Rain Forest Unit 5

Weed Warriors

Overview

Invasive plants are a top concern of resource managers on Maui and the other Hawaiian Islands. The islands are highly vulnerable to invasion by nonnative (sometimes called "alien") plants and animals because native island species have evolved in isolation from pressures routinely encountered by plants and animals on continents. The Hawaiian Islands currently have more than 10,000 introduced plant species, most of which grow only in cultivation. Over 1000 of these introduced plants now have reproducing populations in the wild. At least 100 of these nonnative plant species are considered by scientists and resource managers to pose a threat to native Hawaiian ecosystems because of their potential to displace native species and modify the ecosystem.

But some people see certain nonnative plants in a different light than do resource managers. In this unit, students explore the role of values and perspectives in making decisions involving nonnative plant species. They also learn about why some introduced plants are invasive while others are not and apply that knowledge in a management scenario.

Length of Entire Unit

Five and one-half class periods

Unit Focus Questions

1) What are some different values and perspectives that people hold about nonnative plant species?

2) How do values and perspectives influence decisions about nonnative plant species?

3) What characteristics make some plant species invasive?

4) What threats do invasive plant species pose to native ecosystems?

5) What are some of the invasive plants of most concern to resource managers on East Maui?

6) How can resource managers set priorities for invasive plant management?

Unit at a Glance

Activity #1

Kāhili Ginger Values and Perspectives

Students role-play different perspectives about a nonnative plant species and a proposal to ban the propagation and sale of this plant in Hawai‘i. They explore different types of values and consider how those values might affect people’s decisions and actions.

Length
Two class periods

Prerequisite Activity
None

Objectives
- Recognize that different perspectives exist and affect the way people think about nonnative species in Hawai‘i.
- Identify and articulate several perspectives about nonnative species in Hawai‘i.
- Communicate persuasively about a perspective.
- Differentiate among intrinsic and instrumental value.
- Articulate and examine personal perspectives.

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 characteristics of an inquiring mind.
- OBJECTIVITY: Evaluate various perspectives and their implications before drawing conclusions.

Activity #2

What Makes a Plant Invasive?

Students learn about invasive plant characteristics and how those characteristics influence management decisions by completing homework reading, questions, and a class discussion.

Length
One and one-half class periods

Prerequisite Activity
None

Objectives
- Identify six invasive nonnative plant species of concern to Maui resource managers.
- Identify and explain factors that influence the invasiveness of nonnative plant species.
- Assess the implications of invasiveness characteristics on management approaches.

DOE Grades 9-12 Science Standards and Benchmarks
USING UNIFYING CONCEPTS AND THEMES: Students use concepts and themes such as system, change, scale, and model to help them understand and explain the natural world.
- CHANGE: Explain the effect of large and small disturbances on systems in the natural world.

LIVING THE VALUES, ATTITUDES, AND COMMITMENTS OF THE INQUIRING MIND: Students apply the values, attitudes, and commitments characteristics of an inquiring mind.
- CRITICAL-MINDEDNESS: Evaluate the logic and validity of evidence, conclusions, and explanations against current scientific knowledge.

Activity #3

Managing Invasives on Survivor Island

Students apply knowledge and information about invasive plants to a management scenario.

Length
Two class periods

Prerequisite Activity
Activity #2 "What Makes a Plant Invasive?"

Objectives
- Use critical reasoning skills to prioritize control activities in a hypothetical management scenario.

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.
- OPEN-MINDEDNESS: When appropriate, modify ideas, explanations, and hypotheses, based on empirical data or evidence

RELATING THE NATURE OF TECHNOLOGY TO SCIENCE: Students use the problem-solving process to address current issues involving human adaptation in the environment.
- Evaluate alternative solutions for effectiveness based on appropriate criteria.

Enrichment Ideas

- Research efforts among members of the East Maui Watershed Partnership to control invasive plants. The partnership is a collaborative effort among six public and private landowners and Maui County to protect the 100,000-acre rain forest core of this critical watershed. Online information about the partnership can be found at <ice.ucdavis.edu/~robyn/mauimgt.html>. Students may also want to contact the major partners directly: The Nature Conservancy, East Maui Irrigation Company, Hawai'i Department of Land and Natural Resources, National Park Service, Haleakalā Ranch, Hāna Ranch, and Maui County.

- Conduct library and Internet research on the six invasive nonnative species highlighted in this unit (Activities #2 and #3) to find additional biological information or control strategies that would assist in developing management priorities.

- Research existing public education and awareness campaigns about invasive nonnative species. Design a program, poster, or educational flyer for a species that is not covered in existing educational efforts or make suggestions for improving current campaigns.

- Participate in volunteer efforts to control invasive nonnative plants in the rain forest. (See field trip notes in unit introduction for ideas.)

- Research the efforts of the Maui Invasive Species Committee (MISC) to prevent and control invasive nonnative plant and animal species on the island. Find beginning information about MISC at <www.hear.org>.

Resources for Further Reading and Research

Hawai‘i Ecosystems at Risk at <www.hear.org>.
This site is a central repository of information about invasive nonnative plants and nonnative animals in Hawai‘i, including links to databases and other sites. It includes information about the Maui Invasive Species Committee, Coordinating Group on Alien Pest Species, and other state, national, and regional groups concerned with invasive species.

Moanalua Gardens Foundation, *Forest Treasures* (CD-ROM), Moanalua Gardens Foundation, Honolulu, 2001.
CD-ROM includes images of several invasive nonnative plants, as well as tools for students to create multimedia presentations.

Smith, Clifford W., “Impact of Alien Plants on Hawai‘i’s Native Biota” at <www.botany.hawaii.edu/faculty/cw_smith/>.
This article describes nonnative plants in Hawai‘i and the impacts associated with them, as well as strategies to ameliorate problems.

Stone, Charles P., Clifford W. Smith, and J. Timothy Tunison, *Alien Plant Invasions in Native Ecosystems of Hawai‘i: Management and Research*, University of Hawai‘i Cooperative National Park Resources Studies Unit, Honolulu, 1992.

Activity #1

Kāhili Ginger Values and Perspectives

● ● ● Class Period One Kāhili *Ginger Perspectives*

Materials & Setup

- One copy of the "Perspectives" acetates (master, pp. 8-9)
- Overhead projector and screen

For each group of three to four students

- *One* perspective card from "*Kāhili* Ginger Perspectives" (master, pp. 10-11)
  Be sure that at least one group has each of the four perspective cards. More than one group may have each perspective.

For each student

- Student Page "*Kāhili* Ginger Information Sheet" (p. 12)
- Student Page "What's Your Perspective?" (pp. 13-14)

Instructions

1) Show the whitetip reef shark acetate to the class. Engage students in a brief discussion:
   - Ask:
     "What is this?"
     "What's your reaction to it?"
     "What would your reaction be if you were snorkeling or diving and you saw one?"
   - Observe: Different people have different *perspectives* about sharks. Some people think they're neat, some think they're scary, some are so fascinated that they spend their whole lives studying them, some want to kill them, and some think they should be left alive.

2) Ask students for ideas about what can change people's perspectives. Write a list on the board or overhead. Here are some ideas to insert:
   - Perspectives can vary in different situations,
   - Having more information can sometimes change a person's perspective, and
   - Listening to other people's point of view can change our opinion, bring up questions we may not have thought of before, or give us a broader perspective. People who speak especially passionately or articulately may be able to change the way other people think or feel about a topic because of their strong beliefs, ability to speak convincingly, or well-constructed arguments.

3) Show the *kāhili* ginger acetate to the class, showing only the photo and covering up the printing at the bottom of the page. Ask, "What is this?" Make sure everyone knows it's *kāhili* ginger, but do not go into more detail.

4) Divide the class into groups of three to four. Give each student a copy of the Student Page "*Kāhili* Ginger Information Sheet" and each group *one* of the perspective cards from "*Kāhili* Ginger Perspectives."

5) Uncover the bottom of the *kāhili* ginger acetate, so students can read the proposal. Each group's assignment is to develop a short, compelling, persuasive response to that proposal, from the perspective given on its role card.

6) Give groups 15-20 minutes to develop their responses. Then ask a spokesperson from each group to present the group's response, making it as dramatic, full of feeling, and persuasive as possible.

7) If there is time at the end of class, discuss with students how well they were able to take on another person's perspective. Did they agree or disagree with the perspective they had to work with? Which of the group responses seemed most compelling? Why?

8) As homework, assign the Student Page "What's Your Perspective?"

● ● ● Class Period Two *Values and Perspectives*

Instructions

1) Ask students to define the word "values." Values are commonly defined as things (such as principles or qualities) that have inherent worth or desirability. Ask students to come up with some examples of values and write them on the board or overhead. Some examples of Hawaiian values include *mālama* (caring), *laulima* (working together), *ho'omanawanui* (patience), *'ohana* (family), and *lokomaika'i* (generosity).

   If students have difficulty generating a list of values, ask a few students to volunteer to tell the class something that's really important to them. If it doesn't seem basic enough to be a value, ask the student why that's important, and keep asking the question until you get to the level of basic values.

2) Tell students that there is a different but related way of using the concept of value. Write the phrases "intrinsic value" and "instrumental value" on the board or overhead. Briefly discuss what the terms mean by first asking students for their ideas. Then bring in the following definitions and write some examples on the board or overhead:

   Intrinsic value — Worth or desirability that is ascribed to something simply because it exists. This type of value is also known as "existence value." Intrinsic value systems include spiritual and aesthetic perspectives.

   Instrumental value — Worth or desirability that is ascribed to something because of what it can do for people (or a person). Instrumental value systems include cultural, ecological, economic, educational, personal, legal or recreational perspectives.

3) Brainstorm some examples of how these different types of values would affect someone's actions or preferences. For example, someone who saw a fish as having intrinsic value might prefer to leave the fish living in the ocean. Someone who saw the fish as having primarily instrumental value might prefer to catch it and eat it.

4) Ask for a show of hands from students who believe Hawai'i should enact a law banning the propagation, sale, and distribution of *kāhili* ginger. Then ask for a show of hands from those who disagree. Finally, ask for students who aren't sure to raise their hands.

5) Have students divide into three groups: those who support the law, those who oppose the law, and those who aren't sure. If no students raised their hands for one group, then have only two groups. Give groups 15 minutes to identify and make a list of the beliefs and values that underlie their positions.

6) Now have the three groups reassemble. Have a spokesperson from each group read the list of beliefs and values. After each list is read, discuss the types of values (intrinsic and instrumental) and the value systems (e.g., aesthetic, cultural, economic) that each group expressed.

7) Wrap up the class by asking students to discuss the importance of values in decision making. Did the values of the three groups seem similar or different? If they seem different, do students think that explains the different positions of each group? If they seem similar, what else do students think could explain the differences among the groups' positions?

