Alpine/Aeolian Unit 3

Life in the *Kuahiwi* and *Kuamauna* Zones

Overview

Keen observers of the islands' natural communities, Hawaiians described twelve zones, or types of natural communities, that spanned the islands from the ocean to the tops of the mountains. The two uppermost of the zones, the *kuahiwi* (backbone) and the *kuamauna* (back mountain), are the equivalent of the alpine/aeolian zone on Haleakalā.

Kuahiwi is the alpine desert area, generally closest to the summit, where few plants other than lichens and some tufts of grass grow. Here, the predominant form of life is insects. The *kuamauna* zone begins below the summit and extends into the summit basin. This is the area associated with the *ʻāhinahina*, the Haleakalā silversword. The silversword was once used in lei-making, and so abundant that visitors described the hillsides as shimmering with the silver color that the Hawaiians named it for.

The native species that live in the alpine/aeolian zone of Haleakalā are adapted to its extreme environmental conditions. This unit helps students learn about the main species that live in this zone, how they are adapted to live in this environment, and how they interact with each other.

Length of Entire Unit

Six 50-minute periods

Unit Focus Questions

1) How are organisms adapted to live in the alpine/aeolian ecosystem?

2) What are the main species that live in the alpine/aeolian ecosystem?

3) In what ways do organisms that live in the alpine/aeolian ecosystem relate to each other?

Unit at a Glance

Activity #1

Alpine/Aeolian Challenges and Adaptations

Students learn about plant and animal adaptations to the harsh alpine/aeolian environment through a slide show and a group activity.

Length
One and one-half class periods

Prerequisite Activity
None

Objectives
- Identify key species living in the alpine/aeolian ecosystem.
- Link adaptive responses to environmental conditions in the alpine/aeolian ecosystem.

DOE Grades 6-8 Science Standards and Benchmarks
UNITY AND DIVERSITY: Students examine the unity and diversity of organisms and how they can be compared scientifically.
- Compare and contrast the body structures of organisms that contribute to their ability to survive and reproduce.

Activity #2

Holding On To Water Lab

Students perform an experiment in which they replicate alpine/aeolian environmental conditions and devise structural features that prevent dessication.

Length
One and one-half class periods

Prerequisite Activity
Activity #1 "Alpine/Aeolian Challenges and Adaptations"

Objectives
- Create, observe, and analyze a model of how organisms adapt to dry environments.
- Make inferences based on the model about organisms that live in the alpine/aeolian ecosystem.
- Measure using a balance, and record data.
- Communicate observations related to organisms adapted to living in dry environments.

DOE Grades 9-12 Science Standards and Benchmarks
DOING SCIENTIFIC INQUIRY: Students demonstrate the skills necessary to engage in scientific inquiry.
- Develop and clarify questions and hypotheses that guide scientific investigations.
- Design and conduct scientific investigations to test hypotheses.
- Organize, analyze, validate, and display data/information in ways appropriate to scientific investigations.
- Formulate scientific explanations and conclusions and models using logic and evidence.
- Communicate and defend scientific explanations and conclusions.

Activity #3

Adaptations Game Show

Students play a game to solidify and demonstrate their knowledge of environmental conditions in the alpine/aeolian ecosystem and how plant and animal life is adapted to these conditions.

Length
One class period

Prerequisite Activity
Activity #1 "Alpine/Aeolian Challenges and Adaptations"

Objective
- Link adaptive responses to environmental conditions in the alpine/aeolian ecosystem.

DOE Grades 6-8 Science Standards and Benchmarks
UNITY AND DIVERSITY: Students examine the unity and diversity of organisms and how they can be compared scientifically.
- Compare and contrast the body structures of organisms that contribute to their ability to survive and reproduce.

Activity #4

Web of Life Game

Students play a game to explore the similarities and relationships among species in the alpine/aeolian ecosystem.

Length
Two class periods

Prerequisite Activity
Activity #1 "Alpine/Aeolian Challenges and Adaptations"

Objectives
- Identify key species represented in the alpine/aeolian zone.
- Identify similarities and differences among these organisms and how they are adapted to living in this ecosystem.
- Identify relationships among inhabitants of this ecosystem.

DOE Grades 6-8 Science Standards and Benchmarks
UNITY AND DIVERSITY: Students examine the unity and diversity of organisms and how they can be compared scientifically.
- Compare and contrast the body structures of organisms that contribute to their ability to survive and reproduce.

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.
- Ask questions to clarify or validate purpose, perspective, assumptions, interpretations, and implications of a problem, situation, or solution.

Enrichment Ideas

- Build on Activity#2 "Holding On To Water Lab" by:
  - — Running the lab a second time after students have read about how plants and animals are adapted to the alpine/aeolian conditions. Students can brainstorm other materials to use to protect their sponge insects based on the reading.
  - — Simulating feeding and foraging behavior among insects. Have students leave their sponge insects exposed for one or two hours during the 24-hour period to "feed."
  - — Begin the lab with two or more sets of control and experimental sponges. Each set should have a different initial water weight, to simulate how quickly organisms in drought conditions lose water compared to normal moisture conditions.

- Have students do additional research on one of the main species in the alpine/aeolian zone. They may present their findings to the class, create a visual or multi-media presentation, or write a report.

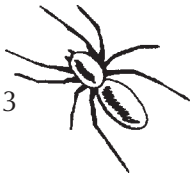
- Play additional rounds of Activity #3 "Adaptations Game Show" using the species listed on the species cards, and the following categories:
  Native plants
  Native insects
  Nonnative insects

- Encourage students to learn the scientific names of species by playing a round of Activity #3 "Adaptations Game Show" using the Latin genus and species names noted on the species cards. Use the same categories noted above.

Resources for Further Reading and Research

Carlquist, Sherwin, *Hawai'i: A Natural History*, 2nd ed., Pacific Tropical Botanical Garden, Lawai, Kaua'i, Hawai'i, 1980.

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, pp. 5-11.



Activity #1

Alpine/Aeolian Challenges and Adaptations

● ● ● Class Period One *Slide Show and Challenges & Adaptations*

Materials & Setup

- Slide projector and screen
- "Living in the Extremes" slide show and script (pp. 7-9)

For each of four student groups

- Student Page "Alpine/Aeolian Challenges and Adaptations" (p. 16)
- One set of Alpine/Aeolian Challenge and Adaptation Cards (master, pp. 12-15)
- Five paper clips
- Pencil with eraser

Instructions

1) Before presenting the slide show, divide the class into four teams. Encourage teams to listen carefully to the information presented for a later activity that focuses on how plants and animals are adapted to life in the alpine/aeolian ecosystem. Show the "Living in the Extremes" slide show, reading the script that accompanies it.

2) Hand out one copy of the Student Page "Alpine/Aeolian Challenges and Adaptations" and one set of Alpine/Aeolian Challenge and Adaptation Cards to each group.

3) Allow student groups the remainder of the class to complete the activity outlined on the student page by matching the adaptations cards to the challenges.

● ● ● Class Period Two *Challenges & Adaptations Discussion*

Materials & Setup

- "Alpine/Aeolian Challenges and Adaptations Answer Key" (teacher background, pp. 10-11)

Instructions

1) Take half a class period to discuss teams' results from the previous day's activity. Begin by asking one team to share the adaptations they matched to one of the challenges and explain their reasoning. Use the answer key to evaluate their responses, keeping in mind that logical reasoning may lead students to slightly different responses in some cases.

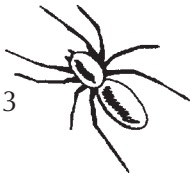
2) Continue the discussion by asking other teams to discuss their responses to each challenge until all have been covered.

Journal Ideas

- How do you think ancient Hawaiians could have protected themselves from the environmental extremes of the alpine/aeolian ecosystem?
- If you were going to spend several days in the summit area of Haleakalā, how would you protect yourself from the environmental conditions?
- Compare the things that people can do to protect themselves with plant and animal adaptations that allow them to survive in the alpine/aeolian ecosystem.

Assessment Tools

- Participation in group activity and class discussions
- Student Page "Alpine/Aeolian Challenges and Adaptations" (teacher version, pp. 10-11)
- Journal entries



Teacher Background

"Living in the Extremes" Slide Show

Photos courtesy of Haleakalā National Park, unless otherwise noted

Slide 1 – Scenery shot

Welcome to Haleakalā. What comes to mind for you when you think about the top of Haleakalā? (Have students call out answers.)

