



SCHOOLYARD TO FOREST

How do invasive species impact native forests, and what can we do about it?

ACTIVITY AT A GLANCE

Students conduct research about a native Hawaiian plant and discover how Hawaiian forest plants have been impacted by invasive species. Students conduct a schoolyard weed survey using a transect method and create an herbarium display of weeds. In the process, they practice math skills aligned to Common Core Benchmarks in fractions, measurement and data.

KEY CONCEPTS

- Native plants arrived in the Islands before the first people. Today they are threatened by invasive species that people have introduced to Hawai‘i.
- Invasive species have qualities that enable them to spread, survive under a wide variety of conditions, and compete with native forest plants.
- Scientists gather data to discover the percentage of native plants vs. invasive species to determine the health of a forest.
- Learning about and growing native Hawaiian plants helps ensure that native forests will be around for future generations.

SKILLS

Measuring, collecting data, developing data sets with fractions, working cooperatively in groups, researching, writing

TIME

4 - 5 class periods

ASSESSMENT

Students:

- Complete a simple research project about a native Hawaiian forest plant.
- Create an herbarium display of weeds, highlighting the characteristics that make it possible for weeds to out compete with other plants.
- Collect data that reflect an understanding of the point intercept line transect method for determining percentage cover, including an understanding of fractions, measurement and data.

Hawai‘i State Standard Benchmarks

Science 5: Life and Environmental Sciences:

- **SC.4.5.3** Describe how different organisms need specific environmental conditions to survive.

Common Core Benchmarks

Math: Number and Operations – Fractions

- **MA.4.NF.6** Use decimal notation for fractions with denominators of 10 or 100.

Math: Measurement and Data

- **MA.4.MD.1** Know relative sizes of measurement units within one system of units including km, m, cm. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit.
- **MA.4.MD.4** Make a line plot to display a data set of measurements in fractions of a unit.

Nā Honua Maui Ola

‘Ike Honua: Sense of Place

- **NHMO.8.1** Be keen observers of their natural environment.



MATERIALS

Provided:

- ✓ Learning Logs 5 - 8
- ✓ Herbarium Display Instructions
- ✓ Potted native Hawaiian plants from the Department of Land and Natural Resources for planting in Kamananui Valley

Needed:

- ✓ Large sheets of black construction paper for mounting weed specimens for herbarium display
- ✓ Elmer’s glue (liquid in a bottle)
- ✓ Index cards for labeling herbarium specimens
- ✓ Resource books (see Suggested Resources)
- ✓ Lamination equipment (optional if you choose to laminate mounted herbarium specimens)
- ✓ Chart paper (or whiteboard) and markers for displaying class data.
- ✓ DVD player, projector and screen (optional if you choose to show DVDs in Suggested Resources)

For each team of 3 - 4 students:

- ✓ Meter sticks or meter tape measures
- ✓ Clipboard and pencil
- ✓ Trowel
- ✓ Large Post-it notes
- ✓ Newspaper

ADVANCE PREPARATION

- Contact the Department of Land and Natural Resources, Division of Forestry and Wildlife Information and Education Coordinator at 587-4188 to determine if native Hawaiian plants are available.
- Make a copy of the Learning Logs for each student and a copy of the Herbarium Display Instructions for each team of 3 - 4 students.
- Decide on the best way to “hook” your students into caring for native Hawaiian plants (see Teaching Suggestion #1) and obtain the suggested resources you plan on using.
- Locate possible areas in your schoolyard for weed investigations and practice gathering data using the line-point intercept method described in the Teaching Suggestions.

VOCABULARY

- alien species – non-native species accidentally or intentionally introduced to an area by humans
- competition – when two plants or animals interact with each other in the same environment for the same thing such as space, water or nutrients
- dispersal – the movement of plants from one place to another by wind, waves or wings
- endemic – native to place and found nowhere else
- habitat – the place where a plant or animal lives
- herbarium – a collection of pressed, dried plant specimens. Herbaria hold tools for our understanding of the plant world.
- indigenous – native to a place, and also native to other places
- invasive – an alien species that grows rapidly and aggressively to the point of causing environmental harm
- native species – a plant or animal that grows naturally in an area and was not introduced by humans (both endemic and indigenous)
- weed – an unwanted plant not planted by people, growing in the “wrong place”



TEACHER BACKGROUND

Hawai‘i is known as the “endangered species capital of the nation,” and some say we are the endangered species capital of the world. How did we come to earn such a dubious distinction? Our Islands represent only 0.2% of the total land area in the United States, yet we have 75% of the country’s endangered species! The major factor in this extinction crisis is the invasion of alien species.