Journal Ideas

- Think of an important decision you've made and discuss why you decided the way you did. What values influenced your decision? Did anyone try to get you to change your mind? Did it work? Why or why not?
- Discuss how protecting native rain forests could be important to someone who ascribes primarily intrinsic value to the forest *and* by someone who ascribes primarily instrumental value to the forest.
- Do you think the fact that a nonnative plant such as *kāhili* ginger has been given a Hawaiian name changes people's perspective about the plant? Why or why not?
- Can the value of *kāhili* ginger be weighed against the value of intact native rain forests? How would you compare or evaluate the two? Why?

Assessment Tools

- Student Page "What's Your Perspective?": Evaluate on the basis of the quality of student reasoning and articulation.
- Participation in class discussions and group work
- Journal entries

Perspectives Acetates

#1 Whitetip Reef Shark or *Manōlālākea*

(Triaenodon obesus)

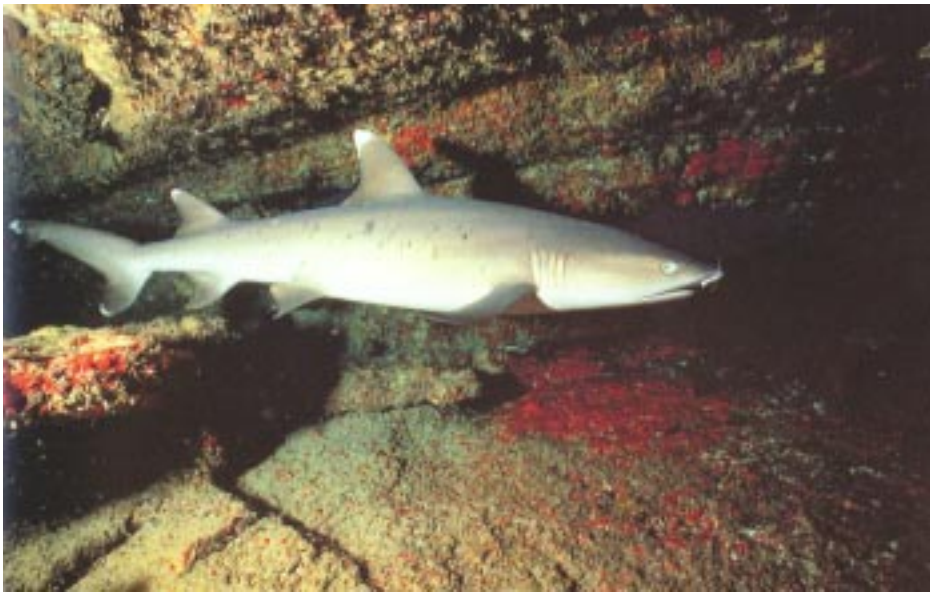


Photo: David R. Schrichte in John Hoover,
Hawaii's Fishes*, Mutual Publishing*

#2 *Kāhili* Ginger

(Hedychium gardnerianum)

Photo: The Nature Conservancy

In New Zealand, *kāhili* ginger is a locally common plant often seen along river bottoms and valley floors. This nonnative species has started to appear in New Zealand's native forests and is predicted to pose a significant threat to many of New Zealand's native forest ecosystems, as well as areas recovering from disturbances such as logging. This species forms vast colonies, choking out native vegetation almost completely and preventing growth of new trees, shrubs, and forest floor plants. *Kāhili* ginger may permanently displace rare plants or cause serious losses to populations of uncommon plants and entire natural communities. To guard against this possibility, New Zealand law prohibits the propagation, sale, and distribution of *kāhili* ginger.

Should Hawai'i adopt a similar law? Why or why not?

Using the information on the "*Kāhili* Ginger Information Sheet" as well as your group's perspective card, develop a compelling, persuasive answer to this question.

Kāhili Ginger Perspectives

Cut along dashed lines

Perspective #1
Nursery Owner

Your nursery grows *kāhili* ginger and sells it to landscapers and home gardeners. Other nurseries and mail order catalogs sell this plant, and if your customers couldn't buy it from you, they'd get it somewhere else. People love this plant because of its fragrant and beautiful flowers. *Kāhili* ginger is the showiest of all of the ginger varieties, with giant flower heads of brilliant yellow flowers with protruding dark orange stigmas (flower parts that receive pollen grains) that give the flowers a dramatic look.

People like how easy these plants are to grow. Once they've become established, *kāhili* ginger plants easily spread throughout an area and require little weeding because the hearty, dense ginger growth crowds out other plants. *Kāhili* ginger helps prevent erosion and its deep green leaves form an attractive planting even when the flowers are not in bloom.

Perspective #2
Hiker

You love to walk in the forest, and your favorite time of year is August and September, when the *kāhili* ginger is in bloom. The yellow flower heads blooming along the trail fill the air with a sweet, sharp, unique fragrance. On your way out of the forest, you love to pick a few flowering stalks to take home with you. The delicate flowers don't last long, but that's a good excuse to go for another hike to pick more! The ginger fruits also provide food for birds, which you love to watch along your hikes.

Although it is not native to Hawai'i, you appreciate this plant's interesting connection to Hawaiian culture. It is named for the *kāhili*, the feathered standard that symbolized Hawaiian royalty. On its stout stalk, the flower head looks like the feathered head of the *kāhili*.

Cut along dashed lines

Perspective #3
Natural Preserve Manager

Your job is to preserve the native Hawaiian rain forest. Nonnative plant species like *kāhili* ginger make that job difficult and expensive. *Kāhili* ginger is an "invasive" plant, which means that it grows quickly and reproduces rapidly, aggressively taking over new areas and outcompeting other plants for light, water, and nutrients. That's bad news for native plants, many of which are important in traditional Hawaiian culture. Especially threatened are the rare plants that are found only in Hawai'i and the native animals that depend on these plants.

Eradicating ginger in an area is a labor-intensive and expensive task that requires systematic attention. Young seedlings may be pulled out, but larger, established plants must be uprooted. Large clumps can be eliminated only by cutting down the vegetation with a cane knife and then applying herbicide to the cut surface of the rhizome. These sites must be monitored for regrowth, and all of the areas of the preserve that are likely habitat for ginger must be patrolled regularly to detect new populations established by birds or rats dispersing seeds that may come from cultivated ginger around homes and businesses.

Perspective #4
Native Insect Researcher

Your studies of native *Drosophila* flies are adding to the scientific community's understanding of evolution and island ecology. You estimate that over 800 species of flies in the family Drosophilidae have evolved here on the Hawaiian Islands over about 70 million years, all of them the descendants of just one or two ancestral species. Because they are a prime example of adaptive radiation and because their behavior and its connection to evolution is relatively easy to study, these flies are a resource of international importance.

Many of these 800 species are found only in tiny patches of habitat offering specific foods and mating sites. Since their habitat is so small, these species can easily be reduced to small numbers or eliminated by anything that degrades the forest, including invasion by aggressive plants such as *kāhili* ginger, which can completely displace all native plants in the understory. From discussions with your colleagues, you know that other researchers share your concern over the potential for *kāhili* ginger and other invasive plants to destroy critical habitat for other unique Hawaiian species.

Kāhili Ginger Information Sheet

Kāhili Ginger

Hedychium gardnerianum, Family Zingiberaceae
Native to India, Himalayan region
Introduced to the Hawaiian Islands as an ornamental plant

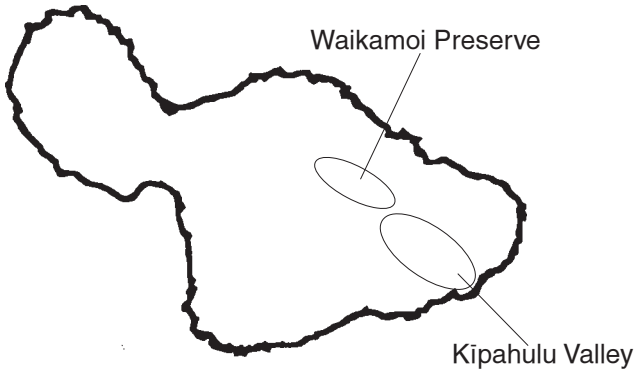
Description

This is a large, showy ginger that can reach heights of up to six feet. It bears large heads of fragrant, bright golden-yellow and red flowers. The flower head turns into a cluster of large, fleshy, bright orange-red fruits. The fruits split open exposing bright red seeds that are very attractive to birds.

Growth Habit

Grows in dense clusters that spread by runners that extend from the base of the plant and sprout new plants

Distribution on East Maui



Kāhili ginger is grown in home gardens and landscape plantings, especially in cool, moist, sunny to partially shaded areas. It also has spread beyond cultivated areas and is now found in protected rain forest areas such as Waikamoi Preserve (managed by The Nature Conservancy) and Kīpahulu Valley (a part of Haleakalā National Park). *Kāhili* ginger is also found in Koʻolau Gap between 600-900 meters (1968-2932 feet) elevation and has displaced thousands of acres of native rain forest in the East Maui watershed. (Distribution is not fully known because only small areas of the Haleakalā rain forest are being actively managed and monitored for the presence of ginger.)

How Spread

Kāhili ginger may be intentionally propagated by transplanting "rhizomes" (thickened, underground plant stems that produce shoots above and roots below). Rhizomes that are dug up can also resprout—for example, in compost piles—if they are not dried and thoroughly burned. *Kāhili* ginger can also be dispersed, sometimes long distances, by birds that eat the fruits and excrete the seeds or carry them to other parts of the forest. Fruits of streamside plants can be carried downstream by running water.

Potential Effects on Native Forests

Because of its bird-dispersed seeds, *kāhili* ginger is capable of spreading to remote forests. Once established, this ginger may spread by growth of its rhizome mass. In time, this species may completely dominate the ground cover and shrub layer of invaded forests, replacing the natural understory plants and preventing the growth of young native trees.

What's Your Perspective?

1) Think back to the class activity. Can you identify any perspectives about banning or not banning *kāhili* ginger that were not presented during the activity? If so, what are they?

2) What is *your* perspective on the question your group worked on during class? Here is that question again:

> In New Zealand, *kāhili* ginger is a locally common plant often seen along river bottoms and valley floors. This nonnative species has started to appear in New Zealand's native forests and is predicted to pose a significant threat to many of New Zealand's native forest ecosystems, as well as areas recovering from disturbances such as logging. This species forms vast colonies, choking out native vegetation almost completely and preventing growth of new trees, shrubs, and forest floor plants. *Kāhili* ginger may permanently displace rare plants or cause serious losses to populations of uncommon plants and entire natural communities. To guard against this possibility, New Zealand law prohibits the propagation, sale, and distribution of *kāhili* ginger.
>
> Should Hawai'i adopt a similar law? Why or why not?

3) What is your opinion based on? What intrinsic and instrumental values are involved in your opinion?