Slide 2 – Archaeological sites near Pu'u Naue

In Hawaiian tradition, this is the sacred House of the Sun. At the height of Hawaiian society, this place was revered as an especially sacred place and visited by few people. *Kāhuna*, Hawaiian spiritual leaders and elders, came here for meditation and to receive spiritual information. Important people were buried up here. There are places where people buried *nā piko* (umbilical cords) of their babies to make sure that they would grow well and that no one had the power to manipulate them.

Slide 3 - Hawaiian adze quarry

Hawaiians constructed shelters in the summit area, but no one lived there. Among those who were given permission to enter this sacred place were men who quarried basalt rock for making adzes and other tools.

Slide 4 – Sunrise shot (Photo: Jeff Bagshaw)

Before going to the summit of Haleakalā, early Hawaiians had to ask permission from human authorities and from the gods. Today, many Hawaiians still pray for permission from the land itself before they go to the summit. This area is no less a sacred place today than it was in times past.

The sun has always been an important part of traditional Hawaiian stories about Haleakalā. Have any of you heard the story of how Māui snared the sun? Here's how it goes:

Early one day, long before sunrise, Māui, the mischievous demigod known throughout the Pacific Islands, crept to the summit of Haleakalā, where he lay waiting for the sun's first spidery legs to appear. As they came over the edge of the rim one by one, he lassoed each ray and secured it to a tree. The sun, now unable to move, begged for its freedom. Māui would not release the sun until it had promised to slow its daily rush across the sky—so that the people could do their work and his mother could finish the drying of the *kapa* (bark cloth) while there was yet daylight.

Māui left some of the ropes attached to the sun—to remind it of its promise to travel more slowly across the heavens. Every evening, just before the sun sets, the ropes can be seen trailing off into the night sky as daylight fades.

And to this day the sun is more careful to go slowly across the heavens, and the great mountain is known as Haleakalā—House of the Sun.

Slide 5 – Summit basin above clouds

The top of this active—but not erupting—volcano rises high above the cloud layer that often covers its slopes. Up here, at the highest elevations on Maui, some people like to say that it's summer every day and winter every night.

Slide 6 - Sunrise with visitors

At night, temperatures can fall below freezing, especially if you factor in the windchill. You know this if you've ever gone up to the summit to watch the sun rise.

Slide 7 – Ice crystals or "hoar frost" (Photo: Jeff Bagshaw)

Sometimes there are ice and frost. Most often, it's just COLD.

Slide 8 – Hikers on Sliding Sands Trail

During the day, however, temperatures can rise into the 80s, and solar radiation is intense. No matter what the temperature, you can easily get a sunburn up here! Human visitors can add or take off layers of clothing as the temperatures change, or put on a hat as the sun intensifies. But the plants and animals living near the top of Haleakalā, in the alpine/aeolian ecosystem, don't have that option.

Slide 9 – *Na'ena'e* growing in a rocky spot (Photo: Jeff Bagshaw)

Up here, the plants and animals have to contend with challenges that go beyond these temperature extremes. In order to survive, they must also be adapted to exist in harsh winds, a dry atmosphere, infrequent and sporadic precipitation, the drying and heating effects of direct sunlight, and an environment with little food.

Slide 10 – Scenic with *na'ena'e* in corner

Up here in the summit area, life isn't easy. The few species of plants and animals that do live here are special because they can survive in this harsh and most sacred of places. Let's take a look at what makes some of these plants and animals so well-adapted to life at the top, starting with *kūpaoa* or *na'ena'e*, the plant in the lower left corner of this picture. This plant has stiff, tough, concave leaves arranged close together to avoid drying by sun and wind.

Why would this leaf structure and arrangement be helpful to avoid drying by sun and wind? (Possible answers: The tough leaves have a hard shell that helps reduce water loss, leaves that are close together have less surface area exposed to direct sun and wind than leaves that are far apart.)

Slide 11 - *'Āhinahina*

Does anyone know what this plant is?

This is the *'āhinahina*, or Haleakalā silversword. It's found only here, near the top of Haleakalā. Silverswords have succulent leaves with gel-like substances and oils that store water and help prevent freezing. Tiny silver-colored leaf hairs that give the plant its name reflect bright sunlight.

Slide 12 – Silversword closeup

What advantage would it be for a silversword to have leaves that reflect bright sunlight? (Answer: Help to keep the plant cool and retain water during the hot days and intense sunlight.)

Slide 13 - Hawaiian long-horned beetle larva

This is the larva of a Hawaiian long-horned beetle. These beetles, like many other insects in the alpine/aeolian zone, directly depend on the silversword for their existence. The larva bores into the lower stems and roots of the plant where they feed on the woody tissue until they pupate and change into adults.

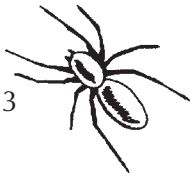
Carabid beetles are another type of insect that lives in the alpine/aeolian ecosystem. They are scavenger-predators that feed in part on insects that are blown in on upslope winds.

Slide 14 - Wolf spider

This large spider constructs shallow burrows under the rocks and cinder. It cements leaves and other windblown debris together to form a circular refuge that protects it from the cold, dry climate.

Slide 15 - *'Ua'u*, the Hawaiian dark-rumped petrel

These seabirds nest primarily in burrows dug in cinders along the upper slopes of the mountain. They use this habitat only for nesting and the parents fly out each day to forage for food at sea. *'Ua'u* nesting success depends on precise timing,



to avoid seasonal temperature extremes that could kill young nestlings. An *ʻuaʻu* pair raises just one chick per year. The strong pair bond of the *ʻuaʻu* male and female also helps these birds reproduce successfully. Parent birds share responsibility for incubating the egg and rearing the young bird.

Slide 16 - Haleakalā flightless moth

This small moth has dagger-shaped wings and walks and hops rather than flying. Originally there were no natural predators in this habitat, so it didn't need wings to escape. Now it is preyed on by carnivorous nonnative yellowjackets and Argentine ants.

Slide 17 – *Tetramolopium*

Many alpine plants are members of the sunflower family and have disc or ray flowers that produce a large number of small seeds. These are accessible to moths, beetles, and other small insects and are easily spread by the wind.

Slide 18 – Petrel habitat

The summit of the sacred house of the sun tests all that might enter or live there with high winds, scorching sun, freezing nights, sparse rainfall, and a substrate that doesn't hold water.

Slide 19 – Lava bomb in shape of bird, Magnetic Peak

This bird is obviously well adapted and well camoflauged for living in the harsh extremes of the alpine/aeolian zone. (Note: This lava bomb, shaped like a bird, has broken due to the elements since the photo was taken.)

Teacher Background

Alpine/Aeolian Challenges and Adaptations

Use this answer key to evaluate student performance on the activity. Note that well-reasoned responses that do not match this key are acceptable. Key numbers match those on the adaptations cards and parenthetical notes following many of the adaptations provide you more information for discussion and explanation.

Extreme Challenge #1: Dry Conditions

- Low rainfall levels and low humidity
- Winds that draw moisture out of plant tissues and out of the ground surface
- Sparse, periodic rains and a long dry season
- Quick water drainage through the lava and cinders
- No ponds or even puddles

Adaptations

1 Some plants, like this *ʻāhinahina*, have succulent leaves that contain gel-like tissues and oils. (These tissues retain and store water.)

4 Insects like this Hawaiian ground beetle (*Barypristus rupicola*) have thick exoskeletons. (These help prevent water loss.)

7 Many insects become semi-dormant or go into deep burrows for extended times.

12 Many plants have large networks of spreading roots. (These networks allow plants to draw in large amounts of water quickly.)

Extreme Challenge #2: Winds

Dry air and winds draw moisture out of the soil and out of plant and animal tissues. Winds contribute to cold temperatures, especially at night. High winds cause damage to soft plant stems and leaves and make flight difficult for insects. On the other hand, the upslope winds blow insects and other organic matter (such as leaves) into the alpine/aeolian zone, providing nutrients and other resources.

Adaptations

5 Some plants, like this *naʻenaʻe,* have waxy leaf surfaces, tough leaves, and strong woody stems. (These characteristics provide strength and durability against the wind.)

