Section 3 – Environmental Importance of Oregon’s Forests

12: Forests and Drinking Water

Overview

Students read about the importance of forests for protecting water resources and then conduct an investigation comparing water filtration from different soil materials.

Time Considerations

Preparation: 30-45 minutes
Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

• Develop a hypothesis regarding rates of filtration based on soil type.
• Compare the absorption and runoff of different soil and soil cover conditions.
• Identify ways that forests help protect drinking water.

Standards Connections

Next Generation Science Standards

• Science and Engineering Practice – 4. Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution.

Common Core State Standards – Mathematics

• Mathematical Practice – MP.2. Reason abstractly and quantitatively.

Oregon Forest Literacy Plan Concepts

• Theme 1, C.3. Forest ecosystems include processes such as photosynthesis, energy flow and the cycling of nutrients, water, carbon and other matter.
• Theme 2, B.1. Forests affect air, water and soil quality.
Theme 2, D.1. Forests provide multiple economic benefits, including jobs and forest products, renewable energy and minerals, financial returns to owners and investors, and ecosystem service benefits such as carbon storage, clean water, recreation and tourism.

Materials

- **Forest Fact Break: Water** video (1:40 minutes), available at learnforests.org
- **Speakers Bureau Presentation: Oregon’s Forests and Water** video (optional), available on the OFRI YouTube channel
- Equipment for showing video(s)
- Soil filtration model, one per group of four students (see Preparation for materials needed) – each labeled with a unique number
- A variety of soil materials, such as
  - fine-grained sand
  - bark chips
  - topsoil
  - clay
  - mulch
  - dried leaves
  - pieces of sod
- Graduated cylinders
- 6-oz cans that are taller than wide (such as tomato paste cans), with both ends removed
- Stopwatches (or stopwatch app for smartphone or tablet)
- Clear plastic cups or other containers for catching runoff
- “Soil Filtration Investigation” student page

Background Information

Clean water is among life’s basic necessities. Healthy forest soils provide natural filtration to keep streams clean and water quality high. Most of Oregon’s municipal water systems use water that originates in forest watersheds, including those managed for wood production. The quality of this source water is among the best in the nation.

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22 Alternatively, you may use stream tables or runoff models. For larger models, adjust the size of can and water used accordingly.

A watershed is an area, usually bounded by mountains and ridges, that collects the rain and snow that falls on it and drains it through a network of streams into a common river or other body of water. All land in Oregon is within one watershed or another.

How do forests keep our water clean? As water reaches healthy forest soils, most is absorbed and, over time, released to nearby streams or groundwater aquifers. In the process, the water is filtered. Most communities in the United States get water from watersheds where mixed land uses, such as agriculture and residential development, may reduce the water’s quality.

**Key Vocabulary**

absorption  
runoff  
soil filtration

**Preparation**

- Make copies of the student page.
- Build a soil filtration model for each group of four:
  - Using a utility knife, cut off the side of a 2-liter plastic bottle so that it resembles a canoe.
  - Place the bottle on a book or board, and put blocks or other objects under one end so that the bottom of the bottle is raised a few inches above the open mouth of the bottle. (The bottle should be at a 25 to 40 degree angle with the spout facing downward.) If making more than one model, all models should be at the same angle.
  - Place a collecting cup near the mouth to capture any runoff.
  - Fill the model with materials according to the Procedure.

**Procedure**

1. To introduce the lesson, show students the 100-second video *Forest Fact Break: Water*. For more details, you may also show the 10-minute *Speakers Bureau Presentation: Oregon’s Forests and Water* video.
2. Explain to students that to learn more about how forests protect drinking water, they will conduct an investigation of the rate at which water is absorbed into various types of soil, and the amount and quality of water that runs off the soil.
3. Divide the class into groups of four students, giving each a “Soil Filtration Investigation” student page and a model to work with.
4. Groups should fill their model with one or a combination of soil materials. You may either have groups choose their materials or assign them specific materials so that the class has different conditions to compare.

5. Encourage groups to form hypotheses regarding the estimated rate of filtration they would expect for their assigned models.

6. Have groups push the open-ended can about 2 cm into the soil material, and then pour 150 ml of water into the can. If the water leaks around the can’s edges, have students twist it a little further into the material until it stops leaking.

7. Students should record on the student page how long it takes for the water to be absorbed. They should also measure how much water they collect in the downstream container, and indicate the clarity of the runoff water they collect (10=perfectly clear, 0=perfectly opaque). Have them calculate the percent runoff and percent absorption as indicated on the student page.

8. Have students share their results with other groups and then use all the data to plot, on the student page, time against percent absorption and against water clarity.

9. Discuss the results:
   - Which model had the highest and which the lowest percent runoff?
   - Which had the cleanest water?
   - Which model is most like a forest?
   - What does this investigation indicate about soils?
   - Was your hypothesis correct? How might you amend it based on what you observed?

Assessment

Give students the following writing prompt, and use their words to assess their learning:
Describe your result from the soil filtration investigation and what it indicates about soils.

Extension Idea

Take students on a field trip to a drinking water treatment facility to find out how urban filtration systems are modeled after natural systems.
Soil Filtration Investigation

Identify which substrates were used for each model and the amount of water added. Then record the results.

<table>
<thead>
<tr>
<th>Model #</th>
<th>Soil Material</th>
<th>Water Added (in ml)</th>
<th>Amount of Runoff (in ml)</th>
<th>Percent Runoff</th>
<th>Percent Absorption</th>
<th>Absorption Time</th>
<th>Water Clarity (10=clear, 0=opaque)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Clay with leaf cover</td>
<td>150</td>
<td>85</td>
<td>56%</td>
<td>44%</td>
<td>4:25 minutes</td>
<td>6</td>
</tr>
</tbody>
</table>

Percent runoff = collected water (in ml) x 100%

150 ml

Percent absorption = 100% – percent runoff
Plot the results of the experiment from all the models.