4) Should companies that sell nonnative plants in Hawai‘i be required to provide information to customers about their potential effects on native ecosystems? Why or why not? Would it make any difference whether the plants are potentially invasive (capable of spreading out of cultivation and disrupting native ecosystems)? Why or why not?

5) Some companies sell plants through the Internet or mail order catalogs, shipping them around the world from a central nursery instead of through locally based nurseries. If companies selling nonnative plants in Hawai‘i were required to provide information about their potential effects on native ecosystems to customers, how could this be set up and enforced for nurseries that do business over the Internet?

Activity #2

What Makes a Plant Invasive?

● ● ● In Advance *Collecting Weeds*

- Have students bring to class examples of plants they think of as weeds. Challenge students to look for plants that seem particularly invasive (capable of rapidly taking over large areas and inhibiting the growth of other plants).

● ● ● Class Period One *Characteristics of Invaders*

Materials & Setup

For each student

- Student Page "Invasive Plants in Hawai'i" (pp. 22-30)
- Student Page "Invasive Plants in Hawai'i: Questions on the Reading" (pp. 31-34)

Instructions

1) Have students display their plants in front of the class. As the class observes the plants, ask whether there seem to be any similarities among them. (If they need ideas, prompt students to look at characteristics such as leaf size, flower size and structure, the form in which plants grow, root shape and size, and so forth.)

2) Divide the class into groups of four to five students. Tell students that there are eleven characteristics that make some plants highly successful invaders. Have student teams work together to identify as many of these as they can, using the plants on display for ideas. Each group should make a list of the characteristics it identifies and explain their reasoning for each one.

3) Now tell students that there are seven main "dispersal mechanisms" that spread invasive plants into the Haleakalā rain forest. A dispersal mechanism is a means by which plant seeds are spread around, which enables the plant to become established in a new area. Challenge student teams to think of as many of the seven dispersal mechanisms as they can, write down their ideas, and explain their reasoning.

4) Give each student a copy of the Student Page "Invasive Plants in Hawai'i." Have students read pages 22-25, stopping before the subsection entitled "Six Invaders of Concern." When students have finished reading, have groups go back to their lists and use the information in the reading to determine the characteristics and dispersal mechanisms they missed. Groups should note these on their lists and place check marks by the ones they identified correctly.

5) As a class, discuss the similarities and differences between student lists and the ones given in the reading.

6) As homework, assign the rest of the Student Page "Invasive Plants in Hawai'i" as well as "Invasive Plants in Hawai'i: Questions on the Reading."

● ● ● Class Period Two *Invasives Identification Quiz*

Materials & Setup

- "Correct Responses for Invasive Plant Identification Quiz" acetate (master, p. 21)
- Overhead projector and screen

For each student

- Student Page "Invasive Plant Identification Quiz" (pp. 35-36)

Instructions

1) Hand out the Student Page "Invasive Plant Identification Quiz," and have students complete it.

2) Go over correct answers, using the acetate of correct responses. Discuss student questions.

3) Optional: Discuss the homework assignment with the class, using the questions on the Student Page "Invasive Plants in Hawai'i: Questions on the Reading" as a guide.

Journal Ideas

- How would you define a "weed"? Does invasiveness potential have anything to do with your definition? How about whether the plant is native?
- When talking about nonnative plants in Hawai'i, people often distinguish between "Polynesian introductions" brought here by early Polynesian settlers, and nonnative plants that were introduced later, after European contact. Does this division make sense to you? Why or why not?

Assessment Tools

- Participation in group work and class discussion
- Student Page "Invasive Plants in Hawai'i: Questions on the Reading" (teacher version, pp. 17-20)
- Student Page "Invasive Plant Identification Quiz" (teacher version, p. 21)
- Journal entries

Teacher Version

Invasive Plants in Hawai'i: Questions on the Reading

1) From the reading, select three of the characteristics that invasive plants may possess, and explain why each one could give these plants an advantage over native plants.

Characteristic	Advantage
• Quick growth to reproductive maturity	Rapidly maturing plants would start producing seed or reproducing vegetatively more quickly than slower native species, thus adding more plants to their populations more quickly.
• Profuse reproduction by seeds and/or vegetative structures such as root runners	Crowding out more slowly reproducing native plants
• Long seed life in the soil	The ability to build up a massive number of seeds in the soil from which new plants can continuously sprout puts native plants with shorter-lived seeds at a disadvantage.
• Seeds that can lie dormant through unfavorable conditions and sprout when conditions are ideal for rapid growth	Dormancy adds to the number of seeds in the soil from which new plants may sprout under favorable conditions. Not sprouting during unfavorable conditions means that these plants may have a reduced risk of seedling mortality compared to native plants that do not have this characteristic.
• Seeds that are adapted to be easily spread by wind, animals, water, and/or humans	The ability to establish new populations in areas that are not directly adjacent to existing ones may give invasive plants an edge in colonizing new areas.
• Production of "biological toxins," substances that suppress the growth of other plants	A form of direct competition which may suppress the growth of nearby native plants
• Spines, thorns, and other structures that cause physical injury and repel animals	Most native Hawaiian plants have evolved without these mechanisms which can be an important protection against introduced predators such as goats, pigs, and cattle.

Characteristic	Advantage
• The ability to "parasitize" or live on other plants.	Parasitic plants can weaken native plants by using nutrients and energy from the host plant.
• Roots or "rhizomes" (underground plant stems that sprout roots below and plant stems above) containing large food reserves	Large food reserves may enable invasive plants to survive longer through drought and other adverse environmental conditions than native plants.
• Survival and seed production under adverse environmental conditions	May enable invasive plants to thrive where and when more sensitive native plants die back or lose vigor
• High photosynthetic rates or large leaves that allow them to tolerate low-light conditions and to grow quickly	May enable invasive plants to become established in shady areas where many native plants cannot live and give juveniles of an invasive species that forms dense thickets an advantage over native species that need more light to survive or thrive

2) If the goal is to control or eliminate invasive plants, why would it be important to identify and remove new populations before they reach reproductive maturity?

Once a population matures, it may rapidly reproduce, growing very quickly in size and density. A smaller population will be easier to treat or remove and have less impact on native vegetation in the area. Also, once an invasion is widespread, there is a much larger area to patrol to find new populations.

3) One job of field crews in protected areas is to look for previously undiscovered populations of invasive plants. If you were in charge of field crews at Waikamoi Preserve or Kīpahulu Valley, which of the plant species covered in the "Matrix of Factors That Influence Invasiveness" would you have field crews look for most frequently? Use the information in the matrix to explain your answer.

Clidemia—this species rapidly reaches reproductive maturity in six months, unlike other species in the matrix that take at least two years.

4) Give two reasons why it would be important for field crews to reinspect areas where they have already manually removed a population of invasive plants and/or treated it with herbicides.

   - To determine whether their treatment worked,
   - To monitor whether any seeds stored in the soil have sprouted into new plants, and
   - To prevent more fruit or seed from being produced by plants that may have survived or been missed in the initial treatment.

5) How long would you have crews return to a treated site to monitor it? Use the information in the matrix to explain your answer.

   Depending upon the species, four to six years, since that's how long seeds can stay viable in the soil. (Responses may also address the fact that seed longevity in the soil is unknown for some plant species. In these cases, students may suggest additional research, long-term monitoring that becomes less frequent over time, and other alternatives.)

6) Imagine that you are in charge of controlling invasive plants in Waikamoi Preserve or Kīpahulu Valley. Use the information provided in the last two columns of the invasiveness matrix ("Vegetative Layers Impacted" and "Potential Displacement of Natives in Layers") to determine the potential threat each plant poses to native rain forest plants. Rank the six plant species in order of the threat they pose to the native rain forest, with "1" indicating the greatest threat and "6" indicating the least threat. (If there is a tie between two species for a given ranking, use other information in the matrix to determine your ranking.) Explain why you ranked the plants the way you did.

   Here is one logical ranking (there may be others, which are acceptable as long as they are based primarily on the information in the last two columns in the matrix and well-reasoned).

   1. Strawberry Guava
      May fully displace all vegetative layers and reaches reproductive maturity more quickly than Miconia
   2. Miconia
      May fully displace all vegetative layers but reaches reproductive maturity more slowly than strawberry guava, so it may be easier to find and control populations before they reproduce
   3. Australian Tree Fern
      May partially to completely displace three of four vegetative layers in the rain forest
   4. *Kāhili* Ginger
      May completely displace the ground and shrub layers
   5. Pampas Grass
      May partially to completely displace the ground and shrub layers
   6. Clidemia
      May partially displace the ground and shrub layers

7) Use the other columns of the invasive matrix to double-check your ranking. Would you change anything based on this additional information? If so, what would you change and why? If not, why not?

Here is one logical response (there may be others, which are acceptable as long as they are based primarily on the additional information in the matrix and well-reasoned).

1) Miconia
May mature more slowly than strawberry guava but is of higher concern because it produces such huge numbers of small seeds that are highly dispersable

2) *Kāhili* Ginger
Its ability to completely displace the ground and shrub layers means that it could disrupt the new growth of any kind of vegetation in the forest. Since pigs are controlled in much of Waikamoi Preserve and Kīpahulu Valley, this plant is a greater threat than strawberry guava, which is primarily spread by pigs.

3) Strawberry Guava
May fully displace all vegetative layers and reproduces quickly

4) Australian Tree Fern
Dispersal by wind is a big concern with this plant since it can be easily spread long distances.

5) Pampas Grass

6) Clidemia

8) How can knowing the potential elevation range help a resource manager plan a control strategy for a particular plant species?

Possible responses include:

For plants that are restricted by elevation, managers can target control efforts to the elevational range in which the plants may be found, rather than spreading efforts to elevations where these plants are unlikely to survive or reproduce.

Also, a broad elevational range can add up to greater destruction because there is a greater amount of habitat that this plant may invade. This potential may increase the priority placed on controlling a given plant.

Frost and cold tolerance means that plants may invade the upper-elevation habitats, which tend to be less altered by human activity, with a more intact native ecosystem. This potential may increase the priority placed on controlling a given plant.

Correct Responses for Invasive Plant Identification Quiz

Photo: The Nature Conservancy

***Kāhili* Ginger**

B. A popular flowering plant in gardens and landscaping

1. Birds are one of the main dispersal mechanisms for this plant, which produces bright red seeds.

Photo: The Nature Conservancy

Miconia

E. Originally brought to the Hawaiian Islands as an ornamental tree because of its dark green and purple leaves

2. Is capable of completely displacing native plants in all vegetative layers of the rain forest

Photo: Steve Anderson

Clidemia

A. A densely branching shrub that is thought to have been introduced to the Hawaiian Islands unintentionally

3. Restricted to elevations below 1300 meters (4264 feet) because it cannot tolerate cooler temperatures or frost

Photo: Steve Anderson

Australian Tree Fern

D. Nurseries sell more of these plants than the native *hāpu'u,* which could serve the same function in landscaping.

4. A dense infestation of this plant in Kīpahulu Valley is thought to have originated from nurseries in the Hāna area, 12 kilometers (7.4 miles) away.