6 Tall flower stems or flowers on branch ends release small seeds (which may then be easily transported by winds).

8 Some insects are flightless. (This keeps them out of the wind. Biologists believe flightlessness evolved in response to the absence of mammalian predators. Flying drains energy and may have little adaptive value where there are no major predators to escape.)

9 Many alpine/aeolian insects are scavenger-predators that eat dead and stunned insects as well as plant matter. (These nutrient sources are blown in on the winds.)

11 On some plants, compact, dense foliage grows close to the ground (where it is out of the wind).

13 Many insects take shelter in crevices or under rocks.

14 Some insects use windblown leaves and other debris in constructing burrows or larval tubes.

Extreme Challenge #3: Cold Nighttime and Seasonal Temperatures

Frost and ice often form on the ground and around plants. Occasionally it snows. Freezing can damage or destroy soft leaves and sensitive new growth and flowering parts.

Adaptations

1 Some plants, like this *ʻāhinahina*, have succulent leaves that contain gel-like tissues and oils. (These help prevent freezing and cell damage.)

2 Many larval forms, such as this Cerambycid moth larva, burrow into plant stems or roots (where they live, sheltered from the cold).

3 Some plants, like the *ʻāhinahina,* grow in a rosette form. (This growth form holds warmth in the center of the plant.)

10 A covering of small hairs grows on leaf surfaces (insulating them from cold).

16 Some insects and their larvae are covered with hairs (which may help to insulate them from the cold).

17 Many insects have seasonal life cycles. Moth larvae, for example, are sheltered in a chrysalis in winter, emerging in the spring as plants begin to flower.

21 Some adult insects build burrows.

Extreme Challenge #4: Intense Solar Radiation

Intense sunlight can cause rapid expiration of water, overheating, and cellular damage in plants and animals alike. The heating effect of the sun is intensified by dark colored lava rocks and soils that become extremely warm over the course of a sunny day.

Adaptations

15 Leaf surfaces are covered by small, silvery hairs or waxy coatings. (These reflect the sun's rays, insulate leaf surfaces from extreme heat, and help hold in moisture.)

18 Many insects are active during the mid-morning hours and around dusk. During mid-day, they seek shelter in crevices, under rocks, or in burrows.

22 Light-colored leaves spread out from the plants. (These help shade the dark cinders and lava rock below the plant from the sun, protecting roots from overheating.)

23 Some insects burrow in cinders all day and feed at night.

Extreme Challenge #5: Pollination and Seed Dispersal

Many insects are small and flightless—some are not particularly efficient pollinators. Moths and beetles are the most numerous types of insects in the alpine/aeolian ecosystem. They act as both pollinators and predators to plants. There are too few birds and no native rodents to help plants disperse seeds.

Adaptations

19 Many plants have disc or ray flowers that look like small sunflowers. (These open flower shapes are accessible to moths, beetles, and other small insects.)

20 Some plant seeds have hard coatings (which protect against predation).

24 Plants produce large numbers of seeds (which is an advantage when it is difficult to produce seeds at all).

25 Seeds are small (so they are easily dispersed by winds and rain).

Alpine/Aeolian Challenge and Adaptation Cards

Extreme Challenge #1: Dry Conditions

- Low rainfall levels and low humidity
- Winds that draw moisture out of plant tissues and out of the ground surface
- Sparse, periodic rains and a long dry season
- Quick water drainage through the lava and cinders
- No ponds or even puddles

Extreme Challenge #2: Winds

Dry air and winds draw moisture out of the soil and out of plant and animal tissues. Winds contribute to cold temperatures, especially at night. High winds cause damage to soft plant stems and leaves and make flight difficult for insects. On the other hand, the upslope winds blow insects and other organic matter (such as leaves) into the alpine/aeolian zone, providing nutrients and other resources.

Extreme Challenge #3: Cold Nighttime and Seasonal Temperatures

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Adaptation #1

Some plants, like this *ʻāhinahina*, have succulent leaves that contain gel-like tissues and oils.

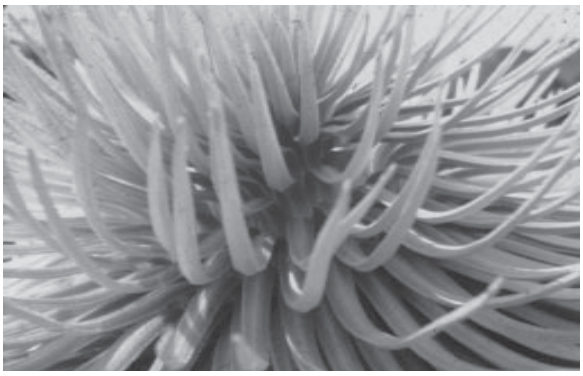
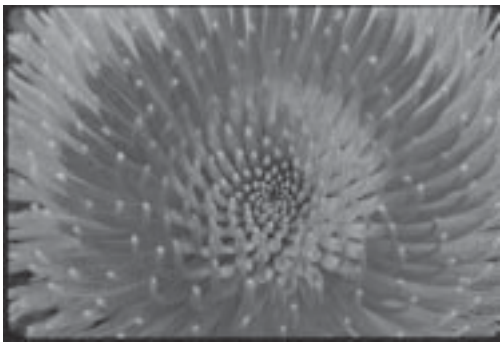


Photo: Haleakalā National Park

Adaptation #3

Some plants, like this *ʻāhinahina* (photographed from the top), grow in a rosette form.



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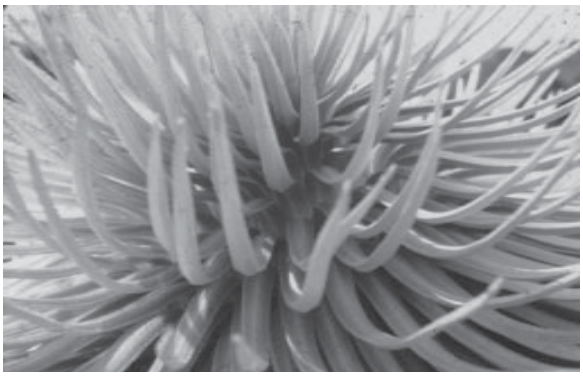


Photo: Haleakalā National Park

Adaptation #4

Insects like this Hawaiian ground beetle (*Barypristus rupicola*) have thick outer or exoskeletons.

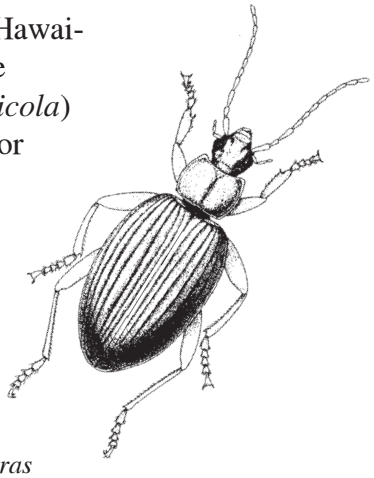


Image: Nancy Sidaras

Adaptation #2

Many larval forms, such as this Cerambycid moth larva, burrow into plant stems or roots.

Photo: Haleakalā National Park

Adaptation #5

Some plants, like this *naʻenaʻe,* have waxy leaf surfaces, tough leaves, and strong woody stems.

Photo: Haleakalā National Park

Adaptation #6

Tall flower stems or flowers on branch ends release small seeds.

Adaptation #11

On some plants, compact, dense foliage grows close to the ground.

Adaptation #7

Many insects become semi-dormant or go into deep burrows for extended times.

Adaptation #12

Many plants have a large network of spreading roots.

Adaptation #8

Some insects are flightless.

Adaptation #13

Many insects take shelter in crevices or under rocks.

Adaptation #9

Many alpine/aeolian insects are scavenger-predators that eat dead and stunned insects as well as plant matter.

Adaptation #14

Some insects use windblown leaves and other debris in constructing burrows or larval tubes.

Adaptation #10

A covering of small hairs grows on leaf surfaces.

Adaptation #15

Leaf surfaces are covered by small, silvery hairs or waxy coatings.

Adaptation #16

Some insects and their larvae are covered with hairs.

Adaptation #21

Some adult insects build burrows.

