



Activity #3

# Rain Forest on a Budget

## ● ● ● In Advance *Student Assignment*

- Assign the Student Page “Water in the Rain Forest—What Goes In and What Comes Out” (pp. 45-53) as homework.

## ● ● ● Class Period One *Rain Forest Water Budget & Demonstration*

### Materials & Setup

- “Water Budget for Windward Haleakalā” acetate (master, p. 44)
- Overhead projector and screen

### *For each student*

- Student Page “Water in the Rain Forest—What Goes In and What Comes Out” (pp. 45-53)

### *Four sets of the following materials for the demonstration*

- Cardboard box, 17 inches long x 12.5 inches wide x 12.5 inches high (or similar)
- 33-gallon garbage bag
- Scissors
- Household sponges—enough to cover the bottom of the box
- Stapler
- Soil
- Board or dish drainer to put under box
- Leafy branches (leaves one to two inches long)
- Plastic 1/2-gallon jug with small holes drilled into the side (not the bottom, because you have to put water in it without letting it run out) or a garden watering can
- Timer
- Catchment container at open end of box
- Four measuring beakers of the same size

### Instructions

- 1) Discuss student responses to the Student Page “Water in the Rain Forest—What Goes In and What Comes Out.” Use the “Water Budget for Windward Haleakalā” acetate as you are discussing question #3.
- 2) After the discussion, show the water budget acetate again, and ask students what they think would happen to each of the water budget elements if the understory and forest floor vegetation and/or canopy layers were disturbed or removed from the rain forest.
- 3) Do the “Rain Forest in a Box” demonstration following instructions in the teacher background (pp. 40-42). This demonstration helps students visualize what happens to the forest soil layer as rain falls in an intact rain forest, as well as one in which the understory and forest floor vegetation and/or the canopy layers have been removed.



- 4) After the demonstration, divide the class into four groups. Each group should select one water budget element and design an experiment to test their hypothesis about the effects of clearing the rain forest on that element. They will be conducting these experiments during the next class period. Encourage students to use the same materials as you used for the demonstration. If a group needs additional materials, students should bring them to the next class.

## ● ● ● Class Period Two *Testing the Effects of Rain Forest Clearing*

### Materials & Setup

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*For each student*

- Student Page “The Waters of Kāne” (pp. 54-55)

*For the demonstration*

- Same four sets of materials from Class Period One

### Instructions

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- 1) Provide each group with one set of “Rain Forest in a Box” materials. Have them conduct their experiments by:
  - a) Writing the question they are trying to answer, as well as their hypothesis;
  - b) Writing a description of the methods they will use to test their hypothesis;
  - c) Setting up and conducting the experiment;
  - d) Recording results; and
  - e) Writing their conclusions.
- 2) Have groups share their methods and results with the rest of the class.
- 3) As homework, assign the Student Page “The Waters of Kāne” and/or one or more of the journal writing topics.

### Journal Ideas

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- What is the likely effect of rain forest degradation on human water supply from the Haleakalā rain forest?
- What do you think would happen to the rain forest if people started pumping large volumes of ground water from the East Maui Watershed? How could you test this hypothesis?
- What are some ways to reduce the growing demand for water from the Haleakalā rain forest? What can you do personally to contribute?
- Do you think surface water should be diverted from East Maui streams for agricultural and household use in Central, Upcountry, and East Maui? West and South Maui? Why or why not?

### Assessment Tools

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- Student Page “Water in the Rain Forest—What Goes In and What Comes Out” (teacher version, pp. 37-39)
- Participation in class discussion and demonstration
- Design, conduct, record-keeping, and reporting of experiment
- Student Page “The Waters of Kāne” (teacher version, p. 43)
- Journal entries



Teacher Version

## Water in the Rain Forest—What Goes In and What Comes Out

- 1) Using the data in Table 1: Mean Monthly Water Budget for Windward Haleakalā for your calculations, identify the three months in which the ratio of fog drip to rainfall is the highest. Below, list these three months and the contribution of fog drip to the water budget as a percentage of total moisture input (fog drip + rainfall). Express percentages using two decimal places.