**Percent Absorption Over Time**

<table>
<thead>
<tr>
<th>Percent Absorption</th>
<th>Absorption time (in minutes:seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0:00</td>
</tr>
<tr>
<td>90</td>
<td>1:00</td>
</tr>
<tr>
<td>80</td>
<td>2:00</td>
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<tr>
<td>70</td>
<td>3:00</td>
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<tr>
<td>60</td>
<td>4:00</td>
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<td>50</td>
<td>5:00</td>
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<td>40</td>
<td>6:00</td>
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<td>30</td>
<td>7:00</td>
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<tr>
<td>20</td>
<td>8:00</td>
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<tr>
<td>10</td>
<td>9:00</td>
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<tr>
<td>0</td>
<td>10:00</td>
</tr>
</tbody>
</table>
What patterns do you notice?
13: Watershed Survey

Overview

Students use mapping imagery to investigate the land use around waterways in their community or in a nearby forested area.

Time Considerations

Preparation: One hour or more
Procedure: Two to three 50-minute class periods

Learning Objectives

Students will be able to:

• Use various online sources (including topographic maps and aerial and satellite images) to visualize a watershed.
• Determine land use in a watershed.
• Predict potential impacts of land use on water quality.

Standards Connections

New Generation Science Standards

• Science and Engineering Practice – 4. Analyzing and Interpreting Data: Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine an optimal design solution.

Common Core State Standards – Mathematics

• Mathematical Practice – MP.2. Reason abstractly and quantitatively.

Source: This lesson was adapted from “Impact of Land Use on Water Quality,” in Watershed Evaluation by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources. Chemeketa Community College. Available at https://learnforests.org/sites/default/files/ImpactofLandUseonWaterQuality.pdf.
Oregon Forest Literacy Plan Concepts

- Theme 1, C.4. Forest ecosystems include processes such as photosynthesis, energy flow and the cycling of nutrients, water, carbon and other matter.
- Theme 2, B.1. Forests affect air, water and soil quality.
- Theme 2, B.2. Forests provide multiple economic benefits, including jobs and commodities such as forest products, renewable energy and minerals, financial returns to owners and investors, and ecosystem service benefits such as climate change mitigation, clean water, recreation and tourism.

Materials

- Remote mapping and imaging program ([Google Earth](https://www.google.com/earth) or NASA’s [World Wind](http) – see Background Information)\(^{25}\)
- Internet access
- “Online Watershed Survey” student page
- Blank paper

Background Information\(^{26}\)

Until recently, the conversion of natural landscapes to human-dominated lands, such as agricultural lands and urban areas, was considered a local phenomenon. It is now clear that land use practices have effects that occur at regional and even global scales and that these practices have a significant impact on environmental quality. Air and water quality, wildlife habitat, and forest health, for example, may all be affected by changes in land use.

In this lesson, students evaluate the potential impacts of land use on the water quality of a local river (or stream). The concept of river as part of a watershed, and the influences of surrounding lands on waterway characteristics such as temperature, water quality, fish and wildlife, is emphasized as students use remote sensing and online sources to gain an understanding of the watershed under study.

\(^{25}\) As an alternative, you may choose to use topographic map printouts instead of a mapping program, although those maps will include little information about land use along the river.

Google Earth is available for free download at https://earth.google.com. World Wind is open source software that can be downloaded for free at http://goworldwind.org/. Both provide high resolution aerial and satellite imagery and include layers such as elevation, terrain, and other features, but World Wind requires more programming expertise.

**Key Vocabulary**

- disturbed
- effluent
- industrial effluent
- sediment
- solid waste dumping
- stream channelization
- volume extraction
- watershed*

  *included in Glossary

**Preparation**

- Choose a river for students to study and identify the coordinates of several specific locations along it.
- Decide which mapping and imaging program to use. Test it out with the “Online Watershed Survey” student page activities.
- Download the program onto student computers.
- Plan to allow time for students to become familiar with the software.

**Procedure**

1. Introduce the activity by asking students how land uses along a river might affect water quality. List their ideas on the board.
2. Explain that students will be using a mapping and imaging program to survey a local waterway to determine the different land uses along its border. If necessary, give students a brief tutorial on how to use the program and allow time to practice using it.
3. Divide the class into pairs or small groups, providing each a copy of the “Online Watershed Survey” student page and the coordinates for or name of the river they’ll study. Introduce the various land uses presented on the student page, and discuss with students the potential impacts (and descriptions) of each presented in the table.
4. Allow time for pairs or groups to complete their survey.
5. Lead a discussion about students’ findings, asking such questions as:
   • What percentage of each land use did you find along the waterway?
   • To what extent might each of these uses affect water quality? How might they affect the forest ecosystem?

Assessment

To assess their learning, ask students to write a few paragraphs describing what they found on their watershed survey and predicting the potential impacts on water quality.

Extension Idea

• Take a field trip to the specified reach of river and document actual land uses and direct and indirect impacts. Compare findings to class predictions.
Online Watershed Survey

1. Using the mapping program, either follow the coordinates provided by your teacher or enter the name of the river you’ll be studying.

2. To become familiar with the watershed you’ll be studying, follow the river from its source to its entry into a major river, bay or the ocean. What types of landscapes do you encounter along the way?

3. Use the “rotation” and “tilt” features to get various three-dimensional views of the watershed. Try changing the elevation exaggeration (under “tools” and “options,” from the default setting of “1” to “2” or “3”). This feature will exaggerate elevation changes and help you visualize the shape of the watershed. Try navigating through the watershed by moving uphill from the river. The watershed boundaries will appear as ridge tops. With careful observation, you should be able to determine the watershed’s approximate boundaries.

4. Draw the approximate shape of the watershed boundaries on a blank sheet of paper. Include the river in your drawing.

5. Look for the following major land uses along the length of the river you are studying:
   - forest (F)
   - agricultural (A)
   - urban (U)
   - residential (R)
   - industrial (I)
   - disturbed (for example, clearcut, mine or new excavation) (D)

6. Closely examine the entire course of the river under study, and indicate in your drawing for step 4 which type of land use borders the river where. (You may use the initials F, A, etc. to indicate the various land uses.)