Adaptation #17

Many insects have seasonal life cycles. Moth larvae, for example, are sheltered in a cocoon or chrysalis in winter, emerging in the spring as plants begin to flower.

Adaptation #22

Light-colored leaves spread out from the plants.

Adaptation #18

Many insects are active during the mid-morning hours and around dusk. During mid-day, they seek shelter in crevices, under rocks, or in burrows.

Adaptation #23

Some insects burrow in cinders all day and feed at night.

Adaptation #19

Many plants have disc or ray flowers that look like small sunflowers, with petals extending from a central, flat disc.

Adaptation #24

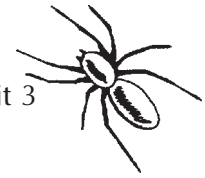
Plants produce large numbers of seeds.

Adaptation #20

Some plant seeds have hard coatings.

Adaptation #25

Seeds are small.



Alpine/Aeolian Challenges and Adaptations

Instructions

1) Have someone in your group read the following passage aloud to the rest of the group:

   The small number of species that survive and thrive in the alpine/aeolian ecosystem are adapted to the conditions in this harsh environment. The plants and animals that live there may bear little resemblance to the ancestral species from which they descended.

   Borne on the winds, transported by waves, powered by their own wings, or carried along by birds, most of the species that colonized the Hawaiian Islands came from Asia, North America, or Australia. Here they encountered conditions that might have been very different from their original habitats. Over millions of years, some of them have developed physical characteristics and behaviors that help them live in the extremes of the high elevations of Haleakalā.

   In this activity, we will be given cards that describe some of the environmental challenges of the alpine/aeolian ecosystem. We will also have other cards which describe the physical and behavioral adaptations exhibited by native plants and animals. These adaptations may have developed in response to the environmental conditions in this zone; they may also have developed for other reasons. No matter what their cause, these characteristics allow plants and animals to survive and thrive in the harsh alpine/aeolian environment.

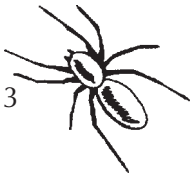
   Our assignment is to match the adaptation cards to the environmental challenge they help organisms survive.

2) Read each of the five "Extreme Challenges" cards and place them on the table where the whole group can see them.

3) As a team, group the "Alpine/Aeolian Adaptations" cards with the challenge card they best fit.
   - Each challenge card will have several adaptations cards grouped with it.
   - There are multiple copies of the same adaptation card if it belongs with more than one challenge.

4) Keep track of your reasoning by writing down the reason each adaptation fits with the challenge on the adaptation card.

5) Once you have decided which adaptation cards match which challenge cards, paper clip the adaptation cards together with the matching challenge cards so that you are ready for the next class period, in which you will report on your results.



Activity #2

Holding On To Water Lab

● ● ● Class Period One *Holding On To Water Lab (1/2 to 1 period)*

Materials & Setup

- A sunny window sill or lamp
- Fan

For each lab group of two to four students

- Small sponges (four sponges of similar size and shape for each lab group)
- Water
- Natural materials such as leaves, sticks, rocks, nut shells, soil
- Small dishes or other impermeable surfaces
- Balance scale

For each student

- Student Page "Holding On To Water Lab" (pp. 19-20)

Instructions

1) Divide the class into lab groups of two to four students.

2) Hand out the Student Page "Holding On To Water Lab Sheet" to each lab group.

3) Explain that the sponges in this activity represent insects that live in the alpine/aeolian environment near the summit of Haleakalā. In this environment—as in other dry environments—water is at a premium. The wind and intense sunlight have drying effects to which plants and insects in this environment have adapted.

   Each sponge-insect has a limited amount of water. The students' job is to conserve that water over a 24-hour period. During that time, students are to protect their sponge-creatures in a manner that will best achieve this goal using only natural materials.

4) Have lab groups do steps one to three on the lab sheet.

● ● ● Class Period Two *Holding On To Water Lab, Continued*

Materials & Setup

For each lab group of two to four students

- Balance scale

For each student

- Student Page "Learning From the Lab" (p. 21)

Instructions

1) Have individuals or groups share their experiments and results with the entire class. Afterward, conduct a class discussion reflecting on the activity.
   a) Were there any patterns in lab results among groups? (For example, was the combination of sun and wind more drying than the sun alone?)
   b) Which methods seemed to work better than others? Why? (Which lab groups had the smallest percent change in the weight of the protected sponges?)
   c) Are the same methods effective for protection against the sun and wind? Why or why not?

   Help students relate their strategies to insect adaptations (and those of other animal and plants) in the alpine/aeolian environment. (If you did Activity #1 in this unit, ask students to draw on what they learned for this discussion. If you did not do Activity #1, use the "Alpine/Aeolian Challenges and Adaptations Answer Key" on pages 10-11 as background to help you guide the discussion.)

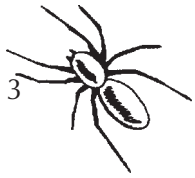
2) Assign the Student Page "Learning From the Lab" as homework.

Journal Ideas

- Relate how plants and animals have adapted to living in dry environments to things that humans do to protect themselves against dry, windy, sunny conditions.

Assessment Tools

- Student Page "Holding On To Water Lab Sheet"
- Lab conduct and methods
- Student Page "Learning From the Lab"



Holding On To Water Lab

In this lab, you (or your lab group) will receive four small sponges. Each represents an insect that lives in the alpine/aeolian environment near the summit of Haleakalā. In this environment—as in other dry environments—water is at a premium. The wind and intense sunlight, in particular, have drying effects to which plants and insects in this environment have adapted.

Each sponge-insect has a limited amount of water. Your job is to conserve that water over a 24-hour period. During that time, you are to protect your sponge-creatures in a manner that will best achieve this goal using only the natural materials your teacher provides.

Divide the four sponges as follows

Sponge #1 — Protected from the sun according to your design and placed in a sunny window sill or under a lamp (that's turned off at night to simulate the sun).

Sponge #2 — Placed in the sunny window sill or under the lamp with no protection (a control sponge).

Sponge #3 — Protected from the sun and wind according to your design and placed under a fan AND in a sunny window sill or under a lamp (that's turned off at night to simulate the sun).

Sponge #4 — Placed under the fan AND in a sunny window sill or under a lamp with no protection (another control sponge).

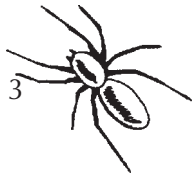
Instructions

1) Soak each sponge with water. To measure the beginning moisture content, weigh your sponges and record the results on the next page.

2) Plan a strategy for using the materials provided to protect one of the sponges from the sun and one from sun and wind. Write down this strategy along with predictions of what will happen.

3) Protect your sponge-insects according to the strategies you devised and place them in small dishes or on other impermeable surfaces in the appropriate location. Use labels to distinguish each sponge from the others and your group's sponges from the rest of the class's.

4) At the end of the allotted time (roughly a 24-hour period), weigh sponges again, record weights, and make comparisons on the table on the next page.

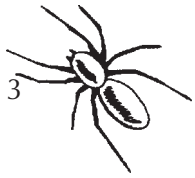


Holding On To Water *Lab Sheet*

1) On the following page write down the questions you are trying to answer through this lab.

2) After you've filled in the lab sheet, write your conclusions on the same piece of paper.

	Exposed to sun		Exposed to sun and wind	
	Protected	Unprotected (control)	Protected	Unprotected (control)
	Sponge #1	Sponge #2	Sponge #3	Sponge #4
Beginning weight (after being soaked with water)				
Describe your strategy for protecting the sponge-insect from drying and why you think it will work. (This is your hypothesis.)				
Prediction of the weight of the sponge after 24 hours				
Actual weight of the sponge after 24 hours				
Difference between the beginning and ending weights				
Percent change				



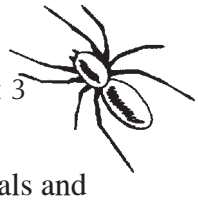
Learning from the Lab

Answer This Question as You Begin the Lab

1) What questions are you trying to answer through this lab?

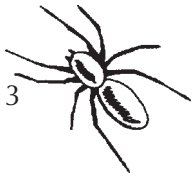
Answer These Questions After You Have Completed the Lab

2) What are your conclusions from the lab? In other words, what answers did you receive to your questions?



