

2023
UPDATED
DIGITAL
VERSION

INSIDE OREGON'S FORESTS

A high school forestry curriculum



Oregon Forest
Resources Institute

Introduction

[*Inside Oregon's Forests*](#) is a high school curriculum developed by the Oregon Forest Resources Institute (OFRI) to help students build a deep understanding of Oregon's forests. The seven modules are loosely organized around topics and concepts from the [*Oregon Forest Literacy Plan*](#), a forest-education conceptual framework developed by OFRI and available at learnforests.org.

Curriculum Goals and Objectives

The overall goal of this curriculum is to provide engaging, standards-based lessons that help high school students understand the environmental, economic and social importance of Oregon's forests, as well as the principles behind forest management. Through the lessons, students will be able to:

- explain basic tree biology
- identify the forest types in Oregon
- describe the environmental, economic and social benefits Oregon's forests provide
- explain scientific and economic principles involved in managing Oregon's forests
- describe current issues facing Oregon's forests
- identify actions they can take to help ensure the sustainability of our forests

Curriculum Overview

Following is a description, as well as a suggested sequence and time frame, for each of the seven modules in the curriculum.

Sequence & Time Frame	Module	Description
Weeks 1-2	<i>Oregon's Forest Heritage</i>	Students are introduced to Oregon forests and their history, and examine some changes in our state's forestland over time.
Week 3	<i>Forest Basics</i>	Students gain an understanding of both tree biology and the forest types in Oregon, and practice identifying and measuring trees.
Weeks 4-5	<i>Environmental Importance of Oregon's Forests</i>	Students explore the environmental importance of forests: for example, how they protect our water resources, provide habitat and store carbon.
Week 6	<i>Economic Importance of Oregon's Forests</i>	Students examine Oregon's forest economy, including the products, energy and jobs that come from forests.

Weeks 7-9	Forest Management	Students learn about forest management and practice forest management skills, such as surveying a forest tract, analyzing forest soil and developing a management plan.
Weeks 10-11	Forest Management Issues	Students explore the impacts of fire, forest pests and climate change on Oregon's forests, and conduct an opinion survey related to a forest management issue.
Week 12-13	Our Responsibility to Oregon's Forests	Students learn about certification as a way to achieve forest sustainability, and plan and carry out a service-learning project.

How to Use the Curriculum

The curriculum is designed to be flexible. Teachers may select modules or lessons that fit their educational goals, as each lesson can either stand alone or build on prior lessons. This curriculum may be used:

- as the basis for a 13-week or semester-long course on forestry
- to teach a single unit on forestry within other high school courses, such as agricultural science and technology, or environmental science
- to help prepare students for the FFA Career Development Event (CDE) on Forestry, or for Envirothon

Curriculum Resources

The following [Resources](#) (available at learnforests.org) support teaching the curriculum:

- Glossary
- Supplies
- OFRI Publications and Videos
- Student Pages
- Field Investigations
- Oregon Standards Connections
- Oregon Forest Literacy Plan Concepts

About OFRI

The Oregon Forest Resources Institute supports and enhances Oregon's forest products industry by advancing public understanding of forests, forest management and forest products.

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OREGON'S FOREST HERITAGE

- 1: Introduction to Oregon's Forests
- 2: History of Forestry in the U.S. and Oregon
- 3: Changes in Oregon's Forestland
- 4: Oregon's Forest Resources
- 5: Who Owns Oregon's Forests?



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OREGON'S FOREST HERITAGE

1: Introduction to Oregon's Forests

Overview

Students consider the truth of different statements about Oregon forests, and then use *Oregon Forest Facts* to validate or refute each statement.

Note that OFRI updates *Oregon Forest Facts* every couple years. The student page statements and possible answers are based on the 2023-24 edition.

Time Considerations

Preparation: 15 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Use resources to validate or refute statements about Oregon's forests.
- Describe ways Oregon's forests are important to the state's economic, environmental and social well-being.

Standards Connections

Oregon Science Standards

- HS.ESS3.1. Earth and Human Activity. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. Resource availability has guided the development of human society.
- Science and Engineering Practice – Analyzing and Interpreting Data. Evaluate the impact of new data on a working explanation and/or model of a proposed process or solution.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – RST.9-10.1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

Oregon Forest Literacy Plan Concepts

- 2.A.1. Forests improve air and water quality, and help stabilize soil.
- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., recreation and tourism).

Materials

- [Oregon Forest Facts](#) (either one copy for each pair of students, or on-screen access), available at learnforests.org
- “Oregon Forests – True or False” student page

Background Information

One of our state’s greatest resources is its forestland, which represents nearly half of Oregon’s 61 million acres. Healthy forests provide vital environmental, social and economic benefits our communities rely on. Some of the many forest benefits include:

- clean air and water
- wood, paper and other renewable, recyclable forest products
- balanced and vigorous plant and animal communities
- fish and wildlife habitat
- recreation

It takes a collaborative effort of public, landowner and legislative support to maintain healthy forest ecosystems, a thriving forest sector economy and a recreational playground.

Key Vocabulary

Clearcutting

sustainable forest management*

forest sector

timber harvest*

reforestation*

**included in Glossary*

Preparation

Make copies of the student page.

Procedure

1. Introduce the curriculum and the lesson by pointing out that throughout Oregon's history, forests have been a crucial component of the state's environment and economy.
2. Give each pair of students a student page and allow them a few minutes to read the different statements and decide which they think are true and which false.
3. Provide copies of *Oregon Forest Facts* or direct students to the booklet online. Direct pairs to use the data provided in the booklet to either validate or refute each statement, citing the evidence they find.
4. As an entire class, discuss the students' findings:
 - a. Which statements did you find to be true? Which were not true?
 - b. Did any of your findings surprise you?
 - c. What did you learn about Oregon's forests from this exercise?
5. Ask the class, "From what you found, how would you say forests contribute to Oregon's environmental, economic and social well-being?" List their responses on a class chart, such as this:

Environmental Well-Being	Economic Well-Being	Social Well-Being

Assessment

Ask students to write a brief essay describing how forests contribute to Oregon's environmental, economic and social well-being.

Extension Idea

Help students connect to Oregon's forests by visiting one near you. See the "Field Programs" tab on the "[Grades 9-12 Programs & Resources](#)" page on learnforests.org for a list of field programs around the state.

Possible Answers to “Oregon Forests – True or False?” Student Page

1. True. Nearly half (47 percent) of Oregon’s total acreage is forestland.
2. True. Oregon’s forestry sector employs tens of thousands of workers.
3. False. The amount of forestland acreage and the volume of wood growing in Oregon have remained about the same since at least the 1920s.
4. True. In 1971, the Oregon Forest Practices Act became the first law in the U.S. to regulate forest practices, ensure reforestation and safeguard water, fish and wildlife habitat, soil and air.
5. False. Federal and state governments manage nearly twice as much acreage of forestland in Oregon as private landowners.
6. False. The majority of timber produced in Oregon comes from large private landowners.
7. False. Oregon’s forests are managed to reflect the varied objectives and practices of landowners. For example, some are managed primarily for timber production, while others are set aside as parks, wilderness areas or reserves to protect habitat.
8. True. Oregon is the top softwood-lumber-producing state and the top plywood-producing state in the nation.
9. False. Oregon forests provide a wide range of products, including lumber, plywood, engineered wood products, paper and paper products, composite wood products, posts, poles and timbers, etc.
10. False. The Oregon Forest Practices Act places limits on clearcuts.
11. True. Under the Oregon Forest Practices Act, forest landowners must replant within two years after harvest.
12. True. In eastern and interior southwest Oregon forests, high growth combined with high mortality has created unusually dense forests that are susceptible to insects and disease and are at risk for larger and hotter fires.
13. True. Under the Oregon Forest Practices Act, timber harvesting, road building and chemical use are restricted near waterways to protect fish habitat and water quality.
14. True. Millions of acres of Oregon forestland are certified under three major certification systems.

LESSON 1

Oregon Forests – True or False?

First, for each statement underline whether you think it is true or false. Then look for evidence in *Oregon Forest Facts* to verify or refute each statement. Circle the correct answer based on your findings.

True or False?	Statement	Supporting Evidence and Page Number
T F	1. About half of Oregon's land area is forest.	
T F	2. The forest industry accounts for tens of thousands of jobs in Oregon.	
T F	3. The amount of forestland in Oregon has shrunk dramatically since 1950.	
T F	4. Oregon was the first state in the country to pass a law regulating forestry practices on all its forestland.	
T F	5. Private property owners control most of the forestland in Oregon.	
T F	6. Three-fourths of the timber harvested in Oregon comes from federal land.	
T F	7. All forests in Oregon are managed in the same way for the same objectives.	
T F	8. Oregon is one of the top lumber-producing states in the U.S.	
T F	9. Wood from Oregon forests is used only for making paper and lumber.	
T F	10. Forest owners in Oregon may clearcut (log all or most of the trees) on their own land without any restrictions.	
T F	11. Oregon landowners must replant forest trees after harvesting them.	
T F	12. A high amount of forest growth has led to a greater fire risk for much of Oregon's forests.	
T F	13. In Oregon, logging is restricted near waterways to protect fish and water quality.	
T F	14. More than 4 million acres of Oregon forest are certified by a sustainable forest certification system.	

2: History of Forestry in the U.S. and Oregon

Overview

Students explore the importance of forests in our nation's and state's history by reading about the Western views of three historical figures in forestry and comparing them to Indigenous views on forests. Then, after reading a summary of Oregon's forestry history, they research forest-related events in Oregon's history to create a timeline of forestry in Oregon.

Note that in this lesson, the term Western refers to cultures and belief systems stemming from European tradition..

Time Considerations

Preparation: 15 minutes

Procedure: Two to four 50-minute class periods, plus time for student research

Learning Objectives

Students will be able to:

- Identify three key Western figures in the history of American forestry and describe how their philosophical views helped shape the field of forestry in the U.S. and in Oregon.
- Compare the perspectives of the three Western figures to Indigenous perspectives on forests.
- Describe important events in the history of Oregon forestry.

Standards Connections

Oregon Science Standards

- HS.ESS3.1. Earth and Human Activity. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Disciplinary Core Idea – HS.LS4.D. Biodiversity and Humans. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and

productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. Resource availability has guided the development of human society.
- Science and Engineering Practice – Engaging in Argument from Evidence. Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – 9-10.RST.1. Analyze what science and technical texts say explicitly as well as inferentially, citing evidence attending to the precise details of explanations or descriptions.
- Writing History, Science, and Technical Subjects – 9-10.WHST.7 and 11-12.WHST.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Oregon Forest Literacy Plan Concepts

- 2.C.1. Forests have been central to the region’s history and are an integral part of Oregon as we know it today.
- 3.B.2. From time immemorial, Indigenous people of Oregon have used fire and other practices such as girdling trees and land clearing to manage the forest. Their traditional ecological knowledge of Oregon’s forests informs forest management practices that sustain forests.
- 3.D.3. Oregon has had a history of conflict over forest management issues. For example, conflicts have arisen over the preservation of ancient or old-growth forests, the protection of endangered species, and whether logging is appropriate on public lands.

Materials

- Optional: [The Greatest Good: A Forest Service Centennial Film](#), available at c-span.org
- “Western Perspectives on Forests” student page
- “Indigenous Perspectives on Forests” student page
- “Tracing Oregon’s Timber Culture” student page
- “Creating a Timeline of Oregon Forestry History” student page
- Optional resources for research:

- [*The USDA Forest Service: The First Century*](#) by Gerald Williams. 2005. Available at fs.usda.gov.
- [*Forests, People and Oregon: A History of Forestry in Oregon*](#) by Ray Miller. 2004. Available at the State Library of Oregon Digital Collections, digital.osl.state.or.us. (Note: Though out of print, this book contains a detailed timeline of important events in Oregon related to forestry.)
- [*Conserving Oregon's Environment: Breakthroughs that Made History*](#) by Michael McCloskey. 2020. (Originally published in 2013.)
- [*A Glimpse into History: What Prominent People Have Said about Nature in Oregon and the Need to Conserve It*](#) by Michael McCloskey. 2018.
- Optional: materials for making a physical timeline (such as index cards and string) or a virtual one (such as a word processing, presentation or spreadsheet app)

Background Information

See the “Tracing Oregon’s Timber Culture” student page for an overview of Oregon’s forest history and the “Western Perspectives on Forests” and “Indigenous Perspectives on Forests” for differing views on the value of forests.

Key Vocabulary

forestry*

**included in Glossary*

Preparation

Look over the student pages and decide which of the first three you want to use with students. For example, you may choose to have students read and compare the “Western Perspectives on Forests” and “Indigenous Perspectives on Forests” student pages, or read just the “Tracing Oregon’s Timber Culture” student page, or use all three. Copy the chosen student pages or make them available electronically. Identify potential resources for student research on the timeline (see Materials for some possibilities).

Procedure

1. Lead a brief discussion to assess students’ understanding of Oregon’s historical connection to forests, asking questions such as:
 - How have forests shaped Oregon’s history?
 - How has Oregon’s history shaped forests?
 - In what ways do you think Oregon’s forests have changed over time?