Photo: Kim Martz and Forest Starr

Strawberry Guava

C. Originally introduced to the Hawaiian Islands as a food source because it bears edible purple or yellow fruit

5. Is spread by pigs and can completely displace native plants in all vegetative layers of the rain forest

Photo: Kim Martz and Forest Starr

Pampas Grass

F. A popular ornamental plant with saw-toothed leaves and white to pink flower plumes

6. Is capable of invading many habitats including grasslands, mesic forests, wet forests, shrublands, and bogs

Invasive Plants in Hawai'i

Oceanic islands such as Maui and the other Hawaiian Islands are highly vulnerable to invasion by "alien" (nonnative) plants and animals. These biological invasions are often successful because native island species have evolved in isolation from pressures routinely encountered by plants and animals on continents. These forces include browsing and trampling by herbivorous mammals, ant predation, many types of diseases, and frequent and intense fires. Native island species evolved without the need for mechanisms to protect against predators and consequently, have reduced ability to compete against introduced species.

Scientific estimates of the rate at which the native biota of the Hawaiian Islands arrived here vary. One estimate puts the average rate at one new species every 35,000 years over a span of 70 million years. Over time, some of these original immigrant species evolved into the endemic plants and animals found on the islands. After the arrival of the Polynesians in the fifth century A.D., the arrival rate for new species increased to about three or four species each century. European contact in the 18th century further accelerated the immigration rate. Over the past 200 years, new insect species have been arriving on the Hawaiian Islands at a rate of 15 to 20 *per year* and plants have been introduced at an average rate of more than 40 per year. At this rate of introduction, native species are under increasing pressure from aliens, with virtually no time (on the evolutionary time scale) to adapt.

Biologists removing miconia plants (Photo: The Nature Conservancy)

The Hawaiian Islands currently have more than 10,000 introduced plant species, most of which grow only in cultivation. Over 1000 of these introduced plants now have reproducing populations in the wild. At least 100 of these nonnative plant species are considered by scientists and resource managers to pose a threat to native Hawaiian ecosystems. Why are some of these introduced plants such a threat while others are not? The answer is that some nonnative plants are more "invasive" than others.

What Makes a Plant Invasive?

Plants that have been introduced into an environment in which they did not evolve may become invasive. In these environments, they usually have no natural controls to limit their reproduction and spread, so they grow quickly and reproduce rapidly. A common term for invasive plants, especially on agricultural lands where they interfere with crop production, is "weeds." In natural areas, invasive plants produce a significant change in the composition, structure, or function of ecosystems.

Invasive plant species possess characteristics that permit them to aggressively invade new areas and outcompete native plants for light, water, and nutrients. Some of these characteristics include:

- Quick growth to reproductive maturity;
- Profuse reproduction by seeds and/or vegetative structures (parts of the plant such as root runners);

- Long seed life in the soil;
- Seeds that can lie dormant through unfavorable conditions and sprout when conditions are ideal for rapid growth;
- Seeds that are adapted to be easily spread by wind, animals, water, and/or humans;
- Production of "biological toxins," natural substances that suppress the growth of other plants;
- Spines, thorns, and other structures that cause physical injury and repel animals;
- The ability to parasitize other plants, taking nutrients from the host plant rather than producing them itself;
- Roots or "rhizomes" with large food reserves. A rhizome is a rootlike stem that grows under or along the ground, sending out roots from its lower surface and leafy shoots from its upper surface;
- Survival and seed production under adverse environmental conditions; and
- Large leaves or the ability to photosynthesize rapidly and efficiently, which allow plants to tolerate low-light conditions and to grow quickly.

Invasive plants often gain a foothold in new areas by establishing in places that have been disturbed by human activity (e.g., road and trail construction, farming, and building houses), by natural events (e.g., high winds and flooding), or by introduced animals (e.g., pigs rooting in the rain forests and cattle or goats grazing native plants). While not necessary for a new establishment of an invasive plant species, disturbing the native ecosystem makes it more vulnerable to invasion.

In general the mild climate and varied habitats of the Hawaiian Islands makes them particularly vulnerable to invasion. Nonetheless, the success of invasive plants may be restricted by temperature or other conditions that limit their growth. On Maui, as in other places, some invasive plants are restricted to certain elevations because cooler temperatures or frost prevent seed germination, kill the plants outright, or inhibit their growth, making them less invasive.

In the Haleakalā rain forest, as in other Hawaiian rain forests, invasive plants are spread by a handful of common "dispersal mechanisms" or means by which they are spread to new areas. Successful plant invaders are spread by introduced and native birds, introduced rats, feral pigs, people, wind, water, and gravity. Each dispersal mechanism a plant can use provides it with a different way to become established in new areas. And each dispersal mechanism poses a different threat for spreading invasive plants to or within the Haleakalā rain forest and beyond to other ecosystems and places. Table 1: Common Dispersal Mechanisms (p. 24) gives more detail about these common dispersal mechanisms.

Invaders in the Rain Forest

Invasive plants possess a combination of characteristics that allow them to compete with and sometimes totally displace native plants. In native Hawaiian rain forests, such as those on Haleakalā, native vegetation grows in four distinct layers (see "Major Layers of a Hawaiian Rain Forest"on p. 30). Different invasive plant species threaten native vegetation in different layers by crowding out plants in a specific layer, shading layers below, outcompeting plants for soil nutrients and moisture, reducing habitat for epiphytic plants (which grow supported on another plant, often a tree), and other impacts.

When researchers and land managers are gauging the threat posed by a nonnative plant

Strawberry guava in fruit (Photo: Kim Martz and Forest Starr)

Table 1: Common Dispersal Mechanisms

Dispersal Mechanism	How It Works	Distance for New Establishments
Birds (Include native and introduced species)	• Birds eat fruit or seeds, fly elsewhere, and excrete the seeds. Excreted seeds may germinate more readily. • They transport seeds attached to their bodies.	• Generally up to two kilometers (one mile) • Birds can move seeds anywhere on Maui and even to or from another island.
Rats (All rats were introduced to the Hawaiian Islands by Polynesians or Europeans.)	• Rats eat fruit or seeds, crawl elsewhere, and excrete the seeds. Excreted seeds may germinate more readily. • They transport seeds attached to their bodies.	• Around 500 meters (1600 feet)
Feral Pigs (Descended from European pigs originally introduced as a food animal.)	• Pigs eat fruit or seeds, walk elsewhere, and excrete the seeds. Excreted seeds may germinate more readily. • Their rooting in the forest causes disturbances that facilitate the establishment of invasive plants. • They transport seeds on their bodies.	• Maximum of a couple dozen kilometers (several miles), usually much less
People	• People unintentionally transport seeds on boots and clothing or by eating fruit or seeds and excreting seeds elsewhere. • They intentionally use nonnative plants in landscaping, horticulture, and food production.	• Potentially global • Unintentional transport could occur anywhere on Maui, between islands, or elsewhere
Wind	• Lightweight seeds are transported on wind currents.	• Likely on Maui and between islands, following prevailing winds
Water	• Seeds are transported in flowing or moving water. • Water can also cause erosion, which may move seeds and cause disturbances that facilitate the establishment of invasive plants.	• Up to several miles, generally downstream • Generally localized
Gravity	• Gravity causes fruits/seeds to fall to the ground. • It contributes to erosion, directly moving seeds and causing disturbances that help invasive plants become established.	• Maximum of several miles, generally downhill • Generally very localized

species within the Haleakalā rain forest, they consider which native vegetative layers the plant would affect and how thoroughly the invader may displace native plants (i.e., whether any native plants are likely to be left in areas invaded by this plant). Other factors they consider include:

- Whether there are elevational limits to the invasive plant's growth,
- Which ecosystems it is capable of invading,
- How it is dispersed,
- How rapidly it reaches reproductive maturity,
- How long the seeds can survive in the soil and still germinate,
- The plant's current known distribution, and
- Whether the plant has established populations in or near pristine or sensitive areas or habitat for endangered species.

Looking at all of these factors helps researchers and land managers decide how likely it is that this plant will reach the native rain forest and how disruptive it is likely to be if it becomes established.

Six Invaders of Concern

Among the most threatening invasive plants to the Haleakalā rain forest are these six "most wanted" (or should that be "least wanted"?) invaders that you'll be learning more about later in this unit:

Clidemia or Koster's Curse *(Clidemia hirta)*

This densely branching shrub is an aggressive invader that grows up to three meters (ten feet) tall. It shades out all vegetation below it. Clidemia is native to the humid tropics of Central and South America. It is found on many Pacific islands and is thought to have been introduced to the Hawaiian Islands as an ornamental plant.

Distribution on East Maui: Clidemia is established throughout East Maui, in a broad belt along the windward side of Haleakalā. Dense infestations occur in Kīpahulu Valley and the Nāhiku and Kailua areas. The complete extent and intensity is not known.

Miconia or Velvet Tree *(Miconia calvescens)*

This decorative tree is an evergreen that grows to about 15 meters (50 feet) in height when mature. Its large leaves (up to one meter or three feet long) are dark green above and purple underneath. Miconia was brought to the Hawaiian Islands as an ornamental in the 1960s.

Distribution on East Maui: Miconia was first detected on Maui in 1990 at a botanical garden near Hāna. There is a large core population near Hāna in the Kawaipapa Gulch area, with smaller populations elsewhere on East Maui.

Kāhili Ginger *(Hedychium garderianum)*

This showy flowering plant grows just over one meter (three feet) tall. It is commonly used in gardens and landscaping, where it is popular for its dark green foliage and showy yellow and red flowers.

Distribution on East Maui: *Kāhili* ginger is found in protected rain forest areas such as Waikamoi Preserve and Kīpahulu Valley. It is also found in Koʻolau Gap between 600-900 meters (1968-2952 feet) in elevation and has displaced thousands of acres of native rain forest in the East Maui watershed. Its distribution is not fully known.

Australian Tree Fern *(Cyathea cooperi)*

This decorative fern is widely used in landscaping and gardening and is often seen in people's backyards. Nurseries sell this fern much more than the native *hāpuʻu*, probably because there is little or no commercial propagation of *hāpuʻu*. The few *hāpuʻu* ferns available for sale are

probably collected as whole plants from the native rain forest.

Distribution on East Maui: Australian tree ferns are scattered across the East Maui watershed from Ko'olau Gap to Kaupō Gap, with dense pockets in certain locations. In Kīpahulu Valley, a dense infestation is thought to have originated from spores transported by wind from nurseries in the Hāna area, 12 kilometers (7.4 miles) away.