7. Estimate the percentage of the river that is bordered by each of the land uses you have identified in step 6. For this activity, consider only lands immediately adjacent to the river.

Source: Adapted from “Impact of Land Use on Water Quality” by Dr. Wynn Cudmore.
8. For each land use, predict the potential impacts on the water quality of the river. Enter one of the following values into each cell in the table:

0 = no negative impact
1 = minor impact
2 = moderate impact
3 = major impact
X = unable to determine

Potential Impacts of Various Land Uses on Water Quality

<table>
<thead>
<tr>
<th>% of River</th>
<th>Heated Effluent</th>
<th>Volume Extraction</th>
<th>Solid Waste Dumping</th>
<th>Industrial Effluent</th>
<th>Increased Temperature</th>
<th>Stream Channelization</th>
<th>Fertilizer or Pesticide Runoff</th>
<th>Livestock Manure Runoff</th>
<th>Sediment Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
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<tr>
<td>Agricultural</td>
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<tr>
<td>Urban</td>
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<td>Residential</td>
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<td>Industrial</td>
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<td>Disturbed</td>
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</tbody>
</table>

Description of Land Uses (for table):

- **Heated Effluent** – waste water released from a pipe or ditch at a higher temperature than ambient water temperature.
- **Volume Extraction** – removal of water from river for irrigation, industrial or residential use.
- **Solid Waste Dumping** – deposits of usually nontoxic materials (such as tires or old appliances).
• Industrial Effluent – discharge from any industrial facility (such as sewage treatment or chemical plant).
• Increased Temperature – inferred from removal of shading.
• Stream Channelization – straightening of stream by excavation or levees.
• Fertilizer or Pesticide Runoff – observed/inferred runoff from agricultural or residential lands.
• Livestock Manure Runoff – observed/inferred runoff from agricultural lands used for grazing livestock (or livestock access to river).
• Sediment Runoff – observed/inferred runoff from disturbed lands resulting in decreased clarity.
14: Forests as Habitat

Overview

Students learn how forests provide habitat for animals and investigate a local study site for animal signs.

Time Considerations

Preparation: 45 minutes or more
Procedure: Two to three 50-minute periods, with time between for student research

Learning Objectives

Students will be able to:

- Identify the habitat needs of forest-dwelling wildlife.
- Identify how forest structure affects wildlife presence.
- Conduct research about forest animals in their habitat to learn about their calls, tracks or other sign.
- Inventory a study site for animal signs.

Standards Connections

Next Generation Science Standards

- Disciplinary Core Idea – HS-LS2.C. A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions.
- Science and Engineering Practice – 8. Obtaining, Evaluating, and Communicating Information: Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Common Core State Standards – English Language Arts

- Reading Standards for Literacy in Science and Technical Subjects – RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
Oregon Forest Literacy Plan Concepts

- Theme 1, B.3. As part of the forest ecosystem, trees have various roles (e.g., supplying oxygen, providing habitat, holding soil, moderating temperature, capturing and storing carbon, and cycling water and nutrients).
- Theme 2, B.2. Forests provide habitat for fish and wildlife.

Materials

- Forest Fact Sheet: Why Do Forest Animals Live Where They Do?, available at learnforests.org
- Find Your Path: Wildlife Biologist video (optional, 2:29 minutes), available at learnforests.org
- “Wildlife in Oregon Forests” student page (optional)
- “Wildlife in Oregon Forests – Questions” student page
- Equipment for showing video(s)
- A Guide to Priority Plant and Animals Species in Oregon Forests (for Preparation), available at learnforests.org
- “Wildlife Signs” student page
- “Wildlife Inventory” student page
- Large master map or sketch of study site (see Preparation)
- Thermometer
- Measuring tape and/or string
- Markers (such as pencils or wood stakes with ribbon or flagging tape tied to one end, or other marker)
- Graph paper for mapping plot area
- Clipboards

Background Information

See the “Wildlife in Oregon’s Forests” student page.

Key Vocabulary

cover
disturbance

Key Vocabulary (continued)

free water
habitat structure
metabolic water
scat
snag*
stand*
vertebrate

*included in Glossary

**Preparation**

- For Part 1, make copies of the “Wildlife in Oregon’s Forests” student page or provide on-screen access to it. Make copies of the “Wildlife in Oregon’s Forests – Questions” student page.
- For Part 2, use *A Guide to Priority Plant and Animal Species in Oregon Forests* to create a list of species found in your bioregion that you may use for assigning students to research.
- For Part 3, choose a study site for the inventory. You may use the same site as in Lesson 10: Tree Identification and Survey, or the site may be on the school grounds, in a nearby park or at local forest. Identify what age forest you are in to further focus on what wildlife may be found there.
- Create a large master map of the study site by projecting a map or sketch of it onto a big piece of butcher paper.

**Procedure**

Part 1—Learning about Oregon Forest Wildlife

1. To introduce the activity, show the brief video *Forest Fact Break: Wildlife* or have students read *Forest Fact Sheet: Why Do Forest Animals Live Where They Do?* to learn about Oregon forests as habitat for wildlife. (You might also show the *Find Your Path: Wildlife Biologist* video to introduce what forest managers do in the field to enhance wildlife habitat.)
2. Allow time for students to read the “Wildlife in Oregon’s Forests” student page.
3. Give students copies of the “Wildlife in Oregon’s Forests – Questions” student page, and have them work in pairs or individually to answer the questions. As a class, discuss the answers.

Part 2—Animal Signs

1. Point out that in order to survive, many wildlife species avoid detection by humans and other animals. That means that people must rely on a variety of signs to determine whether a particular species is present at a site. Ask: What signs might people use to detect the
presence of wildlife? (Possibilities include sounds, prints or tracks, feces or scat, chew or claw marks, egg cases, nests or homes, or shed skin or hair.) Explain that students will become experts at some species’ signs and use the signs to inventory a local study site.

2. Using the list of animals you created in the Preparation, assign individuals (or pairs) an equal number of animals.

3. Provide each student with a copy of the “Wildlife Signs” student page. Allow time for students to research their animal(s) to learn about the various signs for each.