- How do you think our use of and perception of forests have changed over time?
- 2. (Optional) Show *The Greatest Good* or have students read portions of *The USDA Forest Service: The First Century*.
- 3. Ask students what they think the term “conservation” means in relation to forests and other natural resources. Point out that just as they might have differing views about what it means, people in the past have also struggled with how to both use and sustain a resource such as forests.
- 4. Provide students with the “Western Perspectives on Forests” student page and direct them to read about John Muir, Gifford Pinchot and Aldo Leopold, three individuals who greatly influenced forest conservation in the United States.
- 5. Instruct students to use the questions listed on the student page to examine the reading in more detail. You may choose to have them discuss the questions in groups of four or as an entire class, or to write their responses to some or all the questions as homework.
- 6. Have students read the “Indigenous Perspectives on Forests” student page and answer the questions on the student page. Lead a discussion about how the differing views presented on the two student pages influence how forests are used and sustained.
- 7. Introduce the idea that events in Oregon as well as in the nation have shaped both Oregon’s forests and the field of forestry. Invite students to read the “Tracing Oregon’s Timber Culture” student page and answer the questions provided.
- 8. Distribute the “Creating an Oregon Forestry History Timeline” student page. Explain that the groups’ task is to create a timeline showing different events in Oregon’s history and their significance to Oregon forests and forestry.
- 9. Provide research materials or online access, and allow time for students to research and create their timelines.
- 10. Invite groups to present their timelines to the class.
- 11. Discuss such questions as:
 - How has forestry developed over time in Oregon?
 - What events have been significant in Oregon’s forestry history?
 - How have Muir’s, Pinchot’s and Leopold’s views of conservation influenced forestry in Oregon?
 - How have Indigenous views influenced forestry in Oregon?
 - What future events might impact Oregon’s forests? How might we minimize any negative impacts?

Assessment

Have students create a T-chart like the one below, adding evidence from their research.

How have forests shaped Oregon's history?	How has Oregon's history shaped forests?

Extension Ideas

- Have students research individuals who have influenced the field of forestry in Oregon to learn about their contributions. Some possibilities include:
 - Samuel Boardman
 - Francis Elliott
 - Stewart Holbrook
 - Thornton Munger
 - George Peavy
 - Edward Schroeder
 - TJ Starker
 - Loren “Stub” Stewart
 - John B. Waldo
 - Barbara Walker
- Have students read the following essays from [Forest Essays, Grades 7-12](#), available at [learnforests.org](#). Each one-page reading provides a historical perspective on Oregon's forests. Challenge students to identify where each of the events described would fall on their timeline, and whether it represents a particular conservation philosophy.
 - Community Members and School Kids Bring Back a Forest [about the Tillamook Burn]
 - Planting a Tree Could Change Your Life [about Hoedads, members of a cooperative tree-planting group in Lane County, Oregon]
 - 1920s Logger Becomes Leader in Sustainable Forestry [about Bill Hagenstein]
 - How Oregon's State Tree Got Its Name
 - Monster Storm Wreaks Havoc [about the Great Coastal Gale of 2007]
- Explore the history of the Oregon & California Railroad (O&C) lands, Tillamook State Forest or other local forestlands. Who has cared for these lands over time? What

philosophies, perspectives and conflicts have been involved? How do history, legislation and jurisdiction impact them today?

- Invite students to create and conduct an Oregon forest history trivia game. Encourage them to develop trivia questions based on research of historical figures, local place names (e.g., L.L. “Stub” Stewart State Park), businesses (e.g., Stumptown Coffee), teams (e.g., the Timbers) or other cultural references that are connected to Oregon’s forests and forest history. See the reference volume [*Oregon Geographic Names*](#) by Lewis A. McArthur and Lewis L. McArther, available in many libraries, for information about place names.
- Research to learn how the history of the United States is connected to trees and forests. As a place to start, see [*American Canopy: Trees, Forests, and the Making of a Nation*](#) by Eric Rutkow.

Western Perspectives on Forests

The history of forestry in the United States has been shaped by our nation's changing ideas about forests. Three Western individuals from the late 1800s to early 1900s greatly influenced those ideas through their work and their writing. Each cared deeply about America's forests, but had differing views on the value of forests and how to "conserve" or maintain them.

John Muir

John Muir was born in Scotland in 1838, and immigrated to Wisconsin with his family when he was 11 years old. As an adult he became devoted to learning about a world unchanged by humans or machines. He walked from Indiana to Florida, sailed to Cuba, New York and Panama, and eventually made his way to California, where he continued his walking explorations in the Sierra Nevada mountains.

Starting in the 1870s, Muir became known for his newspaper articles and essays, in which he wrote in poetic and spiritual terms about the natural world. He believed wilderness is important for its sheer beauty and its ability to renew the spirit. He also believed nature has value whether or not people can derive a direct benefit from it. For Muir, conservation meant leaving areas untouched by human hands.

Muir fought to preserve areas of pristine forest and keep them from human destruction. He wrote a series of essays pushing for the establishment of Yosemite National Park, which was eventually created in 1890. He also worked to create Grand Canyon and Sequoia national parks. In 1892 he co-founded and became the first president of the Sierra Club, an environmental preservation organization.

Quotes from Muir's writings:

- *"Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and give strength to body and soul alike."*
- *"It took more than three thousand years to make some of the trees in these Western woods—trees that are still standing in perfect strength and beauty, waving and singing in the mighty forests of the Sierra. Through all the wonderful, eventful centuries since Christ's time—and long before that—God has cared for these trees, saved them from drought, disease, avalanches, and a thousand straining, leveling tempests and floods; but he cannot save them from fools—only Uncle Sam can do that."*

Gifford Pinchot

Gifford Pinchot (PIN-show) was the first professionally trained forester in the United States. He was born in 1865 in Simsbury, Connecticut, to an upper-class family. When he entered Yale University, his father suggested he become a forester since he had always loved being in the woods. At that time, no university offered a degree or even a course in forestry, so Pinchot decided to study forestry in France after graduating.

When he returned to the United States, he worked as a resident forester for George Vanderbilt's Biltmore Forest Estate. In 1889 he became head of the U.S. Division of Forestry. In 1900 he founded the Society of American Foresters (SAF), a professional organization aimed at bringing high standards to the new field of forestry. In 1905 he was named Chief Forester of the newly formed U.S. Forest Service under President Theodore Roosevelt. Under his leadership, the Forest Service grew from 60 national forests covering 56 million acres to 150 national forests covering 172 million acres.

For Pinchot, the term conservation meant the efficient use of natural resources, and he held a utilitarian, or practical, view of forests. He believed forests are for people to use, but he also stressed their "wise use." His view was that natural resources should be managed by considering the "greatest good" for the greatest number of people over time.

Quotes from Pinchot's writings:

- *"Conservation is the foresighted utilization, preservation and/or renewal of forests, waters, lands and minerals, for the greatest good of the greatest number for the longest time."*
- *"Without natural resources life itself is impossible. From birth to death, natural resources, transformed for human use, feed, clothe, shelter, and transport us. Upon them we depend for every material necessity, comfort, convenience, and protection in our lives. Without abundant resources prosperity is out of reach."*

Aldo Leopold

Aldo Leopold was born in 1887 in Burlington, Iowa. After graduating from the Yale Forest School in 1909, he pursued a career in forestry, working for more than 20 years with the U.S. Forest Service in New Mexico and Arizona.

In 1933 he published the very first textbook about wildlife management. Later that year he became a professor of game management at the University of Wisconsin. In 1935 he and his

family began restoring a worn-out farm along the Wisconsin River, which further informed and inspired his understanding of the natural world.

Leopold advanced the idea of the “land ethic,” which places value on all living things as well as their interactions in the environment. To Leopold, the term conservation meant managing natural areas based on ecological principles – not just based on economics. He recorded his findings and thoughts in short essays, which were published the year after he died in 1949 as the book *A Sand County Almanac and Sketches Here and There*. His words inspired many conservationists in the 1950s and 1960s, and helped spur the environmental movement.

Quotes from Leopold’s book:

- *“We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect.”*
- *“Civilization has so cluttered this elemental man-earth relationship with gadgets and middlemen that awareness of it is growing dim. We fancy that industry supports us, forgetting what supports industry.”*

Questions

1. Compare the three views of conservation held by Muir, Pinchot and Leopold. In what ways were they similar? In what ways were they different?
2. Choose one of the quotes to analyze more carefully. What does this quote tell you about the person’s beliefs about forestland and natural resources?
3. Name one way each person’s views helped define our nation’s current relationship with forests.
4. Each of these three people spent a lot of time outdoors and in nature. Do you think going outdoors is necessary to develop beliefs about the protection or use of the environment?

Indigenous Perspectives on Forests¹

Following are excerpts from the article “Native American Forestry Combines Traditional Wisdom with Modern Science” by Gail Wells, describing some perspectives held about forests by Oregon tribal members:

- Ten thousand years ago, ancestors of today’s Coquille Indians lived along the southern Oregon coast from Coos Bay to Cape Blanco, and along the inland valleys of the Coquille River drainage. A common misconception among European Americans is that Indians lived passively within their environment, “at one with nature.” On the contrary, aboriginal peoples actively managed their landscape for their own objectives, using the technologies available to them. For coastal tribes and others, the key management tool was fire. The people regularly set fire to meadows and valleys to maintain grassy cover, keep brush at bay, improve habitat for deer and elk, and cultivate fire-adapted plants that were important sources of food and fiber. Hence, the land the first Euro-Americans took to be a pristine, park-like wilderness was in fact the product of thousands of years of Indigenous land management.
- “There’s a tendency in today’s culture,” says Tim Vredenburg [head forester for the Coquille Indian Tribe in Oregon], “to fixate on a particular set of values within a forest, or an ecosystem: jobs, or timber receipts, or old growth or fish habitat – you name it, there’s a position. The tribe’s position is to value all of it. The idea of reserves, of drawing a line around a forest to keep people out, doesn’t make sense to the Coquilles. But neither does the idea of taking everything away and leaving nothing for future generations.”
- “We get many things from the forest – canoes, baskets, clothes, shelter, fir, cedar, spruce, beargrass, camas – and we use all of these things,” explains Coquille tribal chief Ken Tanner. “But they also have a spiritual value which we honor as we honor our ancestors. What we take, we try to give back. What we don’t need, we try not to take.”
- One important reason for burning was to prevent the vigorous Douglas-fir from invading clearings. “The Douglas-fir timber they say has always encroached on the open prairies and crowded out the other timber,” recalled Lucy Thompson (Che-nawah Weitch-ah-wah),

¹ Excerpted from: Wells, Gail. “[Native American Forestry Combines Traditional Wisdom with Modern Science](#).” February 22, 2016. *Solutions Journal*, thesolutionsjournal.com.

a Yurok woman of northern California, in 1991. “Therefore they have continuously burned it and have done all they could to keep it from covering the open lands.”

- In the Siletz language, the word for Earth may be translated roughly as “made for you.” People who depend on the land learn to pay attention to cycles of birth and death, of plenty and scarcity. Over many generations, the Indians of the Oregon coast learned where the best beargrass patches were and how to keep them flourishing, when to burn the high meadows of the summer campground to attract the elk and to keep the Douglas-fir at bay, and how to harvest and process the inner bark of the Port Orford cedar for making blankets.
- “I come from a people who did not have a word for preservation, or for the environment, or for ecology,” says Esther Stutzman, a storyteller of the Komema Kalapuya people of western Oregon and a member of the Confederated Tribes of Siletz. “The word they had was *respect*.”

Questions

1. How are the Indigenous perspectives of forests described in the article similar to and different from the Western perspectives represented by Muir, Pinchot and Leopold?
2. What are the underlying beliefs or values in each viewpoint?
3. Who or what is left out or missing from each?

Tracing Oregon's Timber Culture²

As Oregonians, we often encounter references to forestry in our everyday lives. Many place names, local sports teams and brands use forestry terms and aesthetics to reinforce their Oregon origin. This article from the World Forestry Center in Portland summarizes our state's complex forestry history.

When did Oregon and forestry become synonymous?

Before white settlers arrived in Oregon, it was home to over [20 Indigenous tribes](#) whose people lived symbiotically with the land, maintained the forests, and worked to preserve the environment around them.

As a territory, Oregon was shaped through manipulation of land by the United States government. The Donation Land Act of 1850 dispossessed Indigenous Peoples and pushed white settlers into the territory. White males and married white women were each allotted a 320-acre plot of land in Oregon. Conflict erupted between these white settlers and Native Peoples; many tribes did not survive the wars. In 1854, U.S. army troops forcibly relocated most surviving tribal bands to a newly established coastal reservation. The Act expired in 1855, but resulted in a huge increase in Oregon's population of white settlers.

Today, there are only [nine federally recognized tribes](#) within the state. However, they continue to play a crucial role in the maintenance of forested lands and passing on Indigenous knowledge to other state residents.

The timber industry in Oregon grew alongside the California Gold Rush of the 1800s. As more white settlers moved west hoping to strike it rich, the need for lumber increased. When rail lines were extended into Oregon in the 1870–80s, the Ponderosa Pines of Eastern Oregon and the forested areas of the Western Cascades were there to meet the need. Between the 1880s and 1911, more railways were



² Source: "[Tracing Oregon's Forestry Culture](#)." World Forestry Center. Reprinted with permission from the World Forestry Center.

added and logging boomed. By 1938, Oregon was the nation's leading producer of wood. To this day, Oregon produces more wood building materials than any other state.

As Oregon, and its largest city, Portland, grew in the mid-1800s, more trees were cut to build homes. Because it was easier to leave the stumps instead of removing them, the city of Portland became known as Stumptown. Stumptown Coffee and the numerous other brands that use this moniker pay homage to Portland's early logging history.

Other brands and organizations have also embraced the city's logging history. The Portland Timbers was established in 1975 as part of the North American Soccer League (NASL). In 2011, the team earned a spot within Major League Soccer. Timbers' fans, proudly called the "army," celebrate their team with lumberjack-inspired apparel. Players' jerseys sport an axe-shaped logo and the team's woodsman mascot, Timber Joey, cuts rings from a Victory Log after every home goal.

