Koa Constrictors

Studying Things That Slow the Growth of Koa Crop Trees

Photo courtesy of Paul Scowcroft.
Meet the Scientists

Dr. J.B. Friday, Forester: My favorite scientific experience on this project was seeing how the native plants, particularly the Hawaiian mint, grew back after we controlled the grasses. The Hawaiian forest was once full of plants that are rare today, so it feels good to help restore some of it. Photo by Dr. Dean Meason.

Mr. Paul Scowcroft, Research Forester: My favorite science experience was discovering why hanging a sheet of shade cloth on the east side of native ohia tree seedlings protected them from frost damage. At 6,500 feet elevation, where forests have been turned into cattle pasture, temperatures can easily fall below freezing. Shade cloth is a piece of cloth that lets some sunlight through but also provides some shade.

We wondered if the shade cloth caused the leaves to warm slowly in the morning. This slow warming would be similar to treating frostbite by slowly warming the fingers. We attached electrical wires to the underside of leaves. These wires enabled us to record the leaves’ temperature over time. Some of the leaves were fully exposed to the sky. Some were shielded from the morning sun by shade cloth hung on the east side of the seedling. Others were located within a forest of 5-year-old koa trees. You will learn more about koa trees in this article.

We found that exposed seedlings experienced lower temperatures for a longer time than shade cloth-shielded or koa-protected seedlings. The shade cloth blocked part of the night sky and prevented heat loss into space. The koa trees blocked even more of the sky. In both cases, the results were warmer leaves. Even though the temperature difference was only 2 to 3 degrees, it reduced frost damage. Under koa trees, heat loss was so low that ohia seedlings showed almost no damage and kept growing throughout the winter. From this experiment, we learned that after ice crystals puncture the cell walls of leaves, the cells die. It doesn’t matter how slowly frozen leaves are warmed! Photo by Dr. J.B. Friday.

Dr. Travis Idol, Forest Ecologist: My favorite science experience was measuring the growth of roots into mesh bags filled with soil. The bags were placed in holes in the ground in forests of different ages. That way, we could tell how fast the roots were growing. That would tell us how much energy and biomass the trees were sending belowground where it is not normally visible. The youngest forests (only 5 years old) had the fastest root growth but also the most rapid root death. These facts make sense because young trees have to grow roots, shoots, and leaves quickly to compete with their neighbors. After the forest ages, the fewer but bigger trees have well-established root systems and leaf canopies, and thus don’t have to compete as intensely.

Photo by Dr. J.B. Friday.

Dr. Dean Meason, Forest Scientist: My favorite science experience was working in the soil in the native forests of Hawai'i. Soils can be wet and gooey or light and fluffy. Some soils are rich with organic matter, while other soils are rocky. Soils provide water, nutrients, and support to trees. Without the right soil the trees will die. Soil is very different in Hawai'i. It all comes from volcanic eruptions. In Hawai'i, you can see lava pouring out of Puʻu ʻOʻO into the sea. Walking up into the mountains you can see hard lava slowly turning into rich volcanic soil that plants can thrive in.

Glossary words are in bold and are defined on page 36. Hawaiian words are in italics and their pronunciation is given on page 106.
How do scientists choose what to study? Scientists choose to study things for many reasons. Usually, scientists begin their career studying a topic in which they are interested. Sometimes, they first learned about their favorite topic when they were young. Something about the topic made them curious and they wanted to learn more. (What topic have you found out about that makes you curious to learn more?) When scientists do their research, their attention is on their topic of interest. The specific research questions, however, may be influenced by society. When a social problem is identified in their topic of interest, scientists help solve the problem.

In this research, scientists studied a native tree species in Hawai‘i. Many trees of this species were cut down about 100 years ago. Now, however, demand for wood from these trees is rising. People want to be able to use this tree to create wood products. The scientists in this study were already interested in native Hawaiian trees. They decided to help solve the problem by focusing their interest, experience, and research on this particular native tree species.