4. Have students share their findings with the class. This may be done orally, or through an online document-sharing application.

Part 3—Wildlife Inventory of Study Site

1. Show students the master map (see Preparation), and work with them to determine the area or areas of the site they will observe. For a descriptive study or inventory of the study site, students may divide up the entire site, with different teams collecting data in different sections. For a comparative investigation, students may choose two sites and compare them.

2. Depending on the study site and the type of investigation, determine an appropriate plot size. (Square plots are recommended, but they may be 1 meter, 5 meters or other length per side.) Students can measure plots using premeasured string or tape measures, with markers at each of the corners.

3. Provide students with copies of the “Wildlife Inventory” student page, and discuss the protocol for recording observations. Students will carefully observe their plots, marking on their student page any animals or animal sign they observe within the boundaries of the plot. Remind students that if they want to see and hear wildlife, they need to move slowly and work quietly.

4. At the study site, students should create plots as determined in step 2, and then note the temperature and weather conditions. They should carefully observe the plot, recording any animals or signs of animals they observe within the plot.

5. After making their observations, students may share knowledge with their classmates to determine the species involved (where possible) or to identify any patterns in the observations.

Assessment

• Ask students to describe in writing what they learned about forests as a habitat for wildlife.
• Guided writing: Ask students to write a journal entry on the connections between wildlife habitat and travel or resource use in Oregon.

Extension Ideas

• Conduct the same investigation of the study site several times and compare the findings, or use the plot data to design an investigation to answer a question or solve a problem.
• Invite a member of one of Oregon’s Native American tribes to talk with your students about tribal traditions related to forests, wildlife and fish.
• Encourage students to find out more about Oregon’s wildlife species through the Wildlife in Managed Forests series of publications, with individual booklets focusing on Deer and Elk, American Beaver, Fish Habitat and Passage, Stream-Associated Amphibians, Northern Spotted Owl, Fisher and Humboldt Marten, and Early Seral-Associated Songbirds. These references are available at oregonforests.org.

Possible Answers to “Wildlife in Oregon’s Forests – Questions” Student Page

1. Food, shelter or cover, water, space.
2. Getting enough food.
3. The quality of food is a challenge, as plants are low in protein and difficult to digest; the food supply also varies through the year.
4. Thermal cover.
5. By burning fat.
6. Carnivores have larger space requirements since they are both larger and limited by the quantity of food available.
7. Snags (used for cover, shelter, feeding areas and places to rear young). Other possible answers: logs, forest density and tree size.
9. Marbled murrelet, red tree vole, Oregon slender salamander.
Many species of wildlife depend on Oregon’s forests. As in all ecosystems, animals in forest ecosystems have four basic needs:

- food
- shelter or cover
- water
- space

An animal’s habitat is a place where the arrangement of food, water, shelter or cover, and space are suitable for the animal’s needs.

**Food Requirements**

The food requirements for different wildlife depend, in large part, on whether they are plant eaters or meat eaters.

Herbivores are plant eaters. If you think about a forest, plants are everywhere. Given this abundant resource, herbivores are generally not limited by the amount of food available. Rather, herbivores have problems with the quality of food. Plants in general are low in protein and difficult to digest. In general, protein content and digestibility are highest when a plant is actively growing and lowest during the winter months when the plant is dormant. The availability of plant foods can also change. For example, shrubs can grow out of reach of herbivores or heavy snowfall can cover grasses.

Carnivores are meat eaters. Everything a carnivore eats (other animals) is high in protein and is highly digestible—and so is high in quality. For carnivores, the trick is getting enough food. That means that they are limited by the quantity of food available.

**Shelter or Cover**

Shelter or cover is a basic habitat requirement that protects animals from excessive heat, cold or predation.

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28 Source: Adapted from *Exploration of Oregon Forests: Module 6 – Woodland Wildlife.* Developed by Julie Woodward based on the Oregon State University Forestry Extension’s Basic Forestry Shortcourse.
Biologists often characterize cover according to the way an animal uses it. For example, thermal cover protects animals from energy loss associated with extreme temperatures. Hiding cover shelters an animal from being seen by a predator, while nesting cover refers to vegetation, rocks, and so on, where an animal (usually a bird) hides its nest.

Most people think of vegetation (including trees) as providing cover for wildlife. However, cover or shelter can also be provided by the topography of the land or by isolation. For example, in hilly terrain, wildlife can seek shelter by dropping down behind a small ridge. For species that are hunted, such as deer or elk, finding a spot that is a long way from a road may provide sufficient isolation to protect them.

**Water**

All wildlife species need water in one form or another. Wildlife can meet their water needs in three ways:

- Some wildlife, especially those that hibernate, can use metabolic water. When fat is used or metabolized, water is produced as a byproduct. So, a hibernating bear can meet its water needs by burning fat.
- Most animals get some water in their diets. Many foods are high in water content, and this preformed water may be all they need. This is fairly common in desert-adapted animals.
- Free water includes all the sources we normally associate with wildlife, from puddles to lakes and rivers.

**Space**

Space is a basic wildlife need. Each species has minimum space requirements for obtaining food, cover, and water, and raising young. Animals living in areas with abundant resources generally require less space than animals living in more inhospitable habitats.

Two additional generalizations can be made about the amount of space a species requires. First, because carnivores are limited by the quantity of food available, they have much larger space requirements than herbivores of the same size. And second, larger animals need more space than smaller animals.

**Structural Components of Habitat**

Another attribute that forest stands provide for wildlife is habitat structure. For example, logs and snags are structural components that up to one-half of all wildlife species use at some time.
A snag is a standing dead tree or part of a dead tree from which at least the smaller branches have fallen. Snags can be used for cover, shelter, feeding areas, places to rear young and a host of other needs.

Stand density and tree size also influence a forest’s suitability as wildlife habitat. Dense stands with smaller trees may provide valuable cover to songbirds and a host of mammals. Open stands with larger trees provide access for birds of prey and other predators, and tend to have significantly more vegetation available for mammals such as deer and elk.

