SLOPES, SOILS AND SILTATION

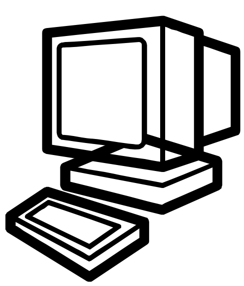
Grades 6–8

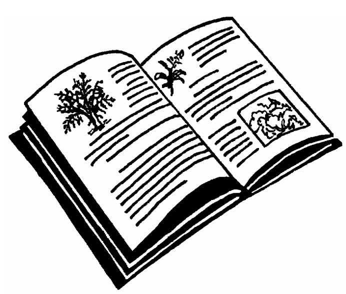
Lesson at a Glance
Students determine how clearing forested slopes affects water and soil resources in the Hawaiian Islands. Through research, students determine how they would revegetate the island of Kahoʻolawe and how to restore the island's water supplies.

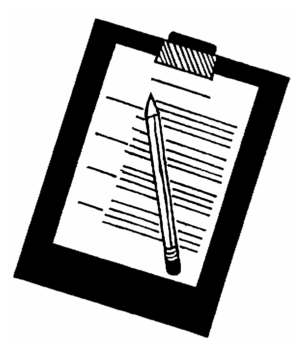
Key Concept
Forests provide watershed protection by preventing soil erosion, reducing surface water runoff and increasing the infiltration of groundwater.

Hawaiʻi Content Performance Standards III, Language Arts

Grade 6			
Strand		Reading	
Standard 1: Reading: CONVENTION AND SKILLS: Use knowledge of the conventions of language and texts to construct meaning for a range of literary and informational texts for a variety of purposes.			
Topic		Locating Sources/Gathering Information	
Benchmark LA.6.1.2		Use grade-appropriate online and print sources to research a topic. *Which plants could be used to help revegetate Kahoʻolawe so as to increase the available groundwater supply and prevent soil erosion?*	
Sample Performance Assessment (SPA)		The student: Finds and reads online (e.g., CD-ROM, internet, intranet, newsgroups) and traditional sources (e.g., encyclopedia, books, periodicals) to answer an inquiry arising from class or personal activities.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Use substantive information from an extensive variety of grade-appropriate print and online resources to thoroughly research a topic.	Use relevant information from a variety of grade-appropriate print and online resources to research a topic.	Use some relevant information from a selection of grade-appropriate print and online resources to research a topic.	Use very little relevant information from grade-appropriate print and online resources to research a topic.







Grade 7			
Strand		Reading	
Standard 1: Reading: CONVENTION AND SKILLS: Use knowledge of the conventions of language and texts to construct meaning for a range of literary and informational texts for a variety of purposes.			
Topic		Locating Sources/Gathering Information	
Benchmark LA.7.1.2		Use a variety of grade-appropriate print and online sources to research an inquiry question. *Which plants could be used to help revegetate Kaho'olawe so as to increase the available groundwater supply and prevent soil erosion?*	
Sample Performance Assessment (SPA)		The student: Finds and reads online (e.g., CD-ROM, internet, intranet, newsgroups) and print sources (e.g., encyclopedia, books, periodicals) to answer a question or inquiry arising from class or personal activities.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Use substantive information from an extensive variety of grade-appropriate print and online resources to thoroughly research an inquiry question.	Use relevant information from a variety of grade-appropriate print and online resources to research an inquiry question.	Use some relevant information from a selection of grade-appropriate print and online resources to research an inquiry question.	Use very little relevant information from grade-appropriate print or online resources to research an inquiry question.

Grade 8			
Strand		Reading	
Standard 1: Reading: CONVENTION AND SKILLS: Use knowledge of the conventions of language and texts to construct meaning for a range of literary and informational texts for a variety of purposes.			
Topic		Locating Sources/Gathering Information	
Benchmark LA.8.1.2		Select appropriate information after evaluating the usefulness of print and online resources to investigate a theme, answer a question, or test a hypothesis. *Which plants could be used to help revegetate Kaho'olawe so as to increase the available groundwater supply and prevent soil erosion?*	
Sample Performance Assessment (SPA)		The student: Conducts research and evaluates information for validity, appropriateness, content, and use by asking questions (e.g., What makes the author an expert? Is the information found in multiple sources? What is the author saying and not saying?).	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Insightfully select highly effective and appropriate information after evaluating the usefulness of print and online resources to investigate a theme, answer a question, or test a hypothesis.	Select appropriate information after evaluating the usefulness of print and online resources to investigate a theme, answer a question, or test a hypothesis.	Select some trivial information after evaluating the usefulness of print and online resources to investigate a theme, answer a question, or test a hypothesis.	Select irrelevant information after evaluating the usefulness of print and online resources that do not help to investigate a theme, answer a question, or test a hypothesis.

Hawai'i Content Performance Standard III, Science, Grade 6

Strand		The Scientific Process	
Standard 1 The Scientific Process: SCIENCE INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.			
Topic		Scientific Inquiry	
Benchmark SC.6.1.1		Formulate a testable hypothesis that can be answered through a controlled experiment (*using models of a forested slope and a cleared slope, hypothesize how the removal of forests from slopes might affect water and soil resources in the Islands*).	
Sample Performance Assessment (SPA)		The student: Constructs a hypothesis (e.g., if, then, and because statement) that is tested through a controlled experiment.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Formulate a testable hypothesis with a detailed justification as to how it can be answered through a controlled experiment.	Formulate a testable hypothesis with a simple justification that can be answered through a controlled experiment.	Formulate a hypothesis without any justification.	Formulate an incomplete hypothesis.