Pampas Grass *(Cortaderia jubata)*

This giant, tussock-forming perennial grass has finely saw-toothed leaves and white to pink flower plumes that grow up to three meters (ten feet) tall. Pampas grass is a popular ornamental plant.

Distribution on East Maui: Pampas grass has been found in the Kīhei area, with extensive populations in other locations, especially along roadways leading up to Haleakalā National Park and in the upper-elevation rain forests on windward Haleakalā.

Strawberry Guava *(Psidium cattleianum)*

This medium-sized tree with a smooth trunk and dark green, shiny leaves bears small, purple or yellow fruits. Strawberry guava was originally introduced to Hawai'i in the early nineteenth century for its edible fruit.

Distribution on East Maui: Strawberry guava is found in protected rain forest areas such as Kīpahulu Valley. Strawberry guava has displaced thousands of acres of native rain forest in the East Maui watershed. Its distribution is not fully known.

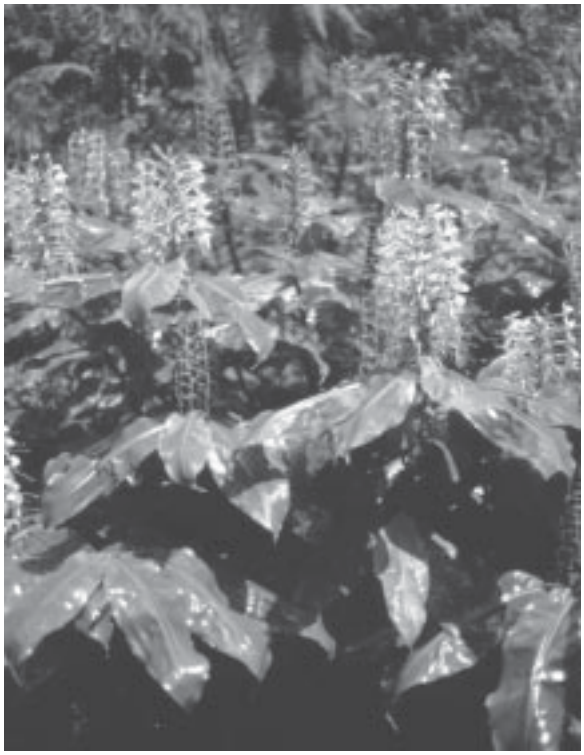
Controlling the Invaders

Especially in protected areas such as Haleakalā National Park and The Nature Conservancy's Waikamoi Preserve, resource managers are waging an ongoing battle against existing invasive plant populations as well as against the threat of future invasions. Within preserve boundaries, the main activities of paid workers and volunteers are:

- Patrolling for new or undiscovered populations of invasive plants on foot or by helicopter;
- Eliminating or controlling populations of invasive plants through manual removal or use of herbicides;
- Monitoring and retreating sites where invasive plant control has been done; and
- Controlling agents of dispersal such as rats and feral pigs through trapping, fencing, hunting, and poisoning.

Cooperating to Get the Job Done

Because so many parts of the Maui rain forest are not protected natural areas and protected areas are threatened by alien plants that come from outside their boundaries, cooperation is key in controlling these nonnative plants and preventing their arrival. On Maui, resource managers and



Kāhili *ginger (Photo: The Nature Conservancy)*

researchers have joined together to form the Maui Invasive Species Committee (MISC).

MISC is a voluntary partnership of private, government, and nonprofit organizations to prevent new pest species from becoming established in Maui County and to stop newly established pests from spreading. MISC maintains prevention, containment, and eradication plans for Maui, Molokaʻi, and Lānaʻi. It also organizes specific eradication and containment projects such as Operation Miconia, and convenes ad hoc meetings to address new threats.

MISC and other groups working outside the boundaries of a specific protected area try to do more than directly control plant populations. They also attempt to control the spread and arrival of invasive plants through public education, inspections of cargo and shipments, early detection of new populations, and other activities such as working with nurseries and landscapers to prevent the sale and planting of invasive species. Looking at the big picture, it is preferable to avoid the arrival of new invasive plant species on the islands than to attempt to detect, control, or eradicate them once they are established. Prevention is a top priority for MISC and other agencies and landowners who are involved in the fight against invasive plants on Maui.

Management Strategies for Invasive Plants

Many resource managers think of management strategies for invasive plants in a sort of hierarchy, with the most preferred strategy and result at the top. Here is one such hierarchy:

1) **Prevention:** Invasive plants cause no problems for native ecosystems if they do not arrive in the first place.

2) **Eradication:** Eliminating the invasion is the next most desirable scenario.

3) **Control the Spread:** If there is a single large population, resource managers may do manual removal (cutting, pulling, or digging up the plants) and/or herbicidal control (sprayed on foliage or applied directly under the bark or to a cut stump) to limit the expansion of that population. At the same time, they must patrol surrounding areas for new, smaller populations to remove them before they are too well established. In some cases, but not always, workers may be able to gradually decrease the size of the core population and may even be able to eradicate it.

4) **Eradicate Populations in Special Areas:** When eradication of the invading species is not possible, managers may focus on identifying and eliminating populations within or near pristine or sensitive natural areas or endangered species habitat.

5) **"Biocontrol":** Managers may release insects or a disease-causing organism that selectively affects the invasive species, weakening it or limiting its reproduction. Biocontrol is used only when eradication is not possible, since a small population of the invasive species must be maintained in order to continue to support the insect or disease.

6) **Do Nothing:** Some invasive species have become so widespread, or removing them would cause such great damage to surrounding native vegetation, that managers decide to take no action to control them.

Matrix of Factors that Influence Invasiveness

Species	Potential Elevation	Habitats Subject to Invasion	Dispersal Mechanisms	Time to Reproductive Maturity	Seed Size and Production	Vegetation Layers Affected	Potential Displacement of Natives in Layers
Clidemia Each fruit contains over 100 seeds, and mature plants produce over 500 fruits per year	0-1300 m (396 ft)	Mesic to wet forest, shrubland, and bogs	Birds Rats People Water Gravity	6 months	.5 mm	Ground to shrub layer (or under-story)*	Partial
Miconia Dark purple fruit each contain huge numbers of seeds and are very attractive to birds	0-1800 m (549 ft)	Mesic to wet forest, shrubland, and bogs	Birds Rats People Water Gravity	4 years	< .5 mm Massive quantities of small seeds, easily bird-dispersed	All: ground to tree canopy	Complete
***Kāhili* Ginger** Grows rapidly by stolons (runners that extend from the base of the plant) and produces red, fleshy seeds attractive to birds	0-2400 m (732 ft) (frost tolerant)	Mesic to wet forest, shrubland, and bogs	Birds Rats People Water Gravity	3+ years	4 mm	Ground to shrub layer (or under-story)	Complete
Australian Tree Fern Produces huge quantities of spores that are carried on the wind	0-1800 m (549 ft) (frost tolerant)	Mesic to wet forest, shrubland, and bogs	Wind People Water	2 years	< .5 mm Massive quantities of small spores, easily wind-dispersed	Ground to subcanopy layer	Partial to complete

* Displacing the ground or shrub layer over time impairs or completely inhibits the regrowth of other vegetative layers.

Matrix of Factors that Influence Invasiveness (cont'd)

Species	Potential Elevation	Habitats Subject to Invasion	Dispersal Mechnanisms	Time to Reproductive Maturity	Seed Size and Production	Vegetation Layers Affected	Potential Displacement of Natives in Layers
Pampas Grass Seeds itself freely, dispersing windborne seeds long distances from tall flowering stalks	0-2300 m (710 ft)	Grassland, mesic to wet forest, shrubland, and bogs	Wind People	2 years	2 mm	Ground to shrub layer (or understory)	Partial to complete
Strawberry Guava Produces golf-ball sized fruits prolifically	0-1800 m (549 ft) (frost tolerant)	Mesic to wet forest, shrubland, and bogs	Birds Rats Pigs People Water Gravity	2+ years	5 mm	All: ground to tree canopy	Complete

Layers of a Hawaiian Rain Forest

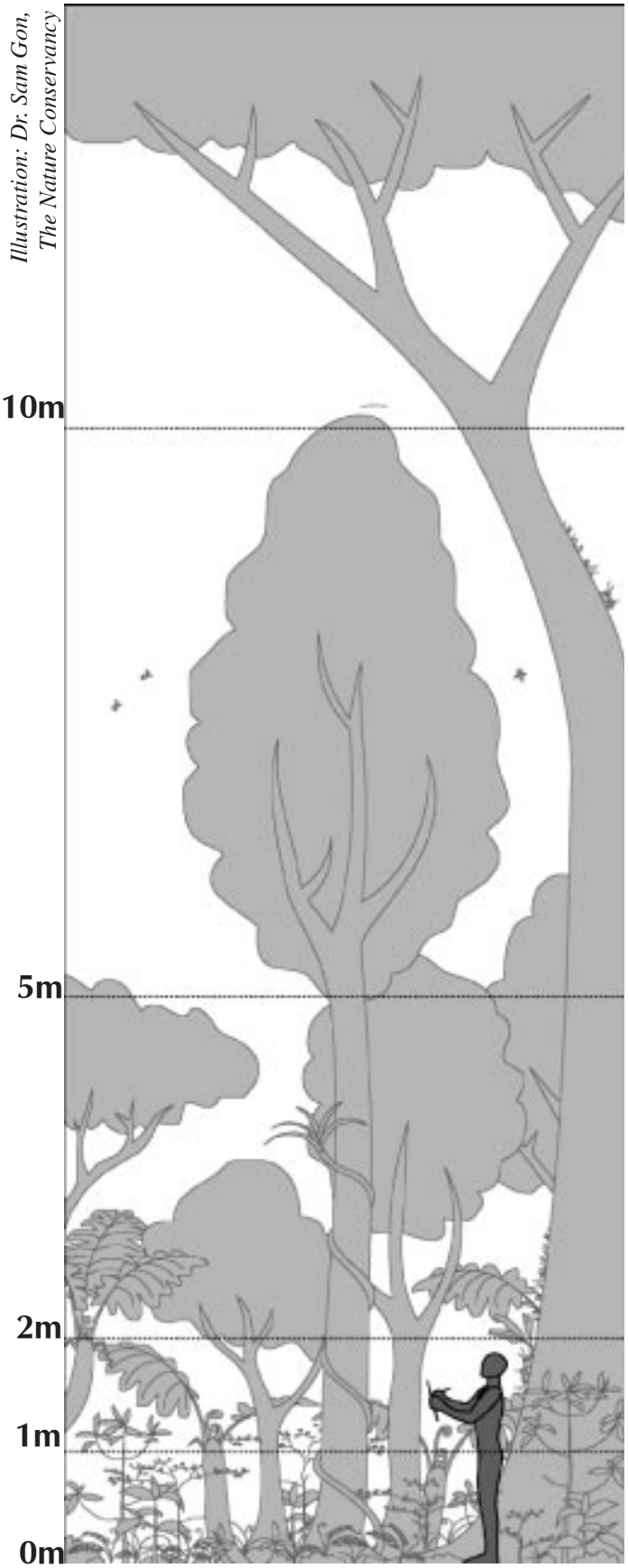


Illustration: Dr. Sam Gon, The Nature Conservancy

Canopy

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

Epiphytes and Climbing Plants

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

Subcanopy Trees and Shrubs

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

Understory

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

Groundcover or Forest Floor

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

Invasive Plants in Hawai'i: Questions on the Reading

1) From the reading, select three of the characteristics that invasive plants may possess, and explain why each one could give these plants an advantage over native plants.