From Canoes to Jets

Transportation technologies have an enormous impact on the physical environment of Hawai‘i and the way of life in the Islands. Forests in Hawai‘i changed vastly after ships began to bring people, other organisms, and new ideas to the land. When the Polynesians first landed in the Islands, they found native forests from near sea level to high mountain ridges. To make the islands habitable, they cleared forested areas for their homes and crops. They also brought plants such as kukui, ‘ōhi‘a ‘ai (mountain apple), hau, and ti, and animals (pigs, dogs, and chickens) to the Islands. They accidentally introduced some stowaways on their canoes, such as rats and skinks.

Trips to Hawai‘i by Captain Cook and his successors brought even more introduced species to the Islands, including goats, cows, and pigs. More recently, jet travel and modern ships have brought new residents, businesses, products, and millions of visitors to our Islands. With this increased commerce, many new plants and animals have arrived on our shores. Many of these plants are valuable for the economy, including the plants we grow for food, such as bananas and papayas, and plants grown for landscaping.

Alien Invaders

The plants that are of concern are the alien species that have become highly invasive in our forests. These alien invaders arrived in the Islands without the predators and diseases that help to keep their populations in balance in their native

environments. Some of the alien plants have biological characteristics that enable them to out-compete native species. See the table below for a summary of these characteristics.

Characteristics of Invasive Plants
<p>Exceptional Reproductive Abilities</p> <ul style="list-style-type: none"> • Produce many seeds • Can reproduce from vegetative shoots • Have seeds that disperse easily
<p>Adaptable to Wide Range of Habitats</p> <ul style="list-style-type: none"> • Able to grow in compacted and nutrient-poor soils • Can grow with little moisture
<p>Aggressive and Competitive</p> <ul style="list-style-type: none"> • Have chemicals to inhibit growth of other plants (allelopathy) • Have dense growth that shades or crowds out other plants • Have vines that smother other plants
<p>Resistant to Predators and Disease</p> <ul style="list-style-type: none"> • Have thorns • Have chemical defenses (poisonous sap)
<p>(Source: Project Stewardship, <i>Invasive Alien Species Control Module</i>. The Nature Conservancy of Hawai‘i)</p>

Most of Hawai‘i’s endemic species (69.9%) live in forest habitats. Many of these uniquely Hawaiian species are unable to compete with alien invaders that have the biological characteristics described in the table above. For example, the strawberry guava (a non-native species) evolved in South America under a different set of ecological conditions. Introduced to Florida and Hawai‘i, the strawberry guava tree, which is very common in Kamananui Valley, has characteristics that make it very successful compared to native plants.

What makes the strawberry guava tree a successful invader?

- It produces lots of fruits loaded with seeds.



- It spreads rapidly and takes over an opening in the forest.
- Young strawberry guava trees can grow well in forest shade and heavy leaf litter.
- It might give off toxic chemicals in its leaves that prevent the growth of other plant species.
- Feral pigs (another non-native, invasive species) eat the fruit, they excrete the seeds throughout the forest, causing new stands of strawberry guavas to sprout.

Although there are other causes for the extinction and endangerment of native species, invasive species that were introduced to the Islands account for much of this loss of biodiversity. While over 13,000 species of plants have been introduced to Hawai‘i due to human impact and

transportation technologies, only about 1% or 130 species have become invasive (DLNR, n.d.). The populations of these 130 invaders are large, as they reproduce and spread, quickly. Largely as a result of these invaders, 57.9% of the endemic species in Hawai‘i (that are not already extinct) are at risk (Sakai et al., 2002).

Within Kamananui Valley there are remnants of the native forest that once grew here. ‘Ōhi‘a trees now compete with the invasive strawberry guava and the native pala‘a fern struggles against the more aggressive clidemia that people have introduced to Hawai‘i. At the ma uka end of the valley, more native species still cling to the valley walls. Here the endangered O‘ahu ‘elepaio still makes its home.

