Treasure Islands

Hawaiian *Kīpuka* and the Future of Native Hawaiian Birds

Photo courtesy of David Flaspohler.

Meet the Scientists

▼ **Dr. Christian Giardina,** Ecologist: I like being a scientist because I like understanding how nature works. It is great to have a job studying plants and animals and the forests in which they live. I am an ecologist who works to protect forests. Sometimes I work to restore forests that have been damaged by **invasive species,** human disturbances, or things like drought from climate change. I use information from my research on forests to understand how to make forests more resistant to disturbances. I also learn how to rebuild forest **ecosystems** after they have been damaged.

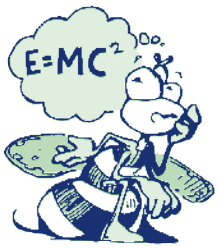
My favorite experience as a scientist happened when I was doing forest **ecology** research in the country of Belize in Central America. I was walking along a river called the Rio Frio (cold river), which ran through the most amazing rainforest. Hundreds of species of giant trees grew in this forest. I came upon an enormous cave that the Rio Frio ran through. Amazing plants grew all along the rim of the cave, and it was full of bats. Bats are some of the most incredible creatures in the world. *Photo by Skeeter Zimsky.*

▶ **Dr. Patrick Hart,** Avian Biologist: I am an ecologist who studies birds on the island of Hawai'i. Hawai'i has some of the most beautiful birds in the world. Many of the **native** bird populations, however, are declining and in danger of **extinction.** I work with other bird ecologists to better understand the causes of this decline. We also work to find ways to protect the remaining birds and even help them increase in numbers. Being a scientist who studies birds is a bit like being a detective. The birds give us clues about why their populations are declining and what we can do to help. Our job is to piece all these clues together into a big picture that we humans can understand. I like this job because it lets me spend time in the forest surrounded by the birds and plants that I love.

One of my favorite experiences recently was flying into a remote rain forest by helicopter to survey birds and plants. Few biologists had ever been to this area. This area was also home to *Pu'u 'O'o,* an active volcano. Our helicopter landed on a field of lava that was a flowing, **molten** river just a week before. Trees along the edge of the flow had been knocked over and burned by the lava and were still smoking. Just steps from the edge of the flow, however, the forest was untouched and beautiful.

▶ **Dr. David Flaspohler,** Avian Ecologist: My favorite science experience was realizing that science is about exploration and curiosity. As an ecologist, I get to spend a lot of time watching nature. I observe the behavior of birds and the ways that they interact with their environment. As a scientist, I have the privilege of being paid to explore some of the most interesting and beautiful creatures on the planet.

Thinking About Science



Scientists try to control as many things as possible in a research project. Let's say that a scientist wants to understand how much water a particular type of potted plant needs to grow its healthiest. The scientist might plant seeds of that plant type in six pots that are made up of the same material, are the same size, and contain the same kind of soil. The pots would be kept in the same temperature and the same amount of sunlight. The only difference is the amount of water given to the plants. All of these things are known as **variables**. By controlling all the variables except for water, the scientist can be relatively certain that any difference observed in how the plants grew was related to the different amounts of water given to the plants.

In this study, the scientists found a natural environment that was similar in many ways to the six pots. This environment is called a *kīpuka*. A *kīpuka* is an area of forest surrounded on all sides by volcanic lava flows (**figures 1a-c**). This means that a *kīpuka* is like a forested island in a sea of hardened lava.

The main difference between the *kīpuka* in this study was their size in hectares and the **complexity** of their plants and trees, especially their heights. The scientists were interested in discovering how many and what species of birds live in different *kīpuka*. If they found any differences, what do you think might be the reasons?

Glossary words are in **bold** and are defined on page 19. Hawaiian words are in *italics* and their pronunciation is given on page 106.

What kind of scientists did this research?

Avian biologist: This kind of scientist studies the characteristics of birds, including their physical bodies and their behavior.

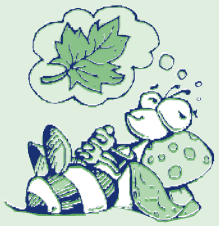
Avian ecologist: This kind of scientist studies how birds interact with their **habitat.**

Ecologist: This kind of scientist studies the relationship of living things with their living and nonliving environment.

Figure 1a. *Kīpuka* are forested islands in a sea of hardened volcanic lava flow. In the Hawaiian language, "s" is not used to refer to the plural. Photo by Babs McDonald.

Figure 1b. *Kīpuka* have definite boundaries between the forested area and the hardened lava that surrounds them. Photo by Babs McDonald.

Thinking About the Environment



The native forests of Hawai'i have been home to 113 species of birds found only in Hawai'i. When a species is found in only one place and no other, it is said to be endemic (ən **dəm** ik) to that area (**figure 2**). Of the 113 endemic bird species, 71 are **extinct,** and 31 are listed as **endangered species**. Seven native bird species are found in *kīpuka* on the island of Hawai'i. Two of these—the *'io* or Hawaiian hawk and the *'Akiapola'au*—are endangered species.

Native Hawaiian bird populations are under threat from many things. Nonnative birds compete for food and nesting sites. Removing forests for buildings or agriculture reduces the habitat of native birds. A disease called avian malaria has killed many of the native birds living at the low **elevations** on the island of Hawai'i (**figure 3**). Avian malaria is spread by mosquitoes, which cannot live in the colder climate of the middle and higher elevations. The *kīpuka*, which are found at the middle elevations, provide protection from avian malaria for native Hawaiian birds. If nonnative birds are found living in the *kīpuka*, native bird species in Hawai'i may suffer even more through competition for food and nest sites.