**Thinking About the Environment**

The *koa* (*Acacia koa*) tree is endemic to Hawai‘i. It is native only in Hawai‘i. Young *koa* trees grow fern-like leaves (figure 1). As *koa* trees grow older, sickle-shaped leaf stems that function like leaves replace the fern-like leaves (figure 2). *Koa* trees are found all over the Hawaiian Islands (figure 3).
Figure 2. As *koa* trees get older, leaf stems that function like leaves replace the fern-like leaves. Photo by Dr. J.B. Friday.

*Koa* trees are special because they provide wood for furniture, cabinets, surfboards, bodyboards, canoes, ukuleles, and guitars (figure 4). They also provide habitat for endangered native bird species. *Koa* trees are culturally important as well. Early Hawaiians built dugout canoes out of the trunk of this tree. Many *koa* trees were cut down in the late 1800s and early 1900s to provide land for agriculture and cattle. In recent years, the demand for the wood from this tree has become larger than the sustainable supply. There is now a need to grow more *koa* trees that can be used for wood products. It is also important to protect *koa* trees so that native birds have a place to live now and into the future.

Figure 3. The Hawaiian Islands are located in the Pacific Ocean. In 1959, Hawai‘i became the 50th State in the United States.

Figure 4. *Koa* wood guitars are known for producing rich tones. These tones get richer as the guitar is played over time. In this photo, Adam Allen is playing an acoustic *koa* wood guitar at Musician’s Warehouse, Bogart, Georgia. Country star Taylor Swift plays a variety of acoustic *koa* wood guitars. See http://taylorswiftkoawoodguitar.com/?p=108. Photo by Babs McDonald.
Introduction

Koa is one of the most valued of tropical woods. A particular type of koa tree, called Acacia koa, is found in the Hawaiian Islands. The wood from this tree is used to create furniture, cabinets, carved bowls, canoes, surfboards, body boards, ukuleles, and guitars (see figure 4). Unfortunately, the future demand for koa wood will not be met unless better ways are found to grow koa crop trees today. Crop trees are trees with straight trunks and few side branches (figure 5). These trunks are best for creating lumber (figure 6).

Although landowners know how to start koa trees from seed, young koa trees face three obstacles as they grow into crop trees. The first is competition from koa trees that do not have straight trunks. The second is competition from nonnative grasses growing under the trees. The third obstacle for koa crop trees is growing in soils that lack the necessary nutrients for healthy growth. Because many new koa forests are growing on land that was once used for cattle or agriculture, the soil is often low in necessary nutrients.

The scientists in this study were interested in studying these three obstacles for koa crop trees. They wanted to measure the growth of koa crop trees over a 3-year period following special treatments. Specifically, the scientists wanted to know how koa crop trees would respond to each of the following treatments: (1) removing nearby noncrop koa trees; (2) killing nonnative grasses with an herbicide; and (3) using an herbicide to kill nonnative grasses and adding the fertilizer phosphorus (P) to the soil.

Figure 5. Koa crop trees have straight trunks. Photo by Paul Scowcroft.

Figure 6. Lumber is cut from koa crop trees. Photo by Dr. J.B. Friday.
Methods

The scientists studied *koa* trees on the northeastern slope of *Mauna Loa* volcano (figure 7). The scientists studied an area covering 12 hectares. The trees had been cut down in the 1960s, and the area was used to graze cattle. Although *koa* trees still grew in the pasture, there were few trees compared with the original forest. The disturbance caused by cutting the trees down and having cattle graze allowed nonnative grasses to grow on the ground. Underground, dormant *koa* seeds lay buried. These dormant *koa* seeds have a hard protective coating. Over time soil acids, bacteria, and fungi break down this protective coat, allowing water and oxygen to get inside the seed (figure 8). Still, the soil must be disturbed in some way for the seeds to germinate. In 1978, a bulldozer was used to disturb the soil. Soon after, the seeds germinated, and young *koa* trees began to grow.

**Figure 7.** The location of the study site on the island of Hawai’i. For more information about *Mauna Loa* volcano, see figure 6 in the article, “Treasure Islands,” in this journal.