**Forest Age and Wildlife Habitat**

In Oregon, about 300 species of native vertebrates use some sort of forest cover for breeding, but forest habitat is not uniform. Disturbance over time has produced a mosaic of forest age classes, each with unique habitat features. While some species thrive in the habitat provided by younger stands or clearings, others need features such as snags and logs provided by older forests.

As forests go through natural cycles of growth, death and regeneration, species may inhabit or be absent from a given area partly in response to natural changes in the structure of trees and other plants.

Different forest types attract different species of wildlife based on their specific habitat needs. Following are descriptions of three different-aged forests and some of the wildlife associated with them.

**Young Open Stands**

This condition occurs within a short time (2 to 10 years) after a disturbance such as wind, fire or logging has removed most of the larger trees. This stage is characterized by young trees or saplings and a variety of smaller herbs and shrubs. Species that prefer this stand type include deer mouse, striped skunk, common nighthawk and the American goldfinch.

**Middle-Aged Stands**

This forest structure occurs after young stands have grown trees to a point where natural crowding has eliminated smaller and weaker trees and the forest has opened up enough to allow ground vegetation. Many species use this type of structure, though none exclusively. Some of the animals that gravitate to this type of habitat include the marten, black-tailed deer, common garter snake and Pacific tree frog.
Older Forest Stands

This structure is distinguished by larger trees, trees of mixed ages, and more logs and snags. Species that prefer this habitat include the marbled murrelet, red tree vole and the Oregon slender salamander.

Summary

Wildlife animals are very dependent on forests for food, shelter, water and space. These are the four basic needs all animals have regardless of their habitat. There are different nutritional demands for each species, season, sex or age class. Carnivores need to find enough food, while herbivores need to find quality food.

Animals use cover in extreme temperatures to hide and for nesting. From a wildlife management standpoint, vegetation is the cover attribute we typically manipulate. However, there are many other attributes of the landscape wildlife use for cover. Water is also an important aspect. Wildlife can meet their needs for water in several different ways: metabolic, preformed and free water.

Forest wildlife species also need appropriate amounts and arrangements of space. Larger animals and carnivores need more space than smaller animals and herbivores.

Another obvious attribute that forest stands provide for wildlife is habitat structure. Forest age also influences habitat and the species that live there. The diversity of animal species in an area depends on the existence of different habitats in the system.
Wildlife in Oregon’s Forests – Questions

1. What are the four basic needs of wildlife?

2. What is the main issue for a carnivore related to its food supply?

3. Explain the challenges with an herbivore’s diet.

4. A snowshoe hare is hiding due to a winter storm. What type of cover does it use?

5. How do bears meet their need for water when they hibernate?

6. Do carnivores or herbivores typically have larger space requirements? Why?

7. Describe an example of habitat structure that affects wildlife.

8. Name three species of animals associated with young, open stands.

9. Give three examples of the type of animal species older forests attract.

---

Wildlife Signs

Animal Species:

Describe this species’ preferred forest habitat.

Describe the following possible signs that might indicate this species’ presence in a habitat. Include illustrations where appropriate.

Sounds (song, call, screech, chirp, or other sound)

Track or Print

Scat (feces)

Eggs or egg cases

Gnaw or claw marks

Other signs:
Wildlife Inventory

Inventory Beginning Time ___________ a.m./p.m.   Ending Time ____________ a.m./p.m.

Current Temperature___________

Current Weather (check all that apply):       Wind:

- clear                                      - calm
- scattered clouds                           - breezy
- complete cloud cover                       - gusty
- rain                                       - windy

Wildlife Seen or Heard

<table>
<thead>
<tr>
<th>Type</th>
<th>Species (if known)</th>
<th>Description of Animal’s Activity (passing through, eating, hanging out, etc.)</th>
<th>Number Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td></td>
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<td>Mammals</td>
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<tr>
<td>Reptiles or Amphibians</td>
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<tr>
<td>Invertebrates (insects, spiders, etc.)</td>
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<tr>
<td>Other</td>
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</table>
## Signs of Wildlife

<table>
<thead>
<tr>
<th>Sign</th>
<th>Species (if known)</th>
<th>Description (What does it look like? Where was it found? Other observations?)</th>
<th>Number Observed</th>
</tr>
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<tbody>
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<td>Scat</td>
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<td>Tracks</td>
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<td>Feathers</td>
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<td>Fur</td>
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<td>Nests</td>
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<td>Chewed leaves, branches, etc.</td>
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<td>Other</td>
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15: Habitat Edges

Overview

In this field activity, students evaluate the edge effect between two different ecosystems or habitats, asking and investigating questions about such variables as air and soil temperature, relative humidity, and wind velocity to compare the two. After designing the specifics of their investigation, students will establish a transect line that runs perpendicular to the edge and will measure physical variables along the transect.

Time Considerations

Preparation: 45 minutes or more
Procedure: Three 50-minute class periods, including the field investigation

Learning Objectives

Students will be able to:

- Identify microclimate differences among habitats and the edge that separates them.
- Develop a testable question and conduct an investigation to answer it.
- Use scientific instruments to measure such factors as air and soil temperature, relative humidity and wind velocity.
- Analyze the impacts of the edge on the two habitats.

Standards Connections

Next Generation Science Standards

- Performance Expectation – HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

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30 This lesson is adapted from the “Edge Effect” sections in *Environmental Science I* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources. Chemeketa Community College. Available at [https://learnforests.org/sites/default/files/EnvironmentalScienceI_0.pdf](https://learnforests.org/sites/default/files/EnvironmentalScienceI_0.pdf).
• Disciplinary Core Idea – HS-LS2.C: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions.

• Science and Engineering Practice – 3. Planning and Carrying Out Investigations: Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence, and in the design decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g. number of trials, cost, risk, time), and refine the design accordingly.

**Oregon Forest Literacy Plan Concepts**

• Theme 1, C.7. Forests are interconnected with other terrestrial (e.g., rangeland) and aquatic (e.g., estuary) ecosystems.
• Theme 2, B.2. Forests provide habitat for fish and wildlife.