Figure 2. If you want to see an *i'iwi,* you will have to visit Hawai'i because that is the only place they are found on Earth. What do you call a species that is found nowhere else? Photo by David Flaspohler.

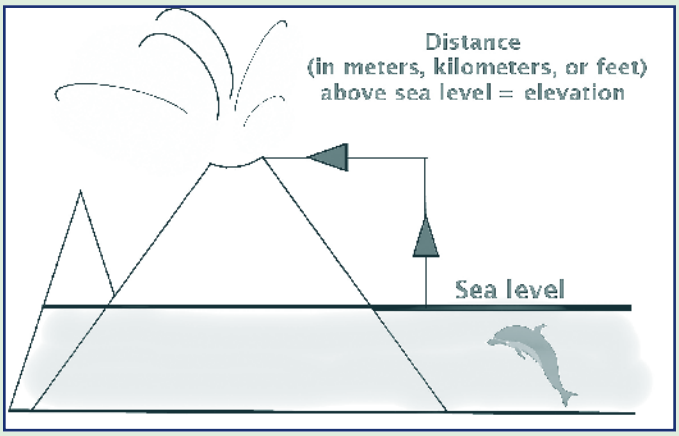


Figure 3. Elevation is a measure of the height of land above sea level.

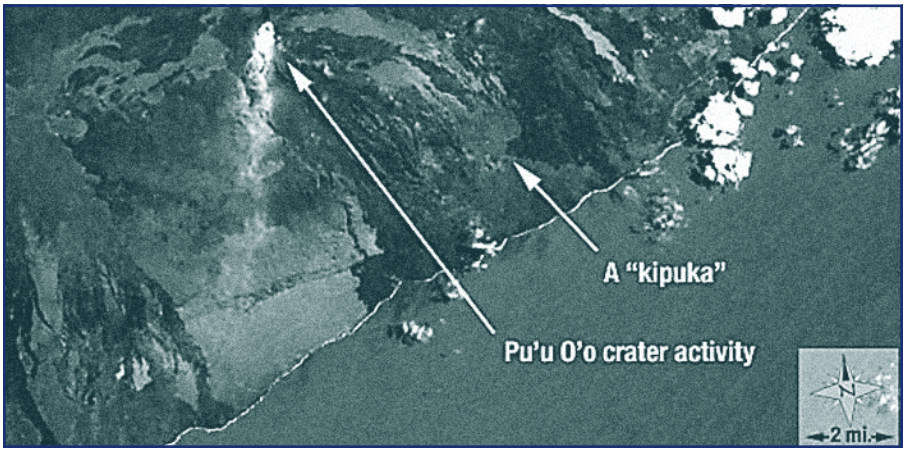


Figure 1c. A *kīpuka* created by a recent *Pu'u 'O'o* volcanic eruption on Hawai'i illustrates how *kīpuka* are formed. The white shapes on the right are clouds, and the lava is flowing into the ocean. The white area on the left is steam from the volcano. Image courtesy of the National Aeronautics and Space Administration.

Be sure to read, "Cultural *kīpuka* in Hawai'i" on page 22.

Introduction

When native wildlife is under threat, scientists want to learn as much as possible about that wildlife's habitat. In particular, some scientists want to know if native wildlife species prefer some habitats. These scientists want to know if nonnative wildlife also live in the preferred habitat. When nonnative wildlife move into the habitat of native species, they threaten the native species even more.

The scientists in this study were interested in learning about birds living in different sized *kīpuka* on the island of Hawai'i (**figure 4**). *Kīpuka* are like islands of forest surrounded by hardened lava (**figure 5**). The *kīpuka* studied by the scientists were located on the *Mauna Loa* volcano (**figure 6**). The *kīpuka* were created during a volcanic eruption in 1855 (**figure 7**). The *kīpuka*, therefore, have been like forested islands for more than 150 years. The scientists considered past studies of birds in other forest habitats. Based on what was already known, the scientists **hypothesized** that larger *kīpuka* with taller trees and more complex vegetation would have a greater variety of native and nonnative bird species.