Race and Forestry

Oregon's constitution originally included a racist provision that excluded free Black Americans from the state. It read that "No free Negro, or Mulatto, not residing in this state at the time of the adoption of this constitution, shall come, reside, or be within this state, or hold any real estate, or make any contracts, or maintain any suit therein." The constitutional provision was only repealed in 1926.

This racist provision meant that most of Oregon's early population and loggers were white. However, despite this prejudiced history, Black Americans and other people of color played a key part in our state's logging industry.

[Maxville](#), Oregon in Wallowa County was a home base for Oregon's black logging population, as well as Greek, Japanese, and other loggers of color. Though the town and recreational activities were segregated, Black and white men worked side by side. Maxville was home to a vibrant logging community until the early-1930s, when lumber companies cut their holdings there and most families moved away. In the mid-1940s Maxville was destroyed by a storm.



An Evolving Economy

Oregon has been at the forefront of the development of logging practices since the very beginning. The state continues to lead the field. Originally loggers used the [steam donkey engine](#) to increase productivity, eventually trading it for electric tools.

Around 1925, when California's demand for lumber fell, Oregon's loggers began to suffer; mill closures and employee layoffs became commonplace by the beginning of the 1930s.

After World War II, however, Oregon's logging industry boomed once again. The post-war increase in production brought a second wave of logging prosperity. New technology, specifically the modern chainsaw, further increased efficiency.

Timber Today

Logging still accounts for a significant portion of Oregon's annual revenue. In the five-year period from 2017 to 2021, Oregon timber harvest averaged around 3.8 billion board feet per year.³ Today, more than 61,000 Oregonians are employed in the forestry industry, and nearly half (47%) of the state is considered forestland. The state is the top U.S. producer of both softwood lumber and plywood. And, more recently, Oregon has become a leader in manufacturing innovative "mass timber" engineered wood products such as cross-laminated timber (CLT) and Mass Plywood Panels (MPP).

Forestry has shaped the state in countless other, more subtle ways. Portland's thriving arts, cultural and nonprofit organizations are indirectly supported by the timber industry, as many of the state's largest philanthropic donors have financial roots in forestry.

So, the next time that you see a new craft beer with a lumberjack on the logo, know that you have Oregon's timber history to thank.

Questions

1. What are five key events that shaped Oregon's forest industry?
2. The article lists several logos and organization names that show the importance of Oregon's forest industry. What are some locations, companies or brand names in your community that reflect the importance of forests and forestry?

³ Source: [Oregon Forest Facts and Figures, 2023-2024](#). Oregon Forest Resources Institute, [learnforests.org](#).

Creating a Timeline of Oregon Forestry History

Events

Donation Land Act of 1850	Oregon became the nation's leading producer of wood
Endangered Species Act	Oregon Forest Practices Act
Homestead Act of 1862	Oregon Private Forest Accord
Lewis and Clark Expedition in Oregon	Oregon's first sawmill
National Environmental Protection Act	Oregon State University College of Forestry established
National Forest Management Act	The Oregon Trail
Northern spotted owl listed as a threatened species	Transcontinental railroad completed
Northwest Forest Plan	
Oregon became a state	

Directions

1. Divide up the list of events above so all the members of your group have about the same number to research.
2. For each, find out the following:
 - a. When did this event occur?
 - b. What was this event? (Describe it in one or two sentences.)
 - c. How did this event affect Oregon forests or forestry? (Describe the effect in one or two sentences.)
 - d. What sources did you use to learn about this event? (Cite the title, author, date and web page, if any, for each source.)
3. Write the information for each event on separate index cards or pages.
4. Sort all the cards or pages into chronological order.
5. Determine the earliest and the latest dates, and use these to decide on units of time for your timeline (1 year, 5 years, decades, etc.).
6. Decide how you will mark and label the dates and other information on your timeline.
7. Create the frame for your timeline, and then add the dates and other information for each event.

3: Changes in Oregon's Forestland

Overview

Students analyze land cover changes in Oregon, describing changes over time in elements such as forests, shrub or scrub, wetlands, cultivated crops and developed areas.

Time Considerations

Preparation: 15 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Evaluate maps of Oregon at different time periods and analyze differences in land and ecosystem elements.
- Articulate several key findings from their map analysis.

Standards Connections

Oregon Science Standards

- HS.ESS3.1. Earth and Human Activity. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Disciplinary Core Idea – HS.LS2.C. Ecosystem Dynamics, Functioning, and Resilience. 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.
- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. Resource availability has guided the development of human society.
- Science and Engineering Practice – 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.

Oregon Forest Literacy Plan Concepts

- 2.C.1. Forests have been central to the region’s history and are an integral part of Oregon as we know it today.
- 4.A.4. We can look to forests to help us address some of the challenges our society faces, including climate change, biodiversity loss, wildfire and human health issues.

Materials

- “Oregon Land Cover – 1851” student page
- “Oregon Land Cover – 2019” student page
- “Oregon Land Cover Definitions” student page
- “Oregon Land Cover Changes” student page

Key Vocabulary

cultivated crop	perennial
deciduous*	scrub
development*	shrub
evergreen*	wetland*
herbaceous	<i>*included in Glossary</i>

Preparation

Plan to project the two “Oregon Land Cover” student pages or provide students electronic access to them. Make copies of the other two student pages or have them available electronically.

Background Information⁴

More than a century of mapping, managing and measuring has yielded quite a bit of information about Oregon’s forests. Early maps provide a good general idea of what forests looked like around the mid- to late-19th century. From them, we know generally where logging, wildfire and other disturbances have occurred, and we know much about patterns of regrowth in forest ecosystems. And with modern tools such as satellites, other remote imaging techniques and

⁴ Source: [What Do Western Oregon’s Forests Look Like After a Century of Management?](#) Oregon Forest Resources Institute, 2009.

records from extensive on-the-ground mapping, we can gain an accurate and precise picture of what western Oregon forests look like today.

Comparing maps showing Oregon's land cover in 1851 and today yields an interesting picture of how it has changed from both human and natural influences. The two maps are snapshots in time of ever-changing forest conditions. The historic map does not represent a timeless or static state – it shows a particular moment in a dynamic history. In the same way, the modern map captures conditions in which human influences have been significant across the whole landscape. One of those influences has been ongoing, conscious management of forests by public and private owners. The forests today do not look the same as the forests of 50 years ago, and 50 years from now they will look different still.

In other words, a forested landscape is something of a moving target. Comparing these two snapshots and analyzing the influences – human and natural – that shaped and continue to shape Oregon's forests reveals a lot about the variability and resilience of forests in the Northwest.

It should be noted that past land managers made decisions based on the best information available to them, and in a cultural context that is different from today's. Since we have the benefit of hindsight when looking at the consequences of those decisions, it's tempting to be judgmental of them. It's also tempting to embrace a nostalgic view of historic ecosystems as being inherently "good." Past management practices left a footprint that is not necessarily "bad," but is certainly different than it would have been if other decisions were made.

It should also be noted that different data sources were used to make the two maps. The 2019 map comes from a national mapping effort called the National Land Cover Database, which is based on satellite imagery. It is very accurate in terms of its spatial and temporal representation, but has broad vegetation categories. The 1851 map is based on a surprisingly accurate and precise historic land-use and land-cover data set, and then converted to match the 2019 map's vegetation categories. Since the underlying data of the 1851 map was collected by people on the ground prior to GPS, the data set lacked the spatial precision of the 2019 map, but had more nuanced information about specific plants and their densities, much of which was lost when converting it to the 1851 map shown here.⁵

⁵ The 1851 data set is more accurately an 1851–1937 composite that is derived from Andrews and Cowlin timber maps for Oregon and Washington (1936–1937), 1851–1920 General Land Office field survey data and notes where available, and modern soil and climate data that constrain the possible vegetation in non-forest areas outside the General Land Office footprint. A map of the underlying data set can be found at the [Oregon Explorer Map Viewer](https://oregonexplorer.info/) at oregonexplorer.info. To find it, click on Land Use/Land Cover, and then on Historic Land Use & Land Cover 1851 (Level 2).

Procedure

1. Introduce the activity by asking students how they think Oregon's landscape has changed from 1851 to the present day. Project the two Oregon land cover maps or provide students electronic access to the maps.
2. Direct students to work in small groups to complete the "Oregon Land Cover Changes" student page by looking at the two maps and describing first the changes they observe (or infer) between the maps, and then any impacts they would predict from those changes. You might choose to have some groups compare specific sections of the map, and other groups compare the overall maps.
3. Have groups share some of their findings and predictions. Lead a discussion about their findings, asking such questions as:
 - What are the biggest changes you observed?
 - Which changes are state-wide and which are more local?
 - What surprises you about the changes you observed?
 - What do these maps tell us about Oregon's forestland? What don't they tell us about Oregon's forestland?
 - Which changes do you think will have the greatest impact in the future?
 - What challenges do these changes represent?

Assessment

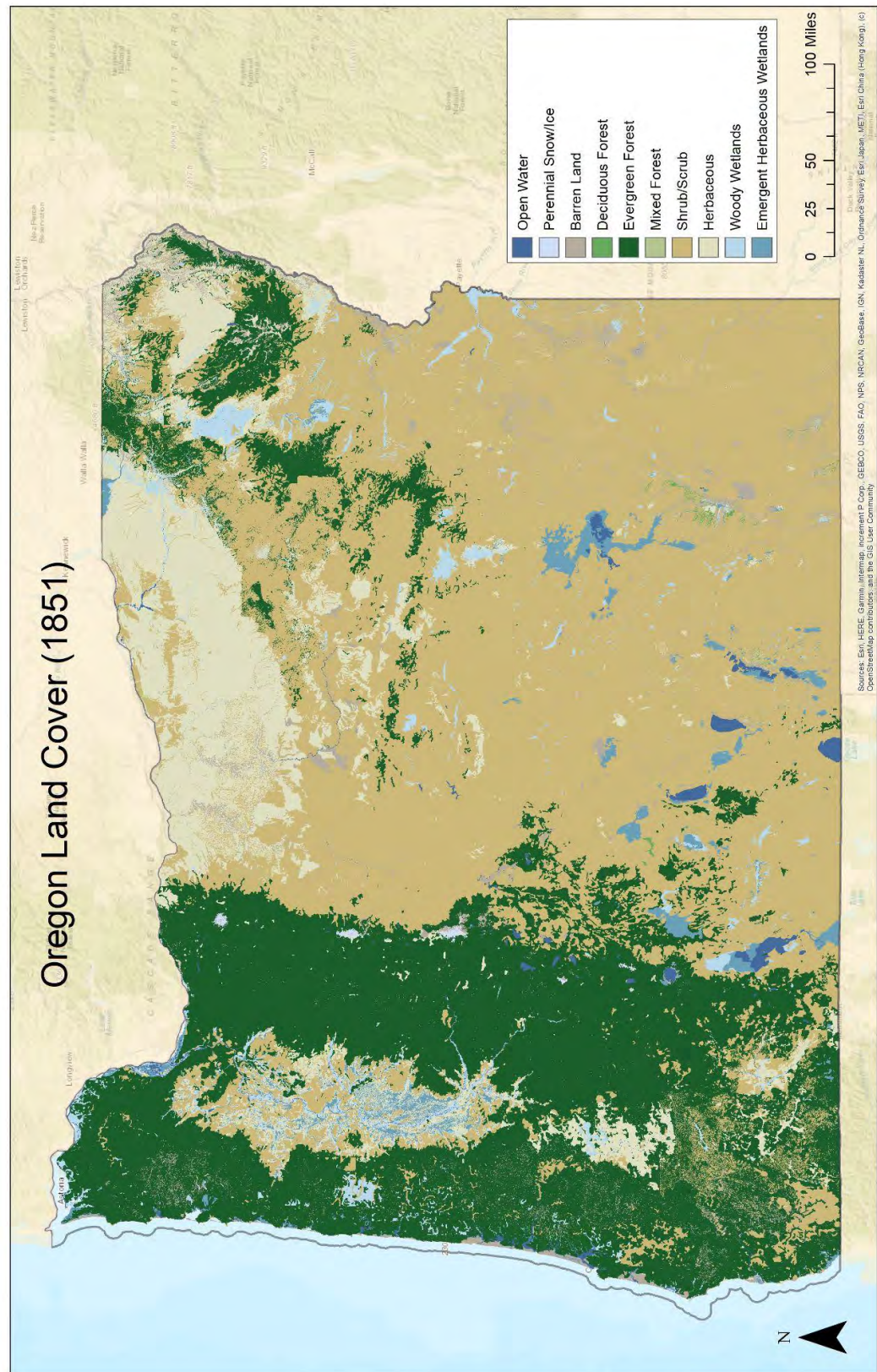
Use student responses to the "Oregon Land Cover Changes" student page to assess their understanding of the lesson concepts.

Extension Ideas

- Using Google Earth or other aerial imagery, look for land use changes in your local area.
- Visit the Oregon Department of Forestry's Forestry History Center in Salem, the World Forestry Center in Portland or your local history museum to learn more about the changing landscape of Oregon's forests and the role of forestry.

