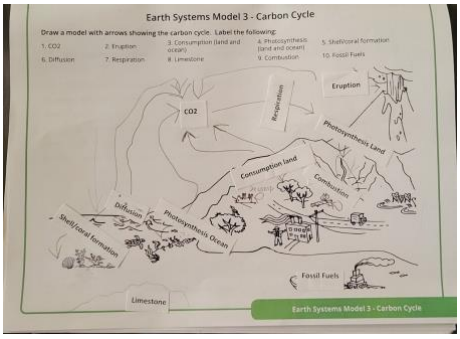
their shells and coral. When they die, they sink to the bottom and become **limestone**. Fresh water that runs into the ocean brings carbon when there are dead plants or animals in the water.

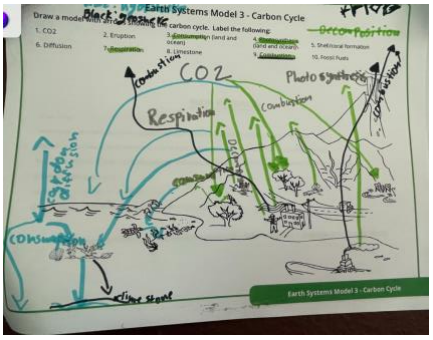
- Draw a label and an arrow to show diffusion between the ocean and the atmosphere.
- Draw labels and arrows to show photosynthesis, consumption, decomposition, and respiration in the ocean.
- Draw labels and arrows to show carbon being taken up by shells and coral.

GEOSPHERE. In the earth's crust, more than 99% of carbon is stored underground. 80% limestone and 20% is fossil fuels. **Limestone** is made from sea shells and dead coral. **Fossil fuels** are made from dead plants that were compressed and heated underground for millions of years to make coal (land plants) and oil or gas (marine plants). Some carbon is also released from molten rock during volcanic eruptions.

- Draw a label and an arrow to show limestone being made from coral and shells.
- Draw labels and arrows to show combustion of fossil fuels.
- Draw a label and an arrow to show release of carbon from a volcanic eruption.

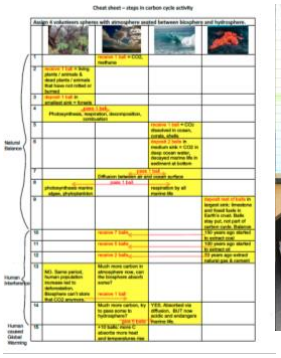






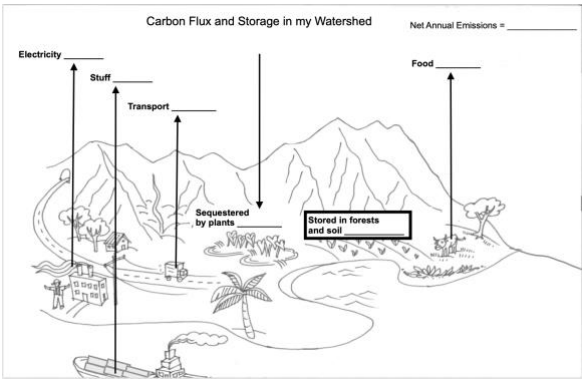
- CARBON SOURCES AND SINKS. All the things that put CO2 into the atmosphere are called carbon sources. All the things that take it out and store it away from the atmosphere are called carbon sinks. What sources and sinks do you see in the model of your ahupua'a? Do you have any other ideas that are not on the model? Which sources and sinks are people responsible for?
  Write your ideas down in your workbook. Underline the ones that people are responsible for. Share out as a class and allow students to add more to their workbook.
- Sources: burning wood and garbage; car, plane and boat engines; power plants and factories; cutting down trees; clearing forests for farming or development; volcanic eruptions, and draining wetlands.
- Sinks: forests, trees, soil, limestone, coral reefs, wetlands. In many parts of the world (but not Hawai'i) fossil fuels stored in the geosphere.