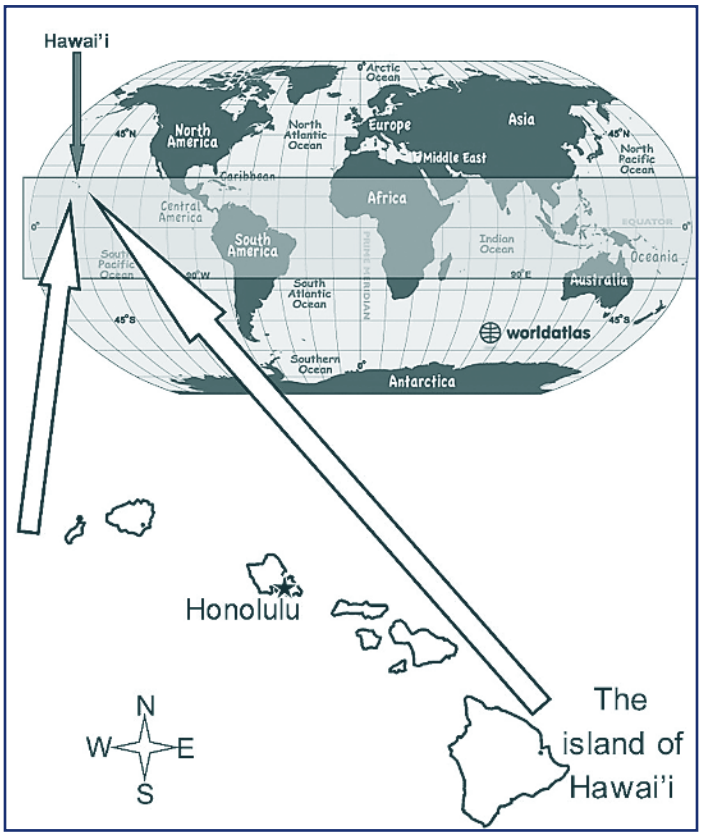


Figure 4. Hawai'i, consisting of a group of islands, is located in the Pacific Ocean. The island of Hawai'i is the largest of the Hawaiian Islands. In 1959, Hawai'i became the 50th State in the United States.

Figure 5. Hardened lava surrounds the *kīpuka*. You can see the edge of a *kīpuka* on the right. Photo by Babs McDonald.

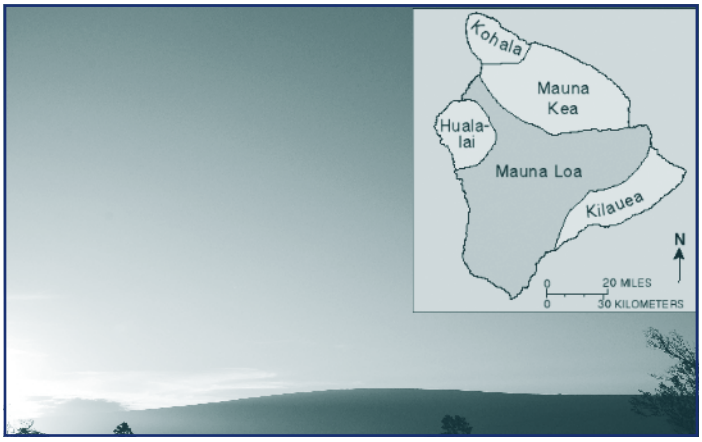


Figure 6. *Mauna Loa* is Earth's largest volcano; it covers about one-half of the island of Hawai'i (See inset). *Mauna Loa* is a shield volcano with gentle slopes. Mauna Loa rises almost 4 kilometers (13,000 feet) above sea level. The true height of *Mauna Loa*, when considered from its base on the ocean floor, is about 17 kilometers (56,000 feet)! This height is almost twice that of Mt. Everest. In this photo, *Mauna Loa* is 56 kilometers (about 35 miles) away and is 2.4 kilometers (8,000 feet) higher than the elevation at which this photo was taken. *Mauna Loa* is an active volcano, and its last eruption was in 1984. See http://www.k12.hi.us/~kapunaha/student_projects/volc_blowout/shield_volcano.htm for more information about shield volcanoes. Photo by Babs McDonald. Inset courtesy of the United States Geological Survey (USGS).

A BIG Question:

Why should humans care about endemic and endangered plant and animal species? By the end of this article, be prepared to discuss whether the scientists' recommendation should be followed in Hawai'i.

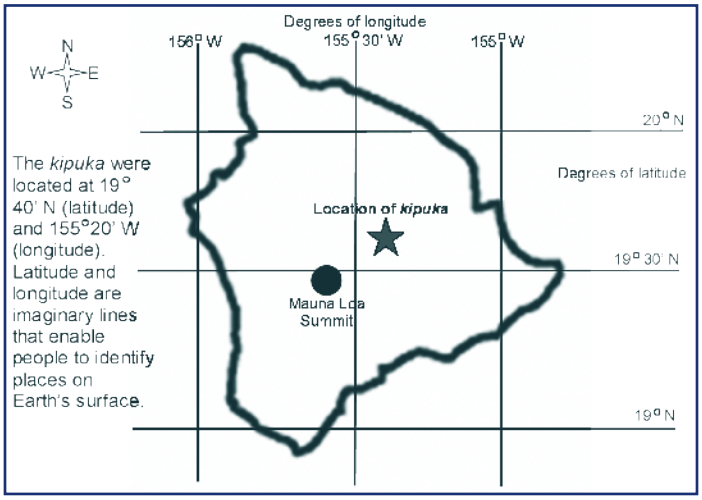


Figure 7. The *kīpuka* are located northeast of the summit caldera of *Mauna Loa* on Hawai'i. A caldera is a cauldron-like feature created when land collapses following a volcanic eruption. A summit caldera is the caldera at the highest point of the volcano. See page 6 for a photo of *Kīlauea* caldera, also on Hawai'i.

Reflection Section

- Why do you think the scientists were interested in learning about the habitat of native and nonnative bird species in Hawai'i? If you need a hint, reread "Thinking About the Environment."
- State the hypothesis in the form of a question.

Scientists state a hypothesis in a particular way. They state a hypothesis as if no relationship will be found between the variables they are studying. This statement is called a null hypothesis. For example, a scientist might hypothesize the amount of water provided to a potted plant has no relationship to its rate of growth. The scientist then tries to prove or disprove the hypothesis. In your own words, state the scientists' hypothesis for this study.