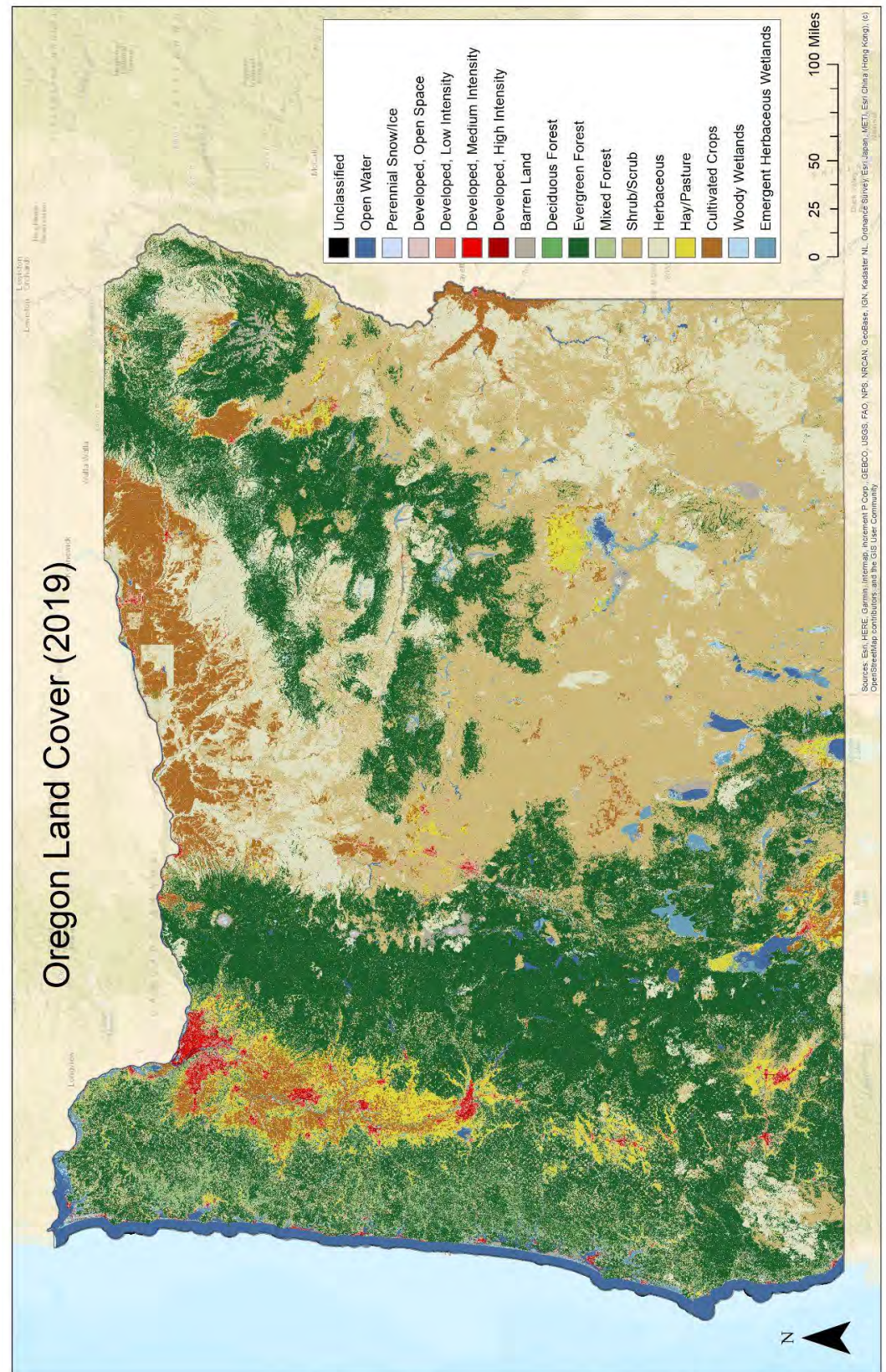
STUDENT PAGE
LESSON 3

Oregon Land Cover – 1851⁶










⁶ Source: Map downloaded from Historic Oregon Land Use and Land Cover 1851 (Generalized). [Oregon Explorer Map Viewer](https://oregonexplorer.info/), oregonexplorer.info.

Oregon Land Cover – 2019⁷



⁷ Source: Map downloaded from National Land Cover Database (NLCD) 2019. [Oregon Explorer Map Viewer](https://www.oregonexplorer.info/), oregonexplorer.info.

Oregon Land Cover Definitions⁸

-  **Perennial Ice/Snow**—Areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
-  **Developed, Open Space**—Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses and vegetation planted in developed settings for recreation, erosion control or aesthetic purposes.
-  **Developed, Low Intensity**—Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
-  **Developed, Medium Intensity**—Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
-  **Developed High Intensity**—Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
-  **Barren Land**—Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
-  **Deciduous Forest**—Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.

⁸ Source: [National Land Cover Database Class Legend and Description](#). Multi-Resolution Land Characteristics (MRLC) Consortium, mrlc.gov.

-  **Evergreen Forest**—Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
-  **Mixed Forest**—Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
-  **Shrub/Scrub**—Areas dominated by shrubs less than 5 meters tall, with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
-  **Herbaceous**—Areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
-  **Hay/Pasture**—Areas of grasses, legumes or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
-  **Cultivated Crops**—Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
-  **Woody Wetlands**—Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
-  **Emergent Herbaceous Wetlands**—Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Oregon Land Cover Changes

Feature	Changes	Impacts
Perennial snow/ice		
Developed (open space, low intensity)		
Developed (medium intensity, high intensity)		
Forest (deciduous, evergreen, mixed forest)		
Shrub/scrub and herbaceous		
Hay/pasture		
Cultivated crops		
Wetlands (woody and emergent herbaceous)		

4: Oregon's Forest Resources

Overview

Students read (or listen to a brief teacher-prepared lecture) about the value of Oregon's forests and the resources they provide, and then answer questions based on the information.

Time Considerations

Preparation: 15 minutes (more if preparing lecture)

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Identify whether Oregon is losing forestland to other uses.
- Describe the Oregon Forest Practices Act.
- Explain how ecological, social and economic benefits of forests contribute to sustainability.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. Resource availability has guided the development of human society.
- Science and Engineering Practice – 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.

Oregon Forest Literacy Plan Concepts

- 4.A.1. People have a reciprocal and complex relationship with forests: We both affect and are affected by forests.

Materials

- “Oregon’s Forest Resources” student page
- “Oregon’s Forest Resources – Questions” student page
- Optional: [Rules to Live By](http://oregonforests.org), available at oregonforests.org

Background Information

See “Oregon’s Forest Resources” student page.

Key Vocabulary

canopy*

conifer*

ecology*

economic value*

forest*

photosynthesis*

sustainability

**included in Glossary*

Preparation

Make copies of student pages or provide electronic access to them. (As an alternative to students reading the “Oregon’s Forest Heritage” student page, you may choose to prepare a brief lecture based on the material.)

Procedure

1. Have students read the “Oregon’s Forest Resources” student reading, or present a brief lecture based on the material.
2. Give students copies of the “Oregon’s Forest Resources – Questions” student page, and allow time for them to answer the questions in pairs or groups.
3. (Optional) Explore the Oregon Forest Practices Act further by inviting students to read some or all the *Rules to Live By* report, and to identify the key rules and benefits of the Act.

Assessment

Use student responses to “Oregon’s Forest Resources – Questions” student page to assess their learning.

Possible Answers to “Oregon’s Forest Resources – Questions” Student Page

1. They help cool and regulate the earth’s climate by removing carbon dioxide from the atmosphere.
2. The amount of forestland in Oregon has remained fairly constant, with about 8 percent loss due to human development.
3. Ecological value: They provide food, shelter and habitat for wildlife; stabilize soil and prevent erosion; regulate temperature and moisture; capture carbon dioxide to produce oxygen; and filter water. Social value: They provide places for people to relax, rejuvenate, find food and have fun, as well as raw materials for wood products. Economic value: They provide softwood lumber and tens of thousands of jobs.
4. Ecological, social and economic benefits are all considered when we talk about forest sustainability.
5. A set of laws and rules governing harvest practices and forest management operations in Oregon.
6. Lumber, door and window frames, fencing material, plywood, newsprint, printer and photocopy paper, egg cartons, food containers, glues, packing material, furniture, toys, playground equipment, pencil stock, cabinets, cosmetics and more.
7. Individual consumer choices affect the demand for forest products – and, in turn, ecosystems and human communities – in Oregon and around the world.
8. Individual responses will vary.

Oregon's Forest Resources⁹

Introduction

A forest is a living, complexly interrelated community of trees and associated plants and animals. Forests help provide the earth with oxygen necessary for life. Green plants take in energy from the sun and use that energy in their cells to transform water and carbon dioxide into oxygen and glucose, a carbon-based molecule. This process is called photosynthesis. High levels of carbon dioxide and other gases in the atmosphere contribute to global warming. Forests help cool and regulate the earth's climate by removing carbon dioxide from the atmosphere. The carbon-based molecules that result from photosynthesis are stored in trees' trunks, stems and leaves.

Trees take moisture and nutrients from the soil, and with the aid of sunlight they grow wood and other natural products used by humans. Oregon's forests are very diverse, ranging from mixed-species, old-growth trees in roadless wilderness areas to single-species, intensively managed industrial forests. To better understand forestry in Oregon, it's important to understand some of the basic facts that shape Oregon's forests.

Oregon's Forest Heritage

Of the 62 million acres of land in Oregon, some 30 million acres, or 47 percent, are classified as forestland. Over the past four centuries, the amount of forestland in the state has remained fairly constant, with about 1 percent having been lost to human development (agriculture, urban growth, highways, electric transmission lines and other infrastructure) since Europeans first visited the Northwest. While the amount of forestland has not changed considerably, its composition has changed, as much of the state's virgin forests were harvested for timber during the 19th and 20th centuries.

Forest Sustainability

The ecological, social and economic benefits of forests are all important to Oregon's citizens. Using our forests sustainably, so they continue to provide these important benefits far into the future, requires us to recognize the interdependent relationships among these various uses and acknowledge the need for balance among them.

⁹ Source: *Exploration of Oregon Forests: Module 1 – Oregon's Forest Heritage*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

- **Ecological Value:** The forest floor provides food, shelter and habitat for animals, from the simplest worm to the biggest bear. Tree roots help stabilize the soil and prevent erosion. The top portion of the forest, called the “canopy,” helps regulate forest temperature and moisture. Forests also capture carbon dioxide (a greenhouse gas), produce oxygen and filter water to keep it clean. These are all important ecological functions, also known as ecosystem services, forests provide.
- **Social Value:** Forests provide places for people to relax, rejuvenate, seek food and have fun. Each year, thousands of Oregonians visit our forests to go hiking, biking, camping, hunting, fishing, foraging, off-roading and wildlife watching. Another reason forests are important to society is that they provide the raw materials for all the wood products that we use on a daily basis, such as housing, furniture, newspaper, books and cardboard.
- **Economic Value:** Oregon harvests more conifers (cone-bearing evergreens) than any other state, and is the leading producer of softwood lumber in the nation. Tens of thousands of people in Oregon earn a living by working directly with the state’s forest sector. Forestry is especially important to rural economies, with most forestry-related jobs located in communities outside the Portland metropolitan area.

Oregon Forest Practices Act

All private and state forestland is protected under the rules of the Oregon Forest Practices Act (OFPA), the nation’s oldest and one of the most comprehensive sets of laws and rules governing harvest practices and other forest management operations. Although US Forest Service and Bureau of Land Management (BLM) lands are not regulated by the OFPA, these federal agencies have agreed to meet or exceed many of its requirements. Oregon’s landmark land-use laws offer further protection by tightly restricting the conversion of forests to other uses, attempting to ensure that future generations will have ample forest resources.

OFPA includes laws that:

- **Require Prompt Reforestation.** On average, more than 40 million new trees are planted each year in Oregon’s forests. Reforestation is required any time forest density drops below established standards following harvest.
- **Require Written Plans.** The Oregon Department of Forestry must be notified of all harvesting operations and be provided site maps for review. In addition, some planned actions require that the landowner or timber operator submit a written plan that documents how the operation will meet the OFPA. In general, harvesting, road

construction or other operations conducted near streams or wetlands require a written plan.¹⁰

- **Protect Water Resources.** To protect water resources in forests, particularly where fish and domestic water supplies are involved, harvest operations are restricted within a certain distance from the banks of streams and water bodies.
- **Protect Wildlife Habitat.** Landowners must be responsive to the nesting and feeding needs of a wide variety of forest wildlife. For example, they must ensure that snags (standing, dead trees), fallen logs or standing green trees are present to provide nesting sites and other habitat for many birds, mammals and other animals.
- **Limit Clearcuts.** Clearcutting is when most or all the trees in an area are cut down. The OFPA limits the size and location of clearcuts.
- **Regulate Road Construction and Maintenance.** Strict regulations govern the location, construction, maintenance and repair of roads on both state and private forestland. Roads must avoid marshes, meadows, drainage channels, riparian areas and, when possible, steep terrain.

Oregon's Wood Products

Different types of trees lend themselves to different kinds of wood products. “Hardwood” broadleaf trees such as oak, cherry and walnut provide dense, durable wood – the kind commonly used to make flooring and furniture. “Softwood” cone- and needle-bearing trees such as pine, fir, spruce and cedar produce lumber that is less dense and lighter in weight. It is often used in construction and papermaking.

Beyond the “hardwood” and “softwood” distinction, the different characteristics of dozens of tree species, such as flexibility, straightness and tightness of grain, make for a wide range of applications.

Wood is a component in 5,000 different products, many of them not as easily recognizable as a baseball bat or table. While some products are made directly from hardwood or softwood lumber, many engineered wood products are made of combinations of sawdust, shavings and other waste materials. A wide range of products comes from wood pulp and plant chemicals extracted from wood pulp.

