## What is a Dry Forest?

### Summary
The students will learn about the history of the dry forest and the traditional importance of plants in the dry forest. They will also learn how the dry forest has changed as a result of the effects of humans and technology.

### Objectives
- Students will learn the difference between native and invasive species.
- Student will learn problems native Hawaiian ecosystems face.

### Materials
**Activity 1: Discussion Series**
- Map of Hawaii
- Map of dry forests
- Invasive species images
- Images of native plants
- Plant ID Cards
- Worksheets (guided notes on discussion)
- KWL Worksheets

**Activity 2: Map Quest**
- Map with historic range and current range
- Paper
- Tracing paper
- Pencil
- Colored pencils/markers/crayons

Optional work:
- Vocabulary word search

### Teacher Prep for Activity
Read the background information and become familiar with some of the native plants, especially wiliwili (*Erythrina sandwicensis*), uhiuhi (*Caesalpinia kavaensis*), and lama (*Diospyros sandwicensis*). More information can be found at [http://www.botany.hawaii.edu](http://www.botany.hawaii.edu). Make sure all worksheets are copied and that the maps are in a form that can be easily displayed to the class.
Background

A Hawaiian dry forest consists of small trees, shrubs, and grasses and receives less than 127 cm (50 in) of rain per year. In Hawaii, 90% of the plant species are native plants, and nearly 25% of them are found in the dry forest. On the island of Hawai’i, dry forests are found on the leeward side of the island. There are protected areas and natural reserves set up at different locations as attempts to save this highly endangered forest.

Hawaiian dry forests are one of the most critically endangered habitats in the world. The forest is highly degraded and its range has been reduced by 90%. The biggest problems for dry forests are fires and invasive grass. One grass that native Hawaiian plants cannot compete with after fires is fountain grass. Fountain grass is fire adapted and easily regenerates after wild fires, which native plants did not historically experience. Fountain grass also competes with native plants for light and water, and crowds out native seedlings. It provides a lot of fuel for wild fires because of the large clumps and bunches that form at the base of the grass. The most common way of controlling fountain grass is the use of herbicide as well as pulling it out of the ground, roots and all.

There are many threatened and endangered plants found in Hawaiian dry forests. Uhiuhi, a medium size tree up to 10 m (35ft) tall, has dark, rough bark. Hawaiians used the wood from uhiuhi to make fishing supplies that sink rather than float because the wood is so dense. There are about 100 wild Uhiuhi left in the Hawaiian Islands. Lama is a small, slow growing tree that grows up to 35 feet tall and 10 feet wide. It grows on all of the Hawaiian Islands, mostly in dry forests, up to elevations of 4000 ft. Traditionally lama was used for medicine as well as for its wood, known as the Hawaiian ebony. Kokia is a small tree that is 4-10 m (13-35 ft) tall. It has showy flowers and star shaped leaves, and is commonly used as a garden or ornamental plant. Traditionally the sap of this tree was used to dye fishing nets red. There are only 3 wild kokia left, all in the North Kona district, and they are not naturally reproducing. Wiliwili grows 35-45 ft tall and has about the same width. The trunk and branches have a few short spines growing on them. It is one of Hawaii’s few deciduous trees, shedding its leaves in the summer in order to conserve water. Wiliwili blooms in the summer after it sheds its leaves and can flower through November. It has large, showy flowers that are curved and claw-shaped. They grow 2-5 cm (1-2 in) long and are usually orange, but can be different colors like red, peach, salmon, green, yellow, or white. Wiliwili wood was traditionally used for buoys for fishing and for the ama of a canoe. The seeds can also be used in leis.
Partnership

Vocabulary
Native: historically found in a location, native species in Hawaii are species that are historically found in Hawaii and were not introduced.
Endemic: found only in one location, endemic species of Hawaii are found only in Hawaii
Endangered: low numbers, a threat of losing a species permanently
Invasive: a species that is non-native and overtakes habitats, becoming much more common than it does in its native range
Fountain grass: an invasive grass species in the dry forest, causes fires
Wiliwili: an endangered native tree species of the dry forest
Uhiuhi: an endangered native tree species of the dry forest
Lama: a rare tree species of Hawaiian dry forests
Deciduous: trees that lose all of their leaves

Procedure
1. Hand out KWL worksheets and have the students fill out the first two parts.
2. Display the map of the Hawaiian Islands.