TEACHING SUGGESTIONS

Part 1: Native Hawaiian Forest

1. “Hook” students into caring for the forested uka region of the ahupua‘a.

- Make connections to native Hawaiian forests in the mountainous regions of the ahupua‘a for students. (Refer students to their ahupua‘a map.)

Some Ideas for Drawing Students into the Topic of Native Hawaiian Forests

- Read aloud a legend featuring native Hawaiian plants.
- Display photographs of native Hawaiian forests and read excerpts about the importance of these forests on our islands. (See Suggested Resources.)
- Show a video or DVD about native Hawaiian forests. (See Suggested Resources.)
- Take students outside to look towards the mountains and ask if anyone has ever been to the rainforest, then encourage a discussion about students’ personal experiences in the forest.
- Assuming that you have been supplied with potted native Hawaiian plants for planting in Kamananui Valley, display the plants and share a little information about each kind.
- Excite students about the opportunity to plant native Hawaiian plants in Kamananui Valley as part of a native reforestation demonstration project with the Department of Land and Natural Resources and Moanalua Gardens Foundation.
- Emphasize the concept of mālama ‘āina--taking care of the land.

2. Assign each student a native Hawaiian plant for independent research.

- Distribute **Learning Log 5**, “Let’s Find Out About Native Hawaiian Plants.”
- Explain that this is a simple research project in which students will need to find and share specific information about a native Hawaiian plant. If necessary, review how to use a table of contents or index. For computer research, demonstrate how to use search terms in a search engine.



- Review the instructions on **Learning Log 5** and assign the project for homework. If any of your students do not have access to a computer, arrange for computer time on campus.
- Schedule a period for cross-sharing students' research. Distribute **Learning Log 6** and instruct students to collect information about four other native Hawaiian plants from their classmates.

Part 2: Alien Invaders - Making Herbarium Displays

3. Introduce students to the *alien species invasion* in Hawai‘i. (Refer to Teacher Background.)

- Ask students to think about what the term *invasive* means. Introduce other terms associated with the concept such as alien species, invaders, and noxious weeds.
- Generate a list of students' ideas concerning invasive plants. What is an invasive plant? What is a weed?

Sample List Generated by Fourth Graders at Wai‘alae Public Charter School on O‘ahu

- A weed kills other plants by drinking the water that was meant for the other plants.
- A weed is invasive.
- A weed can grow over another plant.
- A weed can strangle other plants.
- A weed spreads.
- A weed can give out toxins or poisons into the soil.
- A weed can crowd out the soil.
- Weeds have protections.
- Seeds of weeds will grow into weeds. They can be given out by wind, pigs, birds, etc.
- Weeds have rapid growth rate.
- Weeds compete.

4. Invite students to collect weeds around the school campus for an herbarium display.

- Connect students to the purpose for conducting weed surveys and collecting weed samples. (In order to manage landscapes, gardens, or ecosystems, scientists try to understand the distribution and abundance of weeds in the field. Scientists make observations about the weeds growing in their area.)
- Challenge students to make their own observations about weeds in the schoolyard. Discuss the qualities of weeds that enable them to invade. Refer to the chart of Characteristics of Invasive Plants in the Teacher Background.
- Review the information that teams will record on Post-it notes for each weed specimen they collect: habitat and growth habit (example: growing in the middle of an open, sunny lawn; growing in hard, dry soil; grows upright or creeping; has many seeds).
- Create student teams and distribute **Herbarium Display Instructions** to each group. Give students time to read the information, and go over it as a class.
- Have students divide the jobs listed so that each student is responsible for performing a task. Encourage students to take turns!
- Make sure every team is equipped with the supplies they need for weed collection! (Clipboard and pencil, herbarium instructions, newspapers, large Post-it notes, and digging tool)

5. Take students outside and collect weeds.

- Before you let teams go on their hunt, demonstrate how to collect a weed and record information.



- Emphasize that only one sample is needed for each specimen, and that the specimens need to be of a reasonable size for mounting.
- Make sure that students understand that they are only permitted to collect weeds!
- Set your boundaries and expectations, and let the teams loose! Be sure everyone understands the signal to end the weed collection and gather together.