Oregon's wood and paper products are sold in all 50 states and some 40 foreign countries. They include lumber, door and window frames, fencing material, plywood, newsprint, printer and

¹⁰ Source: “[Forest Management Planning](#).” Oregon State University, oregonstate.edu.

photocopy paper, egg cartons, food containers, glues, packing material, furniture, toys, playground equipment, pencil stock, cabinets, cosmetics and more.

Wood Use in a Global Context

U.S. wood consumption per person has increased 40% since 1960. Much of this demand has been met by imports from around the world. Across the globe, about 50% of all forests have been converted to other land uses (compared with 33 percent in the U.S. and 8% in Oregon). Timber harvests in countries without strong forest practice laws often destroy critical habitat such as tropical rainforests, and affect endangered species. Individual consumer choices help shape forests, ecosystems and communities, not only in Oregon, but across the United States and around the globe.

A Career in Forestry

A career in forestry or wood products offers an exciting chance to benefit Oregon's people, environment and economy. Forestry professionals are engaged in the practice of creating, managing, using and conserving forests and wood products in a sustainable manner to meet the needs, goals and values of forestland owners. They care for trees and other forest resources, including soils, water and wildlife, and make innovative products. Some people are drawn to forestry because they want to work outdoors. Many forest sector careers involve working in the forest, but there are other forest-related jobs that might surprise you: writing policy papers, managing timber investments, using satellite mapping technology, managing product quality and educating the public are just a few examples.

Types of job responsibilities among Oregon's forest sector professionals include:

- Growing trees for wood products
- Managing water quality
- Protecting endangered wildlife
- Ensuring healthy forests
- Planning recreational uses
- Researching tree genetics
- Planning and supervising timber harvests
- Developing mill technologies
- Creating new wood products
- Researching global markets
- Producing renewable biomass energy

Oregon's Forest Resources – Questions¹¹

1. How do forests help combat global climate change?
2. Over the last four centuries, what percentage of forestland has Oregon lost?
3. How do Oregon's forests contribute to the ecological, social and economic well-being of the state and beyond?
4. What factors are included when we talk about the sustainability of Oregon forests?
5. Describe the Oregon Forest Practices Act (OFPA).
6. What everyday products are made of wood or wood byproducts from Oregon trees?
7. How do consumer choices affect Oregon's forests?
8. Which forest-related job responsibility sounds the most interesting to you?

¹¹ Source: *Exploration of Oregon Forests: Module 1 – Oregon's Forest Heritage*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

5: Who Owns Oregon's Forests?

Overview

Students examine a map showing forest ownership in Oregon by ecoregion, and identify differences in ownership and forest management challenges.

Time Considerations

Preparation: 15 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Compare the different ecoregions of Oregon in terms of patterns in forestland ownership.
- Identify challenges faced by forestland owners in Oregon's different ecoregions.
- Recognize the forest management objectives for different types of forest landowners.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS4.D. Biodiversity and Humans. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.
- Science and Engineering Practice – Using Mathematics and Computational Thinking. Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Oregon Mathematics Standards

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

Oregon Forest Literacy Plan Concepts

- 1.A.3. Many different forest types exist within a biome, typically named by their dominant tree species. Common forest types in Oregon include spruce-hemlock, Douglas-fir, ponderosa pine, mixed conifer, and juniper.
- 3.A.4. Oregon's forests are managed under private (e.g., family and industrial), public (e.g., state and federal) and tribal ownership. Each type of ownership may have different management objectives, and is subject to different protection laws and policies. Management objectives may even differ within classes of ownership.
- 3.A.5. Many forest landscapes are made up of a variety of ownerships, a mix of management objectives and a blend of forest ecosystems.

Materials

- Optional: [Forest Fact Sheet: Who Owns Oregon's Forests?](#), available at [learnforests.org](#)
- "Oregon's Forest Landowners" student page
- "Who Owns the Forests?" student page
- Optional: ["Who Owns the Forests?"](#) interactive map, available at [oregonforests.org](#)
- [Oregon's Forests](#) posters, available to order from [learnforests.org](#)
- ["Ecoregions"](#) overviews, available from Oregon Department of Fish and Wildlife's Oregon Conservation Strategy website at [oregonconservationstrategy.org](#)
- Internet access
- Tracing graph paper

Background Information¹²

Oregon contains more than 30 million acres of forestland, and nearly half the state is forested. All that forestland is divided between tens of thousands of different landowners: federal, state and local governments; small businesses and large corporations; tribes, families and individuals.

By far the biggest single forest landowner is the federal government, which owns 60 percent of Oregon's forestland. Most of the federal forestland is managed by two agencies: the US Forest Service and the Bureau of Land Management.

¹² Sources: [Forest Fact Sheet: Who Owns Oregon's Forests?](#) Oregon Forest Resources Institute, [learnforests.org](#).

["Ecoregions."](#) Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, [oregonconservationstrategy.org](#).

Different landowners have different priorities when it comes to managing their forestland. Some grow timber to be harvested for wood products. Others focus on wildlife habitat. And many try to balance a mix of environmental and economic values.

In this lesson, students examine forestland ownership through the lens of Oregon’s ecoregions – portions of the state with similar climate and vegetation. Oregon’s diverse landscapes range from lush rainforests to deserts, contributing to diverse ecosystems that differ from one area to another. These differences, as well as the local history of human use, influence issues facing landowners. They also affect the way landowners perceive, value and manage their natural resources.

Key Vocabulary

ecoregion

federal government

private ownership*

state government

tribal government

**included in Glossary*

Preparation

Make copies of the student pages and of the Oregon Conservation Strategy “Ecoregions” overviews, or provide them electronically.

Procedure

1. Introduce the lesson by asking students who they think owns most of the forestland in Oregon: Is it owned by federal, state or local governments; by tribal governments; by private companies; or by families or individuals? (They may remember from Lesson 1 that approximately 60 percent of Oregon’s forestland is owned by the federal government.) You may want to show them the *Forest Fact Sheet: Who Owns Oregon’s Forests?* as a basis of the discussion. What impact might the ownership of a particular tract of forestland have on how that land is managed or used?

2. Display the Who Owns the Forests? interactive map or student page, and ask students whether they notice any patterns. Point out that the location of forests – and forest ownership patterns – vary in different areas (ecoregions) of the state.
3. Explain that students will be looking at different ecoregions of Oregon to learn more about patterns of forestland ownership in the various regions, as well as the particular challenges owners may face. Divide the class into eight groups, assigning each group one of the following ecoregions:
 - a. Blue Mountains
 - b. Coast Range
 - c. Columbia Plateau
 - d. East Cascades
 - e. Klamath Mountains
 - f. Northern Basin and Range
 - g. West Cascades
 - h. Willamette Valley
4. Give students copies of the “Oregon’s Forest Landowners” student page and the “Who Owns the Forests?” student page, or access to the online interactive map. In addition, give them copies of (or online access to) the *Oregon’s Forests* poster and the “Ecoregions” overview for their assigned ecoregion.
5. Allow time for groups to answer the questions on the student page, using the other materials as resources. Provide sheets of tracing graph paper, and suggest that students may use them to help estimate area on the map.
6. After groups have answered the questions on the student page, ask them to present their findings to the class. Discuss the differences and similarities among the various ecoregions. For example:
 - a. Which ecoregion has the highest percentage of federally owned forestlands?
 - b. Where are privately owned forests – forests owned by industrial companies or by families and individuals – more prevalent?
 - c. What similar challenges do forest landowners face across the state? What are some regional differences?

Assessment

Use the student responses on the student page to assess their understanding and learning.

Extension Idea

Compare and contrast ecoregions in the United States. Download a map of ecoregions (such as from the U.S. Environmental Protection Agency’s “Ecoregions of North America” web page at <http://epa.gov>). Have students research differences in the ecoregions and discuss why the differences exist. Create a visual key to compare their findings.

Oregon's Forest Landowners

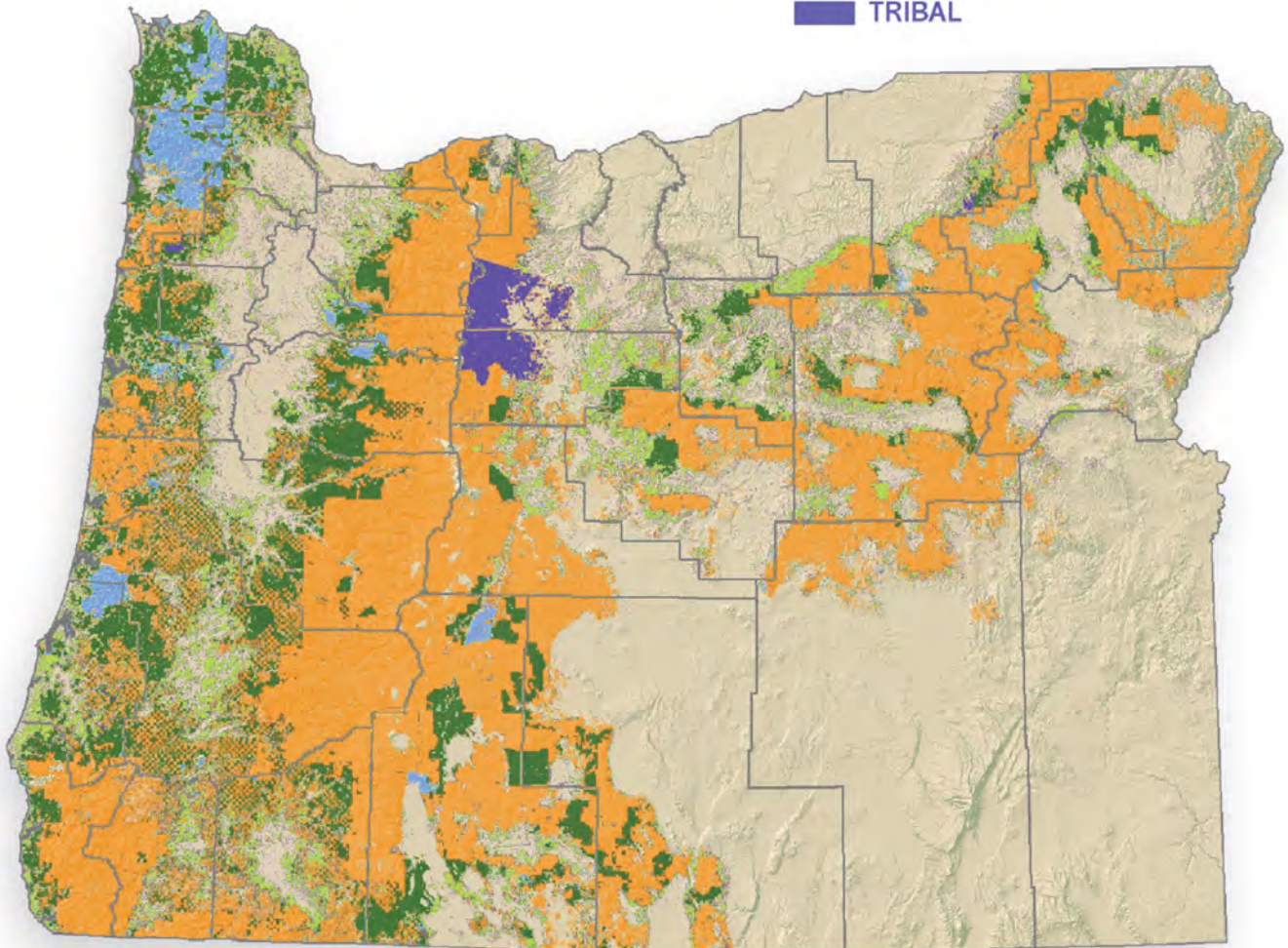
Ecoregion researched: _____

1. Using the map on your ecoregion's overview, draw the boundaries of your ecoregion on the *Who Owns the Forests?* map.
2. Looking at the *Who Owns the Forests?* map, what patterns of forest ownership do you notice in this ecoregion?
3. Estimate the percentage of forestland owned by each of the following entities in this ecoregion. In addition to your answer, explain the method you used to estimate it.
 - a. The federal government (including Bureau of Land Management, National Park and National Forest lands)
 - b. Private industrial companies
 - c. Families and individuals
 - d. Tribal governments
 - e. Oregon state government
4. Using the *Oregon's Forests* poster, identify which forest types are most prevalent in this ecoregion. Why do you think these types are most prevalent here?
5. Using your ecoregion's overview or other sources, identify possible challenges forest owners in this ecoregion face.

Who Owns the Forests?

Forestland ownership

- FEDERAL GOVERNMENT
- LARGE PRIVATE
- SMALL PRIVATE
- STATE & OTHER PUBLIC
- TRIBAL



INSIDE OREGON'S FORESTS

A high school forestry curriculum



FOREST BASICS

- 1: Tree Biology
- 2: Forest Types in Oregon
- 3: Tree Identification and Survey
- 4: Measuring Trees



Oregon Forest
Resources Institute

FOREST BASICS

1: Tree Biology

Overview

Through a brief video and a reading (or lecture), students review the basics of tree biology.

Time Considerations

Preparation: 15 minutes (more, if preparing lecture)

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Identify characteristics commonly used to define a tree.
- Describe the basic biological functions of a tree, including how it supports itself, produces food, transports food and water, and reproduces.
- Describe basic differences and similarities between conifers and broadleaf trees.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS1.A. Structure and Function. Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- Science and Engineering Practice – 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.

Oregon Forest Literacy Plan Concepts

- 1.B.1. A tree is a woody perennial plant, usually more than 12 feet (4 meters) tall at maturity, with a single main stem and a more or less distinct crown of leaves or needles.