Activity 1: Group Discussion Series
3. DISCUSSION 1: Talk about the types of forests found in Hawaii (wet and dry forests).

   Question 1: Where are wet forests found?
   Wet forests are found on the eastern half of the island. These forests can be found at low, middle, and high elevations.

   Question 2: Where are the dry forests found?
   Dry forests are found on the western side of the island. These forests are found at low and middle elevations.

   Question 3: How are dry forests different from wet forests?
   Wet forests get much more rain than dry forests. The plants found in each type of forest are very different from each other. Animals that inhabit both types of forest are different from each other.

4. Use the map to show where types of forests are located.

5. Show where the dry forests are found on Hawaii Island (next map).

6. DISCUSSION 2: Rainfall Differences

   Question 1: How much rain does a dry forest get each year?
   A dry forest is a forest that gets less than 50 inches of rain per year.

   Question 2: How much rain does your town get a year?

   Question 3: How much rain does Hilo get a year?
   Hilo gets more than 100 inches of rain per year.

What is a Dry Forest?
6. DISCUSSION 3: Native plants

Question 1: What is a native plant?
A native plant is a plant that is traditionally found in Hawaii.

Question 2: What is an endemic plant?
An endemic plant is a native plant that is found only in Hawaii.

Question 3: How many species of plants in Hawaii are native plants?
90% of the plants found in Hawaii are native plants.

Question 4: How many of the native plants in Hawaii are found only in the dry forest?
25% of native plant species in Hawaii are found only in dry forests.

Question 5: What does this (the answer to question 4) mean?
There is high amount of native plant diversity found in the dry forests.

7. DISCUSSION 4: Importance of dry forest

Question 1: Are the dry forests important? Why or why not?
There isn’t a “correct” answer, just a question for the class to think about.

Talk about the traditional uses of dry forest plants.

8. DISCUSSION 5: E Malama ai`Aina

Question 1: What does E Malama ai`Aina mean?
It means to take care of the land.

Question 2: How could you E Malama ai`Aina?
They could grow native plants to plant in the dry forest (which we are doing in class), they could grow native plants in their gardens and plant native plants around their yards, they could help their community get rid of invasive plants, they could talk to their family and/or their friends about the importance of the dry forest, etc.

9. DISCUSSION 6: Dry forest habitat

Question 1: How endangered is the dry forest?
The Hawaiian dry forest is one of the most critically endangered habitats in the world.

Question 2: How much of the original dry forest is left?

What is a Dry Forest?
Only 10% of the original forest is left. A good way to visualize this is to have the students think of a football field, and then think of only 10 yards of the football field.

10. Introduce some of the dry forest plants (see plant ID cards)

11. DISCUSSION 7: Problems for the dry forest

   Question 1: What problems do plants in the dry forest have?
   The dry forest has problems with fires. They also face problems due to invasive species. Two of the better known/more problematic invasive species in the dry forest are fountain grass and a gall wasp that lays eggs on wiliwili trees.

12. Collect their worksheets.

ACTIVITY 2: Map Quest

13. Give each student a map of the island and tracing paper of the same size. Have them trace the island. Then, have them trace the historical range of the dry forest (the dark black line) and the current range of the dry forest (shaded 10, 11, 14, 15, and 16).

14. Provide each student with a blank sheet of paper for them to trace the map onto by flipping over the tracing paper and re-tracing on the other side. Have them darken in their outlines.

15. After they have gotten their map onto a sheet of paper, have them color it in with the difference in ranges in different colors. These colors should be complimentary to help illustrated the difference. Make sure they draw in all five volcanoes. Have the students complete the worksheet on the dry forest.

17. To end the session, have students finish filling out KWL sheet and collect. If more work is needed, assign the vocabulary word search.