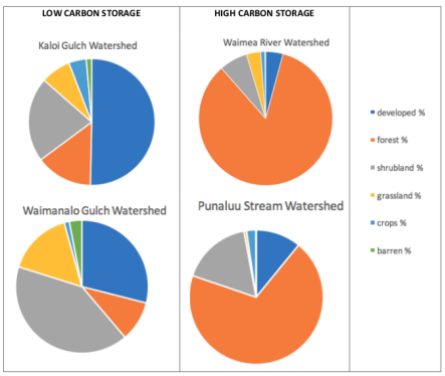
4. REVIEW. This model, a physical enactment, will review and reinforce concepts of the carbon cycle and carbon sinks, and highlight the impact of human interference in the carbon cycle. **It is amazingly effective – please try it.** Volunteers represent each of the 4 spheres. 3 different sized containers represent the carbon sinks found in the biosphere, hydrosphere and geosphere. A plentiful, small item in the classroom represents carbon. The "carbon" is passed back and forth between "spheres" and goes in and out of "sinks" while the teacher asks those observing to explain the process. Instructions and "cheat sheet" in the Appendix.



OPTIONAL

Math extension Scientists gather data and make estimates to quantify the **flux** (flows from one sphere to the other) of greenhouse gases and the amount of carbon **stored**. This data is necessary for people to design effective solutions. Every ahupua'a is in a major watershed. Real data on the watersheds on O'ahu is provided. *Consult the GIS map layer "major watershed" if you do not know which is yours. The data is displayed in 1,000 tons to the 2nd decimal place to best fit math standards.*





1. **Vocabulary.** Explain any new vocabulary and math concepts in the worksheet. Possible vocabulary to pre-teach/review: **flux, sequestered, stored, emissions, net, annual, emissions, acre.**

2. **Locate data and fill in worksheet**. Use Table 1 in Appendix to locate data to fill in Worksheet 3 with fluxes and a sink for your watershed. A flux is something that happens over a period of time – the amount of carbon sequestered in one year from the atmosphere, or the amount of carbon emitted in one year to the atmosphere. These will be shown with the arrows on your model. A sink is carbon that is stored for a longer period of time. This will be shown in a box on your model.

3. **Calculate** the net amount of carbon produced in your ahupua'a watershed. Just like in economics, net means the amount produced minus the amount spent, or in this case, sequestered. To calculate the net amount of carbon produced annually in your watershed, use this formula:
   Net Annual Emissions = Carbon Sequestered - (Electric Power + Transport + Food + Stuff)

4. **Discuss.** How would knowing the net amount of carbon produced in your ahupua‘a help scientists? What does the result tell you about the balance in your watershed? How does the Carbon Stored compare to Net Annual Emissions? What would happen to your Net Annual Emissions if you cut down the forests storing carbon?

5. **Read and compare data.** Look at the column showing carbon stored per acre. Why do you think the land on some watersheds stores more than others? See graphs in Appendix for clues. Areas with more forest (usually wetter and less urban) store the most. Where does your watershed fall within the range from low to high and why?

Next Lesson...Where we’re going... After learning about and understanding the way Earth’s spheres interact through the carbon cycle in my ahupua‘a, and the change caused by humans, I will learn the consequences of the change and how to reduce them.

LESSON 4. What are the negative effects of human interference in the carbon cycle and how can they be reduced?

Phenomenon: Air balloons and water balloons react differently to a flame.

Lesson components:

- View media on symptoms of climate change.
- Do cause-effect activity.
- Read media on solutions in Hawaii and discuss.

Student outcomes:

- Students know how human interference in the natural carbon cycle results in climate change.
- Students know some of the problems caused by climate change.
- Students know two actions being taken in Hawaii to solve climate change.

NGSS:
Performance Expectation: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
DCI: Human Impacts on Earth Systems
CCCs: Cause and Effect
SEP: Analyzing and Interpreting Data

Teacher Preparation

Watch video to prepare for the balloon demonstration.
Earth systems explained with a Hawai'i focus Appendix 2 (covers entire unit)
https://docs.google.com/document/d/1-LJLwm234nDm5wCd9rFZYmztTs9Kx1-o4pCfxQy7Agg/edit?usp=sharing

Materials for Each Class

Candle or long-reach lighter
2 balloons (plus extras)
Climate change cause-effect cards for each group
Computer with internet access
Projector to display computer screen

Preparation of Materials

Print and cut cards
Provide access to the articles in print or on a screen.
Fill one balloon with air and one with water.

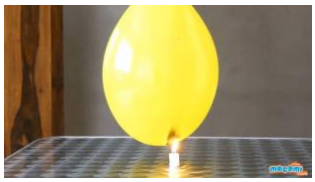
Materials for Each Student

Selected media pieces to read.