- 1.B.5. As part of the forest ecosystem, trees have many roles (e.g., supplying oxygen, providing habitat and food, holding soil, moderating temperature, capturing and storing carbon, and cycling water and nutrients). They may have different roles at different life stages.
- 1.B.6. Trees have complex relationships with other organisms. They may compete or cooperate with each other and with other organisms for nutrients, sunlight, space and water.

Materials

- [Forest Fact Break: Tree Biology](#) video (2:15 minutes), available at learnforests.org
- Technology for sharing video
- “Basic Tree Biology” student page
- “Tree Biology – Questions” student page

Background Information

See the “Basic Tree Biology” student page.

Key Vocabulary

bark	phloem	sprouting
branch	photosynthesis*	stem
broadleaf*	pith	stomata
cambium	primary growth	suckering
conifer*	sapwood	summerwood
dendrochronology	secondary growth	tree*
heartwood	seed reproduction	vegetative reproduction
layering	shrub	xylem
leaf	springwood	

**included in Glossary*

Additional Background for Teachers

The following textbooks may be used to strengthen teacher understanding of forests and forestry science, or to deepen student learning through labs or discussion. Look for them at your local or community college library.

Burton, L. Devere. *Introduction to Forestry Science*, 3rd Edition. Delmar Cengage Learning. 2012.

-and-

Peugh, Renne and L. Devere Burton. *Lab Manual to Accompany Introduction to Forestry Science*, 3rd Edition. Delmar Cengage Learning. 2012.

This textbook and accompanying lab manual – suitable for many high school students – teach the principles of forestry science as well as the forest management practices that contribute to healthy forests.

Hendee, John C. Chad P. Dawson and Wenonah F. Sarpe. *Introduction to Forests and Renewable Resources*. McGraw-Hill. 2012.

Designed for introductory forest courses, this textbook provides an excellent overview of the field of forestry.

Preparation

Make copies of student pages or provide on-screen access to them. (As an alternative to students reading the “Basic Tree Biology” student page, you may choose to prepare a brief lecture based on the material.

Procedure

1. Introduce the topic by asking students how trees get the things they need to survive: food, water and air. Show the *Forest Fact Break: Tree Biology* video as a review of basic tree biology.
2. Have students read the “Basic Tree Biology” student page, or present a brief lecture on the material.
3. Give students copies of the “Tree Biology – Questions” student page, and allow time for them to answer the questions in pairs or groups.

Assessment

Provide students with a list of vocabulary words from the reading and have them either define each word or use all of them in a short essay or paragraph.

Possible Answers to “Tree Biology – Questions” Student Page

1. Tree – usually has a single stem or trunk and is the tallest organism in an ecosystem. Shrub – usually has multiple stems and is shorter.
2. Leaves – produce food from sunlight. Branches – support leaves to get most sunlight, transport water and nutrients. Stems – support branches above competing vegetation, transport water and nutrients. Woody roots – secure tree to soil and transport water and nutrients. Fine roots – take up water and nutrients.
3. Bark – protection. Phloem – transport food within the tree. Cambium – diameter growth of tree. Sapwood (xylem) – water and nutrient transport from roots to leaves. Heartwood (xylem) – supports the tree. Pith – stores nutrients.
4. Stomata – water and air.
5. A process by which green plants use the sun’s energy to transform water, carbon dioxide and minerals into carbohydrates used for growth.
6. Primary growth – starts at the tree’s top and results in more leaf area, height and access to sunlight. Secondary growth – increases diameter of stem, branches and roots to provide greater support.
7. Root – May-June and November. Shoot – July-August.
8. It grows as cambium divides and a ring of xylem cells is laid down.
9. Broadleaf trees – have wide, fat leaves; bear seeds inside fruits, nuts, flowers; are usually deciduous, so don’t photosynthesize in winter months. Coniferous trees – have needle or scalelike leaves; bear seeds inside woody cones; are usually evergreen.
10. Broadleaf – hardwood. Coniferous – softwood.
11. Seed reproduction and vegetative reproduction (sprouting, suckering or layering).

Basic Tree Biology¹

Introduction

Plants are complex organisms that differ greatly in structure. While studying plants, you may discover trees, shrubs, flowering herbs, mosses, lichens and ferns, all of which share some common characteristics.

A **tree** is usually the tallest organism in the ecosystem (usually greater than 20 feet at maturity) and usually has a single stem, which is also known as the trunk. **Shrubs**, on the other hand, generally have multiple stems and relatively short statures.

A tree is a long-lived species. Some species live 1,000 years or more, so they must be able to meet the most severe conditions for long periods of time, including cold and hot temperatures, high winds, drought, rain and fire.

Trees cannot move to a new location if they do not like where they are located, so they must be well adapted to their site in order to thrive. A variety of factors including climate, geology and topography (the shape of the land) determine the tree species found in an ecosystem.

Trees serve many useful purposes to humans such as providing food, shelter, clothing, fuel, clean air, clean water, shade and medicine. Trees also provide food and shelter for many other living organisms such as squirrels, woodpeckers, insects, fungi, lichens and other plants.

Fun Facts

- Oregon's most common tree is the Douglas-fir, which is also the state tree. West of the Cascades, if you looked at any evergreen tree and guessed it to be a Douglas-fir, you would be right eight out of 10 times.
- The largest tree in Oregon is a 329-foot-tall Douglas-fir located in Coos County's Brummet Creek. It is taller than a 28-story building!
- Oregon's oldest known living tree is a Douglas-fir called "Grandma Tree," located in the Coos County Coast Range and estimated to be about 1,100 years old.

¹ Source: *Exploration of Oregon Forests: Module 2 – Tree Biology*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

Tree Structures and Their Functions

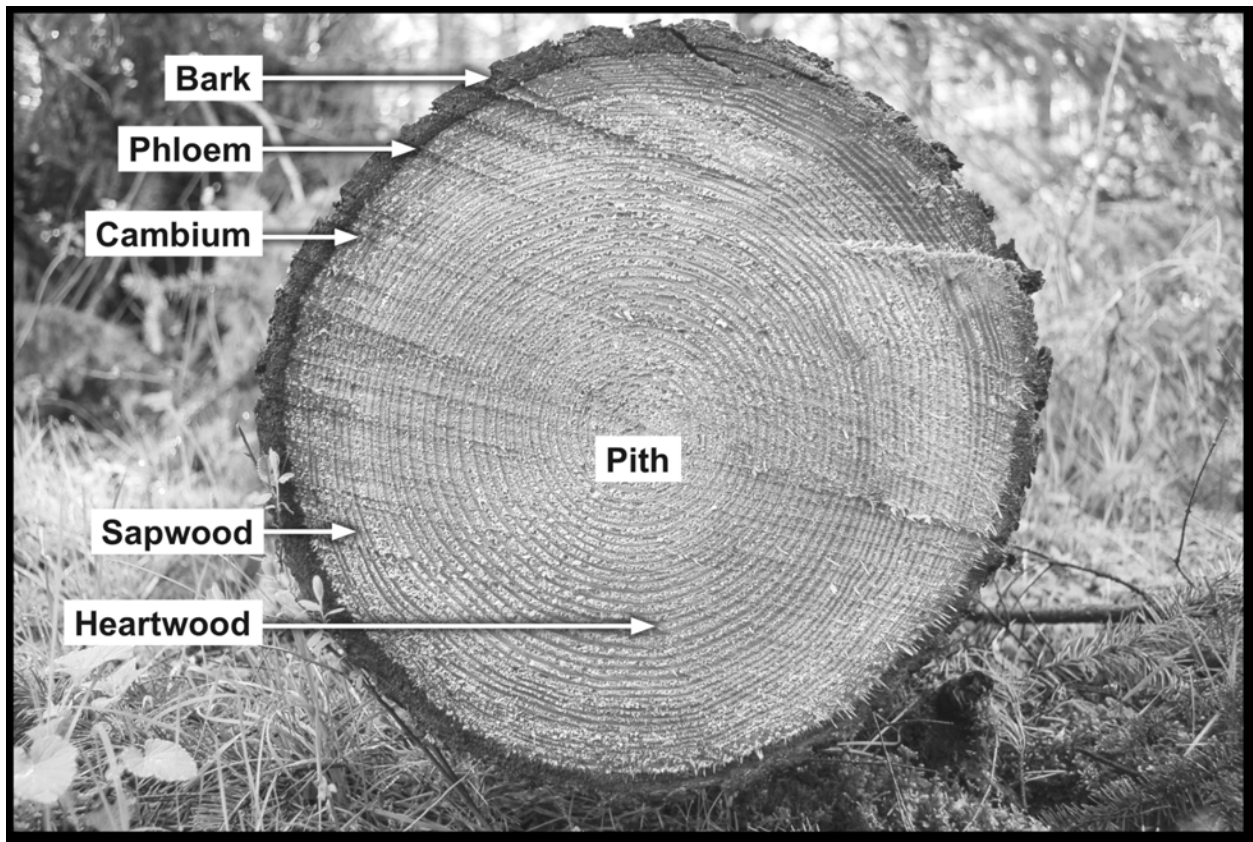
Trees have specialized parts that enable them to meet their basic needs. Following are a few of these parts:

- **Leaves.** Leaves capture sunlight and produce food in a process called photosynthesis. They are an important component of the tree's transport system, releasing water to the air and drawing in carbon dioxide.
- **Branches.** Branches support the leaves and extend them into sunlit areas. They transport water and nutrients to leaves, and nutrients from leaves to the rest of the tree.
- **Stem.** The stem, or trunk, holds the tree's branches high above competing vegetation, and transports food and water.
- **Woody roots.** Woody roots secure the tree to the soil and transport water and nutrients.
- **Fine roots.** Fine roots are responsible for much of the tree's uptake of water and nutrients.

A tree's stem, or trunk, also contains several layers, each of which serves a different function. Moving from the outside of the trunk toward the inside, you will find these layers:

- **Bark.** Bark provides the outer covering of a tree, which can be very thick (Douglas-fir) or thin (western hemlock). Bark protects against fire, disease, extreme temperatures and mechanical damage.
- **Phloem.** Phloem is a layer of living tissue just inside the protective outer bark. Phloem serves as the primary mechanism by which food is transported within the tree, and it is a favorite treat for bears in the spring.
- **Cambium.** Cambium is composed of living cells that actively divide and result in diameter growth. Cells on the outside of the cambium become phloem, while those on the inside become xylem.
- **Sapwood (xylem).** Sapwood, or xylem, is recently formed cells capable of water transport. They serve as the primary mechanism by which water and nutrients are moved from the roots to the leaves.
- **Heartwood (xylem).** Heartwood, also a form of xylem, is the nonfunctioning wood cells that used to be sapwood. They no longer transport water but still provide support. They may have a distinctive color and enhanced decay resistance depending on species and age. The heartwood is the part that shows annual rings. These are produced when the sapwood cells grow rapidly in the spring and are followed by the slower-growing, denser cells of summerwood. The main function of heartwood is to support the tree.

- **Pith.** Pith is found in the center core of the tree trunk and is made of air-filled cells with a distinctive dark color. The pith is a remnant of the first year's growth in the tree, and its main function is to store nutrients.



Cross-section of a tree's trunk.

Leaf Functions

Leaves release oxygen into the atmosphere through small holes called stomata, which are usually located on the underside of the leaf. They can open and close to control movement of water and air. When they are open, water vapor escapes and carbon dioxide (CO₂) can enter the leaf. If there is a drought or high summer temperatures, the tree may close its stomata to conserve water. A lack of carbon in the leaf then limits photosynthesis. Drought-adapted species have found ways to keep stomata open even when water in the soil is limited.

Photosynthesis

Photosynthesis is a natural process by which green trees and plants use energy from the sun to transform water, carbon dioxide and minerals into organic compounds for their growth.

Photosynthesis begins when green plants absorb water through roots and carry it to needles or leaves. At the same time, needles and leaves absorb carbon dioxide from the air. The carbon

dioxide then flows to plant cells called chloroplasts, which contain chlorophyll. Chlorophyll uses sunlight as energy to transform carbon dioxide and water into oxygen and carbon-based compounds such as glucose (sugar). These carbon-based compounds provide energy as well as the building blocks for growth and tissue repair. As the plant grows, it releases oxygen into the atmosphere.

The elements needed for photosynthesis to take place:

- Sunlight
- Carbon dioxide (CO₂)
- Nutrient-rich water from the soil

Photosynthesis produces sugars, which are needed for many things. Since it can only produce a limited amount of food, a tree must budget the sugars created through photosynthesis to satisfy the following priorities:

- Root growth
- Reproduction (flowers, cones, etc.)
- Growth so the tree can compete with other vegetation for light and maintain strength
- Food storage to help with spring growth and maintain the tree when photosynthesis is not possible
- Defensive compounds, which protect the tree against insects, rot and disease. If a tree is weak and not producing enough sugars, then it is more likely to be a target for disease-causing germs, or pathogens.

If sunlight, CO₂, water or nutrients are limited, then photosynthesis is reduced and not as much food is produced.

Tree Growth

Trees grow both in height and diameter. We call this primary growth and secondary growth, respectively. Primary growth starts at the top, or tip, of the tree and branches. Primary growth results in more leaf area, height and increased access to sunlight. Secondary growth increases the diameter of the stem or trunk, branches and roots. Secondary growth provides support to increase the numbers of leaves or needles.

Root growth and shoot growth occur at different times of the year. In the Pacific Northwest, we plant trees in the winter because this is when they are most fully dormant and least likely to become stressed by transplanting.