Methods

The scientists studied 18 *kīpuka* ranging in size from 0.1 hectare to 56 hectares. These *kīpuka* were between 1,470 meters and 1,714 meters above sea level. The scientists also studied a large area of forest land that was just less than 1,000 hectares in size. The scientists used this large forested area as a **control.**

Number Crunches

- What was the **range** of the *kīpuka* in acres? Multiply the number of hectares by 2.47 to find out.
- What was the range in elevation of the *kīpuka* in feet? Multiply the number of meters by 3.27 to find out.
- About how far below the summit of *Mauna Loa* were the *kīpuka* located?

The scientists first identified the complexity and height of vegetation in each *kīpuka*. To determine the complexity of the vegetation, the scientists walked into each *kīpuka*. They observed and recorded the types of vegetation found in each *kīpuka* **(figure 8)**.

Figure 8. The scientists observed and recorded the types of vegetation and trees found in each *kīpuka*. This *hāpu'u* tree fern is endemic to Hawai'i. Photo by Babs McDonald.

To measure the height of the vegetation, the scientists used a technology called LiDAR. LiDAR stands for Light Detection and Ranging. LiDAR uses beams of light to measure distances. These beams of light are sent to Earth from a satellite or an airplane. For this study, an airplane was used. Each beam of light is reflected off of the Earth's surface and is sent back to the airplane. Scientists know the speed of light and the amount of time each light beam takes to return to the plane. With this information, they use a computer program to calculate the distance between the airplane and the Earth's surface. When the light reaches vegetation such as trees or it reaches the ground, it bounces off of the trees or ground and back to the airplane (**figure 9**). With this information, scientists can calculate the height of trees.

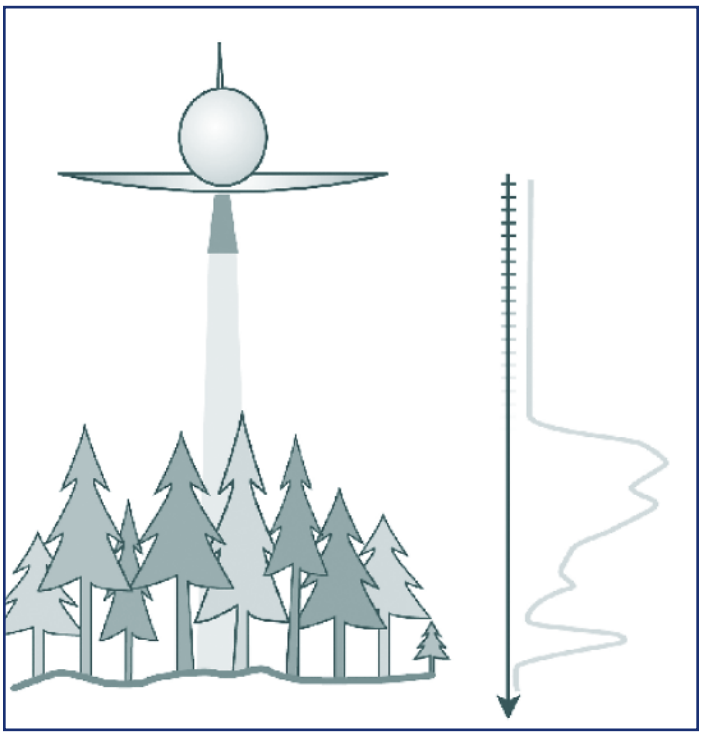


Figure 9. Using LiDAR, scientists can accurately calculate the height of vegetation such as trees.

One of the scientists went into each *kīpuka* to observe and record the species of birds found living in that *kīpuka*. The scientist visited each *kīpuka* twice in the winter and twice in the summer. He did all of his observations between 30 minutes after sunrise and 11 a.m. Each observation lasted for 30 minutes. Half of the time the scientist observed in early morning, and the other half of the time he observed in late morning. Each bird species has a unique song that the scientist learned. When he heard or saw a bird, the scientist recorded its species and the *kīpuka* in which he found it.

Number Crunches

- If it is 11:00 a.m. in Hawai'i, what time is it where you live? Hawai'i is 5 to 6 hours behind the United States Eastern Time. The amount of time depends on whether the Eastern Time Zone is on Daylight Savings (6 hours behind) or Standard Time (5 hours behind). Hawai'i is 10 hours behind Coordinated Universal Time (UTC). UTC is similar to Greenwich Mean Time. (Hint: Hawai'i does not observe United States Daylight Savings Time and is in the Hawai'i-Aleutian Time Zone.) What time is it in Hawai'i right now?

Reflection Section

- How did the large area of forest serve as a control?
- Why did the scientists record the type of vegetation and trees found in each *kīpuka*?

Findings

The vegetation and tree species were similar in all of the *kīpuka* studied. The exception to these similarities was the largest *kīpuka*, in which the native *koa* tree was also found.

The highest number of different bird species that was possible to observe was 14. The scientists found 10 species living in the large nearby forest. As they expected, the scientists found that the smaller the *kīpuka* in hectares, the fewer number of bird species were found living there (**table 1**). The number and type of species did not vary between summer and winter.

Five of the six most frequently found bird species were native species. The nectar-feeding *ʻapapane* was the most commonly found species (**figure 10**). It was found in every *kīpuka* studied as well as in the large forest.

The *iʻiwi* **(figures 11a and 11b)** and *ōmaʻo* **(figure 12)** were two other native species commonly found in the *kīpuka*.

Table 1. The larger the *kīpuka* in hectares, the larger the number of birds species that were found.

Kīpuka number	Area in hectares	Total number of native and nonnative bird species found in the *kīpuka*	Total number of nonnative bird species found in the *kīpuka*
4	0.07	2	0
1	0.07	3	0
11	0.09	2	1
13	0.13	3	0
2	0.13	4	1
17	0.17	2	0
12	0.19	3	0
9	0.57	5	1
14	0.59	3	0
6	1.22	5	1
10	1.70	5	1
3	2.18	6	0
15	3.18	6	0
5	9.28	5	0
7	18.54	6	1
8	35.55	7	1
16	38.64	8	2
18	55.7	9	3
Large forest	About 1,000	10	4

Figure 10. The *ʻapapane* uses its curved beak to drink nectar from flowers. The *ʻapapane* is endemic to Hawai'i. Photo by David Flaspohler.

The endangered *ʻio* (Hawaiian hawk) was found only in the largest *kīpuka* and in the large area of forest (**figure 13**). Of the 11 species observed in the *kīpuka* and the large forest, 5 were nonnative species. The larger the *kīpuka*, the more nonnative species were observed.

The scientists also found that the *kīpuka* with the tallest trees had the greatest number of bird species (**figure 14**).

Figure 11a. An *ʻapapane* and an *iʻiwi*. What are the similarities and differences between the *ʻapapane* and the *iʻiwi*? Which of these birds is the *iʻiwi*? How do you know? Photo by David Flaspohler.

Figure 11b. What kind of food do you think the *iʻiwi* eats? How do you know? Photo by Nolan Lancaster.

Figure 12. After each bird was caught, a band was placed on its leg, and then it was released. Here, Nolan Lancaster and Elizabeth Ames are releasing an *ōma'o*. The bands were placed on the legs in a unique color combination that enabled the scientists to individually identify each bird. Photo by Jessie Knowlton.

Figure 13. The *'io* needs large areas of forest. Photo by Dr. J. B. Friday.

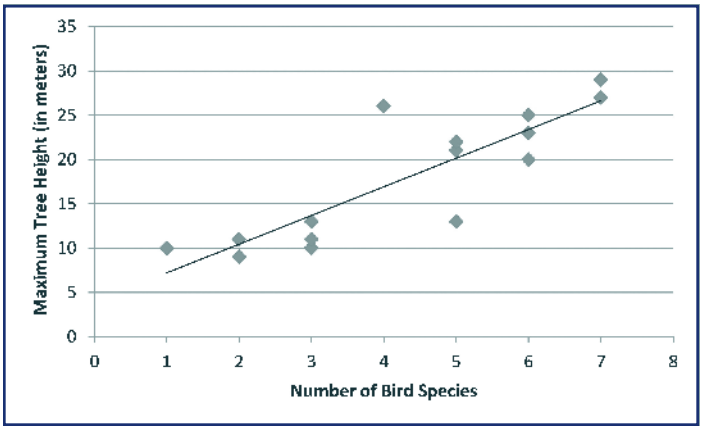


Figure 14. The number of bird species found in the *kīpuka* was closely related to the maximum height of the trees. As you can see in this scatter plot, as the maximum height of the trees increased, the number of bird species also increased. The line in the scatter plot is placed to indicate the general relationship between maximum tree height and number of bird species.

Reflection Section

- Based on the findings, do you think the *'apapane* is likely to be one of the endangered bird species? Why or why not?
- Read the next-to-the-last sentence in "Findings" and examine table 1. What can you say about the *kīpuka* and the future of native bird species?
- Looking over table 1 and figure 14, what can you say about the height of trees in different size *kīpuka*?

Discussion

This study is unusual because the *kīpuka* have been like forested islands for more than 150 years. This number of years is a long time to be isolated from other areas of forest. When *Mauna Loa* erupted in 1855, the *kīpuka* were created at the same time, and the hardened lava has discouraged tree growth around the *kīpuka*. Without new growth, the *kīpuka* have remained isolated from one another. Because the *kīpuka* are surrounded by hardened lava, they have not been disturbed much by human activities. The *kīpuka*, therefore, are a good place to study how different species of birds come into and live in an isolated forest patch.

One of the most interesting findings of this study is that nonnative bird species do not appear to live in *kīpuka* under about 10 hectares in size. Native bird species live in small-sized *kīpuka* without danger of having their habitat taken over by nonnative birds. These small forested islands, therefore, may act as a **refuge** for some native bird species.

The *kīpuka* are located at the middle elevations. This level of elevation is above the range of mosquitoes that carry and spread avian malaria to birds with their bites. As Earth's climate changes and the average temperature rises, malaria-carrying mosquitoes may one day be able to live in the middle elevations. If this change happens, native bird species will need a new habitat to survive. This habitat must be beyond the range of mosquitoes. The scientists recommended restoring small areas of native forest at higher elevations. Because the number of native bird species living in *kīpuka* is also related to the height of trees, it is important to begin native forest **restoration** at higher elevations early to allow trees to grow tall.

BIG Questions:

Why should humans care about endemic and endangered species?

Should the scientists' recommendation be followed? Why?

Reflection Section

- What is one advantage of restoring small forest patches?
- What is one disadvantage of restoring only small forest patches? (Hint: Think about the *'io* or Hawaiian hawk.)
- Why might it be important to begin now to restore patches of native forest at higher elevations?

Adapted from Flaspohler, D.J.; Giardina, C.P.; Asner, G.P.; Hart, P.; Price, J.; Lyons, C.K.; Castaneda, X. 2010. Long-term effects of fragmentation and fragment properties on bird species richness in Hawaiian forests. *Biological Conservation*. 143: 280–288. http://www.fs.fed.us/psw/publications/giardina/psw_2010_giardina(flaspohler)003.pdf.

This research received support from the National Science Foundation, the Forest Service, and a Michigan Technological University Faculty Development Grant.

Glossary

Alien (**ā** lē ən): Differing in nature or character typically to the point of incompatibility.

Avian (**āv** ē ən): Having to do with birds.

Complexity (käm **plek** sə tē): Characterized by having complicated or related parts.

Control (kən **trōl**): In science, a control is a situation used for comparison. Usually, it is found naturally.

Ecology (ē **kä** lə jē): The study of the relationship between living things with each other and with the nonliving environment.

Ecosystem (**ē** kō sis təm): A system made up of an ecological community of living things interacting with their environment, especially under natural conditions.

Elevation (**e** lə **vā** shən): The height above the level of the sea.

Endangered species (en **dān** jərd **spē** sēs): A species threatened with extinction.

Extinct (ik **stiŋ(k)t**): No longer living.

Extinction (ik **stiŋ(k)** shən): The state of being extinct; no longer existing.

Habitat (**hab** ə tat): The place or environment where a plant or animal naturally or normally lives and grows.

Hypothesize (hī **pä** thə sīz): To make an assumption to test its logical consequences.

Invasive species (in **vā** siv **spē** sēs): A plant or animal species not native to an area and with the potential to harm the native environment.

Molten (**mōl** tən): Liquefied by heat.

Native (**nā** tiv): Living or growing naturally in a particular region.

Range (rānj): The region throughout which a kind of organism or ecological community naturally lives or occurs.

Refuge (**ref** yüj): A place that provides shelter or protection.

Restoration (**res** tə **rā** shən): The act of bringing back to an earlier condition.

Species (**spē** sēs): A class of individuals having common attributes and designated by a common name.

Variable (**ver** ē ə bəl): Something that is able or apt to vary.

Accented syllables are in **bold.** Definitions and marks are from http://www.merriam-webster.com.

FACTivity

Time Needed

One to two class periods (one for homework or background research, one period for in-class FACTivity).

Materials

- Copy of charts on pages 20 and 21.
- Treasure Islands article.
- Access to Internet, media center, or encyclopedias.
- Pencil.

The question you will answer in this FACTivity is: What are the similarities and differences between isolated environments of various sizes?

As you learned in this article, a *kīpuka* is a forested island in a "sea" of hardened lava. The lava has isolated each *kīpuka* so that the plants and animals that live there have had a measure of protection from invasive species. The Hawaiian Islands are similar in some ways to *kīpuka*. They are forested volcanic islands in the middle of the Pacific Ocean. The Hawaiian Islands are the most isolated islands on Earth. This isolation had, in the years before humans populated the islands, protected Hawai'i from invasive species.

For this FACTivity, consider the Hawaiian Islands as a type of *kīpuka*. The volcanic island *kīpuka*, however, are much larger than the forested islands created by lava. You will compare the Hawaiian Islands with the *kīpuka* studied in this research. Consider the Hawaiian Islands in two ways: all islands as a *kīpuka* and each island as a *kīpuka*.

The method you will use to answer the question is:

You will work in small groups. Using the chart below, compare the Hawaiian Islands with the *kīpuka* studied in this research. Research may be done at the media center or at home. Think of another isolated environment to compare. If possible, this isolated environment should be close to home or school. This other environment could be very small or quite large, such as an island in a lake or a median strip in the center of a highway. After completing the first chart, summarize the similarities and differences in the second chart. Finally, write a sentence or a paragraph about all isolated environments.

Your teacher will hold a class discussion about the class findings. Discuss what makes these isolated environments similar. What makes them different? What can be said about all isolated environments?

	Forest *kīpuka*	Each Hawaiian island as a separate *kīpuka*	Hawaiian Islands as one *kīpuka*	(Optional) Other isolated environment (describe):
Size				
Animals and Plants				
What isolates the *kīpuka*?				
General description				

Similarities between *kīpuka*	Differences between *kīpuka*

All isolated environments…

Extension

After reading "Cultural *kīpuka* in Hawai'i" on the following page, compare the *Waipi'o* Valley as a cultural *kīpuka* with the forested *kīpuka* described in this article. You may use the chart on the previous page as a guide. After you have completed the comparison, your teacher will hold a class discussion about the similarities and differences between forested *kīpuka* and cultural *kīpuka*. Then read your conclusion about "All isolated environments." Is what you concluded true for cultural *kīpuka* as well? If so, why do you think that is so? If not, why not?

Math FACTivity

Create a bar chart for table 1. Place *kīpuka* area on the Y-axis and the other three columns on the X-axis. Note that you will create two columns for each numbered *kīpuka*. Your teacher will hold a class discussion about whether the table or the bar chart is easier to understand. Does everyone in your class agree? Why do you think that is the case? Why is one easier to understand than the other? What does this discussion tell you about how scientists (and you) should present data?

Cultural Kipuka in Hawai'i

You have just learned about the *kīpuka* in Hawai'i. *Kīpuka* are forested islands in the middle of a sea of hardened lava. Because these *kīpuka* are isolated environments, they have kept their native plant and animal species over time. At the same time, other forested areas in Hawai'i have experienced invasions from **alien** plant and animal species. In 2007, a native Hawaiian social scientist who studies the cultural history of Hawai'i considered an interesting comparison. Just as Hawai'i has forested *kīpuka* she wrote, it also has cultural *kīpuka* (**figure 15**).

Figure 15. Dr. Davianna Pōmaika'i McGregor is a social scientist who studies Hawaiian culture.

The natural environment of the island of Hawai'i is steep and rugged in many places. Over the centuries, native Hawaiians settled in isolated areas of Hawai'i. These places were isolated for different reasons. For example, steep mountains and cliffs might have isolated them. When Caucasians and Asians came to Hawai'i, they usually went to the places to which they could travel easily or that were good for large-scale agriculture.

Waipi'o Valley was particularly isolated (**figures 16–18**). Even today, *Waipi'o* Valley is difficult to visit. A four-wheel drive vehicle is needed to go into the valley. *Waipi'o* Valley is known as the valley of kings. It is considered a sacred place, or *wahi pana*.

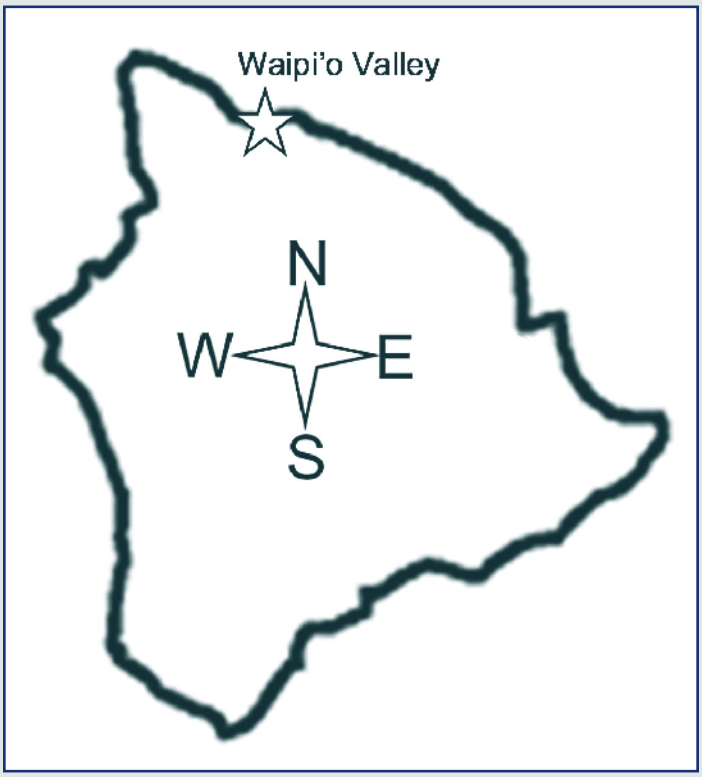


Figure 16. *Waipi'o* Valley is located on the north-northeastern coast of Hawai'i.

Figure 17. *Waipi'o* Valley is known for its beautiful landscapes and steep mountains. Photo by Richard MacKenzie.

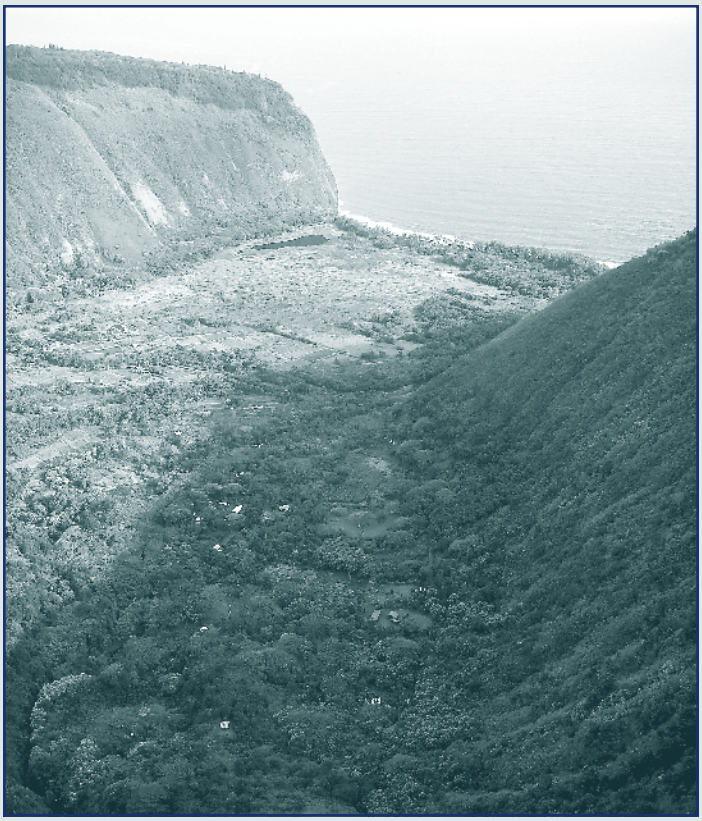


Figure 18. *Waipi'o* Valley is difficult to visit, even today. Photo by Richard MacKenzie.

Because of the isolation of *Waipi'o* Valley, its residents maintained Hawaiian customs and lifestyle to the present day. As had been done by early Hawaiians, native Hawaiians still cultivate taro and traditional varieties of banana, sweet potato, and sugar cane. Taro is a root crop that grows in wet soils and is a main food source for about 10 percent of the world's population. Fishing is still a large part of *Waipi'o* culture, though modern tools are often used. Trees, fruits, nuts, and plants for eating and for medicine are found in the valley. Because the valley is rich in natural resources, its residents felt and still feel little need to buy products beyond what is necessary. In today's cultural *kīpuka*, only things like flour, salt, soap, batteries, and kerosene are brought in from outside the valley.