Strand		The Scientific Process	
Standard 1 The Scientific Process: SCIENCE INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.			
Topic		Scientific Inquiry	
Benchmark SC.6.1.2		Use *models of a forested slope and a cleared slope*, appropriate tools, equipment, and techniques to collect, display, and analyze data.	
Sample Performance Assessment (SPA)		The student: uses *models of a forested slope and a cleared slope*, appropriate tools, equipment, and techniques to collect, analyze, and display data.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Consistently select and safely use appropriate tools, equipment, and techniques to collect, display, and analyze data.	Usually select and safely use appropriate tools, equipment, and techniques to collect, display, and analyze data.	Sometimes select and safely use appropriate tools, equipment, and techniques to collect, display, and analyze data.	Rarely select and safely use appropriate tools, equipment, and techniques to collect, display, and analyze data.

Hawai‘i Content Performance Standard III, Science, Grade 7

Strand		The Scientific Process	
Standard 1 The Scientific Process: SCIENCE INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.			
Topic		Scientific Inquiry	
Benchmark SC.7.1.1		Design and safely conduct a scientific investigation to answer a question or test a hypothesis (*using models of a forested slope and a cleared slope, hypothesize how the removal of forests from slopes might affect water and soil resources in the Islands*.	
Sample Performance Assessment (SPA)		The student: Identifies the dependent and independent variables, writes an experimental design, and safely conducts the experiment.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Consistently design and safely conduct a logical, systematic scientific investigation to answer a question and test a hypothesis.	Usually design and safely conduct a scientific investigation to answer a question or test a hypothesis.	Sometimes design and safely conduct a scientific investigation to answer a question or test a hypothesis.	Rarely design and safely conduct a scientific investigation to answer a question or test a hypothesis.

Hawai‘i Content Performance Standard III, Science, Grade 8

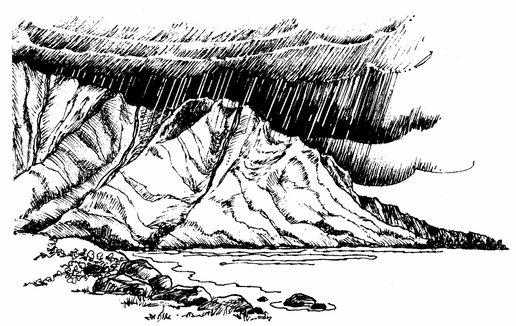
Strand		The Scientific Process	
Standard 1: The Scientific Process: SCIENTIFIC INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.			
Topic		Scientific Inquiry	
Benchmark SC.8.2.1		Determine the link(s) between evidence and the conclusion(s) of an investigation. *Based on the evidence, what can the student conclude about the effects of a forested slope on soil and water resources?*	
Sample Performance Assessment (SPA)		The student: Determines if the conclusion(s) and evidence from an experiment or other sources are logically linked.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Determine and analyze the logical link(s) between evidence and the conclusion(s) of an investigation and apply to the real world.	Determine the logical link(s) between the evidence and the conclusion(s) of an investigation.	Identify a link between evidence and the conclusion(s) of an investigation.	Recognize a link between evidence and the conclusion(s) of an investigation.

Strand		The Scientific Process	
Standard 1: The Scientific Process: SCIENTIFIC INVESTIGATION: Discover, invent, and investigate using the skills necessary to engage in the scientific process.			
Topic		Scientific Inquiry	
Benchmark SC.8.1.2		Communicate the significant components of the experimental design and results of a scientific investigation *that demonstrates the effects of a forested slope on soil and water resources*.	
Sample Performance Assessment (SPA)		The student: Presents formal written report and/or gives an oral presentation that communicates experimental design and results of an investigation.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Communicate, with clarity and detail, the components of the experimental design and results of a scientific investigation.	Communicate the significant components of the experimental design and results of the scientific investigation.	Communicate some significant details related to the experimental design and results of a scientific investigation.	Communicate few details related to the experimental design and results of a scientific investigation.

Objectives

Students will be able to:

1. hypothesize how the clearing of forested slopes will affect soil and water resources;
2. describe the role of forest cover in water infiltration and erosion prevention;
3. help conserve natural resources; and
4. determine how to restore water and vegetation on Kahoʻolawe.



Time

three to four class periods

Subject Areas

science, language arts

Materials

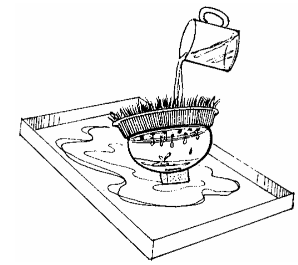
water cycle diagram (provided)
student reading sheet (provided)
two lightweight aluminum pie tins
small bowl (roughly the same diameter as the pie tins)
large pan or bowl
soil (to fill one pie tin)
sod or clump of lawn (to fill one pie tin)
pitcher of water
measuring cup
scissors
newspaper
masking tape
eraser

Preparation

Create a model for class demonstration according to the directions below. As an alternative, student groups could each make a model.

a. Poke some holes or make slits into the bottom of two aluminum pie tins to represent cracks in lava rock. Fill one with soil and one with sod to represent a forested slope.

b. Tape a small bowl (to represent the groundwater lens) under the pie tin filled with sod. Place the bowl and pie tin inside a large pan, which represents the ocean.
c. Place a flat eraser under the bowl to raise the pie tin at an angle (see illustration).