3) Compare your strategies for protecting the sponges in the lab to the adaptations of animals and plants in the alpine/aeolian ecosystem.

4) If you were going to do the sponge lab again, what new ideas for protecting your sponge could you draw from the organisms that live in the alpine/aeolian ecosystem?



Activity #3

Adaptations Game Show

● ● ● Class Period One *Adaptations Game Show*

Materials & Setup

- Horn or obnoxious-sounding noisemaker
- Timer or watch with second hand
- Chalkboard or large dry-erase board

For each team of two to four students

- A bell, buzzer, or noisemaker.

Instructions

1) Conduct the "Adaptations Game Show" using the instructions detailed in the teacher background section (pp. 24-26).

Journal Ideas

- Imagine a plant or insect that is perfectly adapted for life in the alpine/aeolian ecosystem. Draw or describe that "perfect" organism.

Assessment Tools

- Participation and conduct during the game
- Demonstrated knowledge of content learned during the unit
- Journal entries

Teacher Background

Hosting the Adaptations Game Show

Overview

This game helps students solidify and demonstrate their knowledge of environmental conditions in the alpine/aeolian ecosystem and how plant and animal life is adapted to these conditions.

The "Adaptations Game Show" is based on the T.V. game show, "Family Feud." In "Family Feud," teams compete with each other to provide the top eight or five (or another number) answers to a question that was posed to a group of survey participants. It is perhaps best known for the line, "Survey says…"

The basic idea behind the "Adaptations Game Show" is for teams of students to compete with each other to provide items on a list of adaptations that alpine/aeolian species exhibit to a particular environmental condition or challenge. The items on the list are based on readings and activities from the other activities in the unit.

Instructions

1) Ask one student to volunteer to be the timekeeper. Give that student the stopwatch to use.

2) Divide the class into two to four teams. It is difficult to manage more than four teams in this game. Have students move around the classroom so that team members are sitting together.

3) Each team should pick one spokesperson. Give each spokesperson a bell or noisemaker. This will be used for signaling that the team wants to try to answer the question in front of the group.

4) Once the teams are settled in, go over the object and rules of the game, which are:

   Object: To answer the questions quickly and correctly, identifying plant and animal adaptations that help them survive and thrive in the environmental conditions of the alpine/aeolian zone.

   Rules: Each team has a bell or noisemaker to signal that it wants to try to answer a question. The spokesperson is the only team member who can use this noisemaker or bell. She or he is also the only team member who can give the answer to the game host (teacher). Other team members can give suggestions to the spokesperson during the time allowed.

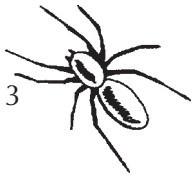
   Summarize the remaining rules and procedures based on the rest of the instructions given below.

5) Write an environmental challenge on the board. Leave several blank spaces under it. Each of these corresponds with a plant or animal adaptation to that challenge.

   For example:

   Challenge: It's WINDY up here!
   1.
   2.
   3.
   4.
   5.
   6.

6) Read the environmental challenge to the class and say, "Go." The first team whose spokesperson rings the bell gets to try to name one adaptation that fits that challenge.



7) Once you recognize the team that will be playing, the spokesperson has **20 seconds** to give an answer. Have the timekeeper measure 20 seconds, give a warning when 15 seconds have passed, and call "Time" when 20 seconds are up.

   During the allotted time, team members may call out ideas to the spokesperson. After considering the suggestions, the spokesperson will answer the challenge with one plant or animal adaptation.

<u>If that adaptation IS on the game host's list</u>:

- **Write the answer** on the board in one of the blank spots.
- **Score a point** for that team.
- **Give that team another 20 seconds to come up with another adaptation**. Continue on until all adaptations have been listed OR until the team fails to give an answer that is on the game host's list.

<u>If the spokesperson does not give an answer within 20 seconds, OR if the answer given is not on the list</u>:

- **Let the other teams have a chance** to add an adaptation. Read the challenge again, say "Go," and allow the team that rings their bell first to play.

8) Continue this process until all adaptations for each challenge have been listed.

Other Tips for Hosting the Alpine/ Aeolian Adaptations Game

- Keep score on the board where everyone can see.

- Have fun and be dramatic! Use your own noisemaker to signal a team response that is not on your list of adaptations. Use a game show host voice or gimmicks.

- Use an "applause meter." If a team's response is not on your list and they protest that it should be, let the spokesperson explain their reasoning. Then ask the rest of the class to applaud if they think the response is actually an adaptation to the environmental challenge. Use the level of applause and your own discretion about whether to score a point for the response.

- Make sure all teams have a chance to play, even if it means bending the rules a little. You're the boss!

- Optional bonus round. At the end, let the team that has the fewest points play this bonus round, with the "prize" for getting both answers being the number of points needed to tie with the first place team.

  Challenge: There's nothing to eat up here! [You may explain this further by saying that the total amount of plant and animal life (or biomass) in the alpine/aeolian ecosystem is low compared to other ecosystems.]
  • Eating insects blown in from below
  • Going out to eat (petrels)

Game Host Challenge and Adaptations List

Challenge: It's WINDY up here

- Tough leaves
- Strong, woody stems
- Tall flower stems with small seeds that can be easily carried by the wind
- Dense, compact foliage growing close to the ground
- Flightlessness
- Finding shelter in rock crevices or burrows
- Eating insects and plant materials blown in from elsewhere
- Using wind-blown debris in burrows or larval tubes

Challenge: It's SUNNY and HOT during the day (and the ground is hot, too)

- Silver hairs (reflecting solar radiation)
- Light colored leaves
- Leaves that spread out (shading the ground under the plant)
- Activity at night, in the early mornings, or in the evenings (foraging, for example)
- Take shelter during the hot part of the day
- Shelter nests and young under rocks or in burrows (especially in plant roots or other parts where they'll have plenty to eat while they're growing up)
- Narrow and/or small leaves (minimize surface area exposed to the sun)

Challenge: It's DRY up here!

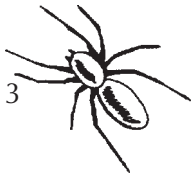
- Succulent leaves (store water in their tissues)
- Waxy leaf surfaces
- Shallow, spreading roots that catch water as it filters through
- Insects take moisure from plant leaves and roots
- Thick exoskeletons
- Semi-dormancy or burrowing during long dry periods

Challenge: It's COLD at night

- Leaves grow in a rosette form (protecting the center part of the plant)
- Hairy coverings (help insulate leaf tissues and insects)
- Succulent leaves containing a gel
- Small flowers that are encased in thick protective shell to protect sensitive flower parts
- Shelter nests and young in protective, insulating cases
- Take refuge in burrows or under rocks

Challenge: It's RAINY and COLDER here during the winter

- Seasonal life cycles (moths, flowering plants)
- Leave during the winter (petrels)



Activity #4

Web of Life Game

● ● ● Class Period One *Web of Life Game*

Materials & Setup

- Alpine/Aeolian Connections Game Cards (master, pp. 30-45)
  (If there are not enough cards to go around, have students share a card.)
- A matching game card black and white photocopy for each student to take home

For each student

- Student Page "Web of Life Game" (pp. 46-47)
- Student Page "How Does Your Species Fit?" (p. 48)

Instructions

1) Begin the class by writing these words next to each other on the board or overhead: "similarities" and "relationships." Ask students to think of some similarities among students in the class and write some examples in a column beneath the word, "similarities." Next ask students to think of some relationships among students in the class and again write examples in a column below the word, "relationships." Explain to students that they will be looking for both similarities and relationships among species in the alpine/aeolian ecosystem during the game they will be playing.

2) Hand out the Student Page "Web of Life Game." Conduct Part One of the game using the game cards provided with the curriculum and following the game instructions (pp. 28-29).

3) Assign the Student Page "How Does Your Species Fit?" as homework.

● ● ● Class Period Two *Web of Life Game, Continued*

Materials & Set Up

- Large pieces of paper and colored pencils or marking pens

Instructions

1) Conclude the "Web of Life Game" by completing Part Two.

Journal Ideas

- Answer the "Think About It . . ." question on your species game card.
- What have you learned about this ecosystem by studying the relationships among species?