Learning Plan: 45 minutes

Phenomenon: Air balloons and water balloons react differently to a flame.

Use a candle or a lighter to demonstrate what happens when a balloon filled with air approaches the flame (it pops) and then a balloon filled with water approaches the flame (it does not pop). Watch the video to see how, or show the students the video (but not the explanation at the end) if you cannot do the demonstration yourself.
https://www.youtube.com/watch?v=0m-Lr4Z2drc



What do you predict will happen? Answers may be recorded on chart paper, white board, or in student workbooks. After observing, what questions do you have about the phenomenon?

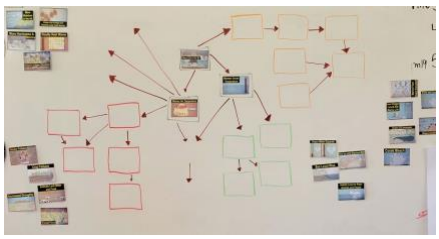
Obtain information from videos on the effects of climate change

Watch 3 very short animated videos one after the other. Maybe slow them down. Watch for different effects of having too much carbon in the atmosphere, and notice what causes what. It will help your group work after the videos.

1) intro
https://planetnutshell.com/portfolio/evidence-of-a-warming-planet/
2) land symptoms
https://planetnutshell.com/portfolio/climate-change-around-the-world/
3) ocean symptoms
https://planetnutshell.com/portfolio/climate-change-in-the-oceans/

Analyze Effects of Climate Change.

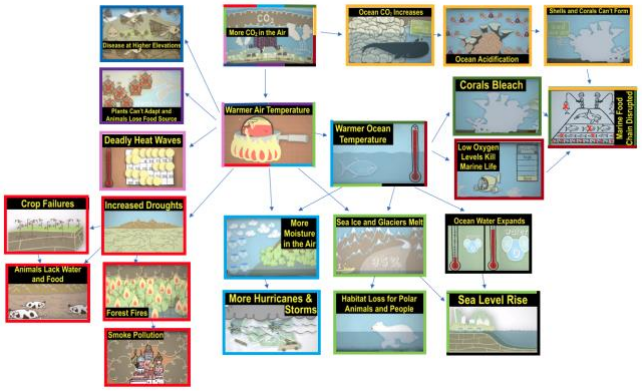
1. **Arrange 23 climate change cause-effect cards.** Based on what they learned in the videos (and what they already know), they need to arrange the cards into chains of cause and effect. Pick the options that best fit your class.



- Distribute cards to students and have them watch the videos again, listening for their card/s and how it fits in the cause-effect chain.
- Do the cards from each video before going on to the next video.
- Together as a class, stick cards on the white board with tape and draw arrows.
- Divide cards up among groups and have each group stick their set up and then present it to the class.
- Give each group a complete set of cards to put on poster paper and draw arrows, or to arrange on a table and create (28) arrows with string or some other product.
- Add arrows individually or in groups to one of the two provided worksheets.

Hints:

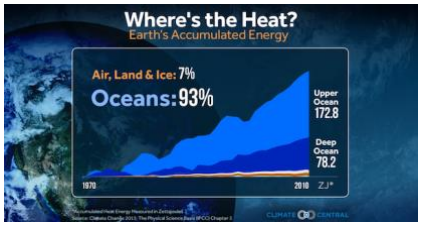
- The color coding of the frames indicates connections along chains of cause-effect.
- Arrange all the cards first, then add the arrows as you will need to shift them around to make room.
- Clusters that go together have matching colored borders to make it easier to sort.
- Start in the middle with the *earliest* cards in the chain (black borders) since cards will go from there in many directions.
- Some effects may have more than one cause.



2. **Discuss and correct.** Go through the cause effect relationships as a class, allowing for discussion and corrections along the way. Some notes to bring in local relevance:
   - The video did not mention coral bleaching, but it is such a big issue in Hawaii that it is included in the cards. What do students know about it? During three recent years ocean temperatures were so hot that half the coral in Hawaii bleached.
   - The video described a situation in Africa where mosquitos that spread the disease malaria are moving higher up the mountain as it warms. In Hawaii, we have native birds living on the mountains that have been safe from avian flu, also spread by mosquitos, because it was too cold for the mosquitos to live there. Now it is getting warmer.
   - The video described the maple trees disappearing from the North Eastern United States because it is getting too warm for them. The native Silversword plant that only lives on the tall volcano on Maui, Haleakala, can only live in cool temperatures. Now it is getting warmer.