The bare soil and the soil on which the sod is growing should have similar textures—soft, loamy, clay soils are recommended. A clump of lawn and soil taken from a yard is best, if the gardener will permit it! Patches of turf from a garden center are less suitable, as their root systems are not well developed.

Teacher Background

Groundwater Resources

Most of our groundwater is contained in lens-shaped bodies of water held within the volcanic rocks of each island. These rocks are **basalt**, which is highly **permeable**, so water readily passes through them. Below sea level, islands are saturated with water. Because fresh water is slightly less dense than salt water, the fresh water floats on the salt water. Two scientists—Baden-Ghyben and Herzberg—first identified the mechanics of this groundwater lens so it is now referred to as the **Ghyben-Herzberg lens**.

On older islands where coral reefs have had a chance to form, **caprock** prevents freshwater from seeping out of the lens into the sea. Caprock is formed when **coastal plain** sediments, including coral fragments, silt and ash, become cemented together. On flat areas near the shore, caprock can be more than 300 m (1,000 ft) thick, extending well below current sea level.

Fresh water is also held above the water table behind vertical or nearly vertical sheets of dense rock that formed when magma rising to the surface of a volcano cooled within the Earth. This intrusive cooling allowed very little gas to escape, resulting in sheets of highly **impermeable** rock, known as **dikes**. (Refer to the diagram on the Student Activity Sheet.)

Forest Cover

Like sponges, forests absorb water. Rainwater drips down to lower forest layers where some evaporate and some drain into the soil. A portion of this water will be absorbed by roots and **transpired** through leaves. Some will drain into streams and flow out to sea. What remains will percolate through the soil to the **groundwater** lens below.

When the forested slopes of the islands are cleared, ground and **surface water** are affected. Without the sponge-like absorption of the forest cover, surface water **runoff** increases and less water seeps down to the groundwater lens. The unprotected soil washes into streams and reefs, disrupting or destroying aquatic ecosystems. The loss of ground cover also exposes the soil to direct solar radiation, causing soil temperatures to rise. Soil moisture and permeability then decline, inhibiting the ability of the soil to support life.

Protecting Watersheds

A **watershed** is a land area through which water drains into a particular body of water. For example, the slopes draining into a stream are the watershed for the stream. Clearing of forested slopes in the islands reached its first peak during the period of intensive Hawaiian population growth between 1100–1650 A.D. Prior to that time, Hawaiians had practiced **shifting cultivation**, where plots of land were cleared and farmed for a few years and then allowed to lay **fallow** as new areas were cleared. When the demands of a growing population required increased food production, more permanent and intensive cultivation of soil led to an elimination of fallow periods and additional clearing of upland slopes. The clearing of slopes created more fertile valley floors as the soil moved to lower ground, but it also caused landslides and **siltation** of streams and reefs.

Problems of **erosion**, siltation and reduced **infiltration** of groundwater intensified after the arrival of Westerners to the islands. More forests were cleared, particularly in upslope regions, to make way for sugarcane, pineapple, cattle ranches, housing, roads and various commercial enterprises. Grazing cattle, goats and sheep caused considerable impact in these lands. To repair damage to the land, a massive reforestation program was initiated in the 1930s. Thousands of trees were planted on barren slopes throughout the state as a watershed protection measure. Today we recognize the importance of forests in protecting our water supply and watershed areas are zoned for **conservation** on each island.

Teaching Suggestions

1. Ask students to describe how their island might have changed over the last 1,500 years. For each example they think of, have them list a cause and an effect such as growing population—more land clearing.

2. Describe the shifting cultivation and the intensified agriculture practiced by Hawaiians and the continued clearing of forest since Western contact. (Do not yet discuss the impact of this land use.)

3. Distribute the Slopes, Soils, and Siltation student reading and the water cycle diagram and discuss the concept of a watershed.

4. Ask students to hypothesize how the removal of forests from slopes might affect water and soil resources in the Islands. Have them write their predictions and reason on the appropriate student activity sheet.

5. Show students the model you have prepared and ask two students to assist with the demonstration.

   a. Pour water gently over the forested slope for 20 seconds.
   b. Remove the pie tin, pour off the water and measure how much water has collected in the freshwater lens. Measure the water that has run off into the ocean. Note how much soil has run off as well.
   c. Place the pie tin filled with soil over the bowl to represent a cleared slope.
   d. Repeat steps a and b and compare the results with the forested slope.

Students could also develop their own models using different methods and then share their models with the class. If students develop their own models using different methods, have them outline the necessary steps. Comparing results from one type of model to another should be very interesting. Students should be prepared to defend their models and the results.

6. Have students compare their hypotheses with the actual results. Initiate a class discussion focusing on the following questions:

   <u>Discussion Questions</u>

   - On which slope did more water infiltrate to the freshwater lens?
   - On which slope was there more runoff to the ocean?
   - How does a forest reduce soil erosion?
   - What might happen to runoff and infiltration when the angle of the slope is reduced or increased?

7. Ask students to summarize the effects of clearing forested slopes. (Refer to diagram on the next page.)

8. Have students complete the Student Reading and Activity—"Revegetating Kahoʻolawe." Students should share and/or report their results to the class.

Extended Activities

- Repeat the experiment with different types of ground cover and/or different soil types (see Hold It! in Geology unit).