**Figure 8.** *Koa* seeds have a hard protective coating. Photo by Dr. J.B. Friday.

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**Phosphorus** is one of the three most essential minerals for all plants, including *koa* trees. The other essential minerals are nitrogen and potassium. Phosphorus is necessary for photosynthesis. It helps *koa* trees withstand stress, promotes growth of leaves and roots, and is involved with the manufacture of sugars and starches. If phosphorus is not widely available, *koa* trees may grow more slowly.

**Why is phosphorus important to *koa* trees?**

Phosphorus is one of the three most essential minerals for all plants, including *koa* trees. The other essential minerals are nitrogen and potassium. Phosphorus is necessary for photosynthesis. It helps *koa* trees withstand stress, promotes growth of leaves and roots, and is involved with the manufacture of sugars and starches. If phosphorus is not widely available, *koa* trees may grow more slowly.

**Reflection Section**

1. Explain in your own words why crop trees are needed for products such as surfboards, body boards, furniture, and guitars.
2. Why did the scientists want to study the three obstacles to *koa* crop tree growth?
3. Look at figure 5. Do you see any noncrop *koa* trees in the photo? How do you know?
In 2001, the scientists identified eight areas to study within the 12 hectares. In four of the areas, noncrop *koa* trees growing close to crop trees were killed (*figures 9 and 10*). This is called “thinning.” In the other four, noncrop *koa* trees were left as a control. A control is used as a comparison in scientific studies. Each of these eight areas was 60 meters long on a side. Within each area, the scientists marked four smaller areas. In three of the smaller areas, the scientists applied one of the three treatments, leaving the fourth smaller area untreated (*figures 11 and 12*).

**Figure 9.** To thin the areas, noncrop *koa* trees growing close to crop trees were killed by girdling. Girdling is a method of cutting around the outer part of the trunk. This cutting stops the flow of sugar-rich fluids down the tree, killing the roots and, gradually, killing the tree. By gradually killing the tree, insects and other animals could still use the tree as habitat. Photo by Paul Scowcroft.

**Figure 10.** Two noncrop *koa* trees killed by girdling. Photo by Paul Scowcroft.
Figure 11. Scientists studied eight areas. Each of these eight areas contained four smaller areas. Only three of the four smaller areas were treated.

Figure 12. Scientists treated the nonnative grasses in this area with herbicide. Photo by Paul Scowcroft.

Number Crunches

How old were the *koa* trees in 2001? How old would they be today?
The scientists identified all potential crop trees. In 2001 and 2002, they measured the diameter at breast height (DBH) of every crop tree. They thinned the noncrop *koa* trees in four of the eight areas. Then they applied the herbicide and phosphorus treatments. In the summers of 2003, 2004, and 2005, the scientists once again measured the DBH of all crop trees.

**What is DBH?**

*DBH* stands for diameter at breast height. In the United States, this distance is 1.4 meters from the ground. This method is a standard way to measure the size of trees (*figure 13*). When the tree is growing on a hill, DBH is measured on the uphill side of the tree.

*Figure 13.* The scientists measured the DBH of every *koa* crop tree in the eight areas. Photo by Paul Scowcroft.

**Number Crunches**

- How many feet above the ground is DBH? Multiply 1.4 meters by 3.28 to find out.
- How many feet on each side was the study area?

**Reflection Section**

- Explain in your own words why scientists use a control in which no treatment is applied.
- Why did the scientists measure the DBH of the *koa* crop trees before and after the treatments?

**Findings**

By the end of the second year, 75 percent of the girdled *koa* trees had died. By the third year, all the girdled trees were dead. The trunks of *koa* crop trees growing in the thinned areas and without other treatments did not grow much larger. In thinned areas with herbicide to control nonnative grasses, the trunk sizes increased by 70 percent. The scientists could not say with confidence, however, that the growth was related to the addition of herbicide. Although a 70-percent increase in size seems high, it was not enough to be sure that the growth was caused by the herbicide treatment. Scientists always err on the side of caution. When they cannot be relatively certain, scientists say that the observed difference in growth is not significant.

In the thinned areas where herbicide was used along with the application of phosphorus, the *koa* crop tree trunks more than doubled in DBH. In this case the scientists were confident that the combination of thinning, herbicide, and phosphorus contributed to the faster growth. The scientists called the doubling a significant difference in observed growth.
What makes an observed change significant?