Top three months for fog-drip contribution	Percent of total moisture input
_____ July _____	_____ 26.05% _____
_____ August _____	_____ 25.99% _____
_____ September _____	_____ 26.43% _____

- 2) In the summer months, trade winds tend to be stronger and more reliable than at other times of the year. This pattern produces a well-developed trade wind inversion. How would this seasonally stronger atmospheric inversion help to explain the patterns in high fog-drip contribution you identified in question #1? Explain your reasoning.

The fog zone on the windward (north) side of Haleakalā volcano extends from the mean cloud base level, at about 600 meters (1970 feet), to the lower limit of the most frequent temperature inversion base height at about 2000 meters (6560 feet). The high July to September ratio of fog drip to rainfall is the result of a well-developed atmospheric temperature inversion and strong trade winds. As the moist air is forced upslope, cloud height is restricted by the inversion, thus favoring fog rather than rain-drop formation.

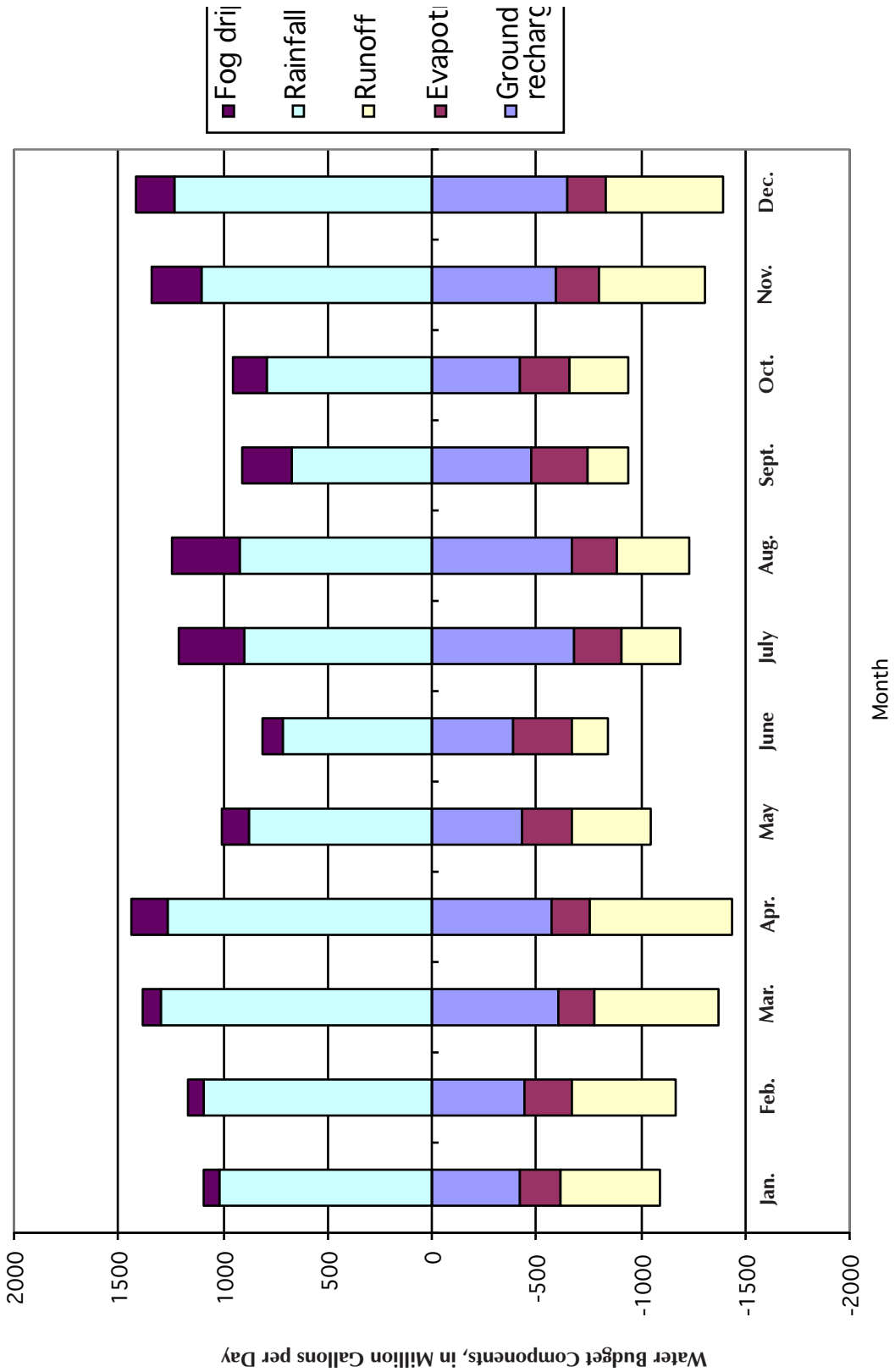
- 3) Using the data in Table 1: Mean Monthly Water Budget for Windward Haleakalā and the blank chart on the following page, create a stacked-column chart representing the relative proportion of water-budget components for windward Haleakalā. A sample stacked-column chart is shown below.

Give this chart a title, labels for each axis, and a legend.

See the completed chart on p. 38.



Water Budget for Windward Halea





- 4) Using the following data, calculate the mean monthly contribution of rainfall and fog drip (in millions of gallons per day) to the water budgets of leeward Haleakalā (zone C on the map) and windward Haleakalā (zone F on the map--see student version for map).

Water budget component	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<u>Windward Haleakalā</u>												
Rainfall	1018	1090	1300	1261	881	713	897	917	671	792	1104	1228
Fog drip	70	77	89	174	129	103	316	322	241	161	237	183
<u>Leeward Haleakalā</u>												
Rainfall	336	268	247	205	107	49	49	82	80	146	192	282
Fog drip	8	7	7	12	6	3	7	12	11	12	16	15

Data in Million Gallons per Day

Answers:

Windward rainfall	989
Windward fog drip	176
Leeward rainfall	170
Leeward fog drip	10

- 5) Explain the difference in relative contribution of fog drip to total moisture input between the leeward and windward zones using the information on the map and what you know about the climate of windward and leeward Haleakalā.

The basic answer is that there is, proportionately, a much smaller fog zone on leeward Haleakalā than there is on the windward side. The windward side is subject to the prevailing trade winds, which bring moisture-laden air from across the ocean. Haleakalā forces these winds upward (the orographic effect), forming clouds that hug the mountainside, capped by a temperature inversion layer.

The same temperature inversion layer caps the cloud/fog layer on leeward Haleakalā. But the winds coming around the mountain and onshore from the south tend not to be as strong, constant, or moist as the trade winds.

- 6) A water budget is a model based on past averages. Some people believe that a series of extremely dry years in the late 1990s may be a sign that East Maui is entering into a prolonged period of reduced average rainfall. If East Maui is indeed beginning a long drought, do you think this estimated water budget should be used as a tool for determining how much surface or ground water can be safely withdrawn from the watershed? Explain your response.

Well-reasoned responses are acceptable.



## *Teacher Background*

# Rain Forest in a Box

## Overview

This demonstration illustrates the importance of the layer of mosses and other vegetation that covers the ground (and many trees) in the rain forest. This thick layer acts as a sponge in the capture and slow release of water in the rain forest. It also illustrates how trees and vegetation slow the speed of water onto the ground.

## Materials

- Cardboard box, 17 inches long x 12.5 inches wide x 12.5 inches high (or similar)
- 33-gallon garbage bag
- Scissors
- Household sponges—enough to cover the bottom of the box
- Stapler
- Soil
- Board or dish drainer to put under box
- Leafy branches (leaves one to two inches long)
- Plastic 1/2-gallon jug with small holes drilled into the side (not the bottom, because you have to put water in it without letting it run out) or a garden watering can
- Timer
- Catchment container at open end of box
- Four measuring beakers of the same size

## Preparation

In advance of the class period, assemble the four sets of materials in the following manner:

- 1) Cut away the narrow (12.5 inches) end of the box.
- 2) Cut open the plastic garbage bag, and line the inside of the box with it. Staple the edges to the box.
- 3) Support the underside of the box with a board or dish drainer.
- 4) Put soil into the box to a depth of approx. 1 1/2 inches; pack it down.
- 5) Completely cover the soil with sponges.
- 6) Prop the back of the box up two inches, so it is on a slight slope.
- 7) Place leafy branches in the box so that it looks like a forest inside.
- 8) Place one quart of water into the 1/2-gallon jug.