- Use the model to experiment with the change in temperature on deforested slopes. Place the model in a sunny window for a while. Then record the temperature of the bare soil and of the soil under the sod. Discuss ways that the increased soil temperature could inhibit reforestation.

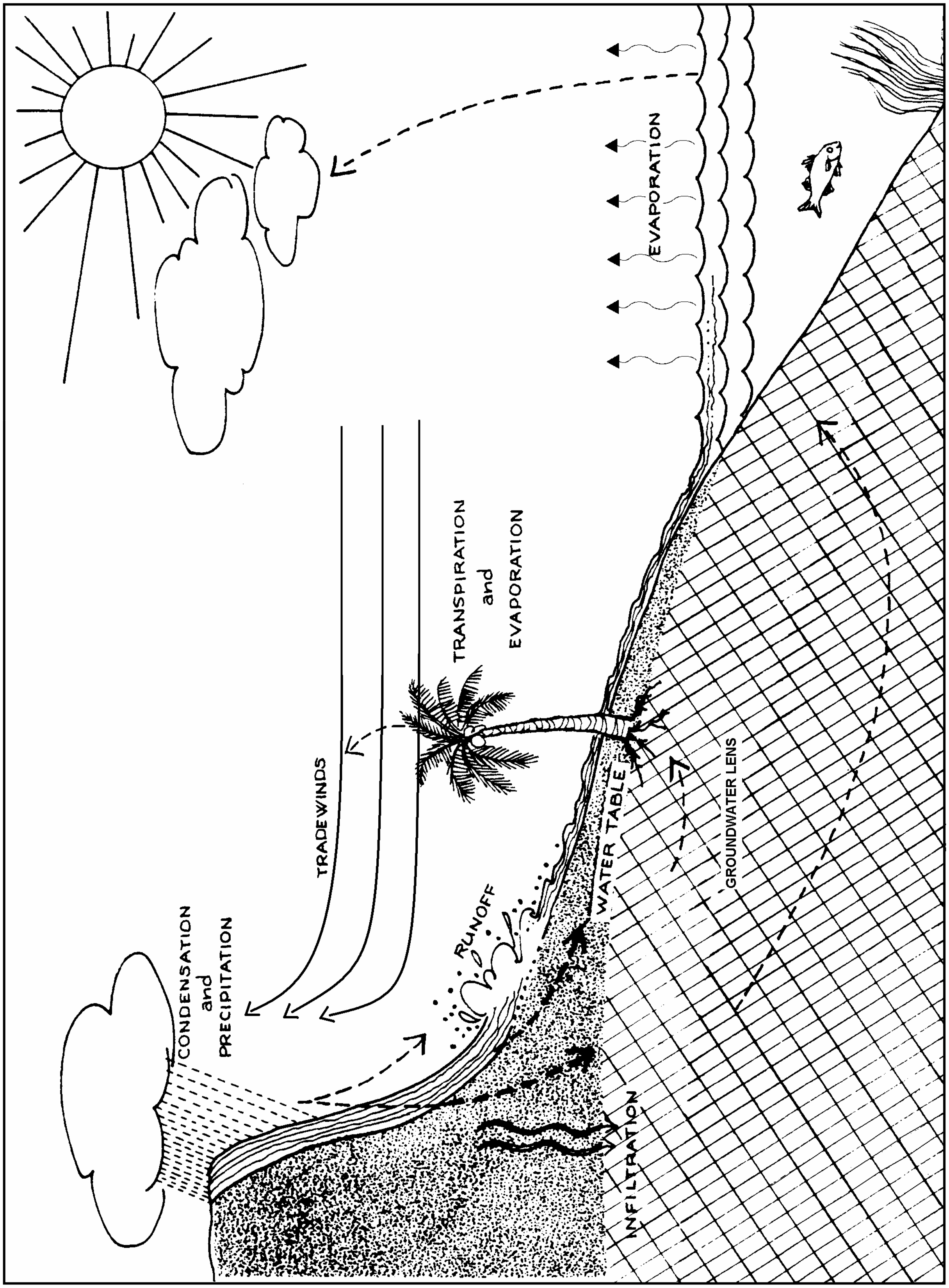
- Go outside and look for signs of erosion. Examine around drainage spouts, compacted pathways and slopes. Discuss ways to prevent this erosion.

- Have students work cooperatively to create a large mural illustrating the effects of clearing slopes. Their illustration should depict siltation of streams and reefs and the loss of fresh water to the groundwater lens. Alternatively, they could illustrate a rainforest with water infiltrating, evaporating and flowing into streams.

- See activities in the Global Unit that extend this concept to the loss of tropical forests in other parts of the world.