6. Press plant specimens for about a week.

- Give teams time to sort through their weed specimens and to carefully place each specimen between sheets of newspaper for pressing.
- Instruct students to place their specimens (between sheets of newspapers) under a heavy pile of books or boxes in a corner of the room.
- Leave the plants to press for about a week or two before mounting.

7. Mount weeds for herbarium display.

- Supply each team with large sheets of black construction paper, Elmer's glue, and index cards.
- Refer students to **Herbarium Display Instructions** on how to mount and label each specimen.
- Summarize the environmental conditions where the plants were collected and the growth habits that students noted about the different plants.

Part 3: Fractions, Measurement and Data

8. Introduce (or review) the concept of a unit of measure, and present students with the meter.

- Discuss how the meter can be used to make measurements.

Discussion Questions

- Why are standard units of measurement important in science?
- What is the best way to divide a meter?
- What are the smaller units of measurement within a meter, and how are they multiplied?
- What is 1/10 of a meter? (decimeter)
1/100 of a meter? (centimeter)



9. Demonstrate how to use the meter to measure abundance of weed species in an area.

- Distribute **Learning Log 7**, “Weed Sampling Using a Line Transect” and go over it with students.
- Gather students around the study area on the school grounds and select three weed species to survey. Have students record the names of these weeds on **Learning Log 7**.
- Lay a survey tape or long string out in a straight line on the study area and space student teams along this transect at regular intervals. (Alternatively, just have students form a long line standing shoulder-to-shoulder and do without the survey tape.)
- Instruct students to lay their meter sticks or meter tapes perpendicularly out from the transect line.
- At 10 cm intervals along a meter stick or meter tape measure, show students how to identify whether or not a weed is intercepting the meter transect. If any part of the weed is touching the



stick or tape at the 10 cm intervals, students are to record “Yes” on their data sheet. If no part of the weed is touching the stick or tape, students are to record “No” on their data sheet.

10. Give student teams approximately 20 minutes to gather and record their data.

11. Return to the classroom and guide students through interpreting their weed survey results.

- Draw a separate line plot for each weed surveyed on chart papers or a whiteboard.
- Ask team members to record their team’s data on each chart.
- In the example line plot below, each “X” represents one team’s measure of the total number of intercepts for one of the weeds surveyed.

Sample Line Plot for Weed #1

		X X X	X						
	X X	X X X	X X X						
intercepts= 1/10 (10%)	intercepts= 2/10 (20%)	intercepts= 3/10 (30%)	intercepts= 4/10 (40%)	intercepts= 5/10 (50%)	intercepts= 6/10 (60%)	intercepts= 7/10 (70%)	intercepts= 8/10 (80%)	intercepts= 9/10 (90%)	intercepts= 10/10 (100%)

- Instruct students to interpret the class data by completing **Learning Log 8** individually or in small groups.
- After giving students time to interpret the data on their own, facilitate a class discussion on the results of the weed survey.
 - Which weeds were most common?
 - What are the characteristics of the most common and least common weeds?
 - Was this a good method for estimating the weeds in the area? Why or why not?

ADAPTATIONS / EXTENSIONS

- Guide students through an inquiry process to develop hypotheses and procedures for studying weeds around campus over a longer term. Find an area that can be left untended. Mark a perimeter around the area and help students design a method for studying weed growth in the area. Have them create hypotheses about potential weed growth, and have them collect data over time. You might have students plant some desirable plants in the same area and see how they fare against the weeds. You might also create an area of the same size that is treated differently, for example it may be tended or students may try various methods of controlling weeds in the area to see how that affects the production of their desirable plants. What “organic” methods might be used to control weeds? (Note: See Lesson 5 for information about student proposals for native Hawaiian plantings on campus, and connect an extension activity like this to their proposals.)
- Encourage students to come up with other ways to measure (count) the number of plants in an area. Invite them to research, implement and compare other sampling methods such as the quadrat method. There are also other ways of using line transect to measure abundance and diversity of plants in an area. This may also be turned into guided inquiry and integrated into math lessons.



REFERENCES

Department of Land and Natural Resources, Division of Forestry and Wildlife. *Hawaii's Most Invasive Horticultural Plants*. <http://www.state.hi.us/dlnr/dofaw/hortweeds/> Contact Information: dlnr@hawaii.gov. (808) 587-0400. Accessed February 23, 2012

Sakai, Ann K., L. Warren Wagner and Loyal A. Mehrhoff. 2002. *Patterns of Endangerment in the Hawaiian Flora*. *System Biology*. 52 (2): 276-302

The Nature Conservancy of Hawai‘i. Not Dated. Project Stewardship, *Invasive Alien Species Control Module*. Honolulu, HI.