"Treasure Islands" refers to the title of a famous young adult adventure novel, *Treasure Island*, by Scots author Robert Louis Stevenson. *Treasure Island* is a story about pirates and buried gold. It was published in 1883.

Just as forested *kīpuka* have protected many native Hawaiian plant and animal species, cultural *kīpuka*, such as *Waipi'o* Valley, have preserved many traditional Hawaiian perspectives and practices. Dr. McGregor studied *Waipi'o* Valley as a cultural *kīpuka*. Dr. McGregor observed, "*Kua'āina* are the native Hawaiians who remained in the rural communities of our islands, took care of the *kūpuna* or elders, continued to speak Hawaiian, bent their backs and worked and sweated in the taro patches and sweet potato fields, and held that which is precious and sacred in their care" (2007, p. 4).

Adapted from McGregor, D.P. 1995. *Waipi'o* Valley, a cultural *kīpuka* in early 20th century Hawai'i. *Journal of Pacific History*. 30(2): 194–209 and McGregor, D.P. 2007. *Nā Kua'āina*: *Living Hawaiian culture*. Honolulu: University of Hawai'i Press.

Additional Web Resources

Hawai'i Volcanoes National Park:
http://www.nps.gov/havo/

U.S. Geological Survey *kīpuka* page:
http://volcanoes.usgs.gov/images/pglossary/kipuka.php/

U.S. Geological Survey *Mauna Loa* page:
http://hvo.wr.usgs.gov/maunaloa/

U.S. Geological Survey Hawai'i volcanoes page:
http://hvo.wr.usgs.gov/

A history of Hawaiian native birds (The National Zoo/Smithsonian Institution):
http://nationalzoo.si.edu/publications/zoogoer/1995/1/hawaiisforestbirds.cfm/

University of California—Los Angeles Botanical Garden taro page:
http://www.botgard.ucla.edu/html/botanytextbooks/economicbotany/colocasia/index.html

Adaptation lesson plan:
http://www.uhh.hawaii.edu/affiliates/prism/documents/unitintroduction.pdf/

Waipi'o Valley (Wikipedia):
http://en.wikipedia.org/wiki/waipio_valley

Waipi'o Valley history:
http://gohawaii.about.com/cs/bigislandland/a/waipio_valley.htm

National Education Standards

National Science Education Standard	Where and How the Standard Is Addressed
Abilities Necessary To Do Scientific Inquiry	Thinking About Science: The control of variables, isolating the reasons for differences in the number of bird species. Introduction Reflection Section: State the research question. Methods: Technology, observation, recording. Findings: Bird banding. Findings Reflection Section: Drawing conclusions from data.
Understanding About Scientific Inquiry	Thinking About Science: The importance of controlling variables. Introduction Reflection Section: Hypotheses and research questions. Methods: Observation protocol. Methods Reflection Section: Understanding the use of a control, understanding the importance of recording observations. Figure 12: Ethical care of wildlife. Discussion Reflection Section: Implications and further study (both questions).
Structure and Function in Living Systems	Figure 13: Number of bird species and tree height. Discussion: The creation and structure of *kīpuka,* number of native bird species and *kīpuka* size. Discussion Reflection Section: Growth and development of trees.
Regulation and Behavior	Introduction: Preferred habitat. Introduction Reflection Section: Relationship between native and nonnative species. Discussion Reflection Section: Native species habitat preference, exclusion of nonnative species by habitat size.
Populations and Ecosystems	Thinking About the Environment: Endemic and endangered species. Introduction: Relationship between native and nonnative species, hypothesis regarding habitat size, tree height, and number of species. Figure 13: Relationship between tree height and number of species. Discussion: Relationship of bird species and mosquitoes.
Diversity and Adaptation of Organisms	Thinking About the Environment: Endemic and endangered species. Introduction: Invasion of species into native habitat. Figure 8: Endemic plant species. Figures 11a and 11b: Adaptations of nectarvores. Discussion: Adaptation to a changing climate.

Structure of Earth System	Thinking About Science: *Kīpuka*. Introduction: Creation of *kīpuka,* figures 6 and 7: Volcanoes.
Natural Hazards	Thinking About the Environment: Mosquitoes and avian malaria. Introduction and Introduction Reflection Section: Invasive species.
Science and Technology in Society	Methods: Use of LiDAR.
Understandings About Science and Technology	Methods: Use of LiDAR, figure 9: LiDAR
Science as a Human Endeavor	Meet the Scientists. Thinking About Science, Introduction, and Introduction Reflection Section: What the scientists were interested in studying.
Nature of Science	Thinking About Science: The use of controls. Introduction: The applied nature of science (solving a problem). Discussion: Implications and the application of science to solve problems.

National Curriculum Standard for Social Studies	Where and How the Standard Is Addressed
Culture	Cultural *Kīpuka* in Hawai'i: Isolation of culture and its implications.
Time, Continuity, and Change	Cultural *Kīpuka* in Hawai'i: Changes in culture over time.
People, Places, and Environments	The BIG Question: Informal decisionmaking regarding human-environment relationships, consequences of human interaction with the environment. Discussion: Consequences of human interaction with the environment. FACTivity: Understanding spatial perspectives.