3. **Connect to the phenomenon.**

The greenhouse effect is caused by CO2 in the atmosphere, but did you notice that more than half of the cards were related to the ocean? The ocean has absorbed over 90% of the extra heat from global warming. This has helped keep our air temperatures from rising even faster, but at a great cost as you figured out in the cause-effect activity.



How could this relate to what you saw with the balloons at the beginning of class? Air doesn't absorb much heat (low heat capacity), so the heat went to melting the rubber and the balloon exploded. Water absorbs a lot of heat (high heat capacity), so the heat was absorbed by the water and it takes the heat away from the rubber so it doesn't pop.

Obtain information from articles on local solutions to climate change

Have all students read the two articles or split the class to have each half read one, then share out. One article is a State level policy to use 100% renewable energy for power. The other is a County level policy to plant more trees in urban areas. Review vocabulary as needed. After reading and/or discussing ask students to write answers to the questions in the workbook.

- How did scientists working in Antarctica help Hawaii's policy makers decide what to do to solve climate change?
- How do the solutions they picked relate to the carbon cycle?

photo: Doug Clark, Western Washington University

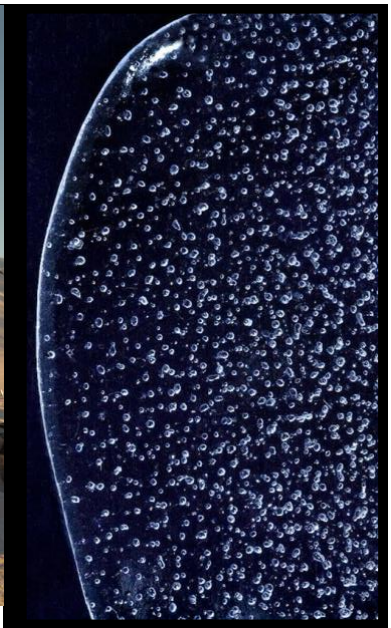


photo: Eric Wolff, EPICA

In case your students are curious how scientists analyze ice cores. Each season's snowfall has slightly different properties than the last. These differences create annual layers in the ice that can be used to count the age of the ice, just like rings inside a tree. Additionally, as the ice compacts over time, tiny bubbles of the atmosphere—including greenhouse gases like carbon dioxide and methane—press inside the ice. These air pocket "fossils" provide samples of what the atmosphere was like when that layer of ice formed. Scientists can directly measure the amount of greenhouse gases that were in the atmosphere at that time by sampling these bubbles. For temperature, they look at the chemical properties (oxygen isotopes) of the frozen water.
https://climate.nasa.gov/news/2616/core-questions-an-introduction-to-ice-cores/

Gov. Ige signs bill setting 100 percent renewable energy goal for state

By Mileka Lincoln June 8, 2015
HONOLULU (HawaiiNewsNow) –

Governor David Ige on Monday signed into law House Bill 623, which focuses on what's being called the most aggressive clean energy goal in the country: Hawaii seeks to become completely energy self-sustaining, using 100 percent renewable sources, by 2045.
"As the most oil-dependent state in the nation, Hawaii spends roughly $5 billion a year on foreign oil to meet its energy needs," Governor Ige said. "Making the transition to renewable, indigenous resources for power generation will allow us to keep more of that money at home, thereby improving our economy, environment and energy security."
Sustainable energy advocates say law will help Hawaii transition from being the most oil dependent state in the U.S. to one of the greenest.