SUGGESTED RESOURCES

Bornhorst, Heidi Leianuenue. *Growing Native Hawaiian Plants: A How-to Guide for the Gardener*. Honolulu: Bess Press, Inc. 2005.

Conservation Council for Hawai‘i. Various posters available from website http://www.conservehi.org/home_posters.html

Culliney, John L. and Bruce P. Koebele. *A Native Hawaiian Garden: How to Grow and Care for Island Plants*. Honolulu: University of Hawai‘i Press,.1999.

Daws, Gavin and Samuel M. Gon, III. *Hawai‘i: The Islands of Life*. Honolulu: The Nature Conservancy. 1988.

Liittschwager, David and Susan Middleton. *Remains of a Rainbow: Rare Plants and Animals of Hawai‘i*. National Geographic Society. 2003.

Lincoln, Noa Kekuewa. *Amy Greenwell Garden Ethnobotanical Guide to Native Hawaiian Plants and Polynesian-Introduced Plants*. Honolulu: Bishop Museum Press. 2009

Nagata, Kenneth M. *How to Plant a Native Hawaiian Garden*. Hawai‘i: Office of Environmental Quality Control. 1992. (This entire manual is available online in PDF format. Search “How to Plant a Native Hawaiian Garden.”)

Pope, Willis Thomas. *Manual of Wayside Plants of Hawai‘i*. Rutland, VT: Tuttle Co. 1968.

Staples, George W. and Robert H. Cowie, editors. *Hawai‘i's Invasive Species*. Honolulu: Mutual Publishing and Bishop Museum Press, 2001.

DVDs

“In the Middle of the Sea.” Available through Moanalua Gardens Foundation, <http://www.mgf-hawaii.org>

“Listen to the Forest.” Available through Mountain Apple Company, <http://www.mountainapplecompany.com/new-releases/listen-to-the-forest>

“We All Need the Forest.” Available through Moanalua Gardens Foundation, <http://www.mgf-hawaii.org>



SCHOOLYARD TO FOREST

LEARNING LOG 5

NAME _____

DATE _____

LET'S FIND OUT ABOUT NATIVE HAWAIIAN PLANTS

INSTRUCTIONS

1. **Research** a native Hawaiian plant on the Internet or in books.
2. Enter the name of your plant in **search engines** on the computer (e.g. Safari or Firefox), or look for the name of your plant in **table of contents** or the **index** of books.
3. Pay attention to how information is organized, look for the information you need, and record it in the boxes below!

Name of Plant (Hawaiian name and common name):		

Write words that identify the plant's habitat here:	Draw and label a picture that describes the plant here. Use color if you can!	
Write more information in the boxes below if you can find it! (Extra credit: Create a small poster, pamphlet or diorama/display that gives information about your plant!)		
Cultural Connections	Conservation	Other Interesting Facts

Write your sources of information on the back (book titles and authors, website addresses etc.)



SCHOOLYARD TO FOREST

LEARNING LOG 6

NAME _____

DATE _____

SHARE INFORMATION ABOUT NATIVE HAWAIIAN PLANTS

INSTRUCTIONS

1. Gather information about four native Hawaiian plants from your classmates.
2. Write or illustrate the information in the boxes below.
3. Summarize: What environmental conditions do these plants need to grow?

Plant Name: _____	Plant Name: _____
Plant Name: _____	Plant Name: _____



SCHOOLYARD TO FOREST

HERBARIUM DISPLAY INSTRUCTIONS

WHAT IS AN HERBARIUM?

An herbarium is a collection of dried, pressed and preserved plant species. Scientists use herbariums for research. Herbariums help people to understand the plant world. An herbarium specimen is most useful when it is prepared and mounted well. It is also important to label each plant specimen properly.

COLLECTING PLANT SPECIMENS

Scientists collect all parts of a plant for an herbarium display. If possible, collect everything including roots, stems, leaves and flowers or seeds. You may need a digging tool to get the roots, since some weeds are deep-rooted. Hold each plant specimen between the pages of an old newspaper. Follow your teacher’s instructions. Work together with your team.