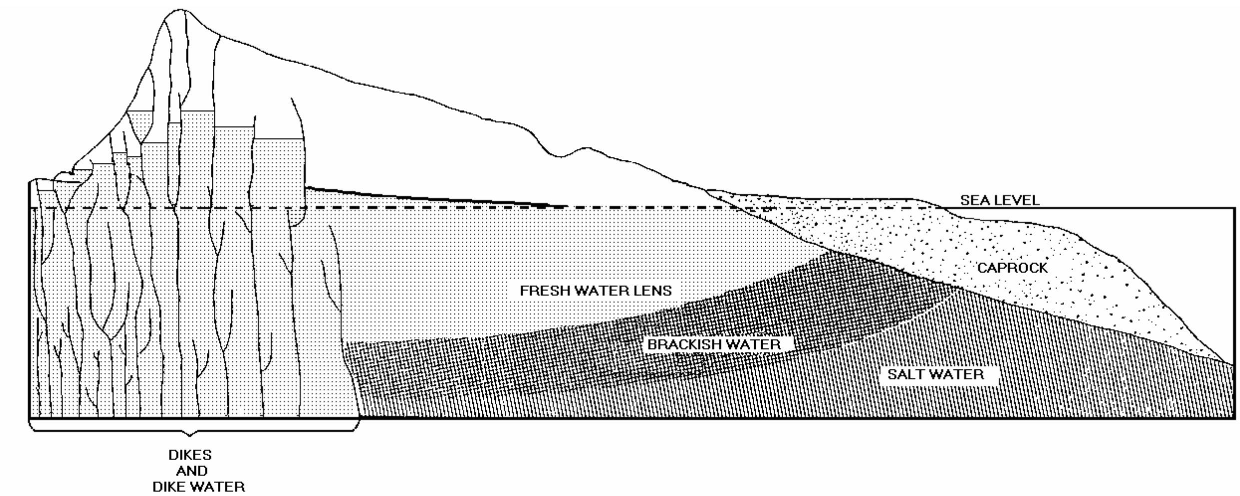
Summary of the Effects of Clearing Forested Slopes

Cause	Effect	Result
clearing of forested slopes	less freshwater infiltration	less freshwater available for human use
	more water runoff	greater flood hazard
	decline in plant and animal habitat	greater risk of species' extinction
	soil exposed to the sun	increased soil temperature
	soil erosion by rain and wind	stream and reef siltation
	loss of fertile topsoil to valley floors	better soil for farming (historically)


CONDENSATION
and
PRECIPITATION
TRADEWINDS
RUNOFF
TRANSPIRATION
and
EVAPORATION
EVAPORATION
WATER TABLE
GROUNDWATER LENS
INFILTRATION

If you could reach way down beneath the topsoil of your island, what do you think you would find? Rock? Sand? Water? Below sea level, the rock in our islands is saturated with water. Most of this water is salt water from the surrounding ocean, but at the top of the salt water is a lens-shaped layer of fresh water. Fresh water is slightly less dense than salt water, so it is able to float above it. Between the fresh water and salt water is a layer of brackish water.

The fresh water comes from rain that trickles down through the many cracks and tiny pore spaces in our basalt rocks. Some will be caught behind impermeable sheets of dike rock and remain "perched" high in the mountains. Some will emerge at a stream cut and join the flow of water out to sea. Most, however, will eventually reach the freshwater lens deep within the ground.



People in Hawai'i, especially those who live on O'ahu, depend heavily on this lens for fresh water. If we pump out fresh water faster than it is naturally replaced, we will soon run out. To help prevent this, people are urged to conserve water. At the same time, scientists are studying the rate at which fresh water is being added to the lens. They have learned that what people do to the surface of our islands directly affects how much water may eventually recharge the groundwater supply. For example, when large land areas are paved, rainwater, which cannot penetrate the hard surface, runs into storm drains and is channeled out to sea. This water will never reach the freshwater lens.

Much of the rain in the Hawaiian Islands falls in the mountains. Some of it will flow into streams and be carried out to sea. The condition of the mountain slopes directly affects how much water will trickle down to the freshwater lens, how much can be pumped for your use and how much will flow out to sea.

How do you think clearing a forest from a mountain slope would affect the amount of water flowing out to sea, or trickling down to the lens? What would happen to the bare soil on the slope?

Write your hypotheses in the space below. Test your predictions on the class model of a forested slope and a cleared slope. Analyze the data collected and summarize your conclusions.

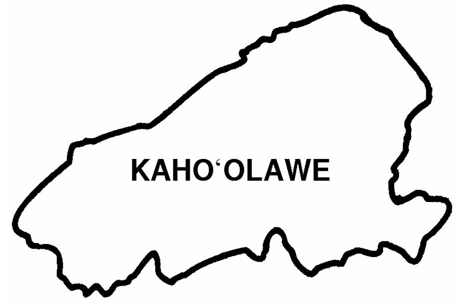
Action: clearing a forest on a mountain slope.

Hypotheses
Effect on groundwater:
Effect on surface water:
Effect on soil:

Testing Method

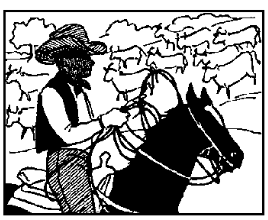
Results
Groundwater:
Surface water:
Soil:

Conclusions



The island of Kahoʻolawe is an important natural and cultural reserve yet few people have ever been there. Although inhabited by very few people today, Kahoʻolawe was inhabited for over a thousand years. Ancient Hawaiians on the island fished, farmed, and lived in coastal and interior settlements. It's modern name is Kahoʻolawe, which means "the carrying away (by the currents)." The traditional name of the island is Kanaloa, after the god of the ocean. It was a place where *kāhuna* were trained and it played an important role in early Pacific migrations.