**Materials**

• A study site (see Preparation)
• Photos or map of the study site (optional)
• “Edge Effect – Designing Your Investigation” student page
• “Edge Effect – Data Analysis” student page
• Measuring equipment, such as
  o Thermometers – to measure air temperature
  o Armored field thermometers – to measure soil temperature
  o Thermohygroimeters – to measure relative humidity and air temperature
  o Light meters, or light meter app for smart phones or tablets – to measure solar radiation
  o Digital anemometer, or wind meter device and app for smart phones or tablets – to measure wind velocity
  o Compasses, or app for smart phones or tablets – to measure wind direction
  o Measuring tape – to measure distances
• Data sheets (designed by students in Part 1)
• Measuring tape
• Flagging
• Transect lines (ropes marked at one meter, five meters, or other distance along their length), optional
• Graph paper (or access to spreadsheet program for tables and graphs)
Background Information

The “edge effect” refers to those physical and biological changes that occur along the transition between two different ecosystems or habitats. The forest border adjacent to a clearcut, for example, represents a boundary between two very different environments that differ in minimum and maximum temperature, relative humidity, soil moisture, amount of solar radiation that reaches the surface, wind velocity, and plant and animal species, among others.

Along edges, there may be profound influences of one habitat upon the other in rather complex ways. Temperatures, for example, might be expected to be higher in forested areas that are along an edge as compared with interior forested areas that are not adjacent to such an edge. Living organisms such as plants and animals may in turn be affected by temperature and other differences.

Many wildlife species, known as "edge species," actually prefer habitat edges, where their different needs can be met side by side. For example, the sunny, open area of a meadow may provide food, while the forested area next to it may provide cover from predators. Deer, quail, and rabbits are examples of edge species. For species like these, the absence of a satisfactory edge can, in fact, make an area unsuitable for them.

Ecological research conducted in the 1980s examined forest patterns at the landscape level in forests in the Pacific Northwest and tropical rainforests. Concern was raised at this time that the pattern of the forested landscape was not adequately protecting the biodiversity of these forests. Research has suggested that biodiversity loss is not simply a matter of decreased acreage (and habitat loss), but also the pattern of habitat loss, including fragmentation (the break-up of large forested stands resulting in the isolation of small parcels of interior forest) and the formation of extensive edges in areas where none existed previously.

One way to determine the effect of an edge on the two habitats is to sample microclimate data along a transect line perpendicular to the edge. Students can make a transect line using rope marked and numbered at regular intervals all along its length, laying it across the study area.

Key Vocabulary

dependent variable

31 Source: Adapted from “Edge Effect One,” in Environmental Science I by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources. Chemeketa Community College. Available at https://learnforests.org/sites/default/files/EnvironmentalScienceI_0.pdf.
Key Vocabulary (continued)

edge effect
edge species
independent variable
transect

Preparation

Choose a study site that illustrates a distinct ecological edge between habitats and that has sufficient area to accommodate the class. Possibilities include a woodlot or grove on campus, a city or county park, nearby natural area, public or private timber land, or other natural resource area. Take pictures, if possible, to share with the class in advance of going there.

Procedure

Part 1 – Planning the Investigation

1. Using the Background Information, introduce the idea of habitat edges.
2. Describe or show pictures of the study site. Explain that students will be conducting their own investigations to determine the impact of the edge on each of the habitats. The basic question they will be addressing is, To what extent does the edge impact the physical characteristics of the two habitats? They will be measuring how air temperature, soil temperature, relative humidity, wind velocity, solar radiation and plant diversity change as one proceeds from the edge to interior habitats.
3. Ask students what differences they think they might observe between the two habitats, and why. How far into each habitat from the edge do they think those differences might extend?
4. Show students the measuring equipment that will be available for the investigation, and demonstrate how to use and set up a transect line.
5. Review the concept of independent variables and dependent variables. An independent variable is the variable that is changed in a scientific experiment or investigation, while a dependent variable is one that is being tested as the independent variable changes. Remind students that in order to determine the relationship between the distance from the edge and the physical characteristics, their investigation should have just one independent variable – the distance along the transect line. All other conditions should be the same.
6. Divide the class into pairs or small groups, providing each with an “Edge Effect – Designing Your Investigation” student page.
7. Depending on your class and objectives, assign each group one or more of the measurements on which to focus their investigation (air temperature, soil temperature, relative humidity, wind velocity, solar radiation or biodiversity), or have them choose.

8. Direct each group to work through the student page to plan their group’s investigation.

9. Have students either present their investigation plan to the class or submit it to you for review and approval.

Part 2 – At the Study Site

1. Bring along materials and equipment needed for students’ investigations. Students should have their data sheets available for recording their data.

2. Allow time for students to conduct their investigations. Circulate among groups, as necessary, to resolve any issues.

Part 3 – Analyzing the Results

1. Direct groups to summarize their data in tables or graphs, using pencil and graph paper or a spreadsheet program. They should calculate the mean (average) for the parameters they study, and plot these means against distance along the transect. Encourage groups to share information with other groups as appropriate.

2. After students have graphed or tabulated their results, invite them to discuss within their group any trends they see in the data. Provide copies of the “Edge Effect – Data Analysis” student page, and have each group answer the questions presented.

Assessment

Use students responses on the “Edge Effect – Designing Your Investigation” student page to assess their ability to plan a scientific study, and their responses on the “Edge Effect – Data Analysis” student page to assess their learning.
Edge Effect – Designing Your Investigation

In this activity, you will design and carry out an investigation to learn more about the effect of edges on forest habitats. Meet with your group to identify the following.

I. Investigation Question

Your investigation will help determine the extent to which an ecological edge impacts the physical characteristics of two habitats. A testable question guides an investigation. State the specific question you will investigate.

Investigation Question:

II. Hypothesis and Rationale

Hypotheses are “educated guesses” based on prior knowledge that provide a possible answer to a question. Clearly state your hypothesis and describe the rationale you have used to make this prediction.