•

•

•

2) If the goal is to control or eliminate invasive plants, why would it be important to identify and remove new populations before they reach reproductive maturity?

3) One job of field crews in protected areas is to look for previously undiscovered populations of invasive plants. If you were in charge of field crews at Waikamoi Preserve or Kīpahulu Valley, which of the plant species covered in the "Matrix of Factors That Influence Invasiveness" (p. 29) would you have field crews look for most frequently? Use the information in the matrix to explain your answer.

4) Give two reasons why it would be important for field crews to reinspect areas where they have already manually removed a population of invasive plants and/or treated it with herbicides.

5) How long would you have crews return to a treated site to monitor it? Use the information in the matrix to explain your answer.

6) Imagine that you are in charge of controlling invasive plants in Waikamoi Preserve or Kīpahulu Valley. Use the information provided in the last two columns of the invasiveness matrix ("Vegetative Layers Impacted" and "Potential Displacement of Natives in Layers") to determine the potential threat each plant poses to native rain forest plants. Rank the six plant species in order of the threat they pose to the native rain forest, with "1" indicating the greatest threat and "6" indicating the least threat. (If there is a tie between two species for a given ranking, use other information in the matrix to determine your ranking.) Explain why you ranked the plants the way you did.

1.

2.

3.

4.

5.

6.

7) Use the other columns of the invasive matrix to double-check your ranking. Would you change anything based on this additional information? If so, what would you change and why? If not, why not?

8) How can knowing the potential elevation range help a resource manager plan a control strategy for a particular plant species?

Invasive Plant Identification Quiz

Select one answer from each category on the following page and note it next to the appropriate image. Use each answer only once.

Photo: The Nature Conservancy

Species Name:

Human Use and Introduction:

Invasiveness and Distribution:

Photo: The Nature Conservancy

Species Name:

Human Use and Introduction:

Invasiveness and Distribution:

Photo: Steve Anderson

Species Name:

Human Use and Introduction:

Invasiveness and Distribution:

Photo: Steve Anderson

Species Name:

Human Use and Introduction:

Invasiveness and Distribution:

Photo: Kim Martz and Forest Starr

Species Name:

Human Use and Introduction:

Invasiveness and Distribution:

Photo: Kim Martz and Forest Starr

Species Name:

Human Use and Introduction:

Invasiveness and Distribution:

Species Name

Miconia
Australian Tree Fern
Pampas Grass
Kāhili Ginger
Clidemia
Strawberry Guava

Human Use and Introduction

A. A densely branching shrub that is thought to have been introduced to the Hawaiian Islands unintentionally
B. A popular flowering plant in gardens and landscaping
C. Originally introduced to the Hawaiian Islands as a food source because it bears edible purple or yellow fruit
D. Nurseries sell more of these plants than the native *hāpu'u,* which could serve the same function in landscaping.
E. Originally brought to the Hawaiian Islands as an ornamental tree because of its dark green and purple leaves
F. A popular ornamental plant with saw-toothed leaves and white to pink flower plumes

Invasiveness and Distribution

1. Birds are one of the main dispersal mechanisms for this plant, which produces bright red seeds.
2. Is capable of completely displacing native plants in all vegetative layers of the rain forest
3. Restricted to elevations below 1300 meters (4264 feet) because it cannot tolerate cooler temperatures or frost
4. A dense infestation of this plant in Kīpahulu Valley is thought to have originated from nurseries in the Hāna area, 12 kilometers (7.4 miles) away.
5. Is spread by pigs and can completely displace native plants in all vegetative layers of the rain forest
6. Is capable of invading many habitats including grasslands, mesic forests, wet forests, shrublands, and bogs

Activity #3

Managing Invasives on Survivor Island

● ● ● Class Period One *Managing Invasives on Survivor Island*

Materials & Setup

For each group of four to five students

- Student Page "Invasive Plants of Hawai'i" (Students should have these from Activity #2.)
- Student Page "Survivor Island Background" (pp. 38-45)
- Student Page "Invasive Plant Action Sheet" (pp. 46-49)

Instructions

1) Divide the class into groups of four to five students. Explain that each student group is a management team in charge of controlling invasive plants within a rain forest preserve on an imaginary island called Survivor Island.

2) Hand out the Student Pages "Survivor Island Background" and "Invasive Plant Action Sheet" to each group. Have each group select a) a **leader**, who will facilitate the group's discussion and make sure it completes its assignment, b) a **recorder**, who will fill out the "Invasive Plant Action Sheet," and c) a **spokesperson**, who will present the group's plan and rationale to the class. Allow students to work together for the remainder of the class. (Groups will have a brief time to work together during the next class period before making presentations.)

● ● ● Class Period Two *Survivor Island Management Reports*

Instructions

1) Reconvene student management teams to work on their plans. When approximately 40 minutes of the class remains, have each group's spokesperson give a five-minute overview of the group's plans and rationale for their priorities.

2) At the end of class, ask students to discuss what they learned by doing this activity.

Journal Ideas

- All resource managers need to set priorities for their work. Was this an easy or difficult task for your group? Why?
- Who should decide management priorities for invasive plants? Why?
- What are the pros and cons of focusing management efforts on one species, such as miconia, that poses a huge threat and paying less attention to others?

Assessment Tools

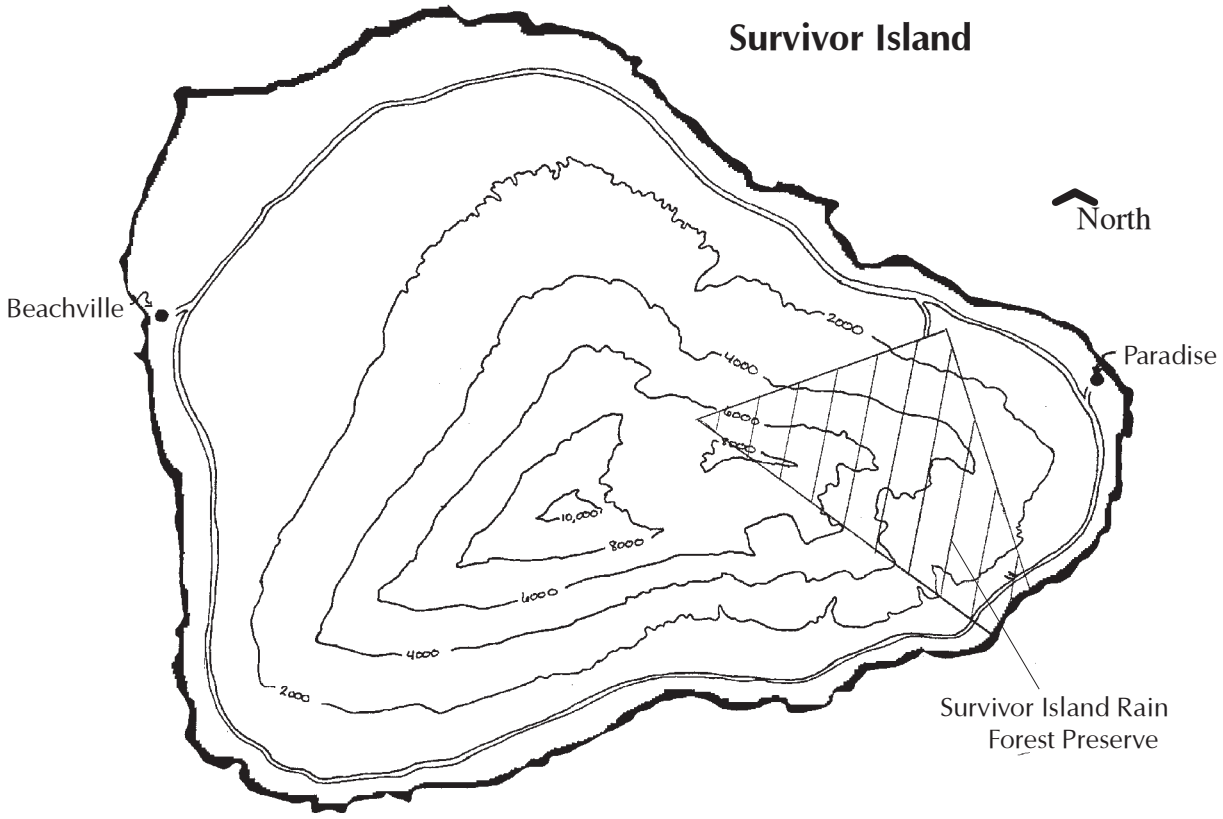
- Group participation and class presentations
- Student Page "Invasive Plant Action Sheet"
- Journal entries