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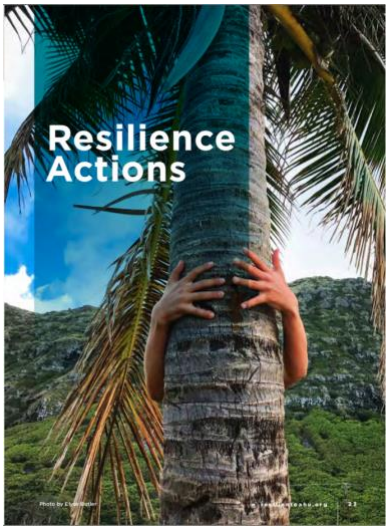
Keep O‘ahu Cool by Maintaining and Enhancing the Community Forest



Trees are critical urban infrastructure and necessary for the health of our communities. Often under-appreciated, these work horses provide multiple free environmental services and are essential components of both climate change adaptation and mitigation. Trees directly address climate change by both absorbing and sequestering greenhouse gas pollution and shading us from the increased heat that we are experiencing.

For City street and park trees, it is important that we maintain accurate information on their numbers and condition. For every dollar spent on tree planting and care, Honolulu’s trees provide $3 in benefits. However, the most recent assessment determined that O‘ahu has lost nearly 5 percent of its total tree canopy over the study area in just four years. The analysis also showed that the loss is not from vast clearings, but from thousands and thousands of pinpricks across all of our communities. The City’s Division of Urban Forestry receives more requests for the removal of street trees than for planting.

These trends cannot continue if we are to have cool, livable, walkable communities on O‘ahu. We must invest in and steward our community forests.

Oahu Resilience Strategy 2019. City and County of Honolulu. p. 98.

The stated City 2019 goal to increase tree canopy across O‘ahu’s communities to 35% by 2035 has since been abandoned. The stated goal in 2025 is to do a tree inventory.

Next Lesson...Where we’re going...After learning about climate change and possible solutions, I will design a plan to make my ahupua’a part of the solution.

OPTIONAL

Social Studies extension

How has the arrival of humans affected earth systems in my ahupua‘a?

Phenomenon: Hawai’i is home to 25% of the world’s endangered species and has been called “the extinction capital of the world.”

Lesson components:

- Create a model of an ahupua‘a that represents the replacement of natural habitat with agriculture, invasive species and urbanization.
- Reflect on the impact of land use changes and climate change in Hawaii on native species

Student outcomes:

- Students know how land use change contributes to climate change and habitat loss for native species.

NGSS:
DCI: Human Impacts on Earth Systems
CCCs: Scale, Proportion, and Quantity; Connections to Nature of Science
Systems;
SEP: Developing and Using Models

Materials for Each Class

Glue sticks or glue
Scissors
If the activity will be done as a class - poster of an ahupua’a

Materials for Each Student

If the activity will be done individually or in groups - one set of biome / animal / urbanization worksheets each.
If the activity will be done as a class on a poster – one larger print out of animal and urbanization worksheets only.

Preparation of Materials

Print materials. If activity will be done as a class, cut the animal and urbanization images for distribution.

Learning Plan: 30 minutes

This lesson places the causes and consequences of climate change in a larger context of land use change and extinction. Place-based connections can be drawn to what students are learning in Social Studies about Native Americans and land use, and the impact of European settlement on the US mainland.

Introduce
Share the essential question.

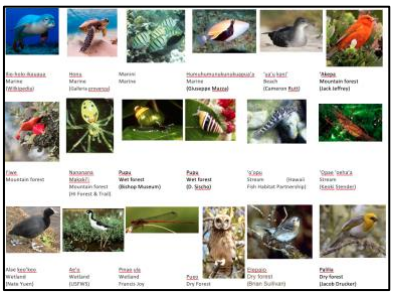
Essential Question: How have humans affected earth systems in my ahupua‘a?

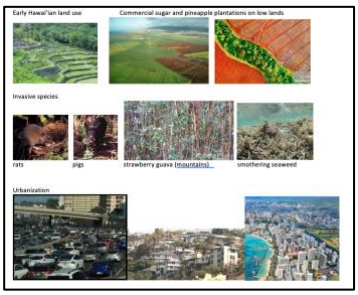
Phenomenon: Hawai’i is home to 25% of the world’s endangered species and has been called “the extinction capital of the world.”

Ask students what questions they have about this phenomenon and record their answers in their workbook or record them on a whiteboard or chart paper to display in the classroom: *What do you wonder?*

Explore

1. Discuss: **How do you think living things got to Hawai‘i before humans arrived?** They should remember from 4th grade - wings, wind, and water. Explain that Hawai‘i is the most remote island chain in the world and the infrequent birds, insects and marine animals that arrived, survived and reproduced evolved for millions of years in isolation, becoming new species endemic to Hawai‘i - found nowhere else in the world.