INTRODUCE BROCHURE PROJECT:

1. Give a brief introduction of the goal of creating the educational brochures. (These brochures can eventually be handed out to the community as an educational resource.)
2. Hand-out the project guidelines and the rubric to the students. (A brochure “check” will occur in week 5 to see how the students are progressing.)

Assessments
Notes and worksheets

Resources
http://www.botany.hawaii.edu

Extension Activities

What is a Dry Forest?
Have students create dry forest maps of the other Hawaiian Islands
Traditional uses and description of dry forest plants
Kokia (Kokia drynarioides)- highly endangered tree found only in North Kona. Grows to be about 25 feet tall. There are only three left in the wild and the sap has been used to dye fishing nets red.

Wiliwili (Erythrina sandwicensis)- grows 35-45 ft tall and about as wide. Deciduous, losing its leaves late summer to conserve water. Its flowers and seeds can be used for leis. The wood can be used for buoys and amas of canoes.

Uhiuhi (Caesalpinia kavaiensis)- grows 12-30 feet tall, with long compound leaves. Its flowers and seeds can be used in leis.

Lama (Diospyros sandwicensis)- a small slow growing tree, less that 35 feet tall. Its traditionally used for wood and medicine.

Ohí’a (Metrosideros polymorpha)- a highly variable tree, can be shrubby to more than 100 feet tall. Its flowers and seeds can be used in leis. It has traditionally been used in medicine and used for its wood.

`Aiea (Nothocestrum latifolium)- a small tree, growing up to 30 feet tall. Its flowers and seeds can be used in leis and was traditionally used for wood.

`Ilima (Sida fallax)- highly variable shrub usually less than 5 feet tall. Can be used in leis and traditionally used for medicine.

`Iliahi or Sandalwood (Santalum freycinetianum)- can be a 3 ft shrub to 40 ft tree. Used for its wood.

Naio or False Sandalwood (Myoporum sandwicense)- shrub to tall tree. Used for wood.

Mamane (Sophora chrysophylla)- a large shrub to tree. Serves as the main food source of the native Palila. Traditionally used for wood. Its flowers and seeds can be used in leis.

What is a Dry Forest?
Find the vocabulary words based on the clues. Follow the directions for each clue.

1. something found only in Hawaii, enclose in a circle
2. trees that lose their leaves, enclose in single box
3. plant that competes with native plants, enclose with a squiggly circle
4. something traditionally found in Hawaii and other places, enclose in two circles
5. native tree with narrow trunk, place single line through
6. native tree with wide trunk, place two lines through
7. a dry adapted plant that competes with native plants, scribble out
8. sticky substance that comes out of a tree, place a large X through
9. a plant that is protected because it is rare, enclose in a regular circle and a squiggly circle

What is a Dry Forest?
KWL-Hawaiian Dry Forests

What do you know about Hawaiian dry forests?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

What do you want to know about Hawaiian dry forests?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

What did you learn about Hawaiian dry forests?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

What is a Dry Forest?
Partnership for Reform through Investigative Science and Math

Name: ___________________________  Date: ____________

Introduction to the dry forest

1) Where are wet forests found?

2) Where are dry forests found?

3) How are dry forests different from wet forests?

4) How much rain does a dry forest get each year?

5) How much rain does your town get each year?

6) How much rain does Hilo get each year?

What is a Dry Forest?

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Introduction to native plants

1) What is a native plant?

2) What is an endemic plant?

3) How many species of plants in Hawaii are native plants?

4) How many of the native plants in Hawaii are found only in the dry forest?

5) What does your answer to question 4 mean?

Importance of the dry forest

1) Are dry forests important? Why or why not?
E malama ai `Aina

1) What does “E malama ai `Aina” mean?

2) How could you E malama ai `Aina?

Dry forest habitat

1) How endangered is the dry forest?

2) How much of the original dry forest is left?

3) What problems do plants in the dry forest have?
Dry forest mapping activity

1) Where do you live compared to the current range of the dry forest?

2) Which side of the island is the dry forest found on?

3) Compared to the original range of the dry forest, how much is left?

What is a Dry Forest?
Hawaii Island Annual Rainfall Data
Communities are listed as they appear clockwise around the island.