Kahoʻolawe is the smallest of the main Hawaiian Islands at 44.6 sq mi (115.5 sq km). It is low in elevation with its highest point a mere 1,477 ft (450 m) above sea level at Puʻu Moaʻulanui. Like its neighbor Lānaʻi, it lies in the rain shadow of Maui. More than 200 years ago, rain fell more abundantly on Kahoʻolawe from a column of clouds that extended from Haleakalā on Maui to the island. Hawaiians named this rain Nāulu. To ancient Hawaiians, that column of clouds was like a lei encircling Maui, Kahoʻolawe, and Lānaʻi. Winter storms from the south also brought precious rain. In ancient times, Hawaiians on Kahoʻolawe probably got their water from springs and wells that are now brackish. The chant *Nā Wai Puna o Kamohio no Kahoʻolawe* tells how Hawaiians got their water from springs at the cliffs of Kamohio. At one time, Kahoʻolawe even had a dryland forest, yet by the time explorers and botanists came to the island, there was mostly grass cover, a few shrubs and trees. Today, it is dry with an average annual rainfall of 25 in.



Kahoʻolawe serves as an unfortunate example of what happens when an environment is highly damaged. In early historical times, Kahoʻolawe was a penal colony (law breakers were banished to the barren island), followed by years of ranching that included goats, sheep, and cattle. Overgrazing by the livestock destroyed much of the vegetation on the island. One rancher, Angus McPhee, tried eradicating the goats but never was fully successful. Rainfall on Haleakalā diminished markedly in the nineteenth century as Haleakalā's forests were destroyed by grazing. This in turn had an adverse effect on Kahoʻolawe's rainfall too because the column of clouds that brought the rains from Maui to Kahoʻolawe were gone. The island was declared a forest preserve in 1910; however, without funds for reforestation, nothing was ever done. The U.S. military used Kahoʻolawe as a bombing target during and after World War II, blowing away much of what was left of the living environment. As a result of the repeated assaults on the island, vast quantities of soil have been removed by bombing, strong winds and erosion caused by rain. The top one-third layer of soil on the island was reduced to a sterile hardpan while the reefs and coastal waters were damaged by silt runoff. Today, soil erosion continues as large red dust clouds blow off the island. The dryland forest at Kānepuʻu, Lānaʻi is a similar environment to Kahoʻolawe's. Like Kahoʻolawe, it is a victim to hoofed animals and erosion. Currently Kānepuʻu is being revegetated and fenced to prevent hoofed animals from entering the fragile environment.

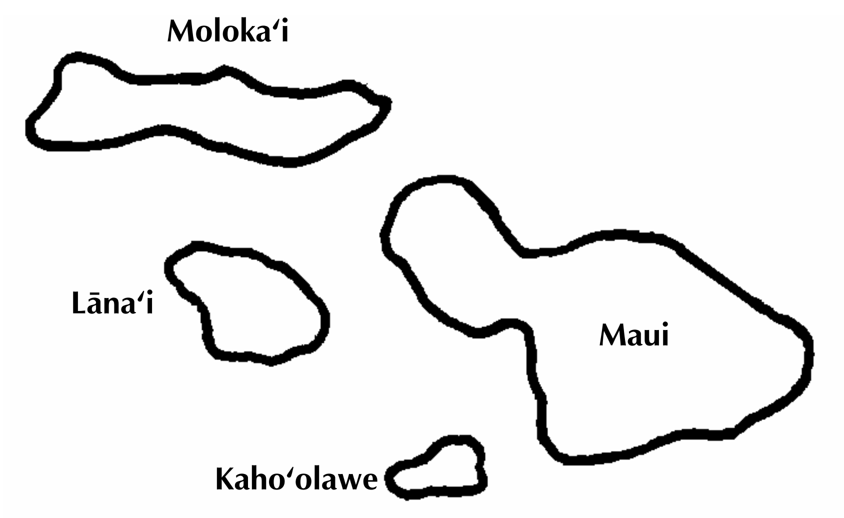
In 1993, the island was turned over from the federal government to the State of Hawaiʻi. The island is held in trust for a future Native Hawaiian sovereign entity while being managed by the Kahoʻolawe Island Reserve Commission (KIRC), a state agency created by the legislature. KIRC works with native Hawaiians such as Protect Kahoʻolawe ʻOhana to help restore the island. For the next 10 years, the Navy began cleaning up the unexploded ordnance.

Due to the lack of a watershed, the island today has little groundwater. At one time Kahoʻolawe had more groundwater. In 1857, a water survey of the island found it had no dependable source of water. The quality and quantity of the groundwater remains unknown, and the cost of drilling would be expensive and useless. Today Kahoʻolawe gets its supply of fresh water from a catchment system, built in 2002, at Puʻu Moaʻulanui. The source of this water is rainfall. The water catchment system can store up to a maximum of 500,000 galllons of water per year. A desalination unit was also built and can produce 9,000 gallons of water a day. These sources of water are used primarily for the irrigation of newly planted vegetation. People who come to the island to work bring bottled water with them for their use.

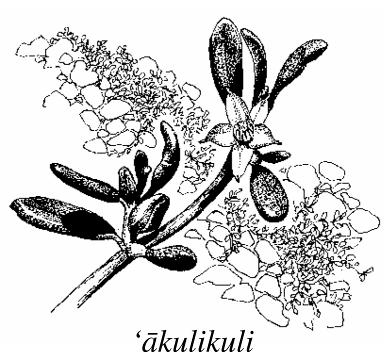
Scientists from the U.S. Geological Survey and the University of Hawaiʻi are studying watersheds on Maui to see if they can learn anything that might help bring rain back to Kahoʻolawe. They would like to see again the columns of clouds that once extended from Maui to Kahoʻolawe. Through these research efforts, the scientists are hoping to discover if forests at different elevations can prevent erosion and recharge the groundwater lens.

In 1997, KIRC held a ceremony on Maui to dedicate three rain *koʻa* (shrines) to call the Nāulu rains to return to Kahoʻolawe. One *koʻa* was constructed at Puʻu Māhoe at ʻUlupalakua on Maui, and two were constructed at Luamakika on Kahoʻolawe. One of the *koʻa* on Luamakika faces ʻUlupalakua and the other faces Līhau in Ukumehame Valley in the West Maui Mountains. In 2002, a third *koʻa* was built at Luamakika to unite all the *koʻa*.

Today, after careful planning, Kahoʻolawe is being revegetated. History has shown that the choice of plants used to revegetate the island is critical. Over the years, a variety of vegetation has been planted and many were later discovered to be poor choices. For instance, the introduced kiawe tree was planted on the island yet it is known to consume a lot of water. Tamarisk, an introduced tree planted as a windbreak, drinks a lot of water and secretes salt, leaving the ground salty. Few plants are able to grow in this salty soil. When Angus McPhee was ranching on Kahoʻolawe, his family planted eucalyptus to help prevent erosion. However, this Australian tree consumes huge amounts of water and nutrients from the ground beneath. It also produces chemicals in its leaves and bark that prevent other plants from growing beneath them. Except for its own leaf litter, the ground below eucalyptus is barren, promoting runoff.

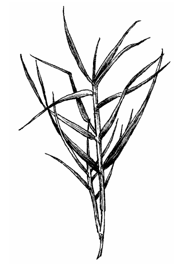


Some native plants that have been growing successfully on Kahoʻolawe are:



ʻākulikuli

ʻiliahi



ʻakiʻaki

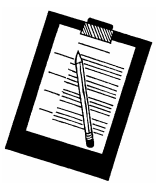
hinahina

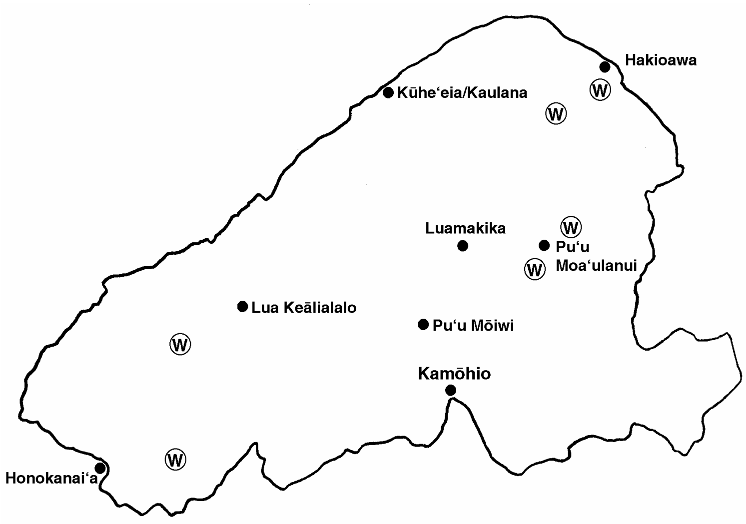
Other native plants include *wiliwili*, *koʻokoʻolau*, *ʻolonā*, *māmane*, *pāʻū o Hiʻiaka*, *pili*, *ʻaʻaliʻi*, *ʻāweoweo*, and *kāwelu*.

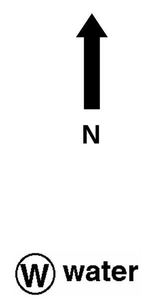
It is hopeful that the experimentation of planting native vegetation will be successful. Then the healing process of Kanaloa's island—the land and the fresh water—can move forward.

You are in charge of ***revegetating Kaho‘olawe so as to increase the available groundwater supply on the island and to bring erosion to a screeching halt***. (Just beware of the unexploded ordnance!) You already know that introduced kiawe, tamarisk, and eucalyptus trees will not be on your list. Perhaps the native Hawaiian plants are the best choice. You need to keep in mind the following critical information. The island is windy and most of the top soil has blown away. The remaining soil is sterile and lacks nutrients to support growing plants. The underlying ground is extremely hard making it difficult for most plants to take root. Some plants can grow only in certain environments. Some plants are hardy. Some plants grow faster than others. Some plants can help break down the soil. Use the student reading and conduct additional research about the island to obtain the necessary information. Here are some resources to get you started:

- Protect Kaho‘olawe ‘Ohana
- Kaho‘olawe Island Reserve Commission, DLNR, State of Hawai‘i, *Environmental Restoration Plan*; www.kahoolawe.hawaii.gov.
- Juvik, Sonia P. and James O. Juvik, eds. 1998. *Atlas of Hawai‘i*. Univ. Hawai‘i Press, Honolulu.
- Krauss, Beatrice H. 1993. *Plants in Hawaiian Culture*. Univ. Hawai‘i Press, Honolulu.
- Ashdown, Inez MacPhee. 1979. *Recollections of Kaho‘olawe*. Topgallant Publishing Co., Honolulu.
- USGS Topographic Map of Kaho‘olawe: http://www.hinhp.org/website/hawaii/kahoolawe/data.html







Kaho‘olawe’s water resources

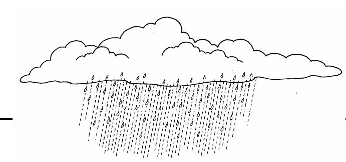
Name of plant and symbol	Type of Native: Indigenous (I) or Edemic (E)	Growth Form: Tree (T), Shrub (S), Vine (V), Grass (G)	Location to be Planted (coast, uplands, ridges, gullies, etc.) and approximate elevation	Benefits of this plant

Why did you choose particular areas on the island for revegetation?

