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 Koʻolau 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 Hawaiʻi 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.

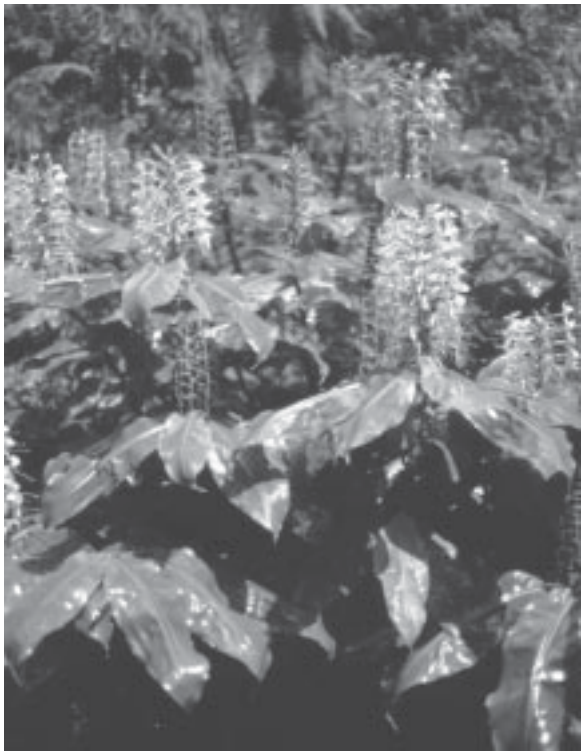
Controlling the Invaders

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 flower-ing 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 under-story)	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

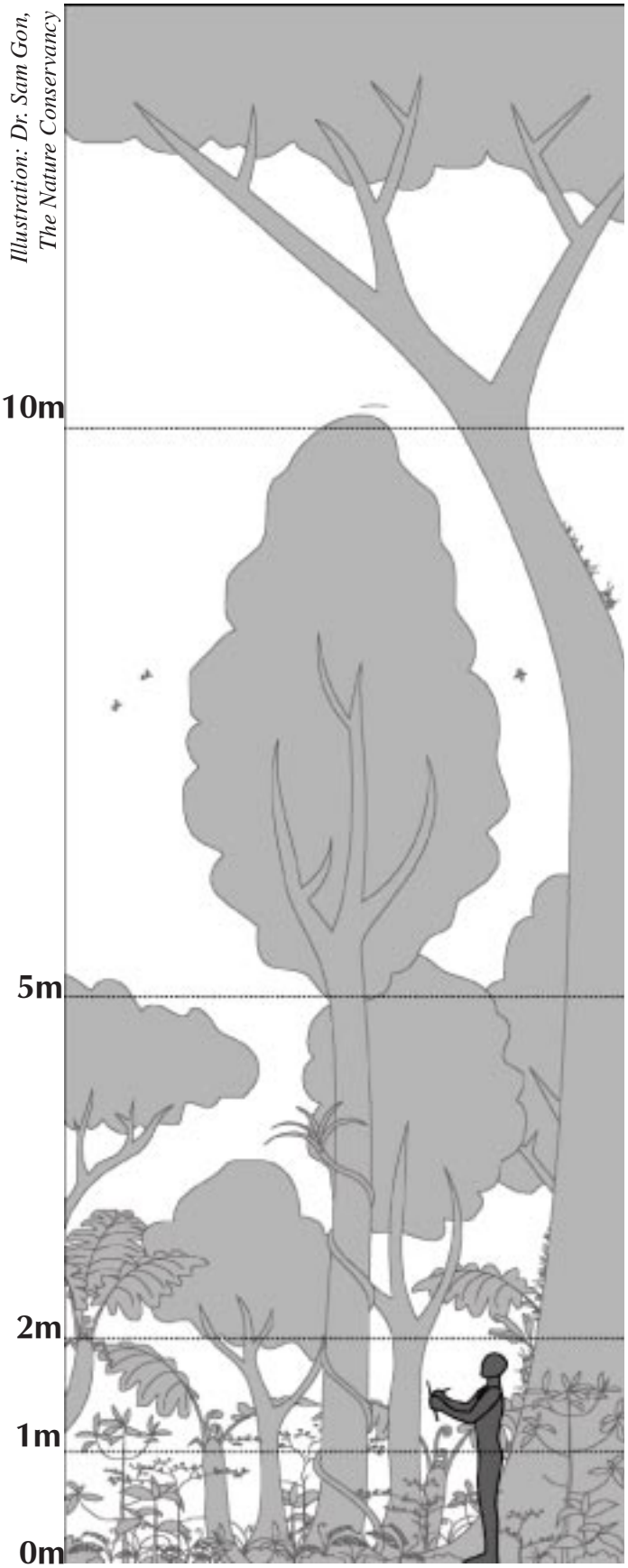


Illustration: Dr. Sam Gon, The Nature Conservancy

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.

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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