Hypothesis:

Rationale:

III. Experimental Design

A. Independent and Dependent Variables

An independent variable is the variable that is changed in a scientific investigation. In the case of a transect line, it is the distance along the line.

A dependent variable is the variable being tested in a scientific investigation. The dependent variable is “dependent” on the independent variable: as the investigator changes the independent variable, the change in the dependent variable is observed and recorded.

Independent variable(s):

Dependent variable(s):
B. Equipment Needed

List all equipment you will need to carry out the procedure you outline below.

1. 5.
2. 6.
3. 7.
4. 8.

C. Procedure

Briefly describe or diagram what your investigation procedure will look like at the study site. Include such information as length of transect line, number of sampling stations, distance between stations, and so on. Also describe exactly how you measure each variable in the field. All measurements should be in metric units.

D. Data Sheet Design

You have decided what information your group will collect and how you will measure it. Now, design a data sheet that will easily accommodate this information.
Edge Effect – Data Analysis

1. What conclusions can you draw from the information you have collected? (Extract as much information from your graphs and tables as possible.)

2. Is your hypothesis supported by the data?

3. If you were to repeat this study, what changes would you make?

4. Based on your measurements, does it appear that the transect line was long enough to reach the true “interior habitat” of either of the habitats? What evidence supports your answer?

5. Assuming that you did sample true “interior habitat,” what is the approximate width of the edge in the habitats sampled? How did you arrive at this number?
6. For each of the forested stands below, assume that each is surrounded by clearcuts, and the “edge effect” penetrates 200 m into the interior forest. For each stand, calculate the total area of edge habitat and the percent of total area in edge.

What conclusions can you draw?

7. Overall, does the edge effect have a positive or negative influence on ecosystem health and stability? Explain.
16: Forests and Carbon

Overview

Students explore the process of photosynthesis, estimate and calculate the amount of carbon in a given tree, and then make a model showing how carbon is sequestered in trees. (Note: Students will further explore the topic of climate change in Lesson 34: The Effects of Climate Change on Oregon Forests.)

Time Considerations

Preparation: 15 minutes
Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Describe the process of photosynthesis, whereby green plants use sunlight to make food energy.
- Calculate the amount of carbon stored in a tree.
- Make a model showing how carbon is sequestered in trees.
- Explain the connections between forests and climate change.

Standards Connections

Next Generation Science Standards

- Performance Expectation – HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- Disciplinary Core Idea – LS2.B: Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
- Science and Engineering Practice – 2. Developing and Using Models: Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
Oregon Forest Literacy Plan Concepts

- Theme 1, A.2. Forests are composed of trees that may differ in species, age and size, and that and are affected by biotic factors (e.g., plants, animals and humans) and abiotic factors (e.g., soils, nutrients, moisture, sunlight and climate).
- Theme 2, B.4. Forests sequester carbon from the atmosphere and are an essential component of the global carbon cycle. Forest products made from wood also store carbon.
- Theme 2, D.2. Forests provide multiple economic benefits, including jobs and forest products, renewable energy and minerals, financial returns to owners and investors, and ecosystem service benefits such as carbon storage, clean water, recreation and tourism.

Materials

- Forest Fact Break: Photosynthesis video (1:20 minutes), available at learnforests.org
- Forest Fact Sheet: How Does Photosynthesis Work?, available at learnforests.org
- Forest Fact Break: Carbon Capture video (2:10 minutes), available at learnforests.org
- Forest Fact Sheet: Are Forests, Carbon and Climate Change Related?, available at learnforests.org
- Equipment for showing videos
- Tree Carbon Calculator, available from the U.S. Forestry Service at http://www.fs.fed.us/
- Tree measurements from Lesson 11: Measuring Trees (or materials for measuring tree diameter as described in that lesson)
- Internet access
- “Plant Food” student page
- “How Much Carbon Is Sequestered?” student page
- “The Carbon Cycle Poster” student page
Background Information

The carbon cycle is the series of processes by which carbon atoms are circulated in the biosphere. In this cycle, carbon dioxide from the atmosphere is converted by plants into complex organic compounds, which are consumed by other organisms; the carbon returns to the atmosphere in the form of carbon dioxide through respiration, the decay of dead material, and the combustion of wood and fossil fuels.

Trees are an important part of the carbon cycle. Through photosynthesis, they absorb carbon dioxide, transform it into carbohydrates (sugars), release oxygen into the atmosphere, and store the carbon in their woody structures as cellulose.

How are forests, carbon and climate change related? Increased amounts of carbon dioxide in the atmosphere result in warmer temperatures. Carbon dioxide, a greenhouse gas, is released through natural events such as volcanic eruptions and forest fires, as well as through human activities such as burning fossil fuels. Scientists generally agree that human contributions to global climate change are increasing, and they are concerned about the future.

Forests store or sequester significant amounts of carbon, reducing the presence of carbon dioxide in the atmosphere. The US Forest Service estimates that U.S. forests sequester a net of approximately 250 million tons of carbon each year, offsetting 10 to 20 percent of the country’s carbon emissions from burning fossil fuels each year.

When a tree is harvested and made into a house, cabinetry or furniture, the wood continues to store the carbon that the tree had sequestered. So the carbon continues to be kept from the atmosphere. In contrast, the manufacture of steel, concrete and plastic requires the use of much more fossil fuel.

The chemical composition of wood varies from species to species and even from one part of a tree to another. But generally, wood is made up of approximately 50 percent carbon, 44

Sources:
percent oxygen, and 6 percent hydrogen, with trace amounts of metal ions. Aside from water, wood has three main components: 41-43 percent cellulose, a carbohydrate derived from glucose; 20-30 percent hemicelluloses, carbohydrates made from glucose and other sugars; and 23-27 percent lignin, a complex polymer that makes the cell walls rigid.

Key Vocabulary

carbohydrate
carbon cycle*
carbon sequestration*
global climate change*
photosynthesis*

*included in Glossary

Preparation

• Make copies of student pages. (Instead of copying “The Carbon Cycle Poster” student page, you may choose to provide on-screen access to it.)