2. Distribute materials from Appendix (to groups or individuals) of the ahupua‘a with the different biomes and worksheet with the native animals. *Students cut out the pictures of the animals that were the first arrivals to the Hawaiian islands and became the native species of these islands. They glue them on to the ahupua‘a in the appropriate biomes. Alternatively, use one poster of an ahupua‘a and have the students come and post their cut out on the poster.* Larger images available on website.

3. Discuss: **Who were the first people to come to these islands? How do you think the biosphere changed when they arrived?** The Polynesians, in voyaging canoes about 2,000 years ago. There were many birds and fish, but the native plants are not edible to humans and there were no large mammals. However, the Polynesians planned ahead and brought with them plants and animals that were useful to them. They also brought some stowaways by accident. Whether they were

brought on purpose or by accident, they are called introduced species. Some introduced species, like taro do not spread easily unless people take care of them. Taro is not invasive. Other introduced species, like rats, can spread all by themselves. These species are invasive. The early Hawaiians cleared forests so they could have places to farm and live. They built terraces, and irrigation systems, they built fishponds. *Students cut and glue the early Hawaiian agriculture and rat.*

4. Discuss: **When people from other parts of the world moved to Hawai‘i what other kinds of changes to the biosphere do you think there were?** With frequent arrivals from all over the world many more invasive plants and animals arrived. Many native plants and animals became extinct or threatened. They started commercial agriculture for export, clearing large tracts of forest for sugar cane and pineapple. S*tudents cut and glue or tape the commercial agricultural uses and the remaining invasive species on to the ahupua‘a. They will cover the first layer.*

5. Discuss: **What impact do you think introduced invasive species had on native plants and animals?** Endemic species did not face a lot of competition, making many of the plants slow growing and delicate. Many of the animals are without defenses because they had no predators. Many native species went extinct due to habitat loss, disease and predators. The endemic species co-evolved together, often forming mutualistic, or symbiotic, relationships. They depend on each other and cannot survive without each other. For example, I’iwi birds have beaks the right shape to drink nectar from the flowers of the ‘Ōhi‘a Lehua trees and in doing so they spread the tree’s pollen. *Students notice the native species are being covered by lack of room in the ahupua‘a - note that this is similar to what happened in the real world.*

6. Discuss: **How did the various industries, first commercial agriculture, then tourism affect immigration to Hawai‘i? Who came? With a growing population, what else changed in Hawai‘i?** Immigrants from various regions of the world, including Europeans, Chinese, Japanese, Portuguese, Koreans, etc. arrived to work in Hawaii. A good example to show would be pictures of population and development growth over time using primary sources if available. *They cut and glue the urbanization onto their ahupua‘a.*

7. Students’ ahupua‘a should be covered disproportionately with buildings, factories, agricultural land, harbors, shipyards, at this time. Ask students: **What do you notice about your picture of your ahupua‘a now? What do you wonder? What happened to all of the plants and animals?** Towns and cities replaced forests. New rules about land ownership were imposed that changed the way water and land was managed and cared for. Guide students to make conclusions regarding the other environmental impacts that humans have made to the islands from the industrialization and development they have created.

8. **What happens when you have a lot of cars, boats, airplanes, power plants, and factories?** This should lead to a discussion of excess carbon dioxide in the atmosphere due to the fossil fuel use for powering the cities and moving the vehicles which leads to rising temperatures. Rising temperatures further stress the remaining native species both on land and in the ocean.

LESSON 5. How can I design tree planting in my ahupua‘a that will reduce the carbon footprint and provide other benefits?

Phenomenon: Phenomenon: Human’s haven’t been able to invent a machine to get the carbon out of the atmosphere, but they can use one that already exists: trees.

Lesson components:

- Identify priorities for tree planting, identify location and select trees that match
- Calculate carbon stored to determine tree numbers per species
- Document expected benefits
- Map

Student outcomes:

- Students use scientific data to choose the right trees and the right number of trees to achieve benefits according to criteria and constraints
- Students utilize multiplication skills (two decimal places)

NGSS:
Performance Expectation: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
DCI: Defining and Delimiting Engineering problems
CCC: Influence of Science, Engineering, and Technology on Society and the Natural World
SEP: Asking Questions and Defining Problems; Constructing Explanations and Designing Solutions

Teacher Preparation

See Resources handout. Review all materials, charts, and other data before lesson.