Assessment Tools

- Student Page "Web of Life Game"
- Student Page "How Does Your Species Fit?"
- Journal entries

Teacher Background

Playing the Web of Life Game

Part One

1) Pass out one game card and one copy of the Student Page "Web of Life Game" to each student. Take a few minutes for students to look at their cards.

2) Tell students the object of this game is to fill in their sheets with as many connections to other species in the alpine/aeolian zone as they can by talking with other classmates and comparing notes about their species.

   Review the student activity sheet with students. It describes three kinds of links that students might be looking for:

   a) Characteristics that a species shares with another species,
   b) Similar kinds of adaptations to the alpine/aeolian environment, and
   c) Ways in which a species interacts with other species.

   Students may find other kinds of links, too, which may include similar habitat or use of habitat (e.g. petrels and wolf spiders both dig protective burrows).

3) BE PREPARED FOR A SOMEWHAT CHAOTIC SCENE AS STUDENTS SORT OUT THEIR STRATEGIES AND LOOK FOR LINKS!

4) If things quiet down too much, encourage students to study their cards for details that they might have missed or to look around the classroom for someone they haven't talked to yet.

5) When the end of class is near, have students return to their seats. Assign the Student Page "How Does Your Species Fit?" as homework.

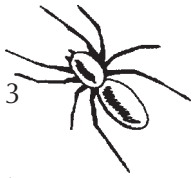
   Also hand out black and white photocopies of game cards for students to take home. Each student should have the photocopy that corresponds to the game card he or she used during class. Students need the information on the game card as well as the completed game activity sheet to do this assignment.

Part Two

1) Spend a few minutes with students reviewing some of the basic links within natural communities. Ideas you may want to cover include:
   - Dependent relationships and independence,
   - Presence or absence of a central species in a natural community,
   - Predator/prey relationships,
   - Parasitism,
   - Mutualistic relationships in which both organisms benefit, and
   - Food webs.
   - Ask students to identify others.

2) Divide students into small groups of four or five students each, and give them about 20 minutes to draw a picture representing relationships of species to each other in the alpine/aeolian zone. They do not have to cover every species in this drawing, but they should study their lists of links from the previous class to include as many species as they can.

3) After about 20 minutes have passed, have students create one collaborative drawing, with you or one of the students acting as scribe. During this time, direct the action, asking questions that help students consider key relationships using the following discussion questions:



Discussion Questions

1) What did students learn about their species and about the alpine/aeolian ecosystem?

2) What might happen to the whole community if different species were removed? (Pick a range of individual species to focus on one at a time.)

3) What kinds of things might cause some of the relationships to be cut off?

4) Ask students to discuss and/or illustrate the possible effects of the introduced species (Argentine ant and Western yellowjacket) on the native web of life.

Activity Option

Materials & Setup

- Lengths of string or yarn in several different colors
- Scotch tape

Instructions

Instead of, or in addition to, having students make drawings that represent species relationships in the alpine/aeolian ecosystem, try this:

1) After you go through the review of basic links within natural communities (Part Two, #1), work with students to assign different colors of string to different kinds of relationships. For example, colors may be assigned to represent:
   - Predator/prey relationships,
   - Parasitism,
   - Mutualistic relationships in which both organisms benefit, and
   - Others that students identify.

2) Have students whose species are related in each of these ways tape either end of the appropriately colored string to their laminated species cards as a way of visually emphasizing the connections.

3) Go through the types of relationships one at a time at first. Then create a "web of life" for the alpine/aeolian zone by adding all of the relationships/string colors together.

4) Follow up with the discussion questions, showing effects of removing species or cutting off relationships by cutting or removing the strings held by the student representing different species.

5) Illustrate the importance of the silversword in the ecosystem by cutting all of the strings that connect the silversword to anything else. Ask students to explain how each of the connected species would be affected if the silversword were removed from the web.

Web of Life Game Cards

Photo: R.C. Zink, Haleakalā National Park

ʻĀhinahina, Haleakalā Silversword

(*Argyroxiphium sandwicense* subsp. *macrocephalum*)

Family Asteraceae

Status Endemic to Haleakalā. Threatened.

Habitat Found only on the upper slopes of Haleakalā.

Characteristics

- Cannot produce fertile seeds without cross-pollination. Depends on insect pollinators for survival.
- About a dozen endemic species of moths, beetles, and other insects are found only with silverswords.
- Leaves are covered with silvery-colored hairs that reflect sunlight and help to hold in heat.
- "Monocarpic"—meaning it flowers only once and then dies.
- Stiff, succulent leaves in a rosette form shelter the interior of the plant from excessive heat or cold. The leaves of the often-spherically shaped plants may help shade the dark cinders below them, protecting shallow roots from too much heat.

Think about it: How might invasions by non-native Argentine ants and Western yellowjackets threaten the *ʻāhinahina*?

Did you know? The *ʻāhinahina* is a part of a group of plants called the silversword alliance. These plants descended from a single ancestor species of tarweed that probably came originally from California. The 28 endemic Hawaiian species in the silversword alliance are in three genera: *Argyroxiphium*, *Dubautia*, and *Wilkesia*.

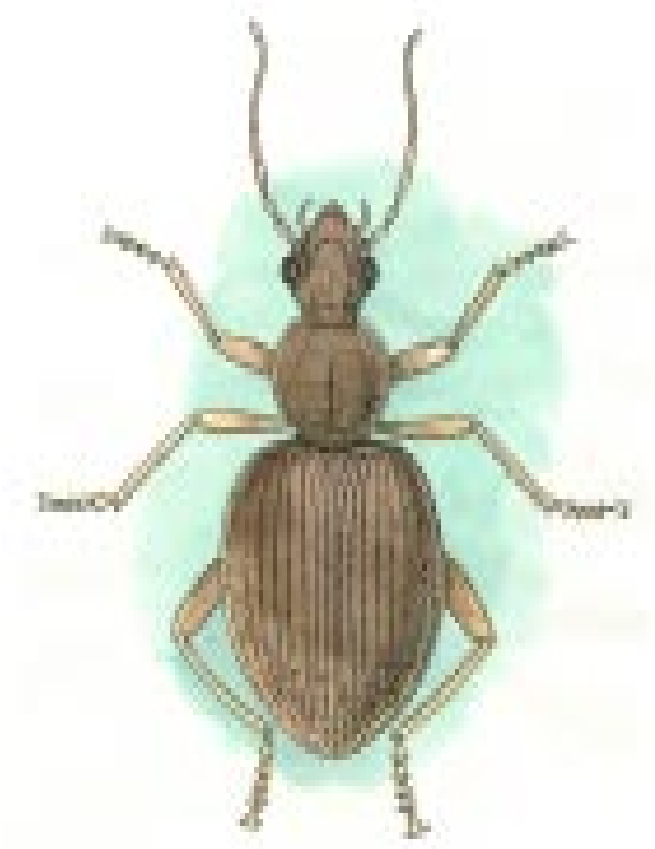


Image: Nancy Sidaras

Carabid Beetle (or Ground Beetle) (*Mauna frigida*)

Order Coleoptera, Family Carabidae

Status Endemic to Haleakalā. Of ten carabid beetle species recorded within the alpine/aeolian zone, nine are endemic to Haleakalā.

Habitat Five of the endemic carabid beetle species, including *Mauna frigida* have been found only on the upper 150 meters (492 feet) of the mountain's summit.

Characteristics

- These five species are flightless scavenger-predators.
- Thick ourer or exoskeletons protect them from water loss and extreme cold.

Think about it: These five species are extremely rare. Little is known about their current status or biology. Some of them may be extinct. How would you go about trying to find out?

Did you know? The 215 Hawaiian endemic carabid beetle species probably evolved from as few as six original immigrants.