Trees respond directly to light, water, nutrients, humidity, temperature and other physical factors in the ecosystem. When these conditions are sufficient for a particular species, tree height and diameter may significantly increase with age. Drought, severe heat, early frost and other physical stresses, as well as interactions with other organisms, can slow tree growth. Each year, a tree increases in diameter as the cambium divides and a ring of xylem cells is laid down.

Close examination of a tree's cross-section reveals that each ring is made of two bands. The first band is a lighter-colored area of large, thin-walled cells (springwood). The second band is a darker-colored area of small, dense, heavy-walled cells (summerwood). By counting these rings outward from the center, it is possible to determine the age of a tree. In the tropical regions of the world, there is not a definite growing season. Therefore, determining the age of a tropical tree is more difficult.

Annual rings result from defined seasons of growth and dormancy. Most trees in North America have annual rings. Annual rings vary in width, and the width of tree rings tells the story of the growth conditions of a tree. Wider rings usually indicate a fast growth rate. If a tree is stressed by less-than-optimal conditions in its environment, tree rings are often narrow.

Fun Fact

Dendrochronology is the study of growth rings. Using dendrochronology, a scientist can estimate climate variation and other past events through the comparison of successive annual growth rings. Tree ring analysis provides insights into a variety of abiotic and biotic factors such as climate, disease, disturbance, management activity, competition and forest productivity. Using this information in conjunction with observations from the rest of the ecosystem, researchers can hypothesize about the causes of changes in tree growth.

Broadleaf vs. Conifer

Trees are generally classified as either broadleaf (or deciduous) trees or conifers.

Broadleaf trees usually have wide, flat leaves and bear seeds inside fruits, nuts or flowers. Most broadleaf trees are deciduous – that is, they drop their leaves in winter – but a few are evergreen. All broadleaf trees are referred to as hardwoods because their wood generally is harder than that of conifers. That's because, unlike conifers, they don't photosynthesize in the winter months. A few, however, such as cottonwoods and balsa, have very soft wood.

Conifers have needlelike or scalelike leaves and usually bear seeds inside woody cones. Conifers are often called evergreens because most hold their leaves all year long. There are, however, some deciduous conifers, such as the larch, that drop their leaves in winter. All conifers are also called softwoods because their wood is relatively soft when compared with that of broadleaf (hardwood) trees.

Tree Reproduction

There are two processes by which trees reproduce: seed reproduction and vegetative reproduction (sprouting, suckering and layering). Broadleaf trees usually sprout profusely from cut stems, or by sending up shoots from underground roots (suckering), or when lower branches of a tree touch the ground and the branch tips become covered and eventually a new tree grows from the branch tips (layering).

Conifer trees typically reproduce by seed production. For example, pine seeds are produced on the scales of the carpellate (female) cones. In the spring, the pine produces clusters of staminate pollen-bearing cones, or strobili. Upon ripening, they disperse their pollen and fall to the ground. Female cones are produced on the tree at about the same time, and are usually greater in number and located on the outside of the crown. Once the female cones have been pollinated, they grow rapidly with developing seeds. Most pines require two years for the seeds to mature. At that time, the cone dries out, the scales open up, and the winged seeds are dispersed (usually by wind). In general, about 85 percent of the seeds fall within 125 feet of the parent tree.

Summary

A tree is the tallest organism in the ecosystem and usually has a single stem, which is also known as the trunk. Shrubs, on the other hand, generally have multiple stems and are relatively short. A tree is a long-lived species that must be well adapted to its site in order to prosper. Trees serve many useful purposes such as providing food, shelter, clothing, fuel and medicine.

Through the use of specialized parts, a tree provides itself with its basic biological requirements. The following are a few of these parts: leaves, branches, the stem, woody roots and fine roots. A tree cross-section highlights additional specialized parts of a tree: bark, cambium, phloem, xylem and heartwood.

Trees can actually clean water by absorbing contaminated water through their roots and releasing clean water through their leaves. In addition, leaves release oxygen into the atmosphere through small vapor holes called stomata, which are located on the undersides of

leaves. They open and close to control movement of water and air. Chlorophyll in leaves converts sunlight to energy that plants use to produce food. This process is known as photosynthesis.

Trees grow both in height (primary growth) and diameter (secondary growth). Root and shoot growth occurs at different times of the year. Trees respond directly to light, water, nutrients, humidity, temperature and other physical factors in the ecosystem. Annual rings are created by defined seasons of growth and dormancy. Most trees in North America have annual rings. Tropical trees generally do not have annual rings, because there is no dormant season.

Trees can be divided into two main categories: broadleaf and conifer. Broadleaf trees are often referred to as hardwoods, because their wood is generally harder than conifers (softwoods). Broadleaf trees reproduce by seeds inside fruits, nuts or flowers, and typically drop their leaves in winter. Conifers reproduce with seeds in woody cones and hold their needles all year long.

Tree Biology – Questions²

1. What's the difference between a tree and a shrub?
2. Name five specialized parts of a tree. Describe the function of each.
3. Name the different parts of a tree cross-section. Identify the function of each.
4. What special cells do leaves have? What exits and enters leaves through these cells?
5. Define photosynthesis and then draw a diagram of the process.
6. Explain the difference between primary and secondary growth.
7. During what months are root and shoot growth most active?
8. How does a tree increase in diameter?
9. List the characteristics of broadleaf trees and coniferous trees.

<u>Broadleaf</u>	<u>Coniferous</u>
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10. What types of wood do broadleaf and coniferous trees have?
11. What are the two methods by which trees reproduce?

² Source: *Exploration of Oregon Forests: Module 2 – Tree Biology*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

2: Forest Types in Oregon

Overview

Students examine different forest types found in Oregon, identifying and comparing the characteristics of the bioregions in which forests grow.

Time Considerations

Preparation: 15 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Explain how characteristics such as soil, elevation, temperature and precipitation determine what types of forest will grow where.
- Identify the factors that characterize at least two different forest types in Oregon.

Standards Connections

Oregon Science Standards

- HS.LS2.2. Ecosystems: Interactions, Energy, and Dynamics. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- Disciplinary Core Idea – HS.LS2.C. Ecosystem Dynamics, Functioning, and Resilience. 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.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.2 and 11-12.WHST.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
- Writing History, Science, and Technical Subjects – 9-10.WHST.7 and 11-12.WHST.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when

appropriate: synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Oregon Mathematics Standards

- Mathematical Practice – MP.2. Reason abstractly and quantitatively.
- Mathematical Practice – MP.4. Model with mathematics.
- Number and Quantity – HS.NQ.B. Attend to units of measurement needed to solve problems through quantitative reasoning and mathematical modeling.

Oregon Forest Literacy Plan Concepts

- 1.A.3. Many different forest types exist within a biome, typically named by their dominant tree species. Common forest types in Oregon include spruce-hemlock, Douglas-fir, ponderosa pine, mixed conifer, and juniper.
- 1.C.7. Oregon's regions vary in soil types, elevation, topography, temperature, wind and rainfall patterns. These variations create the different forest types and species composition that, together with disturbance histories, contribute to the region's biodiversity.

Materials

- [Forest Fact Break: Forest Types](#) video (2:09 minutes), available at learnforests.org
- Technology for showing video
- [Oregon's Forests](#) posters (one for each pair or small group), available to order at learnforests.org
- "Oregon Forests Compared" and "Oregon Forest Types" student pages

Background Information³

Oregon's forests are among the most diverse, productive and magnificent in the entire world. They range from the dry, scenic juniper and pine forests east of the Cascades to the wet, majestic old-growth Douglas-fir forests west of the Cascades; they blanket most of western Oregon and all the mountains of central and eastern Oregon. Although most of our forests are dominated by needle-leafed conifers, many species of hardwoods play important ecological roles. Many of the tree species that grow in our forests have their largest and oldest members here.

Although the percentage of Oregon occupied by forests hasn't changed much in the past 200 years, the structure, composition and distribution of our forests have changed dramatically. Most

³ Source: Adapted from "[Oregon's Diverse Forests](#)." Oregon Forest Resources Institute, oregonforests.org.

forests of the early 1800s have been removed by fire, logging and other disturbances—replaced by native trees but in different mixes than were present originally. Some old-growth forests remain, mostly in remote parts of public lands. Many valley forests have been lost to agricultural and urban development, although many communities now try to preserve remaining stands. Fire suppression that has accompanied settlement has also created many changes.

Given such change over time, much of modern forestry is directed at maintaining the health, diversity and productivity of Oregon’s forest while producing the wood, water, wildlife and recreation that society demands.

Key Vocabulary

bioregion

climate

ecology*

forest management*

forest type*

**included in Glossary*

Preparation

Make copies of the student page.

Procedure

1. Show *Forest Fact Break: Forest Types* video. This 2-minute video introduces the idea that different types of forests grow in different bioregions of Oregon.
2. Divide the class into pairs or small groups, giving each an *Oregon’s Forests* poster. Direct each group to use the poster to discuss and answer the questions on the “Oregon Forests Compared” student page.
3. Assign or have groups choose three different forest types from the map to explore the question: What causes different forests to thrive in different regions of Oregon? Using the “Oregon Forest Types” student page, have students compare and contrast the three forests in terms of their ecology, climate, precipitation and elevation.
4. Instruct groups to create graphs or other visuals comparing their two forests.
5. Ask groups to share their results with the class.

Assessment

Have students use their results as the basis for writing a paragraph that explains what causes different forests to thrive in different regions of Oregon.

Extension Idea

Conduct the activity “Mapping the World’s Forests” from Project Learning Tree’s [Global Connections: Forests of the World](#) secondary module, available from plt.org. In this activity, students examine a system for classifying the world’s forests that uses climate characteristics and vegetation types.

Oregon Forests Compared

Use the *Oregon's Forests* poster to answer the following questions:

1. Which forest type do you live in (or which is closest to your community)?
2. What patterns do you notice about the forest types in Oregon? Identify at least seven different patterns.
3. How does each of these patterns relate to what you understand about Oregon's geography?
4. What might cause these patterns?

Choose three different forest types shown on the *Oregon's Forests* poster. Using the information on the "Oregon Forest Types" student page, compare and contrast the three forest types.

	Forest Type 1:	Forest Type 2:	Forest Type 3:
Ecology			
Climate			
Elevation range			
Precipitation range			

Oregon Forest Types⁴

Douglas-Fir Forest

Ecology: Douglas-fir forests are the most extensive in Oregon; they're also the most important for timber production. Although Douglas-fir is the dominant forest tree west of the crest of the Cascades, it is also an important component of eastside forests.

West of the Cascades, Douglas-fir often forms vast, nearly pure stands, a result of both natural conditions and human management. Common associates include western hemlock (the climax species for much of this region), western redcedar, noble fir, bigleaf maple and red alder (the most common early successional species for most of this region).

East of the Cascades, common associates include incense-cedar, sugar pine, western white pine, ponderosa pine, grand fir, white fir and western larch, depending on moisture and stand history. Understories vary from dense to sparse depending on the availability of moisture, but are generally rich in shrubs and herbs. Douglas-fir is a long-lived, early- to mid-successional species. This means it can colonize recently disturbed sites, and continue to dominate them for hundreds of years.

Climate: Douglas-fir forests grow under a wide variety of conditions. The climate of westside Douglas-fir forests range from wet and mild in the north to drier and warmer in the south. Eastside Douglas-fir forests are drier than those of southwestern Oregon and have more extreme temperature fluctuations, both daily and seasonally.

Elevation: Douglas-fir forests can range from sea level up to 5,000 feet in elevation.

Precipitation: The climate of Douglas-fir forests is varied; therefore, the precipitation range varies from a minimum of 35 inches to more than 160 inches of rain in the Coast Range.

⁴ Source: Forest type information adapted from "[Forests of Oregon](http://www.cof.orst.edu)," Oregon State University, College of Forestry. www.cof.orst.edu. Site inactive January 2022.

Hardwood Forest

Ecology: Oregon has many species of broadleaf trees (hardwoods), but generally they occur as individuals and in small stands, rather than in expansive forests as they do in the eastern United States. As a result, hardwood forests in Oregon are not uniform, but vary by location, environment and stand history.

Oak-dominated woodlands are the principal hardwood type in Oregon, and they once spread across the Willamette, Umpqua and Rogue River valleys. Oregon white oak is the principal species in the north, and is joined by California black oak and canyon live oak farther south. Other common species include Pacific madrone and bigleaf maple. Historically these occurred as open woodlands, but with decades of fire suppression many stands have been invaded by more shade-tolerant conifers like Douglas-fir and incense-cedar. When this happens, the conifers commonly outgrow and shade-out the oaks.

Oregon ash, red alder, bigleaf maple and black cottonwood are common throughout much of Oregon. Along the southern coast, Oregon-myrtle and golden chinkapin join the mix.

East of the Cascades, birches, willows and cottonwoods are common. Oregon ash commonly dominates bottomlands where water stands during the winter, while cottonwoods prefer gravelly stream banks where water drains more effectively. Oregon's riparian forests are getting more attention as their vital contributions to water quality and fish habitat are better understood.

Climate: The climates in which hardwood forests occur vary dramatically, from the wet, mild weather of northwestern Oregon to the warmer, drier weather of southwestern Oregon to the highly variable seasonality of eastern Oregon. Different species of hardwoods are adapted to different environmental conditions.

Elevation: Each hardwood species has a range of elevation it is native to. Oregon white oak is usually found at lower elevations in the interior valleys. It grows from sea level to 3,800 feet in the north and at elevations of up to 7,500 feet at the southern end of its range.

Precipitation: Hardwood forests and species are found from climate areas with less than 10 inches of precipitation in the high desert areas of Oregon, to areas with more than 160 inches of precipitation.