Materials for Each Class

Projector or document camera to display materials.

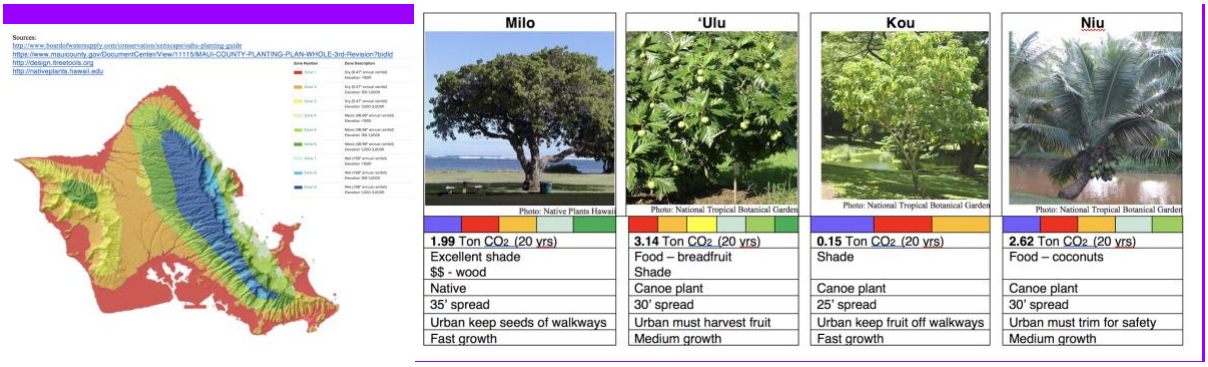
Materials for Each Student

Access to tree cards / planting zone map.
Design task worksheet
Blank paper or map to design tree planting.

Preparation of Materials

Copy tree cards / planting zone map.
If choosing a specific site, create map.

Learning Plan: 1.5 hours



ENGAGE

Phenomenon: Human's haven't been able to invent a machine to get the carbon out of the atmosphere, but they can use one that already exists: trees.

What ideas do you have about this phenomenon? What do you wonder?

EXPLORE

1. Tell the students that today they are going to learn the amount of carbon 16 different types of trees can store because trees sequester different amounts of carbon depending on the size of their trunks, branches and roots. We need to use math to calculate the carbon storage by different types and numbers of trees.
2. Choose one of the trees, for example, the mango tree. Go over the data with students. Discuss whether this would be a good choice for your ahupua'a. Would it be a better choice for certain areas over others, and why? They may decide that mango trees would be good next to people's houses but not great in urban areas where the falling fruit could create hazards and make a mess. You may want to do a few examples depending on how much support the students need before they can work independently with the data.
3. Generate a list of considerations with students before they make their design plan. For example, how large the trees will become, if they like sun, shade, water, no water, high and low temperatures, etc. Also, if the trees are more suited for reforestation, windbreaks in agricultural areas, around people's homes, in landscaping in towns or parks, etc. They should consider if the tree produces materials that are useful for humans.
4. A map of planting zones for your island and the tree cards (from the Appendix) can be posted in multiple areas in the class for students to refer to, or a set can be printed for each group. Depending on whether a particular, real area is chosen, or not, students will be provided with a map or blank paper to draw in their design. Having a map prepared for them will save time. The check list in their workbook will

be their roadmap and they will fill in the table and check off the items they have completed.

5. Get outside. If the planting location is your school, take a walk to notice existing trees and empty spaces and even to measure them before making the plan. You may choose to include existing trees and their carbon storage in your plan. You may hang signs on existing trees showing how much carbon they store to educate the school.
6. You may reduce the number of criteria or constraints. For example, tree options could be limited to match the rainfall and altitude of your selected planting site.
7. One teacher reported using her school as a model for the whole class. Then she chose schools around the island with varying rainfall levels and campus sizes and assigned students to create tree plan for them. The students enjoyed it.

Criteria - the goal to be met

- **Carbon stored** – In 20 years' time, the total Tons of CO2 stored in your trees must add up to at least 23. This is the average amount of carbon a person used each year in your ahupua'a.

More criteria - additional goals (one or more) to choose from

- **Urban trees** – Trees by buildings, streets, and parks reduce extra CO2 because they reduce temperatures and then less AC is used. They also make people healthier by cleaning the air, protecting their skin from sun, and providing beauty. Trees that drop a lot of fruit, nuts or
  spiny leaves are hazardous in urban areas unless they are well maintained.

- **Watershed protection** – Trees on mountainsides absorb rainfall and prevent runoff and erosion that threatens our streams, wetlands and coral reefs. Trees in dry places help keep moisture in the area even after the rain stops.

- **Economic benefits** – Trees can produce food for the owners to eat or sell. They can produce wood that the owners sell to make things and as long as that wood doesn't rot, the carbon stays out of the air.

- **Biodiversity** – Planting native trees protects them from going extinct. It also provides habitat for native birds, insects and snails that might go extinct.

Constraints – all must be satisfied so the trees will be healthy

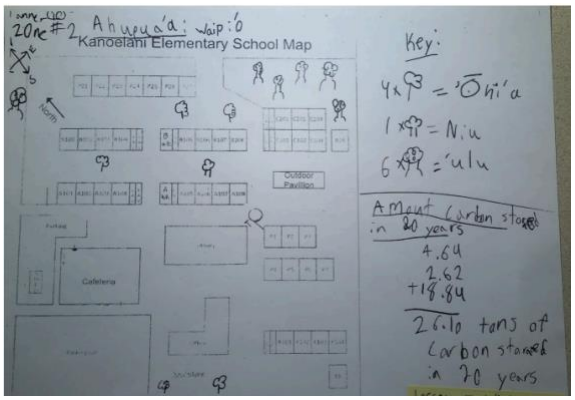
- **Right tree in the right place** – Match the altitude and rainfall color bars with the location you want to plant.

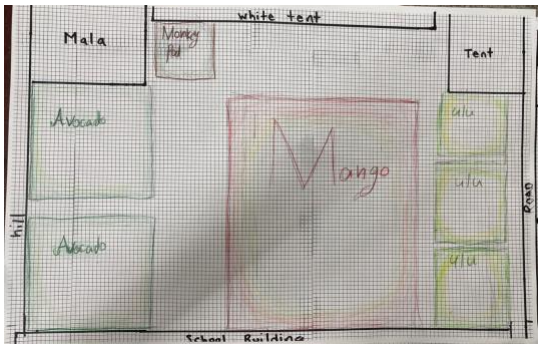
- **Mix** – You need a mix of at least three types of trees in case of a pest or inability of one type of tree to adapt to the changing climate.

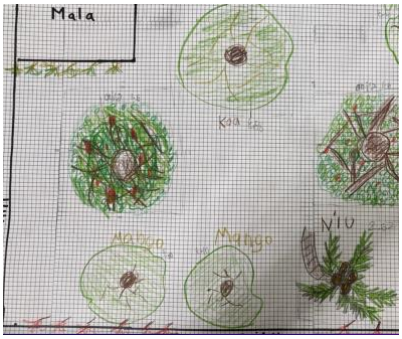
- **Spacing** – Look at the spread to see how far apart to plant trees from each other. Make sure they will fit in the place you selected.

Map

- **Mark a map** or **Draw a picture** of your planting location and your trees in place when they are mature. Use the canopy spread data to space the trees the right distance apart. It can be a google map, iTree Design, or a paper map provided by your teacher.







Part Two: Redesign

1. Present your design to the class. Each small group's findings (amount of carbon sequestered and design plan) will be recorded on a classroom chart visible to all the students.
2. Class discussion - Which designs were the most effective and why? Were any design choices ineffective? Why? If you could design anything differently what would you change and why?
3. Redesign Task - Small group challenge to redesign your plan making changes to increase the amount of carbon sequestered and make design choices that are most likely to be adopted by local area residents due to benefits.
4. Share out - What did your group differently in the second challenge? Record student changes on the class chart.
5. Class voting for best design - anonymous. Total and announce the winners!

Post task reflection -
Is it realistic for every person in your ahupua'a to plant that many trees every year?
How can we make the number of trees needed each year go down?

By reducing our emissions through our own actions on food and stuff, producing less trash, using less electricity and gas. If the whole state moves to renewable power and transport, that will be much simpler for all the people who live here to reduce their emissions.