SHARING RESPONSIBILITIES IN YOUR TEAM: JOBS

Your weed collecting will be more fun if everyone on your team has a job:

- Hold the newspapers and place each specimen between the pages. (1 - 2 people)
- Pull the weeds out of the ground.
- Record information about each species on a post-it and put that information with each specimen. Information to record: habitat and growth habit (example: growing in the middle of an open, sunny lawn; grows upright or creeping; has many seeds).
- Take turns!

PRESSING PLANTS

- When you get back to the classroom, spread out your plant specimens.
- Remove all loose soil.
- Try to mount each plant as it appeared in nature, and have examples of both tops and bottoms of leaves facing up.
- Flatten your weeds between dry sheets of newspaper or magazine.
- Place heavy books or boxes on top of your specimens in an out-of-the-way corner of your classroom and leave it for one or two weeks.
- When the plants are dry and flat it is time to mount them.

MOUNTING PLANTS

- Arrange each dried and flattened weed on a large sheet of black construction paper.
- Attach the weed to the construction paper with Elmer’s glue (the liquid kind that comes in a bottle). You only need to use the glue in a few key locations.
- Let the glue dry for a day without moving the sheet! (Avoid using glue stick or rubber cement.)
- Create an identification label for each specimen and glue it to the construction paper. Labels should include: Name of weed (you can make up a name), date of collection, location of collection (example: Moanalua Elementary School, O‘ahu), habitat and growth habit (example: growing in the middle of an open, sunny lawn; grows upright or creeping).

**SCHOOLYARD TO FOREST****LEARNING LOG 7**

NAME _____

DATE _____

WEED SAMPLING USING A LINE TRANSECT**INSTRUCTIONS**

1. Look carefully at the weed species growing in your study area. Be able to recognize each weed visually. You do not need to know specific names for now.
2. Record the names of three different weeds to investigate at the top of the columns on the data table below. (All groups in class will investigate the same three weeds.)
3. Lay your meter stick or meter tape on the ground extending away from the transect line your teacher has set up.
4. Look to see if the weeds you are sampling are touching the meter stick at each 10 cm mark.
5. On the data table, record "YES" if a plant intercepts the tape, or "NO" if the plant does not.

DATA TABLE

Intercept Point	Weed #1	Weed #2	Weed #3
10 cm			
20 cm			
30 cm			
40 cm			
50 cm			
60 cm			
70 cm			
80 cm			
90 cm			
100 cm			
Total Intercepts	_____	_____	_____
	10	10	10
Decimal notation			



SCHOOLYARD TO FOREST

LEARNING LOG 8

NAME _____

DATE _____

REPRESENT AND INTERPRET DATA: LINE PLOTS

INSTRUCTIONS

1. Create a line plot for each of the three weed species your class surveyed.
2. Copy the class data from the line plots displayed in your classroom.
3. Interpret the data from your class weed survey by writing a list of your observations, and then participate in class discussion to come to conclusions about this investigation.

Weed #1: _____

intercepts= 1/10 (10%)	intercepts= 2/10 (20%)	intercepts= 3/10 (30%)	intercepts= 4/10 (40%)	intercepts= 5/10 (50%)	intercepts= 6/10 (60%)	intercepts= 7/10 (70%)	intercepts= 8/10 (80%)	intercepts= 9/10 (90%)	intercepts= 10/10 (100%)

Weed #2: _____

intercepts= 1/10 (10%)	intercepts= 2/10 (20%)	intercepts= 3/10 (30%)	intercepts= 4/10 (40%)	intercepts= 5/10 (50%)	intercepts= 6/10 (60%)	intercepts= 7/10 (70%)	intercepts= 8/10 (80%)	intercepts= 9/10 (90%)	intercepts= 10/10 (100%)

Weed #3: _____

intercepts= 1/10 (10%)	intercepts= 2/10 (20%)	intercepts= 3/10 (30%)	intercepts= 4/10 (40%)	intercepts= 5/10 (50%)	intercepts= 6/10 (60%)	intercepts= 7/10 (70%)	intercepts= 8/10 (80%)	intercepts= 9/10 (90%)	intercepts= 10/10 (100%)