Survivor Island Background

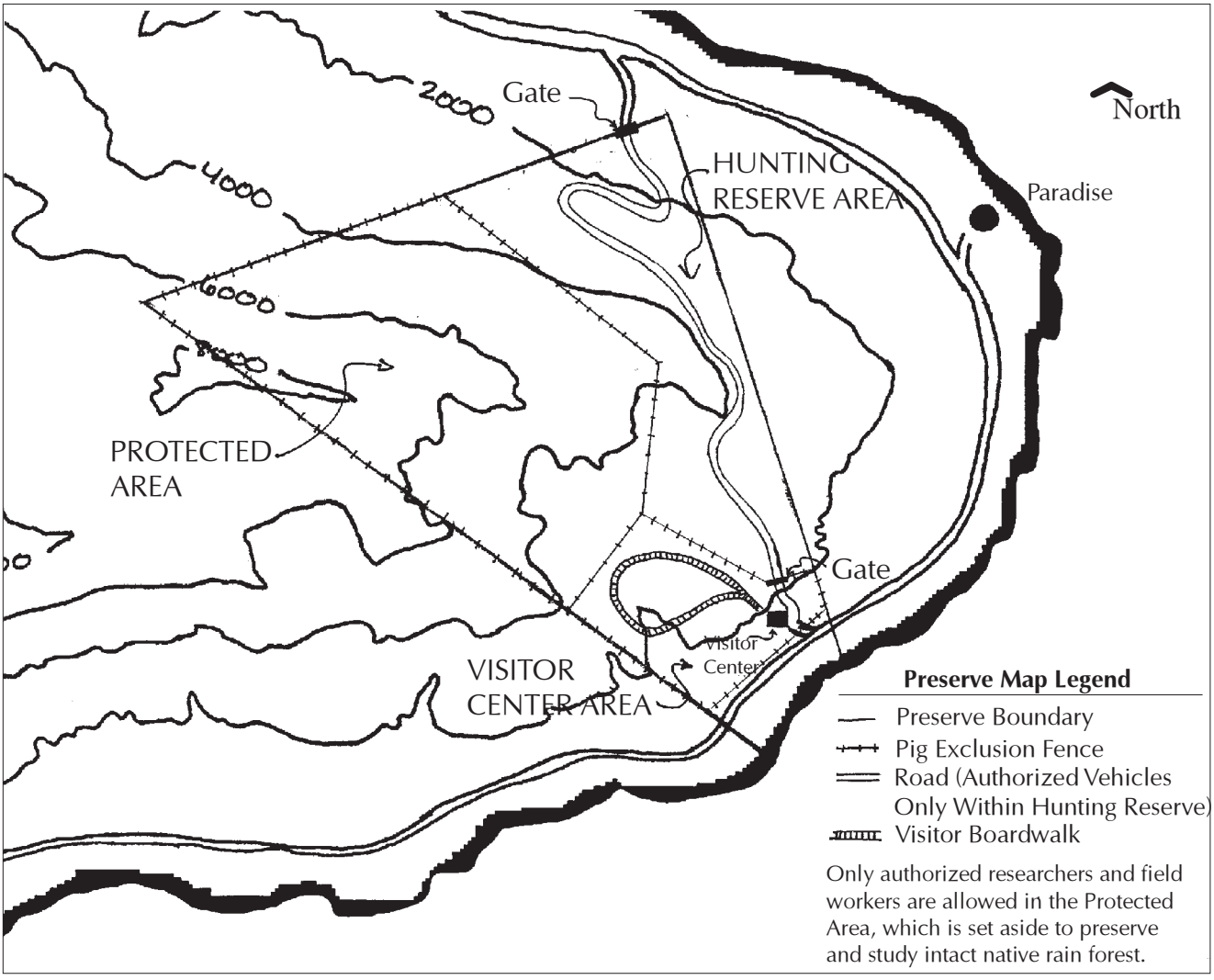
Survivor Island is a small island in the tropical north Pacific, where the trade winds blow from the northeast, just as they do on Maui. There are two small cities on the island, Beachville and Paradise. There are other small communities along the main road that rings the island, although few people live along the rugged, dry southern coast.

In the rain forest on the eastern end of Survivor Island, near the town of Paradise, island residents have established the Survivor Island Rain Forest Preserve. The preserve is divided into three main areas:

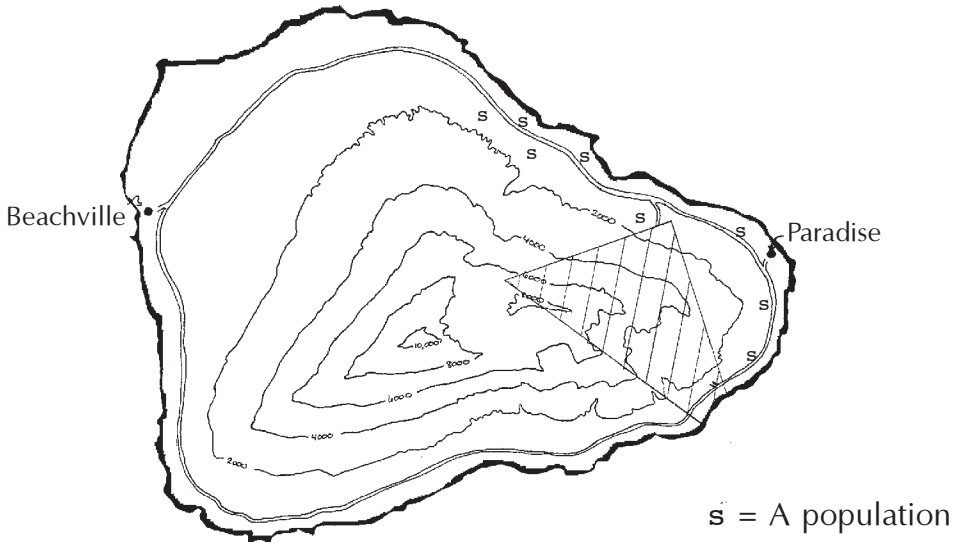
- The Visitor Center Area, where preserve visitors can learn about the native rain forest and the preserve and take a walk through native rain forest along a boardwalk that volunteers built.
- The Hunting Reserve Area, where pig hunting on foot is allowed. Only work vehicles authorized by the preserve are allowed in this area.
- The Protected Area, which is set aside to preserve and study the intact native rain forest. Researchers must obtain permission from preserve managers to work in this area, and in general, the only other people allowed into the area are crews working to eradicate or control invasive plants, inspect the fences surrounding this area, monitor for signs of pigs that sometimes get through the fences, and remove intruding pigs.



Survivor Island Rain Forest Preserve



Invasive Species Information Sheet
Clidemia



Distribution Notes

- Scattered plants have been found and removed from the Visitor Center Area of the preserve.
- Clidemia is common roadside plant along the windward highway.

Control Strategies

New populations

- Small seedlings: Pull by hand
- Larger plants: Remove and bag seed heads and inject herbicide under the bark or cut the plant and treat the cut stump with herbicide

Larger, established populations

- More research is needed on effective herbicides to be sprayed on the foliage of larger populations. These herbicides could also be sprayed on dense mats of seedlings.

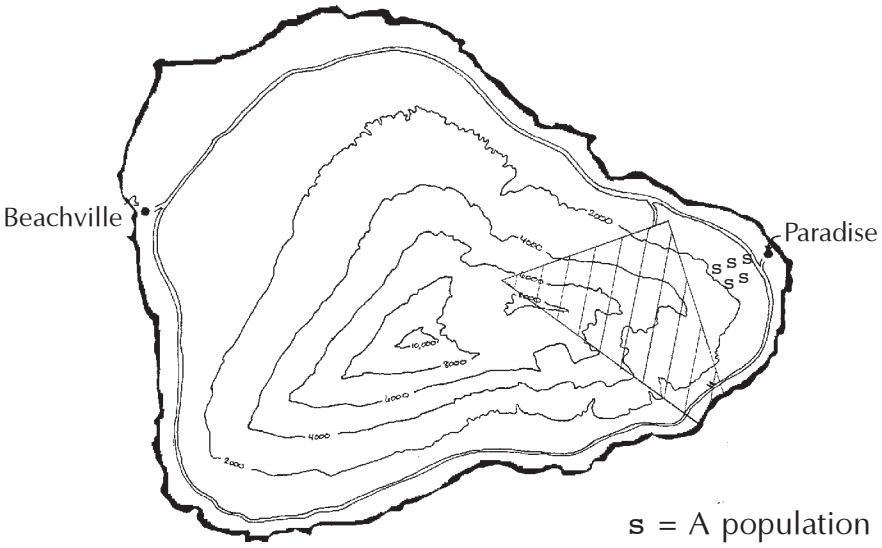
Biological control

- Two partially successful biological control agents have been released, and the results are being monitored. Other insects are being screened.

Inspection and retreatment

- New populations need to be reinspected yearly, with retreatment as necessary.

Invasive Species Information Sheet
Miconia



Distribution Notes

- There is a large infestation outside preserve boundaries up to about 600 meters (1968 feet) elevation. This infestation is believed to have originated at a botanical garden near the town on the eastern tip of the island.
- No plants have been discovered within the preserve yet.

Control Strategies

New populations

- Seedlings and saplings under about three meters (ten feet) tall: Uproot manually, dry completely, and allow to decompose in the contaminated area

Larger, established populations

- Fruiting trees: Limit seed production with helicopter spraying of herbicides (Dye is added so the pilot can see where the herbicide is going and identify treated plants. This treatment is expensive and requires careful planning to avoid spraying native vegetation.)
- Larger trees: Cut down and immediately apply herbicide to the cut stump
- To prevent the dispersal of tiny seeds that look like soil particles, change clothes and shoes and wash all machinery and other equipment before departing infested areas.

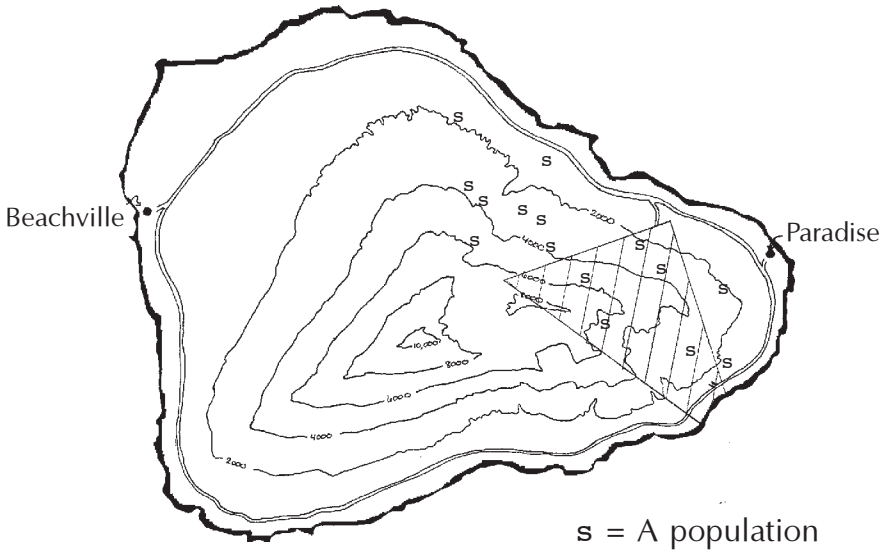
Biological control

- Methods of biological control being investigated include several insects and plant diseases

Inspection and retreatment

- Repeated surveys and treatment are necessary because trees are easily missed by ground crews and aerial surveys during the initial attempt.

Invasive Species Information Sheet
Kāhili Ginger



Distribution Notes

- Large populations have become established in the rain forest both within and outside the preserve.
- A few small populations that have not yet reached reproductive maturity have been found inside the fenced Protected Area.