<table>
<thead>
<tr>
<th>Map Key</th>
<th>Community</th>
<th>Annual Rainfall (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hawi</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Waimea</td>
<td>80</td>
</tr>
<tr>
<td>3</td>
<td>Haina</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>Honokaa</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Ookala</td>
<td>125</td>
</tr>
<tr>
<td>6</td>
<td>Hakalau</td>
<td>300</td>
</tr>
<tr>
<td>7</td>
<td>Hilo</td>
<td>150</td>
</tr>
<tr>
<td>8</td>
<td>Kaumana</td>
<td>225</td>
</tr>
<tr>
<td>9</td>
<td>Kapoho</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>Keaau</td>
<td>125</td>
</tr>
<tr>
<td>11</td>
<td>Mountain View</td>
<td>175</td>
</tr>
<tr>
<td>12</td>
<td>Volcano Village</td>
<td>100</td>
</tr>
<tr>
<td>13</td>
<td>Hawaii National Park (Crater)</td>
<td>80</td>
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<tr>
<td>14</td>
<td>Kulani Mauka</td>
<td>50</td>
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<tr>
<td>15</td>
<td>Pahala</td>
<td>40</td>
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<tr>
<td>16</td>
<td>Naalehu</td>
<td>40</td>
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<tr>
<td>17</td>
<td>Manuka</td>
<td>60</td>
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<td>18</td>
<td>Pohakuloa</td>
<td>20</td>
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<td>19</td>
<td>Mauna Loa Observatory</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>Kainaliu</td>
<td>75</td>
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<tr>
<td>21</td>
<td>Kailua-Kona</td>
<td>30</td>
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<tr>
<td>22</td>
<td>Holualoa mauka</td>
<td>75</td>
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<tr>
<td>23</td>
<td>Puu Waawaa</td>
<td>25</td>
</tr>
<tr>
<td>24</td>
<td>Waikoloa</td>
<td>20</td>
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<td>25</td>
<td>Puako</td>
<td>10</td>
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<tr>
<td>26</td>
<td>Kawaihae</td>
<td>10</td>
</tr>
</tbody>
</table>

Dry Forest Brochure Guidelines

These educational brochures should:
- provide accurate information about the dry forest
- include all references that are obtained outside of class
- include four of the required elements
- be at a quality level that is appropriate to hand out to the public

Required elements for the brochure:
- background information about the Hawaiian dry forest (required)
- information about one native dry forest plant species
- information about one invasive species in the dry forest
- information about organizations that help the dry forest
- ways to help conserve the dry forest

Grading of brochures:
- meeting required elements
- presentation of brochure to class
- rubric is attached