When scientists do experiments or make observations, they realize that they usually will not be able to make a conclusion for sure. In most instances, the best they can do is conclude that an observed change is not due to a chance occurrence. Depending on the number of observations and the strength of the observed change, scientists might call an observed change significant. When scientists are fairly certain that the observed change was not caused by a chance occurrence, it is considered a significant change. Scientists do not just decide for themselves whether a change is significant. They use mathematical equations to determine whether a change is significant.

When most people say that something is significant, they mean that the event or object has a great amount of importance. When scientists say that an observed change is significant, they mean that it is very likely the change was not caused by chance.

Reflection Section

If you were one of the scientists doing this research, what would you recommend to managers wanting to increase the growth rate of *koa* crop trees?

Is phosphorus important to the growth of *koa* trees? How do you know?

Discussion

The scientists believed that thinning alone did not improve growth because it would take more than 3 years for *koa* crop trees to respond to an increase in available sunlight. The scientists recommended that if thinning is the only treatment to be used, it should be done when the trees are young. The disadvantage of thinning at a young age has to do with the identification of crop trees and noncrop trees. When trees are younger, it is more difficult to identify which trees will become the best crop trees. When *koa* trees are older, the most effective way to grow *koa* crop trees is to thin the noncrop trees, use herbicide to kill nonnative grasses, and apply phosphorus as a fertilizer.

Reflection Section

How are *koa* wood guitars and phosphorus related?

Why would thinning alone be best done when the trees are young?
Glossary

Biomass (bī ō mas): Living matter.

Dormant (dōr maνt): Temporarily inactive.

Elevation (e  lava ḡən): The height above the level of the sea.

Endangered (in daŋ jərd): Species whose continued existence is in danger.

Germinate (jar mo nāt): Sprout or develop. Come into being.

Habitat (ha bə tat): The place or environment where a plant or animal naturally or normally lives and grows.

Herbicide ((h)ər bə sīd): A substance used to destroy or slow plant growth.

Native (nā tiv): Growing or living naturally in a particular place.

Nutrients (nū trē ənts): Substances that provide nourishment.

Organic (ər ga nik): Of, relating to, or derived from living organisms.

Seedling (sēd liŋ): A young plant grown from seed.

Species (Spē sēs): A class of individuals having common characteristics and designated by a common name.

Sustainable supply (sa stā na bal sa plī): Something that satisfies a need or wish and is managed so that it is not used up or permanently damaged.

Tropical (trā pi kəl): Of or relating to a region or climate that is frost-free, with temperatures high enough to support year-round plant growth given sufficient moisture.

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

FACTivity

Note: This FACTivity can be used with any Natural Inquirer article.

Time Needed
40 minutes

Materials
• This article.
• Graphic organizer on page 37.

In this FACTivity, you will explore the reasons the scientists in this study might have chosen to be involved in the study. The question you will answer in this FACTivity is: Based on this FACTivity, what can you conclude about why each of these scientists became involved in this research project?

The method you will use to answer the question is: Reread the first paragraph in “Thinking About Science.” Then read one scientist’s statement at a time. Identify word clues or phrases from each statement that appear to be related to the research described in the article. Write word or phrase clues in the organizer below. In the last column, state the relationship between the clues and the research.

For example, in Mr. Scowcroft’s statement, the phrase, “forests have been turned into cattle pasture” is a phrase clue. This would be written in the second column. In the last column, you might state that, “Mr. Scowcroft studies koa forests that had earlier been turned into pasture.” This statement would be a sound conclusion because Mr. Scowcroft studied these areas during one of his favorite science experiences and the same type of area was studied in the article.
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Now answer the question posed at the beginning of this FACTivity.

The first Polynesians in Hawai‘i carved canoes and used these to travel over large distances. This is called holomoana or voyaging, a practice that continues today. In Hawai‘i, koa trees are still shaped into canoes (figure 14). This is done for recreation and to keep alive the cultural practice and art of carving canoes. The art of carving canoes is called kalai wa a.