Control Strategies

New populations

- Seedlings: Pull by hand
- Larger plants: Cut vegetation from the rhizome and apply herbicide to the cut surface of the rhizome

Larger, established populations

- Contain the periphery of large populations, using the techniques above to gradually reduce its size
- Search out new, small satellite populations and destroy

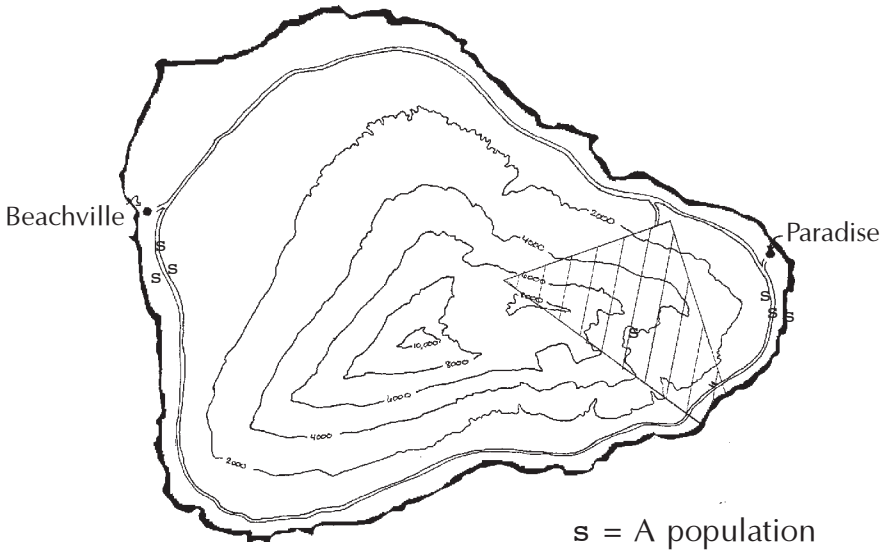
Biological control

- A bacterium has been used for about five years to control large infestations in a protected area of a neighboring island. This bacterium was an agricultural pest that was attacking ginger crops and has been modified to attack only *kāhili* ginger.

Inspection and retreatment

- Infested areas need to be reinspected yearly and retreated if necessary.

Invasive Species Information Sheet
Australian Tree Fern



Distribution Notes

- One small population has been found at around 1400 meters (4592 feet) within the fenced Protected Area.
- Australian tree fern is used extensively for landscaping in and near both of the main towns on the island.

Control Strategies

New populations

- Cut the main growth stem of all plants into small pieces

Larger, established populations

- Contain the periphery of large populations, using the technique above to gradually reduce its size
- Search out new, small satellite populations and destroy them

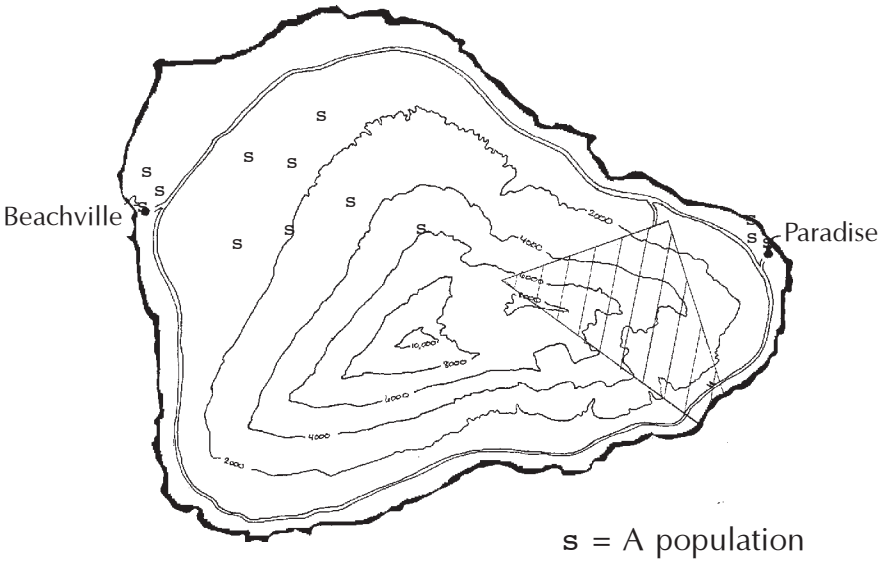
Biological control

- No known effective biological control agent

Inspection and retreatment

- Infested areas need to be inspected yearly and retreated if necessary.
- Retreatment intervals need to be refined to prevent plants from reaching reproductive maturity.

Invasive Species Information Sheet
Pampas Grass



Distribution Notes

- No populations have been discovered in the preserve.
- Scattered populations have been found on the leeward slopes of the island.
- Pampas grass is used extensively for landscaping in and near both of the major towns on the island.

Control Strategies

New populations

- Small plants, low-density populations, or where planted ornamenatally: Dig plants out by hand

Larger, established populations

- Large, well-established plants or high-density populations: Treat with herbicides
- Avoid seed dispersal by bagging and cutting off flowering plumes and seed heads and wear dedicated footwear and other gear
- Experiment with using heavy plastic tarps to kill previously cut plants and prevent the subsequent establishment of seedlings (This method would be useful only on a small-scale basis.)
- Use helicopter spraying of herbicides in sensitive high-elevation areas (Dye is added so the pilot can see where the herbicide is going and identify treated plants. This approach is expensive, but with careful planning, minimizes the disturbance to surrounding native vegetation.)

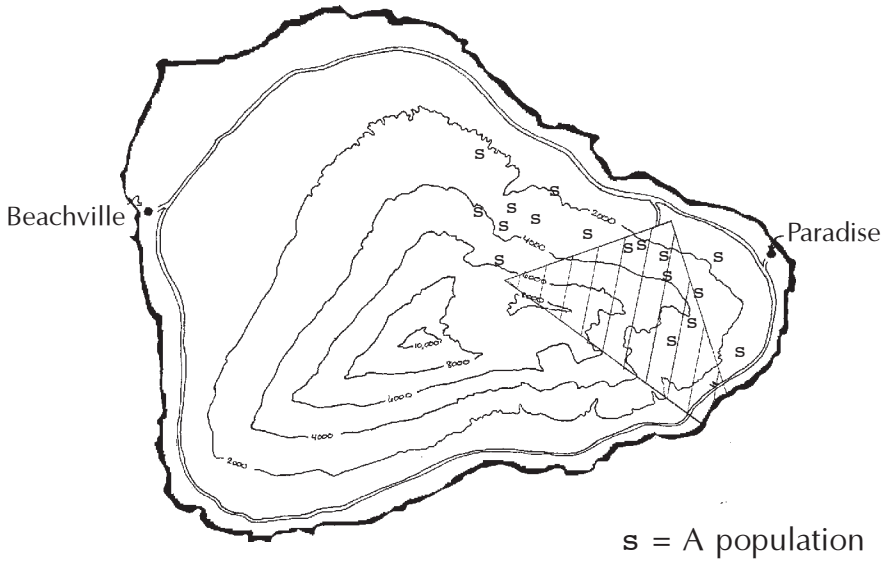
Biological control

- Has never been used successfully for any grass species worldwide

Inspection and retreatment

- Aerial reconnaissance is used to find pampas grass in high-elevation roadless areas.

Invasive Species Information Sheet
Strawberry Guava



Distribution Notes

- Extensive populations are found in the Hunting Reserve Area of the preserve and in the rain forest outside the preserve.
- After the Protected Area was fenced, the handful of small populations known to exist within the protected area were removed using manual removal and chemical control.

Control Strategies

New populations

- Pull very small plants and apply herbicide to larger plants

Larger, established populations

- Feral pig management is a necessary first step because huge quantities of seed are dispersed by feral pigs during the fall fruiting season.
- Pig control must be followed by manual removal of plants or control with herbicide.

Biological control

- Because of the extent of the infestation, biological control is probably the only method that will work on a large scale. Two insects currently being studied have considerable potential. However, because the common guava is grown commercially here, biological control agents must be species-specific to the strawberry guava, which makes the prospects slim.

Inspection and retreatment

- Reinfestation is low in pig-free, intact forests, but areas still need to be occasionally inspected.

Invasive Plant Action Sheet

Your group is in charge of controlling invasive plants within the Survivor Island Rain Forest Preserve. Each year, you develop an Invasive Plant Action Plan based on current information about invasive plants in the preserve, as well as the existing budget. Over the course of the year, you may modify your plan if new information comes in or if the budget changes.

In this activity, your group will work together to identify key elements of your Invasive Plant Action Plan, following instructions given. Use information from:

- Student Page "Invasive Plants in Hawai'i" (Activity #2)
- Student Page "Survivor Island Background"

Action you may take in your plan may include, but is not limited to:

- Sending out field crews to search for new populations, either in specific areas or throughout the whole preserve;
- Trapping, killing, or excluding animals that disperse invasive plants;
- Manually removing invasive plants (e.g., by cutting or uprooting);
- Using herbicides to kill or control populations of invasive plants;
- Using biological controls;
- Inspecting previously treated areas and retreating with herbicides or manual removal if necessary;
- Researching specific aspects of invasive plant biology or control methods; and
- Educating the public to help prevent the spread of invasive plants.

Your plan may include action that takes place within or outside the boundaries of the preserve.

Phase 1: Initial Planning

In past years, your group has developed a list of the six invasive plant species that pose the greatest threat to the native rain forest within your preserve. This year's budget allows you to carry out a **total of ten control or prevention actions**. You must take **at least one action on each listed species**. Indicate your priority actions in the following table, being as specific as you can.

Species	Action #1	Action #2	Action #3	Action #4	Rationale
Clidemia					
Miconia					
Kāhili Ginger					
Australian Tree Fern					
Pampas Grass					
Strawberry Guava					

Questions

1) Are any of your proposals likely to be objectionable to Survivor Island residents or preserve visitors? If so, list them here and describe the likely objections.

2) If you got a grant that allowed you to add two more actions to your plan, what would they be and why?

Phase 2: Miconia Discovered

A month after your group makes its original plan, visiting researchers discover a large population of miconia in a little-visited part of the preserve's Protected Area. They estimate that the plants are about two years old.

You learn that, in Tahiti, miconia was introduced in 1937 as an ornamental plant and now covers over two-thirds of the island, having taken over the native forest. Between 40 and 50 of the 107 plant species endemic to Tahiti are on the verge of extinction solely due to the miconia invasion. Once miconia becomes established in an area, it is exceedingly difficult to eradicate, especially after the plants reach reproductive maturity. A single miconia tree can produce eight million seeds each year, and the fruits they're contained in are highly attractive to birds, which can rapidly spread them to other areas. Some of the researchers suggest that the miconia threat is so great that your group should divert almost all of its invasive species management efforts to try to control this newly discovered population.

You haven't spent much of the money in your budget yet, so your group convenes another time to rearrange priorities based on this new information. For each new action that you want to take to address the newly discovered miconia problem, you remove one action from your Phase One plan.

Fill in the table on the following page to show how you would change your plan and why.

Revised Action Plan

Species	Actions Added or Removed	Rationale
Miconia		
Clidemia		
Kāhili Ginger		
Australian Tree Fern		
Pampas Grass		
Strawberry Guava		