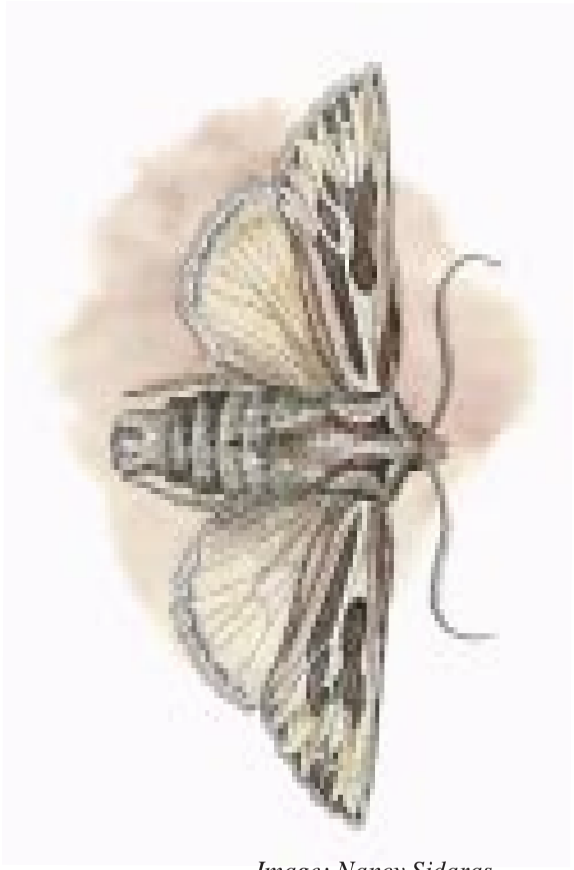


Image: Nancy Sidaras

Hawaiian Noctuid Moth (*Agrotis arenivolans*)
Order Lepidoptera, Family Noctuidae

Status Endemic to Hawai‘i.

Habitat •Larvae have been seen feeding on the leaves of the native shrubs *pūkiawe* and *na‘ena‘e*. They also feed on the seeds of the *‘āhinahina*.
•Caterpillars burrow in cinders during the day and feed at night.

Characteristics
•Adults have a layer of long, thick hairs on their wings and bodies that help keep them warm, reflect sunlight, and prevent water loss.
•Adult noctuid moths visit flowers at night, probably acting as pollinators for native plants.

Think about it: Noctuid larvae are abundant in the alpine/aeolian zone. But wherever the Argentine ant is established, very few of these caterpillars can be found. What do you think is happening?

Did you know? The larvae (caterpillars) of most Lepidoptera species around the world feed on plants. But the larvae of at least one Hawaiian noctuid moth species in the alpine/aeolian zone feed on other insects as well as on the leaves of the few plants that occur in the area. Their arthropod prey is either dead or in a stupor from the cold night air.

Photo: Haleakalā National Park

Wolf Spider (*Lycosa hawaiiensis*)

Order Araneae, Family Lycosidae

Status Endemic to Haleakalā.

Habitat •Lives only at or near the mountain's summit.
•Makes shallow burrows under rocks by cementing windblown leaves and other detritus together with silk. The burrows protect them from the cold, dry climate.

Characteristics
•Normally dark in color, turns silver when hunting among the *ʻāhinahina* rosettes.
•A predator-scavenger that hunts on the ground rather than building webs.
•A large spider, measuring between 3.5-5 cm (1.4-2 in) in length.

Think about it: How might a dark-colored body and long legs help a wolf spider survive in the cold temperatures of the alpine/aeolian zone?

Did you know? Mother wolf spiders carry silk egg sacs (larger than their own bodies) beneath them. As the young hatch, they ride on their mother's back while she hunts.

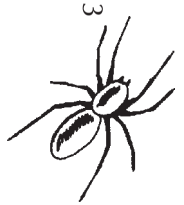


Photo: Eric Nishibayashi

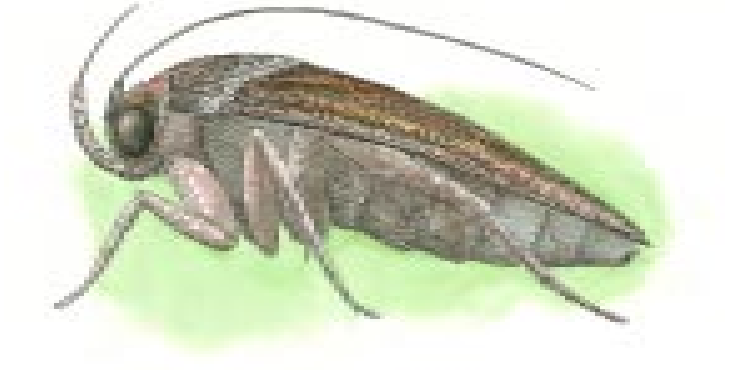


Image: Nancy Sidaras

Haleakalā Flightless Moth
(*Hodegia [Thyrocopa] apatela*)
Order Lepidoptera, Family Gelechidae

Status Endemic to Haleakalā.

Habitat
- Found only on the upper slopes of Haleakalā.
- Seen most often on warm days in rocky areas but also attracted to lights at night.

Characteristics
- 1 1/4 cm (.5 in) long, silver-grey color.
- Has dagger-shaped wings but cannot fly. Instead, it walks and hops along the ground.
- Larvae live in silken tubes woven in with dried *naʻenaʻe* leaves and bits of cinder.
- Larvae are covered with a thick layer of hair.

Think about it: What weather conditions in the alpine/aeolian zone might make it an advantage to walk instead of fly?

Did you know? Western yellowjackets prey on this moth. Researchers believe Argentine ants, too, would pose a threat if they became established in the moth's very small range.

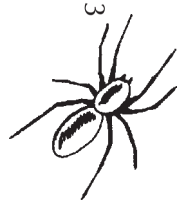


Image: Nancy Sidaras

Argentine Ant (*Linepithema humile*)

(formerly *Iridomyrmex humilis*)

Order Hymenoptera, Family Formicidae

Status Alien (probably native to Argentina and Brazil).

Habitat Have established a population near the edge of the alpine/aeolian zone.

Characteristics

- On Haleakalā, areas occupied by Argentine ants show reduced numbers of many native insect species, including Lepidoptera larvae, carabid beetles, ground-nesting bees and wasps, and others.
- Noctuid moth caterpillars have been found among its prey.

Think about it: Researchers believe this species has the potential to eliminate most native arthropod species, including those that pollinate the *ʻāhinahina* and other plants. How do you think this would change the ecology of the alpine/aeolian zone?

Did you know? Argentine ants are "eusocial" (truly social) insects. Biologists believe that social behavior gives insects a competive edge over more solitary insects.

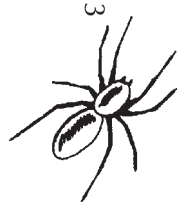


Image: Nancy Sidaras

Western Yellowjacket (*Vespula pensylvanica*)

Order Hymenoptera, Family Vespidae

Status Alien (native to western North America).

Habitat On warm summer days, very common on the mountain's summit, even where there is little plant cover.

Characteristics

- After dry winters, large numbers of worker wasps emerge in the late summer. They prey intensely on other arthropods.
- Haleakalā flightless moths have been found among their prey.

Think about it: Yellowjackets often prey on rare species with small ranges, native plant pollinators and flightless species. What effects do you think intense predation would have on the ecosystem?

Did you know? Western yellowjackets are "eusocial" (meaning truly social). Biologists believe that social behavior gives insects a competive edge over more solitary insects.

Photo: Kim Martz and Forest Starr

Plant Hopper (*Nesosydne argroxiphii)*
Order Homoptera, Family Delphacidae

Status Endemic to Haleakalā.

Habitat Found only on *ʻāhinahina.*

Characteristics

- Silver colored, like the silversword.
- Sucks sap from the leaves of the silversword, but does no serious damage.
- Very tiny (1-2 mm or .04-.08 in).

Think about it: What advantage would a silver color be for an insect that lives exclusively on *ʻāhinahina* plants?

Did you know? Plant hoppers tap at different pitches to attract a mate. Each species has a different pattern of tapping.

Image: Nancy Sidaras

Hawaiian Long-Horned Beetle
(*Plagithmysus terryi)*
Order Coleoptera, Family Cerambycidae

Status Endemic to Haleakalā.

Habitat Larvae bore into lower stems and roots of flowering *ʻāhinahina* plants.

Characteristics

- Larvae feed on the woody tissue of the *ʻāhinahina* until they transform into adults.
- Mates and lays eggs in May and June when winter rains diminish, days are warm, and the silverswords begin to flower.

Think about it: The *ʻāhinahina* is the only known host plant for this beetle. How does this help explain the fact that, while an occasional plant will be so weakened that it topples over, most of the time the larvae cause no apparent damage?

Did you know? Over 136 species in the endemic genus *Plagithmysus* are believed to have evolved from a single ancestral species.