For Native Hawaiians and those who paddle traditional canoes, canoe building is a spiritual experience. In ancient times, canoe building was undertaken by traditional builders only after making customary offerings to the gods and receiving signs understood as blessings to continue. Today, traditional offerings of thanks and respect are still practiced. From the time a decision was made to build a canoe until its first voyage, events were seen as good or bad omens. Koa trees were harvested in the mountain forests. The elepaio, a species of flycatcher, was observed over many days to note its tree-pecking behavior. If a elepaio was seen pecking into a tree, the tree was known to have insects. This would make it unsuitable for a canoe. Many of these traditional approaches to harvesting koa logs and shaping canoes are still practiced today.

Shaping a canoe from a solid koa log is complicated. After the canoe tree is cut, the future canoe is roughly shaped on the outside. After the outside shaping is done, the inside is hollowed out. In the past, this was done with stone tools. Today, power tools are also used. After the inside is hollowed out, the canoe tree is light enough to be hauled from the forest to the shore. Hauling a canoe to shore was an important cultural event, requiring many people working (laulima) in unison (lokahi). The entire community celebrated this event. After bringing the canoe close to shore, the canoebuilder finished shaping the canoe. This work was so respected that no one was allowed to talk in the building while the canoebuilder was at work (figure 15).

Koa wood canoes are long and thin and require an outrigger for stability. An outrigger is made up of a long float (ama) attached to the canoe with two bars of wood (iako). An outrigger does more than prevent capsizing (figure 16). It keeps the canoe stable in even the roughest ocean conditions. Today in Hawai‘i, koa canoes are special vessels. They require an outrigger for stability.
are used for racing and for ceremonies. Koa wood canoes are paddled by members of canoe clubs (*halau wa’a*) during races. These paddlers are continuing an ancient practice that is a foundation of traditional Hawaiian culture.

Another *koa* product is traditional surfboards (*alaia*). *Koa* was one of the three most common trees used for surfboards in ancient Hawai‘i. *Koa* wood surfboards are still used today.

Surfboards came in many forms, shapes, and sizes. The long surfboards (*olo*) were carved from the *wiliwili* tree (*erythrina sandwicensis*). The *wiliwili* tree produces very light but strong wood. Surfboards from these trees were reserved specifically for nobility.

Ancient Hawaiians began using wooden boards to surf waves very early in Hawaiian history (**figure 17**). Although other early societies used surfboards, Hawaiian surfboard styles were more varied, and the Hawaiian art of surfing was more developed. Early Hawaiians created wood boards of various sizes so that different styles of surfing and different sizes of people could ride the waves.

Surfing remains a way of life in Hawai‘i. Surfers ride waves today in the traditional manner. Paddling surfboards from a standing position has also become popular (**figure 18**). Surfing ocean waves is an art that was begun thousands of years ago in Hawai‘i and will continue into the future.

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**Figure 18.** Surfboards are sometimes paddled from a standing position. Photo by Dr. Ken Cordell.


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**Hawaiian saying:**

_E ola ke koa:_

*Live like a koa tree; Live a long time, like a koa tree in the forest._

(From http://www.bishopmuseum.org.)

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Boa constrictors are snakes that live in Central and South America. They kill their prey by slowly squeezing it until it suffocates. Constrict means to stop or inhibit. The three things studied by the scientists in this study inhibited the fast growth of *koa* crop trees. That makes them *koa* constrictors!
### Additional Web Resources

- **Gallery of koa tree photos by Dr. J.B. Friday:**

- **Koa Ethnobotany information: Bishop Museum:**

- **Anatomy of a Tree—Arbor Day Foundation:**
  [http://www.arborday.org/trees/RingsTreeAnatomy.cfm](http://www.arborday.org/trees/RingsTreeAnatomy.cfm)

- **History of the Polynesian Voyaging Society:**
  [http://www.pvs-hawaii.com/about_pvhistory.htm](http://www.pvs-hawaii.com/about_pvhistory.htm)

- **Using Polynesian noninstrument navigation:**

- **Building ancient koa wood surfboards:**

### National Education Standards

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