How do you plan to wisely use your limited supply of water on your plants? Ⓦ **water**

Using arrows, identify the wind direction on the map. How does the wind affect your plants and the environment? How does the wind affect groundwater replenishment?

How will these plants help renew the groundwater supply?



Nā Wai Puna o Kamōhio no Kahoʻolawe
The Spring Waters of Kamohio on Kahoʻolawe
passed down to Harry Kūnihi Mitchell by his grandmother's cousin

ʻUʻina Haʻi
Mai ke kumu o Lanikau
Ka maka o Lonokaʻehokūānuenue

E pili i ke kumu o Kahiki

Ke kumu o Moaʻulanuiākea i hānau ʻia

Kumu uli paʻa o nā kūpuna

Mai ke kihi o ka hono ʻo Kamōhio
 i hikina
Ka wai puna pua o Kāne
Me ka wai heʻe o Kanaloa
Nā wai wili lua ke kau nei
Kau lī lua i ka puʻu ke ʻapu iho
Nihi pali ke alo o nā wai

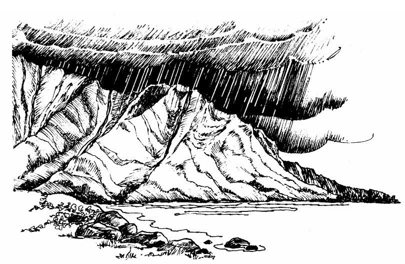
Kūmanamana ka pōhaku kau
 pueo ʻula
Mai ke alo o Wākea hoʻohaulani
 moku i ʻō
Kū haʻililani kapu ʻo Kanaloa—
 Kahoʻolawe
ʻUlalena ka ua ke nihi nei
Kukū ka ʻale o ka makani
Hololua, holopili, holokake
Kuakea ka ʻili o ka honua
Mōlehuleh ke alo o ka honua
Hele nahe ka hōkū ke kau nei
Mai komohana, kūkulu hema,
 kūkulu ʻākau, hikinia
Naue mai ke aloha no ka ʻāina
 Kanaloa—Kahoʻolawe

Revelation
From the source from heaven above
The eyes of the god Lonokaʻeho-who-
 stands-on-the-rainbow
Whose knowledge comes from the
 creation of Kahiki
Born from the *kahuna* class of
 Moaʻulanuiakea
With deep knowledge of his ancestors'
 teachings
And from the east bend of Kamōhio Bay

Spring forth the flower waters of Kāne
And the slippery waters of Kanaloa
Which are hidden high in the cliffs
They are cool and refreshing to drink
The trail leading to the springs is
 dangerous to traverse
The pillar rock above is like a red owl

The presence of the god Wākea towards
 the land brings good feelings
The heavens declare the *kapu* on Kanaloa—
 Kahoʻolawe
The reddish rain is creeping over the land
The wind is stirring up white caps
The wind is blowing from three directions
The ocean is covered with white caps
It's beginning to get dark over the land
The evening star is slowly appearing
Followed by stars from West, South, North,
 and East
I love this island of Kanaloa—Kahoʻolawe

Kahoʻolawe Nā Leo o Kanaloa, pp. 47–48. ʻAi Pōhaku Press, Honolulu.



How to Read a Topographic Map

Adapted from the U.S. Geological Survey, Dept. of the Interior

What is a Topographic Map?
A map is a representation of the Earth, or part of it. A topographic map shows the shape of the Earth's surface using contour lines. Contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface such as mean (average) sea level. Contours make it possible to measure the height of mountains, depths of the ocean bottom and steepness of slopes.

A topographic map shows much more than contours. The map includes symbols that represent such features as streets, buildings, streams, and woods. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or to reduce production cost. Consequently, maps may have slightly different symbols for the same feature. On the Kaho‘olawe topographic map, you can see the symbol for an unpaved or dirt road (= = = = =, dotted double lines) that runs from the coast to the summit. There are also symbols for elevation (△, ⊥, 5) and marine shore boundaries (– – – – –, dotted lines off the coast).

Large Is Small
Making sense of a topographic map requires an understanding of scale. Simply defined, scale is the relationship between distance on the map and distance on the ground. A map scale usually is given as a fraction or a ratio—1/10,000 or 1:10,000. These "representative fraction" scales mean that 1 unit of measurement on the map—1 inch or 1 centimeter—represents 10,000 of the same units on the ground. The first number (map distance) is always 1. The second number (ground distance) is different for each scale; the larger the second number is, the smaller the scale of the map.

U.S. Geological Survey Scales
The U.S. Geological Survey (USGS) publishes maps at various scales. The scale used for most U.S. topographic mapping is 1:24,000. USGS maps at this scale cover an area measuring 7.5 minutes of latitude and 7.5 minutes of longitude and are commonly called 7.5-minute quadrangle maps. Map coverage for most of the United States, including Hawai‘i and the attached Kaho‘olawe map, has been completed at this scale.

Maps at 1:24,000 scale are fairly large and provide detailed information about the features of an area, including the locations of important buildings, campgrounds, fence lines, and roads. On a map with a scale of 1:24,000, 1 cm = 240 m (1 in = 2,000 ft). The attached Kaho‘olawe map was reduced to 66 percent: 1 cm = 320 m.

Although the attached Kaho‘olawe map does not have a north arrow, the map is oriented so that north is above, west is to the left, east is to the right, and south is below.