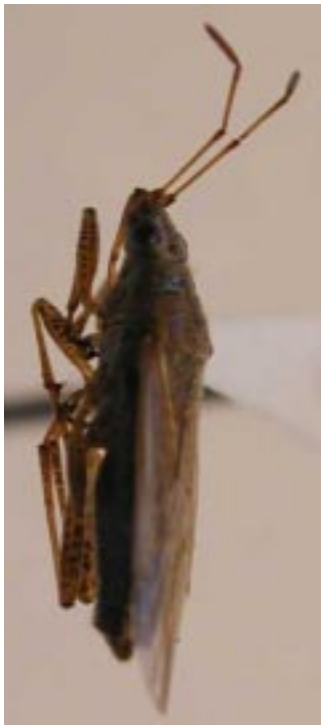


Photo: Kim Martz and Forest Starr

Seed Bug (*Nysius communis*)

Order Heteroptera, Family Lygaeidae

Status Endemic to the Hawaiian Islands.

Habitat •Found in the summit area, as well as in other habitats on the mountain.
•Commonly seen on *ʻāhinahina* and *naʻenaʻe* in the alpine/aeolian zone.
•In other ecosystems, found on other host plants such as *koa* and *ʻōhiʻa lehua*.

Characteristics
•Swarms are often seen in the summit area.
• Feeds on plant juices.

Think about it: How would piercing and sucking mouth parts help these insects obtain food?

Did you know? In the 1960s, swarms of various species of *Nysius* bugs sometimes interfered with visibility from the observatories on Haleakalā. Bushes surrounding the observatories were treated with the insecticide DDT to keep the insects out of the area.

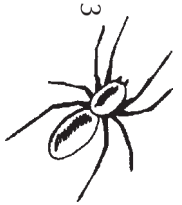


Photo: Kim Martz and Forest Starr

Tephritid Fly (*Trupanea cratericola*)

Order Diptera, Family Tephritidae

Status Endemic to Haleakalā.

Habitat Found only in association with *ʻāhinahina* (Haleakalā silversword).

Characteristics

- Females lay eggs in the buds of *ʻāhinahina* flowers. The eggs hatch as the flower develops.
- Larvae feed on seeds from *ʻāhinahina.*
- Wings are patterned.

Think about it: Females have a long ovipositor, the body part through which they lay eggs. Why would this characteristic be important for the survival of eggs and larvae?

Did you know? Nobody knows where these flies spend the winters.

Image: Nancy Sidaras

Hawaiian Yellow-Faced Bee
(*Nesoprosopis [Hylaeus] volcanicus*)
Order Hymenoptera, Family Colletidae

Status Endemic to Haleakalā.

Habitat Lays eggs in a winding, silken tube nest, usually under a rock.

Characteristics

- Solitary, unlike the social honeybee that lives in cooperation with other bees.
- Visits flowers to gather pollen and nectar to feed its young.
- Small—only 6-12mm (.024-.048 in) long.

Think about it: Why would these small bees be so critical to the pollination of many native plants including *pūkiawe* and the *ʻāhinahina*?

Did you know? Another species of Hawaiian yellow-faced bee (*N. volatilis*) found in the alpine/aeolian zone is a nest parasite. It lays its eggs in the nest of the bee species *N. volcanicus* or the related *N. nivalis*. It may visit flowers, as well, but only to gather nectar to feed itself.

Photo: Haleakalā National Park

Naʻenaʻe or *Kūpaoa* (*Dubautia menziesii*)
Family Asteraceae

Status Endemic to Maui.

Habitat A common shrub in the alpine/aeolian zone.

Characteristics

- Stiff, succulent, concave leaves similar to those on a silversword.
- Leaves grow along the stem in crowded ranks.
- From mid-June through November, yellow flowers are borne at the ends of branches.

Think about it: Why would bearing flowers at the ends of branches be an advantage for plants that rely on insects for pollination?

Did you know? Although it bears little resemblance to the *ʻāhinahina*, the *naʻenaʻe* can hybridize with the *ʻāhinahina*. Both belong to a group of plants called the silversword alliance. These plants descended from a single ancestor species of tarweed that probably came originally from California. The 28 endemic Hawaiian species in the silversword alliance are in three genera: *Argyroxiphium*, *Dubautia*, and *Wilkesia*.

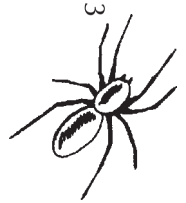


Photo: Michele Archie

***Pūkiawe* (*Styphelia tameiameiae*)**
Family Epacridaceae

Status Indigenous.

Habitat One of the most common shrubs in the alpine/aeolian ecosystem on Haleakalā.

Characteristics

- Tiny stiff, succulent leaves grow all around the stem. The leaves store water.
- Tiny white flowers and inedible, dry berries that may be red, pink, or white.

Think about it... *Pūkiawe* leaves are used in traditional Hawaiian medicine to treat colds and headaches. Lei-makers often use *pūkiawe* in elaborate *lei haku*. Should people be allowed to collect *pūkiawe* for these traditional uses within Haleakalā National Park, where plants and animals are protected from collection and hunting?

Did you know? The tiny Hawaiian yellow-faced bees are an important pollinator of this plant.

Photo: Haleakalā National Park

Tetramolopium
(*Tetramolopium humile* subsp. *haleakalae*)
Family Asteraceae

Status Endemic to Haleakalā.

Habitat •Found only in the alpine/aeolian zone.
•Often grows sheltered by chunks of lava, large boulders, or crevices of lava flows.

Characteristics
•Small, narrow, hairy leaves.
•Grows in a compact form low to the ground, like a dense cushion of leaves.

Think about it: How would small, hairy leaves and a cushion-like shape help this plant conserve water?

Did you know? Tetramolopium is a relative of the daisy and aster, two flowers that are common in home gardens and flower shops.

Photo: Eric Nishibayashi

ʻUaʻu, Hawaiian Dark-Rumped Petrel (*Pterodroma phaeopygia sandwichensis*)

Family Procellariidae

Status
- Endemic to the Hawaiian Islands.
- Formerly known from all of the larger Hawaiian Islands.
- Endangered.

Habitat
- Seabird that uses the alpine/aeolian zone only for nesting.
- Most often nests in crevices or deep burrows dug in cinder along cliffs.

Characteristics
- Spends winters on the open ocean and return to nest on Haleakalā.
- Parent birds forage for squid and other food at sea, returning to tend and feed their young at night.

Think about it: How would introduced predators such as rats and mongoose pose a threat to the *ʻuaʻu*?

Did you know? Haleakalā is the only protected habitat for the *ʻuaʻu*. Ninety percent of the world's known population is found there.

Web of Life Game

Instructions

This game has you looking for links between the species that is on your game card and other species in the alpine/aeolian zone. These links might be:

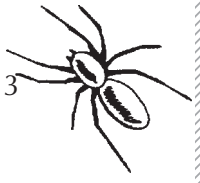
- Characteristics that your species shares with another species.
- Similar kinds of adaptations to the alpine/aeolian environment.
- Ways that your species interacts with other species.
- Other kinds of links. Be creative!

This is easy! Simply talk with your classmates who are holding cards for different species. Fill the name of the species in the table on the next page in the "Species" column. If you find a link, write that down in the other column. If you don't find a link with that species, make a note about that, too.

Strategy Hints

See how your species "fits" in the alpine/aeolian ecosystem. In order to do that, you'll want to know about all the other species, being thorough in comparing notes with the holder of that species card.

Pay attention to the details on your card so you don't miss any links. It's not the number of "links" that counts—it's that you learn how your species is related to other species in the alpine/aeolian zone.



Write the name of your species here:

Species	Links

How Does Your Species Fit?

Using your game card and completed table of links with other species as background information, describe how your species relates to the other species in the alpine/aeolian ecosystem. Think about questions such as the following in writing your answer:

- What characteristics does your species share with other species (for example, food sources, coloration, shape, or behavior)?
- Do any of these characteristics seem to represent similar kinds of adaptations to the alpine/aeolian environment? Which environmental characteristics might they be adaptations to?
- How does your species interact with other species? Are there other species it depends upon?
- Are there any patterns that would help you describe how your species fits in the alpine/aeolian zone?

Write your answer in the space below, and use the other side of the sheet if you need more space: