



Rain Forest Unit 2

Rain Forest Relationships

Overview

In this unit, students learn about some of the main species in the rain forests of Haleakalā and how they are related within the unique structure of Hawaiian rain forests.

The primary canopy trees in the rain forest of Haleakalā and throughout the Hawaiian Islands are 'ōhi'a (*Metrosideros polymorpha*) and koa (*Acacia koa*). At upper elevations, including the cloud forest zone within the rain forest, 'ōhi'a dominates and koa is absent. In the middle and lower elevation rain forests, below about 1250 meters (4100 feet), koa dominates, either intermixed with 'ōhi'a, or sometimes forming its own distinct upper canopy layer above the 'ōhi'a.

These dominant tree species coexist with many other plants, insects, birds, and other animals. Hawaiian rain forests are among the richest of Hawaiian ecosystems in species diversity, with most of the diversity occurring close to the forest floor. This pattern is in contrast to continental rain forests, where most of the diversity is concentrated in the canopy layer.

Today, native species within the rain forests on Haleakalā include more than 240 flowering plants, 100 ferns, somewhere between 600-1000 native invertebrates, the endemic Hawaiian hoary bat, and nine endemic birds in the honey-creeper group.

Length of Entire Unit

Five class periods

Unit Focus Questions

- 1) What is the basic structure of the Haleakalā rain forest?
- 2) What are some of the plant and animal species that are native to the Haleakalā rain forest? Where are they found within the rain forest structure?
- 3) How do these plants and animals interact with each other, and how are they significant in traditional Hawaiian culture and to people today?



Unit at a Glance

Activity #1

Rain Forest Slide Show

Students learn about the Haleakalā rain forest by watching a slide show and writing about their feelings about the importance of preserving native rain forests.

Length

One-half to one period

Prerequisite Activity

None

Objectives

- Become familiar with the basic characteristics and structure of a native Hawaiian rain forest.
- Describe a personal perspective on the importance of native rain forests and efforts to preserve them.

DOE Grades 9-12 Science Standards and Benchmarks

None

Activity #2

Rain Forest Species Research

Students research a native rain forest species, finding and presenting information about it in an educational and attractive format.

Length

One period plus research time outside class

Prerequisite Activity

None

Objectives

- Use written and Internet resources to find basic information about a native rain forest species.
- Present the information visually and in written form.
- Describe the characteristics and habitat of a native rain forest species, as well as its relationship to other species, past or current use by humans, and/or significance in traditional Hawaiian culture.

DOE Grades 9-12 Science Standards and Benchmarks

LIVING THE VALUES, ATTITUDES, AND COMMITMENTS OF THE INQUIRING MIND: Students apply the values, attitudes, and commitments characteristic of an inquiring mind.

- HONESTY: Acknowledge references, contributions, and work done by others.
- SELF-DIRECTED: Use research techniques and a variety of resources to complete a report on a project of one's choice.



Activity #3

Rain Forest Species Presentations

Students present information about native rain forest species.

Length

Two class periods

Prerequisite Activity

Activity #2 “Rain Forest Species Research”

Objectives

- Make a two- to three-minute presentation based on research conducted on a native rain forest species.
- Create a visual representation of where in the rain forest structure different species are found.

DOE Grades 9-12 Science Standards and Benchmarks

DOING SCIENTIFIC INQUIRY: Students demonstrate the skills necessary to engage in scientific inquiry.

- Communicate and defend scientific explanations and conclusions.

Activity #4

Rain Forest Trivia

In teams, students demonstrate their knowledge of rain forest species.

Length

One class period

Prerequisite Activity

Activity #3 “Rain Forest Species Presentations”

Objectives

- Demonstrate knowledge of rain forest species.
- Demonstrate attentiveness to, and learning from, other student presentations.

DOE Grades 9-12 Science Standards and Benchmarks

None



Enrichment Ideas

- Following the instructions in Activity #2, research and create species cards for introduced species. Here is a list of some familiar introduced species.

Polynesian Introduced Plants

- *Kukui* or candlenut tree (*Aleurites moluccana*)
- *Wauke* or paper mulberry (*Broussonetia papyrifera*)
- *Mai'a* or banana (*Musa x Paradisiaca*)
- 'Ulu or breadfruit (*Artocarpus altilis*)
- *Kalo* or taro (*Colocasia esculenta*)
- 'Awa or kava (*Piper methysticum*)
- 'Ohe or Hawaiian bamboo (*Schizostachyum glaucifolium*)
- 'Ōhi'a 'ai or mountain apple (*Syzygium malaccense*)

Recent Plant Introductions

- *Kāhili* ginger (*Hedychium gardnerianum*)
- Strawberry guava and common guava (*Psidium cattleianum* and *Psidium guajava*)
- African tulip tree (*Spathodea campanulata*)
- *Liliko'i* or passionfruit (*Passiflora edulis*)
- Avocado (*Persea americana*)

Introduced Mammals

- Polynesian rat (*Rattus exulans*)
 - Norway rat (*Rattus norvegicus*)
 - Black rat (*Rattus rattus*)
 - Pig (*Sus scrofa*)
 - Cat (*Felis catus*)
 - Axis deer (*Axis axis*)
 - Small Indian mongoose (*Herpestes auropunctatus*)
 - Domestic goat (*Capra hircus*)
- Use the rain forest species cards from Activity #2 to create a representation—such as a large drawing, a model, or a collage—of the Haleakalā rain forest. The representation should show the structure of the rain forest,

where different species live, and some of the important relationships among species within the rain forest.

- Adapt the “Web of Life Game” using the rain forest species cards (Activity #2). This game builds knowledge about relationships among species. (See Alpine/Aeolian Unit 3, Activity #4 “Web of Life Game.”)
- Make up and play different games using the rain forest species cards (Activity #2).
- Research native species that are endemic to Haleakalā. Some of the species cards from Activity #2, such as the one for Hawaiian lobeliads, encompass many species. Some of these are unique to Haleakalā.

Resources for Further Reading and Research

Hawai'i Audubon Society, *Hawaii's Birds*, 5th ed., Hawai'i Audubon Society, Honolulu, 1997.

Medeiros, Arthur C., and Lloyd L. Loope, *Rare Animals and Plants of Haleakalā National Park*, Hawai'i Natural History Association, Hawai'i National Park, 1994.

Moanalua Garden Foundation, *Forest Treasures* (CD ROM), 2000.

Stone, Charles P., and Linda W. Pratt, *Hawai'i's Plants and Animals; Biological Sketches of Hawai'i Volcanoes National Park*, Hawai'i Natural History Association, National Park Service, and University of Hawai'i Cooperative National Park Resources Study Unit, Hawai'i Volcanoes National Park, 1994.



Activity #1

Rain Forest Slide Show

● ● ● Class Period One *Setting the Stage*

Materials & Setup _____

- “Rain Forest Slide Show” (included with this curriculum)
- “Rain Forest Slide Show Script” (pp. 6-12)
- Slide projector and screen

Instructions _____

- 1) Show and narrate the slide show using the script.
- 2) As homework, or for the remainder of the class period, have students write responses to questions posed in the last segment of the slide show or the following questions:
 - What impact do you think the loss of native rain forests has had on native plant and animal species?
 - How about the ability to live and practice traditional Hawaiian culture?
 - Do you believe preserving rain forest habitat on Haleakalā is important? Why or why not?

Journal Ideas _____

- Have you ever been in the native rain forest? If so, what was it like? If not, what do you think it would be like?
- Do you believe the Hawaiian concepts of *wao akua* and *wao kanaka* are useful today? If so, how? If not, why not?
- Should the Hawaiian concepts of *wao akua* and *wao kanaka* be used in managing the Haleakalā rain forest today? If so, how? If not, why not? Be specific.

Assessment Tools _____

- Writing assignment
- Journal entries



Teacher Background

Rain Forest Slide Show Script

Slide #1

Upper rain forest

Welcome to *wao akua*, a place of mist, of clouds, and of spirits. In Hawaiian tradition, these upper reaches of the native forest are the realm of Kū, god of war, governance, and upright growth (such as trees). Humans could only enter this sacred area for specific purposes and with permission from the gods.

Before entering the forest, Hawaiians asked for permission from the forest to enter and work or take its resources. They also stated their good intentions before entering and asked for protection while they were in the forest. Here's a typical chant:

Noho Ana Ke Akua

Noho ana ke akua i ka nāhelehele

I ālai 'ia e ke kī'ohu'ohu

E ka ua koko

E nā kino malu i ka lani

Malu e hoe

E ho'ōulu mai ana 'o Laka i kona

mau kahu

'O mākou, 'o mākou no a

The Gods Dwell

The gods dwell in the forest

Hidden by the mists

By the low lying rainbow

O beings sheltered by the heavens

Clear our paths (of all that may trouble us)

Laka will inspire and enrich her devotees

That's us, us indeed

Slide #2

Lower rain forest

Below the *wao akua* is the *wao kānaka*, an area where people live and work and crop cultivation is extensive.

Slide #3

Rain forest aerial

Rain forests are characterized by high rainfall (exceeding 80 inches annually, but often much more) and no distinct dry period during the year. Rain forests have developed on the eastern flanks of Haleakalā as a result of the moisture-laden northeast trade winds received during most of the year.

Slide #4

Rain forest

The native rain forest of Haleakalā once extended from just above the coast up to approximately 2500 meters (8200 feet). These areas were home to many species of native birds, insects, and plants.



Slide #5

Researchers in rain gear

This area receives between 80 and 300 inches of rainfall annually. In some areas, sometimes called cloud forests, moisture comes more from plants intercepting moisture directly from low-lying clouds and fog. What do you think is the most rainfall ever measured in the Haleakalā rain forest? (In 1994, a rain gauge in Kīpahulu Valley in Haleakalā National Park recorded 575 inches of rain!)

Slide #6

Hāna Hwy. scene

The *wao kānaka* of today has been cultivated, logged, and invaded by nonnative plants introduced from all over the world. Although unrecognizable by ancient Hawaiians, this is probably the image most of us have of the rain forests on Maui.

Slide #7

Graphic?

What we might not realize is that the *wao akua* continues to thrive in the upper reaches of the rain forest in the place of mist, clouds, and spirits. As in earlier times, much of the remaining native rain forest is *kapu* or off-limits — it is protected and preserved.

Does anyone know how ancient Hawaiians used the rain forest? (Wait for answers, then continue with the slide show.) Here are some of the ways . . .

Slide #8

Featherwork

Among the people who were allowed to enter the *wao akua* in the times of old were the skilled *kia manu* (birdcatchers). Colorful feathers from native forest birds were fashioned into lei, capes, and ceremonial helmets for the *ali'i*.

Slide #9

I'iwi

The trained *kia manu* captured birds such as this *'i'iwi*, the *'ō'ō*, or *'apapane*, plucked the desired feathers, and then released the bird. *I'iwi* and *'apapane* are still fairly common today; however, many native Hawaiian birds, like the *'ō'ō* are now extinct.

Slide #10

Koa tree or canoe

Traditionally, canoes were hewn from a single *koa* trunk harvested from the forest. The *kahuna kālai wa'a* (expert of canoe-making) and the necessary work party would spend days preparing spiritually before venturing into the forest to search for the proper tree. Offerings of food and prayer preceded the tree cutting and rough shaping of the canoe. Guided by a spiritual protector, the canoe was then lowered down the mountain.



Slide #11

'Ama'u fern

The *wao kānaka* is where the 'ama'u fern grows. In traditional Hawaiian culture, the 'ama'u has many uses. Its trunk can be steamed and fed to pigs, and people ate it in times of famine. The fronds were cooked and eaten or used to thatch houses or mulch upland taro gardens.

Slide #12

Taro

Does anyone know what this plant is? (Taro) Taro or *kalo* was grown as a food staple. It was planted along streams and drainages, where it would grow naturally. It was cultivated in irrigated terraces. All parts of the *kalo* were harvested. The root was pounded into a paste called *poi* and the leaves were eaten as green vegetables. *Kalo* was a sacred food that could only be planted, harvested, and cooked by men. Women could only eat certain types. Today, *kalo* continues to be an important part of the culture of Hawai'i.

Slide #13

'Olonā

Other useful native plants from the rain forest include 'olonā. Eight times stronger than hemp, 'olonā is an endemic plant of Hawai'i and highly prized as a source of tough, durable fiber for ropes and fishing nets. In earlier times, it was commonly used as base material for ti-leaf cloaks and feather capes.

Slide #14

'Ie'ie

'Ie'ie is a woody vine that wraps itself around the trunks of trees. The long slender aerial rootlets were made into cordage for lashing house posts and for securing outriggers to canoes. The rootlets were also used in plaiting the framework for *mahiolo* (helmets) and feather images such as *Kūlā'ikimoku*, the war image of *Kamahameha*, and in *hīna'i* (basket fish trap). The decorative flowering branches of 'ie'ie were used on the *kuahu* (altar) in the *hālau hula* as a tribute to the goddess *Laka*.

Slide #15

Kapa

Bark from the *wauke*, a plant brought to Hawai'i with the Polynesians, was soaked and beaten into *kapa*, a paper-like cloth which was fashioned into soft, flexible attire. *Kapa* made in Hawaii displayed the greatest varieties of textures and colored designs found in Polynesia.

Slide #16

Māmaki

And *māmaki* was used for making firm, heavy *kapa* from the fibers of the mature stems. It is rougher and not as white as *kapa* made from *wauke* and was considered second in quality to it. The leaves are brewed into tea for use as a general tonic. You can still pick some up at Long's today! Though rather tasteless, the white fleshy mulberry-like fruit is eaten by people and birds, and has some medicinal uses.



Slide #17
Forest shot

The ancient Hawaiians depended on the rain forests for food, clothing, medicine, and transportation. They realized that their physical and spiritual well-being depended on perpetuating these resources and maintaining a high respect for the land.

Slide #18
Rain forest layers

The rain forests of Hawai‘i are typically multilayered, consisting of a continuous canopy tree layer over a lower subcanopy layer of trees and shrubs, and even lower understory and forest floor layer of smaller shrubs, herbs, and ferns. The dominant trees in the upper canopy filter but do not block the sun from the lower layers and forest floor.

Slide #19
Continental rain forest

Hawaiian rain forests are “upside down” in comparison to the tropical rain forests, such as the one pictured, of South America and Asia. Does anyone know why that is? (Wait for answers, then continue.) Continental tropical rain forests are known around the world as hotbeds of biological diversity. Huge numbers of plant and animal species live in these rain forest ecosystems.

Slide #20
Continental canopy

Most of the species diversity in these continental rain forests is concentrated in the canopy, which can include hundreds of species of trees that shelter a wide array of mammals, birds, insects, and epiphytes. Epiphytes are simply plants that grow supported by other plants. Almost any plant that grows in the rain forest can sometimes be seen growing as an epiphyte, for at least part of their life. In fact, a distinguishing rain forest feature is the abundance of epiphytes on tree trunks and branches.

Slide #21
Hawaiian canopy

By contrast, in Hawaiian rain forests, the canopy is dominated by just one or two species, usually ‘ōhi‘a and koa, or both. Some forest birds and insects live primarily in association with these two species of canopy trees. Also, the only native mammal that lives in the Haleakalā rain forest is in these trees. Who knows what that mammal is? (The ‘ōpe‘ape‘a or Hawaiian hoary bat. It may be found roosting in these trees during the day.)

Slide #22
Subcanopy

Greater diversity is displayed in the subcanopy or the second tree layer of the Hawaiian rain forests, where up to ten species form an open to closed canopy ranging in height from about 20 to 40 feet. ‘Ōlapa is perhaps the most abundant tree species and is often seen growing epiphytically on much larger ‘ōhi‘a trees.



Slide #23
Understory

Most of the biological diversity in Hawaiian rain forests is contained in the understory, especially the ground-cover or forest floor layer. In this lowest layer of the forest, a profusion of shade-loving native plants that require cool, humid conditions thrive. This tapestry of plant life includes various ferns, herbs, shrubs, and saplings of canopy tree species. Chief among these are the ferns and fern allies; more than 100 species are found in the rain forests of Haleakalā. Some of the most abundant terrestrial ferns of the rain forest are *hāpu‘u* (tree fern), *palapalai*, and *‘ama‘u*.

Slide #24
Herb or shrub

Sharing the forest floor with the ferns are native herbs, shrubs, and saplings of canopy tree species. The most abundant herbaceous flowering plants of the rain forest floor are *‘ala‘ala wai nui*, weak-stemmed trailing members of the black pepper family. Shrub species most commonly encountered are the *‘ōhelo kau lā‘au*, *pūkiawe*, *kanawao* and young growth of trees such as *‘ōlapa*, *‘ōhi‘a*, and *kōlea*.

Slide #25
Smilax (*hoi kuahiwi*)

Unlike many other tropical forests, Hawaiian rain forest do not support large numbers of climbing vines, also known as lianas. Nonetheless, several native vines are notable components of many forests. These include *‘ie‘ie*, a fibrous-stemmed, prickly-leaved climber in the screwpine family that was noted earlier as important to early Hawaiians, and *hoi kauhiwi* or smilax. This Hawaiian endemic vine has prominently veined, heart-shaped leaves and smooth or bumpy twining stems.

Slide #26
Mint

More rarely encountered are delicate vines in the mint family. *Stenogyne*, a small vine with oblong, scallop-margined leaves, is the most frequently seen Hawaiian mint. Hawaiian mints are often called “mintless mints.” Does anyone know why? (They lack the strongly scented oils most mints have . . . that give us peppermint, spearmint, etc.) They are highly palatable to non-native ungulates like cattle, goats, and pigs; thus, they have been eliminated or much reduced in pig-impacted forests.

Slide #27
Epiphyte

Common epiphytes include most species of mosses and lichens, the flowering *‘ala‘ala wai nui*, many small ferns, and larger plants such as the shrubby *‘ōlapa*, which often get their start in life by taking root in crevices of other trees. In these forests, epiphytes and trees may be so intertwined that it is difficult to identify the original host tree.



Slide #28
Endemic species

While Hawaiian rain forests are among the most species-diverse ecosystems on this isolated archipelago, they are relatively species-poor when compared to continental rain forests. Hawaiian rain forests, however, do support a large number of endemic species, found nowhere else in the world.

Slide #29
Drosophila

The rain forests of Hawai‘i support a large array of insects and spiders. This fly is one of over 500 species of flies in the Drosophilidae family that have been identified in Hawai‘i. Nearly one-quarter of the known species in this family are found in Hawai‘i, including many that are narrowly endemic. That means that they occur in only a very small area. Hawaiian *Drosophila* flies are an example of explosive adaptive radiation, an evolutionary process through which a large number of divergent and unique species arise from a single common ancestor species. Some researchers believe that Hawaiian rain forests offer a unique opportunity for studying evolution in action. Does anyone know how these flies attract mates? (The males compete with each other by doing a dance to attract females. The females select the best dancers.)

Slide #30
Cyanea horrida

Examples of endemic species known only from the rain forests of Haleakalā are ‘ōhā or lobelias such as *Clermontia tuberculata* and *Cyanea horrida*.

Slide #31
Geranium multiflorum

Other endemic Haleakala species are two geraniums or *nohoanu*. This *Geranium multiflorum* is known only from East Maui. Since endemic species are often known from a limited area, it is not surprising that many, such as this one, are considered in danger of extinction.

Slide #32
Po‘ouli

The rain forests of Haleakalā also provide essential habitat for 13 endemic birds, eight of which are federally listed as Endangered Species. Early in 2001, there were only three known *po‘ouli* on the slopes of Haleakalā. This is one of them.

Slide #33
Degraded rain forest

Although rugged terrain and dense growth may seem to offer the Haleakalā rain forest some protection, these forests are under continuous pressure by feral pigs and goats, rats and mice, invasive alien plants, and diseases that threaten the native birds.



Slide #34

Fencing crew

Haleakalā National Park, the State of Hawai‘i, The Nature Conservancy and the East Maui Watershed Partnership have active management programs in the rain forests of Haleakalā including fencing, feral animal control, invasive plant control, and research.

Slide #35

Original rain forest extent

Like most other native ecosystems on Maui, the native rain forest has been significantly reduced in size since people came to this island. Originally reaching to the ocean in a broad band across the windward side of Haleakalā . . .

Slide #36

Today’s rain forest extent

Today the native rain forest covers a much smaller area and is cut off from the ocean by a swath of landscape altered by humans. The remaining intact native rain forests are by and large in higher elevations.

Slide #37

Forest shot

These rain forests of Haleakalā, considered *wao akua* by the early Hawaiians, continue to hold mysteries and unique flora and fauna that many people want to protect and value for this and future generations. Do *you* think it’s important to protect and value these forests? Why does it matter? What can you do about it? Think carefully about these questions—because they’re your homework assignment!



Activity #2

Rain Forest Species Research

● ● ● Class Period One *Species Cards*

Materials & Setup

- Research materials: at minimum the three listed in #3 below, and others that you can gather or check out of the library [See the Student Page “Rain Forest Species Cards” (pp. 36-41) for suggested resources.]

For each student

- Student Page “Rain Forest Species Cards” (pp. 36-40)
- One card from the “Rain Forest Species Assignments” (master, pp. 27-35)

Instructions

- 1) Hand out the Student Page “Rain Forest Species Cards” to each student. Also give each student one Species Assignment card—a different species for each student. There are 36 species total.
- 2) If you have a smaller class, you may select a representative sampling from the species cards, making sure you have a blend of invertebrates, birds, and plant species from the canopy, subcanopy, understory, forest floor, and vines categories. See the teacher background “Rain Forest Species Card Information Summary” for species that fit in each category (pp.15-26).

OR

You may offer extra credit to students who create more than one species card.

- 3) For the rest of this class, as homework, and during the next class period, students will create a card for the species assigned to them. The primary information resources available as part of this curriculum are:

Hawai‘i Audubon Society, *Hawaii’s Birds*, 5th ed., Hawai‘i Audubon Society, Honolulu, 1997.

Medeiros, Arthur C., and Lloyd L. Loope, *Rare Animals and Plants of Haleakalā National Park*, Hawai‘i Natural History Association, Hawai‘i National Park, 1994.

Moanalua Garden Foundation, *Forest Treasures* (CD ROM), 2000.

Stone, Charles P., and Linda W. Pratt, *Hawai‘i’s Plants and Animals; Biological Sketches of Hawaii Volcanoes National Park*. Hawai‘i Natural History Association, National Park Service, and University of Hawai‘i Cooperative National Park Resources Study Unit, Hawai‘i National Park, 1994.

Additional sources of information can be found in the library and on the Internet. A beginning listing of resources is part of the student page.



- 4) Encourage students to create their own images for the species card rather than using the one on the Species Assignment card. Also encourage them to bring to the next class art supplies, reference books they have at home, and species information they photocopy from printed sources or download from the Internet so they can work on their species cards during class.

Note

If you have difficulty locating resources for student research or if you do not want students to research the species cards, give each student the relevant information from the teacher background (pp. 15-26). Students can create their species cards using this information.

● ● ● Class Period Two *Rain Forest Species Cards*

Materials & Setup

- Research materials (see Class Period One)
- Colored pens, pencils, scissors, glue and other supplies for student use in creating species cards

Instructions

- 1) Allow students to finish their species cards during this class period.

Journal Ideas

- Make up a chant or a poem about your rain forest species.
- What was the most interesting thing you learned about your species? Why?

Assessment Tools

- Rain forest species cards
- Journal entries



Teacher Background

Rain Forest Species Card Information Summary

The following summarizes some of the available information about each species. You may use these summaries to help check students' work. Note: Unless otherwise noted, "endemic" refers to the Hawaiian Islands, denoting species that today are thought to be unique to one or more of the Hawaiian Islands.

NATIVE INVERTEBRATES

Haleakalā flightless lacewing (*Pseudopsectra lobipennis*)

- Endemic to Haleakalā
- It no longer has lace wings. Its hardened and beetle-like front wings cup and protect its body and its rear wings are small and strap-like.
- In spite of alien rodent predators, this rare insect still survives in the dense rain forests of Kīpahulu Valley within the park.
- The adults hunt at night on tree trunks.

Hawaiian crickets

(Family Gryllidae, one indigenous genus [*Paratrigonidium*] and 3 endemic genera [*Leptogryllus*, *Thaumtogryllus*, and *Prognathogryllus*])

- All Hawaiian crickets are brown and flightless.
- Some are loud, strong "singers." A male cricket sings by rubbing his wings together to attract females of his species. Each species has a unique song.
- It lives in 'ōhi'a and koa rain forests up to 1500 meters (4920 feet) in elevation. Within Haleakalā National Park, most are found in the rain forests of Kīpahulu Valley.
- Alien rodents (mice and rats) prey on these rare insects.
- The number of named, endemic Hawaiian crickets is over 200 species, twice the total known for the continental U.S. One species is named *kipahulu* after Kīpahulu Valley.

Hawaiian ground beetles (Family *Carabidae*)

- Ground beetles prey on arthropods and snails.
- Ground beetles are an example of adaptive radiation. The 215 endemic species of ground beetles on the Hawaiian Islands are believed to have evolved from as few as six original immigrants.
- Ground beetles are found in many different natural communities on Haleakalā including high-elevation shrublands, the alpine/aeolian zone, and the rain forest.
- In the late 1980s, scientists discovered and described two new species of ground beetles inside deep lava tubes in Kīpahulu Valley.



Hawaiian long-horned beetles (*Plagithmysus spp.*)

- Endemic genus (There are other genera of Hawaiian Long-Horned Beetles, as well.)
- The larvae of these wood-boring beetles feed within living, often damaged trees. Females lay their eggs in the bark of trees. On hatching, the larvae burrow into the wood, feeding there for a year or more before pupating into adult beetles.
- Most often, one beetle species has only one tree species as its host. *Plagithmysus cheirodendri* is endemic to East Maui and feeds exclusively on the wood of *kōlea* trees. Other long-horned beetles are associated with *koa*.
- Wood-boring beetles are an example of adaptive radiation. Over 136 species are believed to have evolved from a single ancestral species that arrived on the islands millions of years ago, probably from North America.
- Long-horned beetles are found in many different natural communities on Haleakalā. The most common is associated only with the *māmane* tree, some are found only in rain forests, and one species has adapted to feed only on the *‘āhinahina* in the alpine/aeolian zone.
- The Maui parrotbill, a Hawaiian honeycreeper, uses its bill to tear apart plant stems in search of the pale larvae of these beetles, one of its primary foods. The naturalist R. C. L. Perkins found that the stomachs of the parrotbills he collected in 1894 were filled with long-horned beetle larvae.

Haleakalā weevil (*Oodemas spp.*)

- Endemic genus
- These weevils are also known as snout beetles, for their long snout. They have small (1/4-inch long), shiny, black, rounded bodies that resemble seeds.
- At least 15 species of *Oodemas* are known from Haleakalā, either in the deep rain forests or in native shrublands.
- The 58 species of small, rare *Oodemas* weevils are found only on the Hawaiian Islands. They seem to have no close relatives in the rest of the world.
- These weevils are a favorite food for birds. The adults hide under bark and in mosses and leaf litter during the day. They emerge under cover of darkness to feed on native plants and to mate.

Hawaiian carnivorous inchworm (*Eupithecia spp.*)

- Endemic genus
- The larvae of at least 18 species of Hawaiian moths have abandoned the usual vegetarian diet of caterpillars throughout the world. These caterpillars practice ambush predation, in which they settle on the edges of leaves or on plant stems waiting for a tiny spider or insect to approach.
- These carnivorous species are related to other *Eupithecia* moth species on Haleakalā that feed on flowers, seeds, leaves, and other plant parts.
- The first species of carnivorous inchworms was discovered in 1972.
- These inchworms are about 1.25 centimeters (.5 inch) long.
- There are at least 18 different species using different types of perch sites. They are colored and shaped to blend in with their favored hunting sites. Some that perch on moss-covered tree trunks even look mossy themselves!



Happy-face spider (*Theridion grallator*)

- Endemic
- These spiders are found in many of the rain forests of Hawai‘i, although they may be difficult to spot.
- Happy-face spiders are named for the bright patterns that appear on their abdomens. Some of these patterns resemble smiling faces.
- They are so small that you need a magnifying glass to really appreciate their markings. Including their legs, they are only 1.25-2 centimeters (about .5-.75 inch) long.
- They live under the leaves of rain forest trees and shrubs such as *kanawao* (*Broussaisia arguta*), *kawa‘u* (*Ilex anomala*), and *‘oha wai* (*Clermontia* spp.). They spin irregular-shaped webs in which they catch their prey.
- Females lay eggs on the underside of leaves. Once the tiny spiderlings hatch, the mother captures food for them, wrapping it in silken loops.

Pulelehua or Kamehameha butterfly (*Vanessa tameamea*)

- Endemic (One of only two butterflies native to Hawai‘i)
- A striking orange, black, and white butterfly that measures about five centimeters (two inches) across.
- Most commonly found in mesic woodlands and low- to mid-elevation wet forests. Higher-elevation rain forests and dry forests are less favored but still provide habitat for these butterflies.
- Larvae of this butterfly feed on the leaves of the *māmaki* (*Pipturus albidus*) and other native plants that, like *māmaki*, belong to the nettle family (*Urticaceae*). Parts of the caterpillar resemble *māmaki* flower clusters, and the chrysalis looks like a dead, curled-up leaf.
- Adult *pulelehua* feed on nectar from many native plants and are probably important pollinators for those plants.

Picture wing flies (Family Drosophilidae)

- There are more than 800 species of Hawaiian *Drosophila*. They are a premier example of adaptive radiation.
- *Drosophila* species now occupy a range of habitats. Different species feed on different food items, including rotting fruit and leaves, tree sap, and fungi.
- About 100 of the Hawaiian *Drosophila* species are “giant” picture wing flies. With wingspans up to 2.5 centimeters (one inch), these flies have ornate wing and body patterns that enable the different species to recognize each other.
- Male flies set up breeding territories called “leks” and attract females there. Males have evolved a wide array of courtship behaviors that have been recorded by scientists studying the role of sexual selection in the development of new species.
- Like many of the native arthropod species in Hawai‘i, most of these fly species are endemic to single islands, and even to very small areas on specific islands. Since their populations are often small and have a limited range, they are especially sensitive to habitat changes.



Flying earwig Hawaiian damselfly or *Pinao 'ula* (*Megalagrion nesiotes*)

- Endemic to East Maui and Hawai'i
- This species was recently rediscovered on Maui after 75 years with no specimens collected there. Originally known from both East Maui and Hawai'i, this damselfly is likely to be extinct on Hawai'i Island.
- “Flying earwigs” got their name from the pincer-like appendages on the tip of the male fly's tail.
- Adults tend to fly and perch low amidst the tangled vegetation of the rain forest understory. Unlike many other damselfly species, this species tends to live well away from ponds and streams.
- Observations suggest that breeding habitat is probably fern banks, steep and moist slopes, and scattered pockets of water, such as those collected in the leaves of rain forest plants.
- Away from the water, the *pinao 'ula* often makes its home in the *pa'iniu* plant.

Tree snails (*Partulina* spp.)

- Endemic
- Tree snails range from one to 7.5 centimeters (1/3 to three inches) in length. Their color ranges from white to brown to black, and many are banded. There is a great deal of variation in size, color, pattern, and shape.
- Graze on microscopic algae or fungi
- Various sources of introduced biota have had a negative impact on the snails and their habitat, among them the “cannibal snail” which was originally introduced to control the African snail. This predator eats the tree snail young and eggs. Rats are another chief predator on native tree snails.
- The “singing” tree snails were famous among European naturalists after early explorers brought specimens back from the Hawaiian Islands. It took about 50 years before crickets were found to be the source of the song!

NATIVE BIRDS

'I'iwi (*Vestiaria coccinea*)

- Endemic
- A member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- The 'i'iwi is about 15 centimeters (six inches) long, scarlet-orange in color, with a deeply curved, orange bill.
- The 'i'iwi prefers nectar but will sometimes eat insects and spiders, and feeds its young on insects. It is often found high in the canopy, feeding in flowering 'ōhi'a trees. It can also be found lower in the rain forest dipping into the long, curved flowers of mints (*Stenogyne* spp.), other native plants, and introduced species.
- Its feathers were prized by Hawaiians for use in making feathered capes for royalty.
- It is not as common on Maui as the 'apapane and the 'amakihī, but is still widespread at upper elevations. (It is very rare or extinct on O'ahu, Moloka'i, and Lāna'i.)
- 'I'iwi build their nests five meters (16 feet) or higher up in trees.



‘Apapane (*Himatione sanguinea*)

- Endemic
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- The red plumage of these 13-centimeter (five-inch) birds matches the color of the red ‘ōhi‘a lehua blossoms perfectly. It is often found in the forest canopy searching for nectar from the ‘ōhi‘a, but it also frequents flowering *koa* and *māmane* trees.
- The ‘apapane forages in the forest canopy for nectar and insects.
- This species often nests in the crowns of ‘ōhi‘a lehua or in tree ferns, but its nests have also been found in lava tube skylights.
- The ‘apapane is among the most common honeycreepers in the state. Its range extends from the rain forests into upper-elevation shrublands and even into planted forests. Unlike many other honeycreepers, it is still found down to sea level in some areas.
- Its feathers were used in some Hawaiian featherwork.

‘Amakihi (*Hemignathus virens*).

Also, Maui ‘Amakihi (*Hemignathus virens wilsoni*) a Maui endemic subspecies

- Endemic
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- This yellow-green bird measures about 11 centimeters (4.5 inches) in length and has a downcurved bill, shorter than that of the ‘i‘iwi.
- The ‘amakihi feeds on nectar, insects, spiders, and fruit from forest trees and plants.
- It generally nests in uppermost tree branches.
- The ‘amakihi is among the most common honeycreepers in the state. Its range extends from the rain forests into upper-elevation shrublands and even into planted forests and higher elevation residential areas such as Kula and Kēōkea.

‘Alaahio or Maui creeper (*Paroreomyza montana*)

- Endemic to Haleakalā (formerly also found on West Maui and Lānai)
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- Found on East Maui only, most commonly in the rain forest but also in the upper-elevation shrublands.
- Females of this small (11-centimeter or 4.5-inch) species of honeycreeper are green, the males yellow-green.
- They forage in pairs or small flocks, usually in the trees and shrubs of the rain forest understory, feeding on insects and spiders. Less often, they will feed on the nectar of ‘ōhelo and ‘ōhi‘a flowers.
- Often, an ‘alaahio will be seen high above the forest floor, gleaning insects from the bark of a *koa* tree.



‘Ākohekohe or Crested honeycreeper (*Palmeria dolei*)

- Endemic and endangered
- Once found on both Maui and Moloka‘i but now restricted to East Maui
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- This primarily black bird sports a distinctive tuft of head feathers that range in color from light gray to light orange. It is one of the larger honeycreepers at 18 centimeters (seven inches) in length.
- It is an aggressive bird that often drives off other honeycreepers from flowering trees, enforcing the top end of a “pecking order” among nectar-sipping forest birds.
- It builds its nests in tree tops high in the upper canopy.
- It feeds primarily on the nectar of ‘ōhi‘a blossoms. Its crest probably aids in pollinating the brush-like flowers of the ‘ōhi‘a. ‘Ākohekohe will take nectar from other native plants, and it also eats insects such as caterpillars.

Po‘ouli (*Melamprosops phaeosoma*)

- Endemic to Haleakalā (The *po‘ouli* is endangered, with a population possibly numbering only three individuals in early 2001.)
- First described in 1973 on the upper northeastern slopes of Haleakalā
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- The name *po‘ouli* means “dark-headed,” which is an apt description of this small (14-centimeter or 5.5-inch-long) honeycreeper. Brown above and pale gray below, *po‘ouli* wear a dark mask over the face and head.
- It builds its nest of twigs, lichens, mosses, and grasses high up in the ‘ōhi‘a canopy.
- It forages in understory shrubs and trees tearing at bark, mosses, and lichens on branches looking for invertebrates such as native tree snails and wood-boring larvae.

Maui parrotbill (*Pseudonestor xanthophrys*)

- Endemic to Haleakalā and endangered.
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- Parrotbills are small birds (14 centimeters or 5.5 inches long) that are mostly olive green with yellow and brown markings, a bold eye stripe, and a large bill that resembles a parrot’s.
- The Maui parrotbill is a flocking bird. With its low numbers, it is often seen in flocks with ‘*alauahio*.
- It is found in the shrubs and trees of the rain forest understory and subcanopy, foraging for insect larvae in woody branches and stems. It can be found in ‘ōhi‘a and ‘ōhi‘a-koa rain forests, as well as in *koa*-dominated forests.
- The Maui parrotbill uses its beak like a can opener to split and crack branches, prying out insect larvae with its tongue and upper mandible.
- There is no known Hawaiian name for this species.



Nukupu'u (Hemignathus lucidus)

Also, Maui *Nukupu'u (Hemignathus lucidus affinis)*, a Maui endemic subspecies

- Endemic and endangered, possibly extinct. (The last birds were seen in the 1980s.)
- This bird is a member of the Hawaiian honeycreepers, a group that at one time included some 52 species descended from one original finch species. The honeycreepers are an example of adaptive radiation.
- Yellow and olive-green birds range from 11 to 14 centimeters (4.5-5.5 inches) long with a long, curved upper mandible.
- The *nukupu'u* uses its upper bill to search in bark crevices for spiders, caterpillars, *Oodemas* weevils, and other insects.
- Its preferred habitat, the *koa* forest, has been destroyed on a large scale, occupying only a small part of its original range. Now, with the *koa* forests dramatically decreased in size, and the presence of malaria-carrying mosquitoes at lower elevations, the *nukupu'u* is most commonly found in 'ōhi'a-dominated forests above 1500 meters (4,920 feet).

NATIVE PLANTS

Canopy

'Ōhi'a (Metrosideros polymorpha)

- Endemic
- *Polymorpha* means “many forms.” This species is found in a variety of forms, both within and outside the rain forest. Geographically speaking, its closest relatives occur in Australia.
- In the rain forest, it may grow straight and tall, reaching a height of 18 m (60 feet) or more. In the cloud forest zone, a part of the rain forest where most moisture comes from a nearly-constant cover of fog and clouds, the tree is smaller, with a gnarled and twisted trunk and leathery leaves. In the extreme wet of mountain bogs, 'ōhi'a stands only a few inches high.
- This is the dominant tree in the wetter rain forests at middle and upper elevations. It forms a nearly continuous canopy in these areas.
- Although its flowers are adapted to wind pollination, native birds feeding on nectar also assist in pollination.
- It may begin its life as an epiphyte—a plant that grows using another plant for support, and taking nutrients from air and rainwater. Wind-blown seeds often lodge and germinate on tree fern trunks.
- 'Ōhi'a wood is important in Hawaiian canoe-making, used for the gunwale (*mo'o*) of the canoe because it is hard enough to take the constant rubbing of the paddle. It was also used for the seats, spreaders, decking, and mast of the canoe, and for the ridgepoles, posts, rafters and thatching poles in houses.
- In Hawaiian tradition, it is believed that picking the blossoms causes rain.



Koa (*Acacia koa*)

- Endemic (Geographically speaking, its closest relatives occur in Australia.)
- *Koa* can reach heights of 30 meters (100 feet), piercing the ‘ōhi‘a *lehua* canopy in places and towering above the rain forest.
- *Koa* may dominate the canopy in relatively drier parts of the rain forest. Sometimes it shares the canopy with ‘ōhi‘a. In other places, the *koa* will grow taller and can form a distinct upper canopy layer above the ‘ōhi‘a.
- *Koa* forests have been greatly diminished by logging and ranching. These trees are slow-growing and not easily renewable.
- *Koa* is the host to many rain forest insects.
- Its small, fuzzy, yellow flowers are important sources of nectar for native forest birds, although not as important as the red flowers of ‘ōhi‘a *lehua*.
- *Koa* wood was prized by the Hawaiians, and was used to carve canoes, paddles, surfboards, spears, and calabashes (‘*umeke la‘au*) to hold food, kapa and feathered garments. *Koa* was not used to store *poi*, as it imparted a bitter taste.
- Hulls of single (*kaukahi*) and double (*kaulua*) canoes were carved out of a single *koa* log.
- *Koa* bark was used as a dye for *kapa* and for timbers of grass houses.

Loulu or Fan palm (*Pritchardia* spp.).

Also, (*Pritchardia arecina*), the species found in the Haleakalā rain forest

- Endemic (The members of this genus are the only fan palms native to Hawai‘i. There are 19 endemic species, each of which is unique to a particular island.)
- These palms grow emerge above the canopy singly or in small patches.
- Fossil evidence suggests that *loulu* was more common in ancient times than it is now.
- These fan palms were used in the construction of *heiau loulu*, temporary *heiau* where offerings were made to the gods who presided over fishing.

Subcanopy

Hāpu‘u pulu or Tree fern (*Cibotium glaucum*)

Also *Hāpu‘u i‘i* (*Cibotium chamissoi*)

- Endemic
- These large ferns can grow taller than three meters (ten feet) on a stocky “trunk,” which is actually a network of interwoven aerial roots that absorb moisture.
- They can be very abundant in the shade created by rain forest trees such as ‘ōhi‘a *lehua* and ‘ōlapa. Where pigs range through the rain forest, however, these ferns are greatly diminished. They are recovering in areas that have been damaged by pigs in the past but are now fenced and patrolled to keep pigs out.
- *Hāpu‘u* are sometimes called “the mother of ‘ōhi‘a” because their trunks make a good place for seedling germination.
- Tree ferns are covered with brown silky hairs called *pulu*. *Pulu* was traditionally used for stuffing pillows, dressing wounds, and embalming the dead.
- During times of famine, the pith of the trunk was cooked and eaten, and the fiddleheads were eaten, as well.



‘Ōlapa (*Cheirodendron trigynum*)

- Endemic
- This tree ranges in height from five to 15 meters (16 to 50 feet). ‘Ōlapa is sometimes part of the understory and sometimes part of the canopy.
- In Hawaiian rain forests, ‘ōlapa often grows intermixed with *hāpu‘u* tree ferns and ‘ōhi‘a.
- This tree bears clusters of small, purplish fruits which are eaten by native birds.
- ‘Ōlapa is one host plant for native *Drosophila* flies.
- The soft wood of ‘ōlapa makes good habitat for the burrowing insects on which many birds feed.
- ‘Ōlapa sticks were used by the *kia manu* (bird catchers). They covered the sticks with *kēpau* (sap) and placed them in the forest. The sap trapped birds that landed on these sticks. The wood burns when it is wet and was used by the *kia manu* for fires in the wet forest.
- In hula, ‘ōlapa is the name given to dancers who are graceful enough to imitate the motions of ‘ōlapa leaves fluttering in the breeze.

Māmaki (*Pipturus spp.*)

- Two Kaua‘i endemic species and two Maui endemics (*P. albidus* and *P. forbesii*)
- *Māmaki* grows as a shrub or small tree two to six meters (six to 20 feet) tall.
- It is in the nettle family. It is unusual because it lacks the stinging hairs associated with most nettle species.
- Birds eat the fruits of the *māmaki*, helping disperse the seeds.
- *Māmaki* was used to make a *kapa* similar to that made from *wauke* but coarser in texture.
- Rope and cordage were made from *māmaki* fibers.
- The leaves of *Pipturus albidus* are the primary food of the larvae of the *pulelehua* or Kamehameha butterfly (*Vanessa tameamea*).
- *Pipturus forbesii* is endemic to Haleakalā, found at upper elevations in the rain forest as well as in subalpine shrubland.

Kanawao or Pū‘ahanui (*Broussaisia arguta*)

- Endemic
- A multibranched shrub 1.5-4.5 meters (five to 15 feet) tall, *kanawao* bears clusters of small flowers that produce small red-maroon fruits that mature to a blue-black color.
- It often grows in association with ‘ōhi‘a *lehua* and ‘ōlapa.
- This plant is a favored habitat for the happy-face spider.
- The soft wood of *kanawao* makes good habitat for the burrowing insects on which many birds, such as the Maui parrotbill, feed.
- *Kanawao* fruits were believed to aid conception.
- The cluster of fruits was used to symbolize an expansion in the number of chiefs in traditional Hawai‘i.



Kōlea (*Myrsine* spp.)

- *Kōlea* is the collective name for most of the 20 endemic species of *Myrsine* found in Hawai‘i. Only some of these species are found in the rain forest (such as *M. lessertiana* and *M. emarginata*).
- The 20 Hawaiian *Myrsine* species are thought to have evolved from one or two ancestral species, making this group an excellent example of adaptive radiation.
- Some *kōlea* grow as shrubs, while others are trees. *Kōlea* is a common understory tree.
- Dark-colored fruits are clustered along stems or branches.
- At least one *kōlea* species, *kōlea lau nui* (*Myrsine lessertiana*), provided wood for early Hawaiian house posts and beams as well as beaters for *kapa*. Red dye was made from the bark, and black dye was derived by burning the plant to make charcoal.

Understory

‘Ōhelo (*Vaccinium* spp.)

- Three endemic species (*V. calycinum*, *V. dentatum*, and *V. reticulatum*)
- Related to blueberries and cranberries
- ‘Ōhelo grows as a shrub or tree, on the ground, or as an epiphyte using other plants for support. Depending on the species and the habitat, ‘ōhelo can range from several centimeters to several meters in height.
- All three ‘ōhelo species can be found in rain forest and bog areas on Haleakalā.
- Birds eat the small, usually red, fruits and help disperse seeds. When ‘ōhelo is in bloom, nectar-feeding birds favor it.
- The fruits of the ‘ōhelo were eaten by Hawaiians traveling to the uplands. They are still eaten by some people. Dried ‘ōhelo leaves are still used to make tea.
- ‘Ōhelo is considered to be sacred to Pele, the Hawaiian volcano goddess. Visitors to Kīlauea would customarily offer a branch bearing berries to Pele before eating themselves. This tradition lives on today when people offer a berry or two to Pele before eating. (Breaking branches off the plants is illegal in Haleakalā National Park.)

‘Ōhā and Hāhā (and others), or Hawaiian lobelias (*Lobelia*, *Cyanea*, and *Clermontia* spp.)

- Four endemic Hawaiian genera and many endemic species are represented among Hawaiian lobelias. (*Lobelia* is not an endemic genus. *Clermontia* and *Cyanea* are among the four endemic genera.)
- Rats and pigs can cause serious damage to these flowering plants, although pigs can be—and are—excluded from parts of the rain forest.
- The four endemic genera (totaling nearly 100 species) all evolved from a single common ancestral species that arrived in Hawai‘i millions of years ago. Among Hawaiian plants, this is the most prolific example of adaptive radiation.
- Hawaiian lobelias are shrubby species. Many of them have a characteristic lobeliad “rosette” growth form, in which leaves in circular formation grow at the end of single vertical stems (like palm trees). Others have branched trunks or vertical branches.
- The nectar of many lobelias is attractive to native honeycreepers. The flower shapes coevolved with the honeycreepers, so there is a correspondence between beak shape and flower shape.



Vines and Climbing Shrubs

'ie'ie or Climbing screwpine (*Freycinetia arborea*)

- Indigenous
- This woody, climbing plant is found in the rain forest at lower and middle elevations up to about 1400 meters (4592 feet).
- Sometimes 'ie'ie sprawls across the forest floor. It often wraps around and climbs the trunks of taller trees such as *koa* and 'ōhi'a. It produces many aerial roots ('ie) that attach the plant to the host tree.
- 'ie'ie used to be pollinated by native honeycreeper species that are now extinct. Introduced birds such as the Japanese white-eye (*Zosterops japonicus*) now do the job.
- This plant was greatly diminished by pig damage. Rats are also major threats to 'ie'ie. It is now rare to find flowers that have not been eaten by rats. Rat predation on flowers impairs reproduction.
- The fibers in the stem were used to make cordage to tie together house rafters and bind the outrigger (*ama*) to the canoe (*wa'a*).
- Aerial roots were woven into very fine and durable baskets and funnel-shaped traps to catch fresh-water shrimp and fish as well as helmets (*mahiolo*) which were worn by chiefs going into battle.
- 'ie'ie was sacred to early Hawaiians. The plant was dedicated to the forest god, Kū. In a *hālau hula*, 'ie'ie represented the demigoddess Lauka'ie'ie.

Maile (*Alyxia oliviformis*)

- Endemic
- A climbing shrub or vine with glossy, leathery leaves, tubular yellow flowers, and purple-black fruits shaped like olives
- There are many varieties of *maile*, distinguished by differences such as leaf size and shape, and scent. Different Hawaiian names reflect these differences (e.g., *maile ha'i wale* or brittle *maile*, and *maile pākaha* or blunt-leaved *maile*) and illustrate ancient Hawaiians' acute observation skills.
- *Maile* is woven into a fragrant, open-ended lei that symbolizes respect for the wearer.
- *Maile* is dedicated to the *hula* goddess, Laka. It has inspired many songs, chants, and dances.

Hawaiian mints (*Stenogyne* spp.)

- Endemic
- Of eight *Stenogyne* species known from East Maui, five are thought to be extinct. Unlike most other mint species found elsewhere in the world, Hawaiian mints are “mintless”—they do not have aromatic foliage that deters browsing, because they evolved in an environment in which there were no browsing animals. So they are vulnerable to grazing by introduced cattle, pigs, and goats.
- Rat predation is a significant problem for these plants.
- *Stenogyne kamehamehae*, with its clusters of long, curved red or white flowers, is found in rain forests on both Moloka'i and Maui. *Stenogyne rotundifolia* is a Maui endemic that still survives in the upper reaches of Haleakalā rain forests in areas not disturbed by feral pigs.
- Deep, curved *Stenogyne* flowers attract native nectar-sipping bird species whose beak shapes co-evolved with the mint flower shapes. These birds pollinate the flowers.



Forest Floor and Epiphytes

Uluhe or False staghorn fern (*Dicranopteris linearis*)

- Indigenous
- A shrubby, vining fern that forms densely tangled mats on the rain forest floor
- Thickets of *uluhe* can quickly take over when openings are created in the forest canopy, but they do not do well in deep shade. This dense growth can overtake other vegetation and prevent the growth of other plants, including most alien weed species. *Uluhe* can form vegetative mats as much as six meters or 20 feet deep!
- *Uluhe* is often found growing in association with *‘ōhi‘a lehua*.
- In traditional Hawaiian medicine, the bitter juice of this plant was taken as a laxative or emetic.

‘Ala‘ala wainui (*Peperomia* spp.)

- *‘Ala‘ala wainui* is the Hawaiian name for all the plants in this genus, most of which are endemic.
- These plants, which are members of the pepper family, are succulent herbs that range in height from seven or eight centimeters (three inches) to just over a meter.
- *‘Ala‘ala wainui* may grow on the ground or as epiphytes, perched on trees or rocks.
- This plant is extremely susceptible to pig damage, as its fragile stems are easily trampled.
- The sticky fruit are probably dispersed on birds' feet and feathers.
- Many plants in this group were used to make medicines for a variety of health problems and to produce a gray dye for *kapa*.

Pa‘iniu (*Astelia* spp.) or *Kaluaha* (*Astelia menziesiana*)

- Endemic
- The long, silvery leaves of *pa‘iniu* form rosettes from the center of which grow flowering stalks that bear a cluster of small, bright-orange fruits.
- It is an herbaceous plant that may grow as an epiphyte, using native tree trunks or branches for support, or it may be rooted in the ground.
- This species is used as an indicator of the presence or absence of pigs. If you find *pa‘iniu* growing on the ground, you know there have not been pigs in the area.
- This is a favored home for *pinao ‘ula*, the Hawaiian Damselfly.
- Birds eat the *pa‘iniu* fruit, assisting in seed dispersal.
- The silvery skins of the leaves were woven into flower garlands called *lei pa‘iniu*.

Limu or Mosses and Liverworts

- *Limu* refers to many forms of algae, as well as mosses, lichens, and liverworts.
- Numerous species of mosses (*limu kele*) and liverworts live in the rain forests. They form a spongy, blanket-like cover on some native trees, rocks, and other surfaces.
- These fragile plants are easily destroyed by browsing and trampling pigs, goats, and deer.
- The “sponge” of *limu* absorbs water, providing a source of additional moisture during dry spells and helping prevent erosion caused by rapid runoff.



Rain Forest Species Assignments

Cut along dashed lines

Invertebrate

Haleakalā flightless lacewing

(*Pseudopsectra lobipennis*)

Order Neuroptera,
Family Hemerobiidae



Illustration: Nanci Sidas

Invertebrate

Hawaiian crickets

(One indigenous genus [*Paratrigonidium*] and 3 endemic genera [*Leptogryllus*, *Thaumtogryllus*, and *Prognathogryllus*])

Order Orthoptera, Family Gryllidae
(*Paratrigonidium* and *Leptogryllus* are most common on East Maui.)

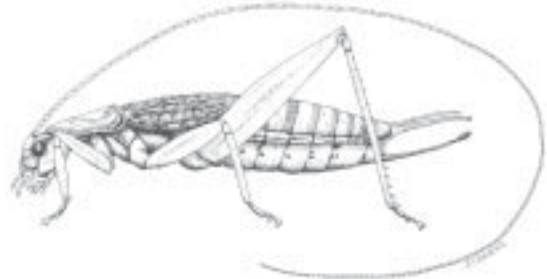


Illustration: Nanci Sidas

Invertebrate

Tree snails

(*Partulina spp.*)

Order Pulmonata,
Family Achatinellinae

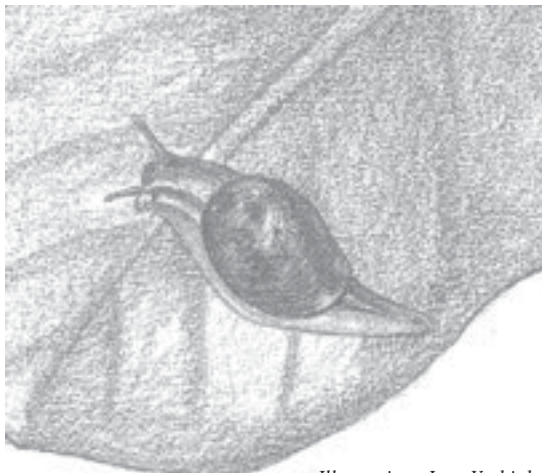


Illustration: Joan Yoshioka

Invertebrate

Hawaiian ground beetles

(Family Caribidae)

Order Coleoptera
(The genus *Mecyclothorax* is most common on East Maui.)



Illustration: Nanci Sidas



Cut along dashed lines

Invertebrate
Hawaiian long-horned beetles
(*Megopis reflexa* and
Plagithmysus spp.)
Order Coleoptera,
Family Cerambycidae

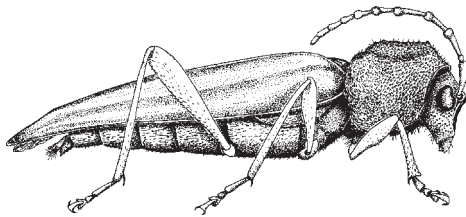


Illustration: Nanci Sidas

Invertebrate
Haleakalā weevil
(*Oodemus* spp.)
Order Coleoptera,
Family Curculionidae

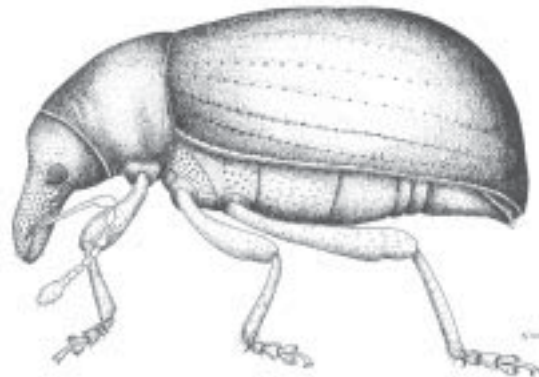


Illustration: Nanci Sidas

Invertebrate
Hawaiian carnivorous inch-worm (*Eupithecia* spp.)
Order Lepidoptera,
Family Geometridae
(The green grappler, *Eupithecia orichloris*, is a common East Maui species.)



Illustration: Nanci Sidas

Invertebrate
Happy-face spider
(*Theridion grallator*)
Order Araneae, Family Theridiidae



Illustration: Nanci Sidas



Cut along dashed lines

Invertebrate
***Pulelehua* or Kamehameha
butterfly**
(*Vanessa tameamea*)
Order Lepidoptera,
Family Nymphalidae



SIDARAS

Illustration: Nanci Sidaras

Invertebrate
Picture wing flies
(Family Drosophilidae)
Order Diptera



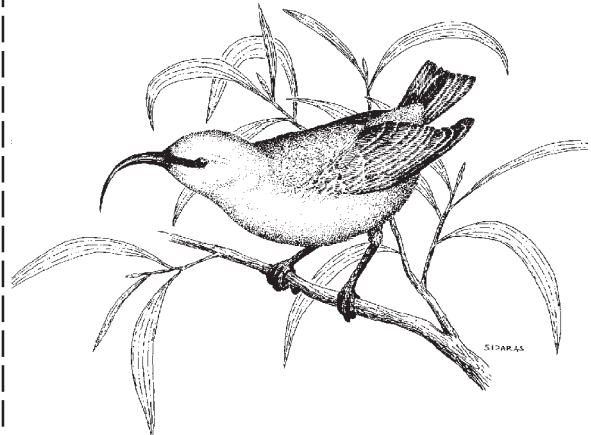
Illustration: Joan Yoshioka

Invertebrate
**Flying earwig, Hawaiian
damselfly or *Pinao 'ula***
(*Megalagrion nesiotes*)
Order Odonata,
Family Coenagrionidae



Illustration: Joan Yoshioka

Bird
Nukupu'u
(*Hemignathus lucidus*)
Order Passeriformes, Family
Fringillidae, Subfamily Drepanidinae



SIDARAS

Illustration: Nancy Sidaras



Cut along dashed lines

Bird

'Iwi (*Vestiaria coccinea*)

Order Passeriformes,
Family Fringillidae,
Subfamily Drepanidinae



Photo: Eric Nishibayashi

Bird

'Apapane (*Himatione sanguinea*)

Order Passeriformes,
Family Fringillidae,
Subfamily Drepanidinae



Photo: Eric Nishibayashi

Bird

'Amakihi (*Hemignathus virens*)

Order Passeriformes,
Family Fringillidae,
Subfamily Drepanidinae



Photo: Eric Nishibayashi

Bird

Maui 'Alauahio or Maui creeper

(*Paroreomyza montana*)

Order Passeriformes,
Family Fringillidae,
Subfamily Drepanidinae



Photo: Eric Nishibayashi



Cut along dashed lines

Bird

**'Ākohekohe or Crested
honeycreeper** (*Palmeria dolei*)
Order Passeriformes, Family
Fringillidae, Subfamily Drepanidinae



Photo: Eric Nishibayashi

Bird

Po'ouli
(*Melamprosops phaeosoma*)
Order Passeriformes, Family
Fringillidae, Subfamily Drepanidinae



*Photo: Paul Baker, Maui Forest
Bird Recovery Project*

Bird

Maui parrotbill
(*Pseudonestor xanthophrys*)
Order Passeriformes, Family
Fringillidae, Subfamily Drepanidinae



Photo: Eric Nishibayashi

Plant

Limu or Mosses and Liverworts
Class Musci (Mosses),
Class Hepaticae (Liverworts)



Limu growing on tree trunks (Photo: Steve Anderson)



Cut along dashed lines

Plant

'Ōhi'a lehua

(*Metrosideros polymorpha*)

Order Myrtales, Family Myrtaceae



Illustration: Joan Yoshioka

Plant

Koa (*Acacia koa*)

Order Fabales, Family Fabaceae



Illustration: Joan Yoshioka

Plant

Loulu or Fan palm

(*Pritchardia spp.*)

Order Arecales, Family Arecaceae

(*Pritchardia arecina* is a common East Maui species.)



Illustration: Joan Yoshioka

Plant

Hāpu'ū pulu or Tree fern

(*Cibotium glaucum*)

Also **Hāpu'ū i'i**

(*Cibotium chamissoi*)

Order Filicales, Family Dicksoniaceae



Illustration: Joan Yoshioka



Cut along dashed lines

Plant
'Ōlapa
(*Cheirodendron trigynum*)
Order Apiales, Family Araliaceae



Illustration: Joan Yoshioka

Plant
Māmaki (*Pipturus* spp.)
Order Urticales, Family Urticaceae



Illustration: Joan Yoshioka

Plant
'Ōhelo (*Vaccinium* spp.)
Order Ericales, Family Ericaceae
(*Vaccinium calycinum* is a common East Maui species.)



Illustration: Joan Yoshioka

Plant
'Ōhā and Hāhā (and others) or Hawaiian lobelias (*Lobelia*, *Cyanea*, and *Clermontia* spp.)
Order Campanulales,
Family Campanulaceae,
Subfamily Lobelioideae
(Common East Maui species include *Lobelia grayana*, *Cyanea hamatiflora*, and *Clermontia arborescens*.)



'Ōhā (Clermontia parviflora) (Illustration: Joan Yoshioka)



Cut along dashed lines

Plant

Kanawao or Pū'ahanui

(*Broussaisia arguta*)

Order Rosales, Family Hydrangeaceae



Photo: Steve Anderson

Plant

Kōlea (*Myrsine* spp.)

Order Primulales, Family Myrsinaceae

(*Myrsine lessertiana* is a common East Maui species.)



Illustration: Joan Yoshioka

Plant

'Ie'ie or Climbing screwpine

(*Freycinetia arborea*)

Order Pandanales,

Family Pandanaceae



Photo: Carol Gentz

Plant

Maile (*Alyxia oliviformis*)

Order Gentianales,

Family Apocynaceae



Illustration: Joan Yoshioka



Cut along dashed lines

Plant

Hawaiian mints (*Stenogyne* spp.)

Order Lamiales, Family Lamiaceae

(*Stenogyne rotundifolia* is a common East Maui species.)



Illustration: Nanci Sidaras

Plant

Uluhe or False staghorn fern

(*Dicranopteris linearis*)

Order Filicales, Family Gleicheniaceae



Illustration: Joan Yoshioka

Plant

'Ala'ala wainui

(*Peperomia* spp.)

Order Piperales, Family Piperaceae

(*Peperomia cookiana*, *lilifolia*, and *waikamoiana* are common East Maui species.)



Photo: Kim Martz and Forest Starr

Plant

Pa'iniu (*Astelia* spp.) or

Kaluaha (*Astelia menziesiana*)

Order Liliales, Family Liliaceae



Illustration: Joan Yoshioka



Rain Forest Species Cards

Species card instructions

Based on your research, fill in your blank species card using the following suggestions and questions as guidance. The answers to all of these questions are not readily available for every species, so work with the information you can find.

Species type and names

These appear on your species assignment card. Include common, Latin, and Hawaiian names, where appropriate.

Status

Is this an endemic or indigenous species? Where else in the world is this species found? Is it common, rare, threatened, or endangered? Why? Is it threatened by alien species? If so, how?

Description and characteristics

What does the species look like? How does it behave? What could you tell others about this species that would help them identify it?

Where in the rain forest?

Where does it fit in the structure of the rain forest? If it's a plant, is it a canopy species? Subcanopy? Understory? Ground cover or forest floor? Epiphyte, vine, or climbing shrub? If it's an invertebrate or bird, where would you be most likely to find it?

Rain forest relationships

How does this species interact with other rain forest species? What is its habitat?

Think about it...

A thought-provoking question about this species

Did you know?

A fun fact about this species (This could be a native Hawaiian cultural use, a unique characteristic, or something else that interesting.)

Sources of information

Citations for the information source(s) you used in creating this species card

Species image

An image of the plant or animal that you draw, colorize, or photocopy



A Beginning List of Resources for Research

Available through your teacher

Hawai‘i Audubon Society, *Hawaii’s Birds*, 5th ed., Hawai‘i Audubon Society, 1997.

Medeiros, Arthur C., and Lloyd L. Loope, *Rare Animals and Plants of Haleakalā National Park*, Hawai‘i Natural History Association, Hawai‘i National Park, 1994.

Moanalua Garden Foundation, *Forest Treasures* (CD ROM), 2000.

Stone, Charles P., and Linda W. Pratt, *Hawai‘i’s Plants and Animals; Biological Sketches of Hawaii Volcanoes National Park*, Hawai‘i Natural History Association, National Park Service, and University of Hawai‘i Cooperative National Park Resources Study Unit, Hawai‘i National Park, 1994.

Websites

Bishop Museum Natural Sciences Department at <www.hbs.bishopmuseum.org>. Click on Natural Sciences Department under the Research and Collections icon.

College of Tropical Agriculture and Human Resources at <www.ctahr.hawaii.edu>. Click on “forests” under “environment,” or the “ornamentals and flowers” subsection.

Hawai‘i Biological Survey at <www.hbs.bishopmuseum.org/hbsl.html>.

Hawaiian Ecosystems at Risk at <www.hear.org>.
Contains links to many other informative websites

Native Hawaiian Plant Society at <www.philipt.com/nhps>.

The Nature Conservancy at <www.tnc.org/hawaii>.

University of Hawai‘i Botany Department, “Hawaiian Native Plants” at <www.botany.hawaii.edu/faculty/carr/natives.htm>.

Includes photos of many native Hawaiian plants

U.S. Fish and Wildlife Service, Pacific Islands Ecoregion, “Hawaiian Endangered Species” at <pacificislands.fws.gov/wesa/endspindex/html>.

Also, try doing Internet searches through a search engine, using the common or Latin name of your species.



Check the library or friends and family for these additional resources

Abbott, Isabella Aiona, *Lā'au Hawai'i: Traditional Hawaiian Uses of Plants*, Bishop Museum Press, Honolulu, 1992.

Hadfield, Michael G., "Extinction in Hawaiian Achatinelline Snails," in E. Alison Kay (ed.), *A Natural History of the Hawaiian Islands; Selected Readings II*, University of Hawai'i Press, Honolulu, 1994, pp. 320-334.

Howarth, Francis G., and William P. Mull, *Hawaiian Insects and Their Kin*, University of Hawai'i Press, 1992.

Krauss, Beatrice H., *Native Plants Used as Medicine in Hawai'i*, Harold L. Lyon Arboretum, Honolulu, 1991.

Polhemus, Dan and Adam Asquith, *Hawaiian Damselflies: A Field Identification Guide*, Bishop Museum Press, Honolulu, 1996.

Pratt, H. Douglas, *A Pocket Guide to Hawai'i's Trees and Shrubs*, Mutual Publishing, Honolulu, 1998.

Wagner, Warren Lambert, and S. H. Sohmer, *Manual of the Flowering Plants of Hawai'i*, University of Hawai'i Press, Honolulu, 1999.



Sample Species Card

‘Ōpe‘ape‘a or Hawaiian hoary bat (*Lasiurus cinereus semotus*)
Order Chiroptera, Family Vespertilionidae

Status

- Endemic subspecies to the Hawaiian Islands (Other members of this species are found in temperate areas of North and South America, and several island groups including the Galapagos archipelago.)
- Hawaiian hoary bat populations were probably never very large, and there are now approximately a few thousand left. They are less common on Maui than on Kaua‘i and Hawai‘i.

Description and characteristics

- This small reddish-gray bat weighs just over half an ounce.
- A nocturnal animal, the bat hunts at night and roosts during the day.
- It uses high-pitched cries and sonar to locate its food—flying insects.

Where in the rain forest?

- It clings to tree branches or rocks to roost upside down during the daytime.

Rain forest relationships

- It feeds on flying insects.
- It can be found in native ‘ōhi‘a and koa forests. It has also adapted to human-altered landscapes, sometimes roosting in nonnative macadamia and eucalyptus trees.

Think about it...

One hundred years ago, there were proposals to introduce nonnative bat species to the Hawaiian Islands to help keep insect pests in check. If they’d been successfully introduced, what effects might these nonnative species have had on the native Hawaiian bat?

Did you know?

The Hawaiian name, ‘ōpe‘ape‘a, may come from the Hawaiian word *pe‘a* which means “cross-shaped” or “sail-shaped.”

Sources of information

Medeiros, Arthur C., and Lloyd L. Loope, *Rare Animals and Plants of Haleakalā National Park*. Hawai‘i Natural History Association, Hawai‘i National Park, Hawai‘i, 1994, pp. 3-5.



Illustration: Nanci Sidasaras



Blank Species Card

Species type

Species name (common and scientific)

Status

Description and characteristics

Where in the rain forest?

Rain forest relationships

Think about it...

Did you know?



Activity #3

Rain Forest Species Presentations

● ● ● In Advance *Preparing for Class Presentations*

- Using the species cards they created in Activity #2, have students prepare for a two- to three-minute in-class presentation using the Student Page “Presentation Preparation” (p. 44). Each student should also write down two questions they think other students should be able to answer after listening to the presentation, as well as the answers to those questions.
- Use colored markers to draw a rain forest scene on two long strips of newsprint taped together—long enough to cover the longest section of open wall that you have available in your classroom. Your scene doesn’t need to be artistic, but it does need to show the distinct sections of the rain forest structure: canopy, subcanopy, understory, and ground cover or forest floor. See “Hawaiian Rain Forest: General Structure and Composition” (p. 43) for an explanatory diagram. Students will place species cards on this representation to show where species fit in the rain forest.
- Prepare for Activity #4: “Rain Forest Trivia” if you wish to use it as an assessment tool after the presentations.

● ● ● Class Periods One and Two *Rain Forest Species Presentations*

Materials & Setup

- Newsprint rain forest representation (see “In Advance,” above)
- Masking tape for posting the newsprint
- Scotch tape for posting species cards on the newsprint rain forest representation

For each student

- Student Page “Presentation Preparation” (p. 44)

Instructions

- 1) Have students do two- to three-minute species presentations. Monitor their times, and give them signals when they have 30 seconds left. Make it clear that these presentations must not exceed three minutes. Sometimes we only have a limited amount of time to convey information, so we need to learn to speak clearly and succinctly.

Do the presentations in the following order:

- 1) Plants: Canopy and subcanopy first, then other plants
 - 2) Invertebrates
 - 3) Birds
- 2) Prior to each presentation, the student should give you his or her two questions. Monitor the presentations to make sure students cover the answers to these questions during their presentations.



- 3) At the end of each presentation, have the student tape his or her species card to the large rain forest drawing in the part of the rain forest where it is most likely to be found.

Journal Ideas

- Was it easy or difficult to keep your presentation to two or three minutes? Describe another situation in which it was important for you to keep your communication brief and to-the-point.

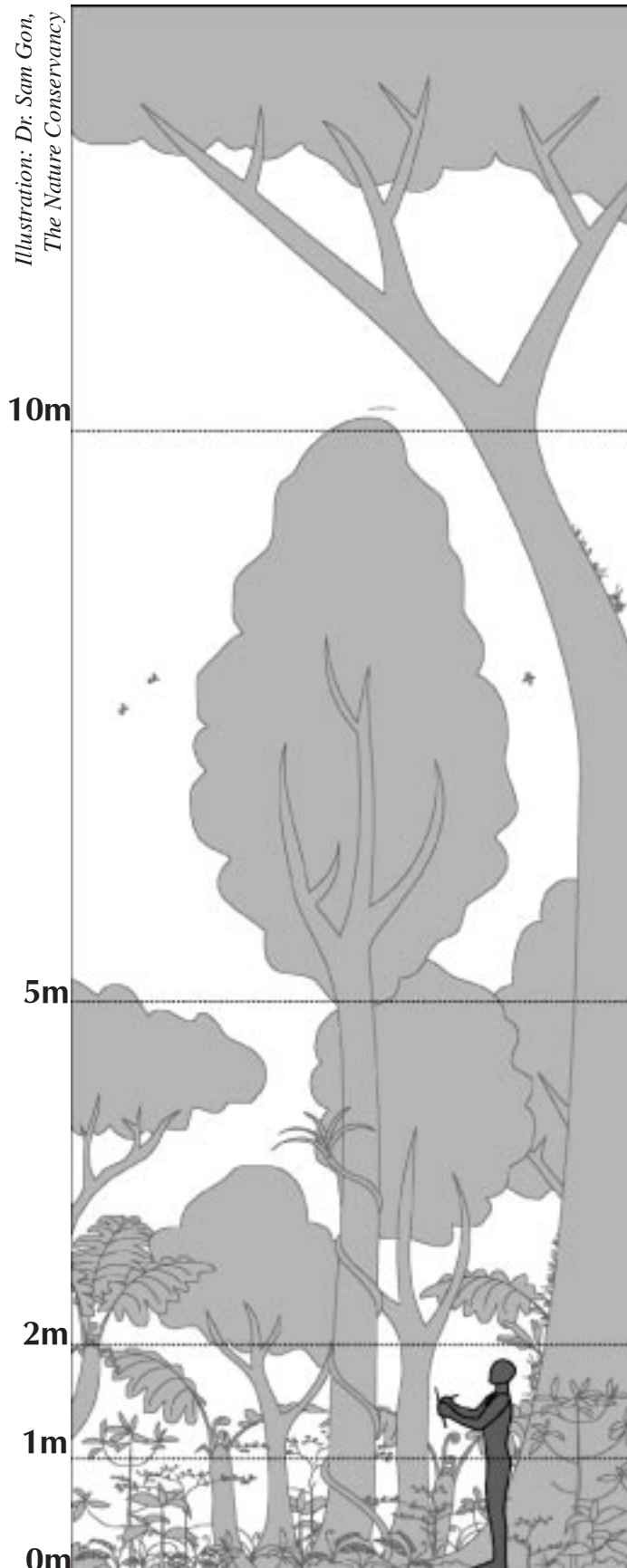
Assessment Tools

- In-class presentations
- Leave about ten minutes at the end of each class period to give a quiz using the questions about the day's presentations. Have students write down their responses and hand in their quizzes. Use the student question and answer sheets to grade the quizzes.



Hawaiian Rain Forest: General Structure & Composition

Illustration: Dr. Sam Gon,
The Nature Conservancy



Canopy

Height above five meters (16 feet) This layer includes the majority of trees, primarily consisting of *Acacia koa* and *Metrosideros polymorpha*. The height of the main canopy layer is usually under ten meters (33 feet). In some places, taller trees emerge above the prevailing canopy height.

Epiphytes and Climbing Plants

Epiphytes are present in all layers, increasing in cover and diversity closer to the ground. Epiphytes include mosses and liverworts, lichens, a variety of ferns, and flowering plants. Vines and climbing plants are most abundant in lower layers, but may extend to the canopy.

Subcanopy Trees and Shrubs

Height, two to five meters (6.5-16 feet)
In this layer, large tree ferns, shrubs, and saplings of canopy trees are present.

Understory

Height, one to two meters (three to 6.5 feet)
Typically, present here are tree ferns, shrubs, and saplings of subcanopy and canopy trees.

Groundcover or Forest Floor

Height, to one meter (to three feet)
Here are found small ferns, small shrubs, herbs, sedges and grasses, mosses and liverworts, and seedlings from all layers.



Presentation Preparation

In class, you will make a two- to three-minute presentation about your species, using the information you gathered as you did research for the species card. Your presentation may be no longer than three minutes, so plan carefully.

As you plan your presentation, think of two important things you want your classmates to learn from your presentation. Write these two things in question-and-answer format. You will hand these in to your teacher before you make your presentation.

In addition to these two points, consider topics such as the following in planning your presentation:

- Where does this species fit in the structure of the rain forest? (Is it a canopy species, subcanopy species, understory species, or ground cover/forest floor species? Is it an epiphyte or climbing species?)
- Is it a native species? (Indigenous? Endemic?) Is it a Polynesian introduction, or an alien species more recently introduced?
- Is it rare? Endangered? Why?
- What are its basic characteristics?
- How is it related to other species in the rain forest?
- Is/was it used or significant in Hawaiian culture? If so, how? (Many of the native plant species cards contain notes about traditional significance. You may research other uses of these plants, specific details or examples of their use, or stories, songs, or chants that mention these plants.)
- Is it still used today?
- Is there current research being done on this species? If so, what are scientists trying to learn?



Activity #4

Rain Forest Trivia

● ● ● In Advance *Preparing for the Game*

- 1) You may use this activity to assess student learning from Activity #3 “Rain Forest Species Presentations.” To do this, hand out one copy of the student page “Rain Forest Trivia Questions” to each student in advance of the in-class presentations. Students should write on the Student Page the two questions they think other students should be able to answer after listening to the presentation, as well as the answers to those questions.
- 2) Label each of three large envelopes with one of the following categories: Native Invertebrates, Native Birds, Native Plants.
- 3) Prior to each presentation, the student should give you his or her two “Rain Forest Trivia Questions.” Monitor the presentations to make sure students cover the answers to these questions during their presentations. Then place the questions into the appropriate envelope (Native Invertebrates, Native Birds, Native Plants).

● ● ● Class Period One *Rain Forest Trivia*

Materials & Setup

For each student

- Student Page “Rain Forest Trivia Questions” (p. 47)
- Students’ Rain Forest Trivia cards, categorized into the three labeled envelopes

Instructions

- 1) Go around the class, asking each student a question drawn from one of the envelopes. Rotate among categories for variety, or have each student select a category.
- 2) Draw a card from that category, read the question, and have the student answer it. If the student cannot answer it correctly, open the question to the rest of the class. Allow time for clarification and explanations from the student who wrote the question, after other students have answered (or attempted to answer) each question.
- 3) You may make this activity competitive by dividing the class into teams and scoring a point for each correct answer. In this competitive version, the student who wrote the question is not allowed to answer it until someone else has offered an answer, even if s/he is on the team receiving the question.



Journal Ideas

- What was the most interesting thing you learned about native Haleakalā rain forest species? Why?

Assessment Tools

- Student Page “Rain Forest Trivia Questions”
- Participation in Rain Forest Trivia game and student recollection of answers to trivia questions s/he wrote
- Journal entries



Rain Forest Trivia Question #1

Your name

The name of your species (common, Hawaiian, and Latin, if applicable)

Question

Answer

----- Cut or tear here -----

Rain Forest Trivia Question #2

Your name

The name of your species (common, Hawaiian, and Latin, if applicable)

Question

Answer