## Procedure

### Experiment 1 - How much water drains out with the forest vegetation intact?

- 1) Explain to students what you are about to do, and have them write down hypotheses about what will happen.
- 2) On one “rain forest in a box,” slowly sprinkle the quart of water onto the leafy branches. Note the length of time this takes.
- 3) Let the box drain into the catchment container for one minute.
- 4) Pour the water and any soil into a measuring beaker or cup. If there is soil in it, let it stand awhile so the soil can settle out. Then measure the volume of soil and water, and record the results.
- 5) Squeeze out the sponges and measure the water they hold. Record the results.
- 6) Have students compare the results to their hypotheses.

### Experiment 2 — Simulating understory destruction

Using a different “rain forest in a box,” do exactly the same as above, but without the sponges.

### Experiment 3 — Simulating canopy opening

Using a new “rain forest in a box,” repeat the procedure, but without the leafy vegetation.

### Experiment 4 — Simulating canopy opening and understory destruction

Carry this investigation one step further by taking both the leafy branches and the sponges out and sprinkling the water on the bare soil.

## Interpretation

- 1) Measure the height of the soil layer in all beakers.
- 2) Measure the height of the water layer in all beakers.
- 3) Measure the height of the water taken from the sponges.
- 4) Make a bar graph for comparison.



## Discussion

- 1) Did the sponge layer do anything to retard the flow of water and soil as runoff?
- 2) How does the sponge layer appear to be valuable in the forest?

It slows the water getting to the ground, so the soil isn't washed away and releases the moisture slowly into the ground to recharge the aquifers.

- 3) What acts like a sponge in the rain forest?

The forest floor is covered with a mat of mosses, lichens, and low-growing plants, along with a layer of soil and decaying plant matter that act as a sponge.

- 4) In nature, where does the runoff go?

Into streams and then to the ocean

- 5) What destroys the sponge layer in the forest?

Pigs root in the forest floor for fern roots and earthworms; the hooves of wild cattle break up the sponge; people walking over the same area break down the sponge.

- 6) Discuss the role that vegetation plays in slowing down the flow of water onto the ground.

Leaves and branches provide surface area, which forces the rain water to slow as it falls.

- 7) Why is it important that the rain falls slowly onto the ground?

Soil isn't washed away.

- 8) Why is the topsoil valuable?

Most of the decomposition in the forest happens in the top soil layer, so all the nutrients are here.





*Teacher Version*

## The Waters of Kāne

On the following page is a translation of a *mele* from Kaua‘i that describes elements of the hydrologic cycle. It is entitled “*Ka Wai a Kāne*,” or “The Waters of Kāne.” (Kāne is one of the four great Hawaiian gods.)

Read “*Ka Wai a Kāne*.” Then, on this page or a separate piece of paper, write your own *mele* that reflects the hydrologic cycle on windward Haleakalā. Be sure to include the water budget components you worked with in this unit.

Other ideas for your *mele* include:

- Rain forest alterations that can or have changed the water budget,
- Specific places on East Maui,
- Inversion layer and lifting-condensation levels,
- Seasonal differences,
- Orographic lifting,
- Differences between the windward and leeward sides,
- Other climate characteristics you studied in this unit, and
- How people can help keep the “waters of Kāne” flowing on East Maui.

Basic parameters for evaluating the students’ *mele* include:

- Accurate inclusion of the main water budget components (rainfall, fog drip, runoff, evapotranspiration, soil-moisture storage, and groundwater recharge),
- Accuracy in describing/including other concepts related to the hydrologic cycle, and
- Accurately locating places on Maui with respect to the hydrologic cycle.

You may also want to account for creativity, evidence of additional research, the range of additional information included beyond the six components of the water budget.



Water Budget for Windward Halea