• Test out the Carbon Tree Calculator. (As a simpler alternative, you might use the National Tree Benefits Calculator, available at http://treebenefits.com which estimates the quantity of carbon dioxide sequestered in a year.)

Procedure

Part 1 – Photosynthesis

1. To get students thinking about photosynthesis, have them work in pairs or small groups to consider what trees use as food, answering the questions on the “Plant Food” student page. (Note that while this may seem like a simple exercise, it helps uncover students’ thinking and understanding about photosynthesis. You may find that even though they may be able to describe photosynthesis, many high school students still hold incorrect notions about it.33)

2. As a refresher on photosynthesis, show the 90-second Forest Fact Break: Photosynthesis video, or have students read Forest Fact Sheet: How Does Photosynthesis Work? If students need a further refresher, you might have them simulate the equation for photosynthesis (as below), with different students standing in for the various atoms.

Equation for photosynthesis:

$$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$

Sunlight energy

Where: CO$_2$ = carbon dioxide, H$_2$O = water, C$_6$H$_{12}$O$_6$ = glucose (sugar), and O$_2$ = oxygen

**Part 2 – Carbon and Trees**

1. Ask students what they think wood is made of. Using the information from the Background Information section, explain that as trees grow, they absorb carbon dioxide, which becomes stored or sequestered in the tree’s tissue in the form of cellulose and hemicelluloses, which are carbohydrates. Point out that while the chemical composition of wood varies from species to species, it is approximately 50 percent carbon, 44 percent oxygen, and 6 percent hydrogen.

2. Show the 2-minute video, *Forest Fact Break: Carbon Capture*, or have students read the *Forest Fact Sheet: Are Forests, Carbon and Climate Change Related?* Discuss the connection between forests, carbon and climate change.

3. Introduce the *Carbon Tree Calculator*, demonstrating how to use it by inputting a tree’s size (DBH) or age, climate zone and species.

4. Give students copies of the “How Much Carbon Is Sequestered?” student page. Using data from Lesson 11: Measuring Trees, direct students to first estimate and then calculate the amount of carbon sequestered in the trees on your school grounds or other study site.

5. Give students copies of “The Carbon Cycle Poster” student page. Point out how the outside arrows depict the carbon cycle – with carbon being incorporated into living tissue by photosynthesis and then returning to the atmosphere through respiration, the decay of dead organisms or the burning of fossil fuels. Point out the three main processes – carbon absorption, carbon storage and carbon release – that are described at the bottom of the student page.

6. Have students work in pairs to identify the points in the cycle where carbon is absorbed, where it is stored, and where it is released.

7. Challenge students to create a model – a poster, flow chart, graphic organizer or other visual representation – depicting how carbon ends up either in a tree or in a wood product. The model should include how carbon is absorbed and stored and how it can be released.

**Assessment**

Use student-created models from the lesson to assess their understanding of the carbon cycle.
Extension Ideas

- To explore the relationship between forests, climate change and the carbon cycle in more depth, see Forests and the Carbon Cycle, a set of high school lessons developed by the California Forest Foundation. Available at http://calforestfoundation.org.
- Research the concept of carbon credits. What are they? How do they work? How might their use impact forests? How might timber harvesting affect carbon credits?

Possible Answers to “Plant Food” Student Page

1. Answers may vary, but food is any substance that supplies the energy an organism needs to live and grow. Both plants and animals require food to survive. Plants are able to make their food using energy from sunlight to transform carbon dioxide and water into carbohydrates. Animals must get food by eating plants or other animals.

2. Trees use sugar (such as glucose) as food. While fertilizer, soil and minerals may provide important nutrients, they do not provide energy, which is the necessary requirement for something to be considered food in a biological sense. Sugar is the only item in the list that is considered food for a plant.
1. All living things need food to survive. How would you define food? How is it the same for plants as it is for animals? How is it different?

2. Which of the following do trees use as food?

___ Sunlight
___ Sugar
___ Carbon dioxide
___ Fertilizer
___ Soil
___ Water
___ Chlorophyll
___ Minerals

Explain your thinking.

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### How Much Carbon Is Sequestered?

<table>
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<tr>
<th>Tree</th>
<th>Diameter (DBH)</th>
<th>How much carbon would you estimate is stored in the tree?</th>
<th>How much carbon is there (from the carbon calculator)?</th>
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Student Page
Lesson 16

The Carbon Cycle Poster

WHERE'S ALL THE CARBON?

The atmosphere, oceans, and land are the three main reservoirs of carbon on Earth. Carbon moves between these reservoirs through natural processes and human activities, such as burning fossil fuels and deforestation. The carbon cycle is crucial for regulating the Earth's climate and supporting life on our planet.

THE ATMOSPHERE

Carbon dioxide (CO₂) is a greenhouse gas that traps heat in the atmosphere, contributing to global warming. Human activities, such as burning fossil fuels and deforestation, are increasing the atmospheric CO₂ concentration, leading to climate change effects like rising sea levels and more frequent extreme weather events.

THE OCEANS

The oceans are a vast reservoir of carbon, with about half of the CO₂ emitted by human activities remaining in the atmosphere for a few years before being absorbed by the oceans. The ocean's ability to absorb CO₂ is crucial for reducing atmospheric CO₂ levels, but it also poses environmental risks, such as ocean acidification.

FORESTS AND SOILS

Forests and soils are natural carbon sinks, absorbing CO₂ through photosynthesis. However, deforestation and soil degradation, which releases stored carbon back into the atmosphere, are significant contributors to climate change. Protecting and restoring forests and soils is essential for mitigating climate change.

Large amounts of carbon are locked deep underground in limestone and fossil fuel deposits such as coal, oil, and natural gas. Some of this carbon is released through fossil fuel burning and cement production.

HUMAN ACTIVITY is the emission of many billions of tons of CO₂ every year.

Some of this CO₂ is absorbed by oceans and plants, leading to long-term effects on the atmosphere and oceans.