What is a Dry Forest?
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<table>
<thead>
<tr>
<th>Grade:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science/Math Benchmark</strong>&lt;br&gt;S6.1.1&lt;br&gt;S6.1.2&lt;br&gt;MA6.9.1</td>
<td>Student produces an accurate and imaginative brochure about native Hawaiian dry forests. Student is able to thoroughly explain the habitat’s background information, problems, solutions with many details, correct scientific vocabulary words, and a mostly correct use of graphs.</td>
<td>Student produces an accurate brochure about native Hawaiian dry forests. Student is able to explain the habitat’s background information, problems, solutions with some details and some correct scientific vocabulary words, and a mostly correct use of graphs.</td>
<td>Student produces a somewhat accurate brochure about native Hawaiian dry forests. Student is somewhat able to explain the habitat’s background information but has few details, lack of correct of scientific vocabulary words, and the use of graphs.</td>
<td>Student produces an inaccurate brochure about Hawaiian dry forests. Student is unable to explain the habitat of the dry forests and/or the facts are inaccurate. Scientific research was not done properly. No use of graphs.</td>
<td>Student has no product to show the class, or project is not turned in by the due date.</td>
</tr>
<tr>
<td><strong>Language Arts Writing Benchmark</strong>&lt;br&gt;LA 6.1.1&lt;br&gt;LA 6.1.2&lt;br&gt;LA 6.4.1&lt;br&gt;LA 6.4.2&lt;br&gt;LA 6.4.3&lt;br&gt;LA 6.4.7&lt;br&gt;LA 6.5.1&lt;br&gt;LA 6.5.2&lt;br&gt;LA 6.5.5</td>
<td>Consistently uses many plant vocabulary words to explain habitat. Provides insightful details about dry forests. Writing is understandable. A few words are not spelled correctly. There are a few punctuation and grammatical errors. Uses relevant information from appropriate sources.</td>
<td>Uses many plant vocabulary words to explain habitat. Many details about dry forests. Writing is understandable. A few words are not spelled correctly. There are a few punctuation and grammatical errors. Uses relevant information from appropriate sources.</td>
<td>Uses a few plant vocabulary words to explain habitat. A few details about dry forests. Writing is somewhat understandable. Some words are not spelled correctly. There are some punctuation and grammatical errors. Uses some relevant information from appropriate sources.</td>
<td>Barely uses any plant vocabulary words to explain habitat. Barely any details about dry forests. Writing is not understandable. Format was not followed. Most words are not spelled correctly. There are many punctuation and grammatical errors. Uses little relevant information from appropriate sources.</td>
<td></td>
</tr>
<tr>
<td><strong>Language Arts Oral Communication Benchmark</strong>&lt;br&gt;LA 6.6.0&lt;br&gt;LA 6.7.0</td>
<td>Gives a highly effective presentation speaking loudly and clearly with great intonation, looking at the audience, able to describe brochure comfortably, able to answer questions from audience.</td>
<td>Gives an effective presentation speaking loudly and clearly, looking at the audience, able to describe brochure, able to answer most questions from audience.</td>
<td>Gives a somewhat effective presentation by not doing 2 of the following: Speak loudly and clearly enough, look at the audience, able to read report, able to answer questions from audience</td>
<td>Gives an ineffective presentation by not doing 3 or more of the following: Speak loudly and clearly enough, look at the audience, able read report able to answer questions from audience</td>
<td></td>
</tr>
</tbody>
</table>

What is a Dry Forest?

16
| **Kokia**  
*Kokia drynarioides* | **Uhiuhi**  
*Caesalpinia kavaiensis* |
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Highly endangered tree found only in North Kona. Grows to be about 25 feet tall. There are only three left in the wild and the sap has been used to dye fishing nets red.</td>
<td>Grows 12-30 feet tall, with long compound leaves. Its flowers and seeds can be used in leis.</td>
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| **Wiliwili**  
*Erythrina sandwicensis* | **Lama**  
*Diospyros sandwicensis* |
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<td>Grows 35-45 ft tall and about as wide. Deciduous, losing its leaves late summer to conserve water. Its flowers and seeds can be used for leis. The wood can be used for buoys and amas of canoes.</td>
<td>A small slow growing tree, less than 35 feet tall. It’s traditionally used for wood and medicine.</td>
</tr>
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</table>

| **Ohia Lehua**  
*Metrosideros polymorpha* | **Aiea**  
*Nothocestrum latifolium* |
<table>
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<th></th>
<th></th>
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<tbody>
<tr>
<td>A highly variable tree, can be shrubby to more than 100 feet tall. Its flowers and seeds can be used in leis. It has traditionally been used in medicine and used for its wood.</td>
<td>A small tree, growing up to 30 feet tall. Its flowers and seeds can be used in leis and was traditionally used for wood.</td>
</tr>
</tbody>
</table>

**What is a Dry Forest?**

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What is a Dry Forest?

18
<table>
<thead>
<tr>
<th>Plant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilima, Sida fallax</td>
<td>- Highly variable shrub usually less than 5 feet tall. Can be used in leis and traditionally used for medicine.</td>
</tr>
<tr>
<td>Mamane, Sophora chrysophylla</td>
<td>- A large shrub to tree. Serves as the main food source of the native Palila. Traditionally used for wood. Its flowers and seeds can be used in leis.</td>
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<td>Iliahi or Sandalwood, Santalum freycinetianum</td>
<td>- Can be a 3 ft shrub to 40 ft tree. Used for its wood.</td>
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<td>Naio or False Sandalwood, Myoporum sandwicense</td>
<td>- Shrub to tall tree. Used for wood.</td>
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What is a Dry Forest?

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