Klamath Mixed Conifer Forest

Ecology: The Siskiyou and Cascade mountains of southwestern Oregon are occupied by a complex mix of forest types. Forests near the coast are dominated by conifers in the upper portion of the overstory and hardwoods in the lower portion of the overstory, while forests nearer the Cascades are dominated by conifers, with fewer hardwoods. There are relatively few pure stands of any single species. Because conifers are the commercially important species, these forests are often lumped together as “mixed conifer” forests.

Elevation, distance from the ocean, fire history and past management practices all influence these forests. Near the coast, Douglas-fir and tanoak are the most important species. Golden chinkapin, Pacific madrone and canyon live oak are secondary hardwoods, while sugar pine, ponderosa pine and incense-cedar are secondary conifers. Port-Orford-cedar and bigleaf maple occur on moist sites, while Jeffrey pine is common on serpentine soils (high in magnesium). With increasing elevation, hardwoods become less common, and grand fir and white fir join the mix of conifers. Near the Cascades, forests are dominated by mixed stands of Douglas-fir, ponderosa pine, sugar pine, incense-cedar and white fir. This is the northernmost extension of the mixed conifer forests that dominate the Sierra Nevada Mountains of California. Throughout the mixed conifer forests, understories are sparse and shrubby with lots of poison oak.

Climate: Climates range from cool and moist near the coast to hot and dry in the interior. Complex topography creates a variety of microclimates that support such diverse forests.

Elevation: The geography of mixed conifer forests is diverse, and elevation ranges from 450 to 6,000 feet.

Precipitation: The average precipitation ranges from 15 to 80 inches, depending on the elevation and microclimate.

Lodgepole Pine Forest

Ecology: Pure and nearly pure stands of lodgepole pine are found throughout central and eastern Oregon. Lodgepole pine is a pioneer species that rapidly colonizes disturbed sites and often gives way to more shade-tolerant species like ponderosa pine. Most lodgepole pine stands develop after fire or logging; however, they may form climax forests on sites with deep pumice and volcanic ash.

Lodgepole pine forests grow in dense stands with lots of dead trees. They are very susceptible to insect attacks, especially mountain pine beetles, and are frequently in danger from fire.

Climate: Lodgepole pine is an adaptable species that often flourishes where other trees cannot. Lodgepole forests are found in climates with short, dry summers and snowy winters. They commonly occur in frost pockets and on both excessively wet and dry soils.

Elevation: Lodgepole pines will grow from sea level to 11,000 feet elevation. The lodgepole pine forests in Eastern Oregon are generally below 6,000 feet.

Precipitation: Precipitation levels range from less than 10 inches up to possibly 35 inches, with some variability.

Ponderosa Pine Forest

Ecology: Ponderosa pine forests are widely distributed in eastern Oregon, ranging in elevation from 2,500 to 6,000 feet. Ponderosa pine occurs in pure stands or may be mixed with lodgepole pine, grand fir, Douglas-fir, western larch, western white pine, incense-cedar, white fir and quaking aspen. Volcanic pumice soils often support pure stands of ponderosa pine. Ponderosa pine is also an important component of the mixed conifer forests of southwestern Oregon, but does not form pure stands there. The Willamette Valley of western Oregon also supports a native population of ponderosa pine.

Climate: Ponderosa pine forests are the second-driest forests in Oregon; they thrive in climates with short, dry summers and cold, snowy winters. The range of these forests is closely tied to soil moisture.

Elevation: Ponderosa pines will grow from sea level to about 9,000 feet.

Precipitation: Ponderosa pines thrive in the dry climates of the high desert, ranging from less than 10 inches to around 35 inches of precipitation.

Sitka Spruce/Western Hemlock Forest

Ecology: Forests dominated by western hemlock and Sitka spruce hug the fog belt along the Oregon coast, seldom reaching more than a few miles inland or a few hundred feet above sea level. Both species are shade-tolerant, but Sitka spruce is more resistant to salt spray. Sitka spruce sometimes grows in pure stands but is more commonly mixed with western hemlock,

western redcedar, Douglas-fir, red alder and lodgepole pine (commonly called shore pine along the coast).

Near the California border, Port-Orford-cedar, Oregon-myrtle (also called California-laurel) and coast redwood join the mix. The understory is typically dense with shrubs, ferns, herbs and epiphytes. Hemlock and spruce seedlings often establish on rotting tree logs called “nurse logs.” Straight lines of trees originally established on the same log are commonly seen.

Climate: The climate of this zone is wet and mild. Frequent and dense summer fog helps limit the evaporative power of the sun, while “fog drip” that condenses on tree crowns adds to soil moisture.

Elevation: This forest starts near sea level and extends up to approximately 2,000 feet.

Precipitation: Being located near the coastline, western hemlock and Sitka spruce forest precipitation is high, ranging from 65 to 165 inches.

Subalpine Fir Forest

Ecology: Subalpine forests are a combination of several forest types, all occurring above 4,500 feet in the Cascade, Siskiyou and Wallowa mountains. These forests vary widely depending on stand age, fire history and local conditions. Common trees include Pacific silver fir, California red fir, noble fir, white fir, subalpine fir, western hemlock, mountain hemlock, Douglas-fir, Alaska-cedar, incense-cedar, lodgepole pine, western white pine, Engelmann spruce and quaking aspen. Many species of huckleberries occur in the understory.

Climate: These forests occur in cold climates with heavy winter snowpacks and short growing seasons. At their upper limit, they form open park-like forests and merge with alpine meadows.

Elevation: These forests start at 4,500 feet and extend up to the end of forest zones on the alpine level.

Precipitation: These forests are covered in snow for several months. Precipitation is usually over 100 inches per year.

Western Juniper Forest

Ecology: Western juniper “forests” are the driest forests in the Pacific Northwest. In Oregon they’re found primarily east of the Cascades, although they also grow on hot, dry, low-elevation sites in southwestern Oregon. Due to intense competition for water and an extreme aversion to shade, western junipers grow in open, park-like stands. The widely spaced juniper trees are typically surrounded by big sagebrush, bitterbrush and grasses.

Juniper trees grow on rocky outcrops in eastern Oregon. Ponderosa pines often occupy canyons and moist, north-facing slopes within these forests. Western junipers also occupy shallow-soil areas within other eastside forest types. Prior to European settlement and fire suppression, western juniper forests were primarily limited to shallow soils and rimrock, where vegetation was too sparse to carry fire. Fire suppression has permitted western juniper to expand rapidly into traditional rangeland, where it competes with native grasses for water and nutrients.

Climate: Western juniper forests are found in climates with hot, dry summers and cold, dry winters. Most precipitation falls during the winter.

Elevation: Western junipers can grow from 500 to over 10,000 feet in elevation. Most of the forests are found in the high desert areas of Oregon.

Precipitation: The western juniper tree is a large consumer of water, but often grows in areas with precipitation of less than 30 inches per year.

Western Larch Forest

Ecology: The western larch, one of the world’s few deciduous conifers, is noted for its brilliant golden autumn colors. Rather than forming extensive forests, stands of western larch commonly develop within Douglas-fir, grand fir and ponderosa pine forests following fire or major disturbance from wind, soil movement or logging. Without periodic disturbance, larch stands will eventually be taken over by Douglas-fir on drier sites or grand fir on milder sites. Lodgepole pine, western hemlock, western white pine and Engelmann spruce also occur in this forest type.

Climate: Western larch prefers cool, moist sites and depends on frequent disturbance.

Elevation: Western larch grows primarily on the east side, at elevations up to 6,000 feet.

Precipitation: The climates of western larch forests vary and depend on location in Eastern Oregon. Precipitation ranges from 15 to 65 inches per year.

Urban Forest

Ecology: By definition, urban forests occur near or within urban boundaries. Although they sometimes include remnant stands of native forests, more often they're a mix of native and introduced trees that have been planted along streets and in parks for recreational and landscaping purposes. Without careful tending urban forests would perish, or be overrun by native forests. As communities grow in area and population, urban forests will play an increasingly significant role in the lives of Oregonians.

Climate: With appropriate care, urban forests can be maintained in almost any climate. Rather than being a product of the climate in which they occur, they are often valued for the climate they help create. Their canopies reduce air pollution, filter rainwater and create shade that cools city temperatures.

Elevation: The elevation of urban forests varies by each area. Many are close to sea level or just a few hundred feet above sea level.

Precipitation: Most urban areas within the Willamette Valley have precipitation of 35 to 65 inches per year on average.

3: Tree Identification and Survey

Overview

Students identify the genus of trees around their school, recording both the variety and abundance of the trees they find. Note: This lesson should be conducted when deciduous trees have their leaves.

Time Considerations

Preparation: 15 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Use a dichotomous key to identify different tree genera.
- Conduct a tree survey of their school grounds (or other location) and identify the genus of each tree.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS1.A. Structure and Function. Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- Science and Engineering Practice – Analyzing and Interpreting Data. Analyze data using tools, technologies and/or models in order to make valid and reliable claims or determine an optimal design solution.

Oregon Forest Literacy Plan Concepts

- 1.A.1. A forest is an ecosystem dominated by trees, and includes a variety of other organisms. The trees in a forest may differ in species, age and size.

Materials

- Access to “[Common Trees of the Pacific Northwest](#)” on the Oregon State University website, oregonstate.edu (or hard copies of *Trees to Know in Oregon* by Edward C. Jensen)
- “[Trees of Oregon's Forests](#)” tree guide, available at oregonforests.org
- Sample tree branchlet for demonstrating a dichotomous key
- Map or aerial photograph of your school grounds or other survey location (from Google Earth or other source)
- “Tree Survey” student page
- Journals, electronic tablets or smartphones
- Internet access
- Optional: labels for tagging trees

Background Information

Oregon is home to a wide range of trees, including 30 native coniferous species and 37 native species of broadleaf trees. Oregon varies greatly in terms of elevation, temperature, wind, rainfall and soil composition. Combinations of all these factors help determine the dominant tree species of an area.

Using a dichotomous key that centers on leaf shape and form, students can find out the genus or species of the trees they see around them. A dichotomous key is a tool that allows the user to determine the identity of items in the natural world, such as trees, wildflowers, mammals, reptiles, rocks and fish. The key consists of a series of choices that lead the user to the correct name of a given item. “Dichotomous” means “divided into two parts.” Therefore, dichotomous keys always give two choices in each step.

A genus is a group of organisms, in this case trees, that are closely related and share similar characteristics. For example, all trees in the pine genus (*Pinus*) have long, narrow needles bound in bundles and hard, woody cones with thick, tough scales. “Genera” is the plural term for more than one genus.

All plants have two types of names: a common name and a scientific name. Common names are written in English (or in German if you’re in Germany, or in French if you’re in France), but scientific names are always written in Latin, so they can be used anywhere in the world. Scientific names are always italicized or underlined.

Example:

Common name = sugar pine

Scientific name = *Pinus lambertiana* or Pinus lambertiana

The genus name refers to the general type of tree (e.g. “pine” or *Pinus*), while the species name refers to the specific type of pine (e.g. “sugar” or *lambertiana*). An organism’s scientific name includes the genus followed by the particular species name.

Key Vocabulary

common name

dichotomous key

genus

scientific name

Preparation

- Gather a sample branchlet from a tree on your school campus.
- Make copies of the student page.

Procedure

1. Introduce the lesson by asking students how they might go about determining what trees are present on the school grounds or other study site.
2. Using a sample branchlet from one of the trees, demonstrate using the “Common Trees of the Pacific Northwest” dichotomous key to determine the tree genus (and, possibly, species).
3. Show students the map or photograph of the study site. On the map, number each tree pictured.
4. At the study site, have students find each tree shown on the map and, if you choose, tag it with a number that corresponds to the map. (Draw on the map any newly planted trees and cross out any trees that have been removed.)
5. As a class, decide how to divide up the area to be surveyed.
6. Give each pair or small group a “Tree Survey” student page and assign them an area to survey. They should identify each tree in that area and write a brief description of it. If you have electronic tablets or smartphones, students may use the dichotomous key to identify the trees on-site. Otherwise, have them draw pictures of the trees and close-up illustrations or rubbings of the leaves and bark to identify the trees later. In addition to the

“Common Trees of the Pacific Northwest,” they may use the “Trees of Oregon’s Forests” tree guide for information about the tree.

7. Upon completing the tree survey, have students present their most important findings and add their tree identification to the map key.

Assessment

Have students use the dichotomous key to identify two or more “mystery trees” included on the “Common Trees of the Pacific Northwest” site.

Extension Ideas

- Create a spreadsheet or other database for all the trees in the study area, with the genus and species as well as students’ descriptions of each tree. Students may also measure and include the diameter at breast height (DBH), height, basal area and board feet of each tree.
- Learn to identify the forest plant species listed for the FFA Forestry Career Development Event (CDE).
- Look for patterns in tree size by measuring and graphing the height and diameter of trees in the study site by species.

Tree Survey

Tree Number	Tree Identification	Tree Characteristics

4: Measuring Trees

Overview

Students practice measuring tree diameter at breast height (DBH) and tree height.

Time Considerations

Preparation: 15 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Describe why measuring trees is important to forest managers.
- Determine the diameter of a tree using one or more methods.
- Estimate the height of a tree.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS1.A. Structure and Function. Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- Science and Engineering Practices – Planning and Carrying Out Investigations. Select appropriate tools to collect, record, analyze, and evaluate data.

Oregon Mathematics Standards

- Number and Quantity – HS.NQ.B.3. Use reasoning to choose and interpret measurement units consistently in formulas, graphs, and data displays, as a way to understand problems and to guide the solution of multi-step problems.

Oregon Forest Literacy Plan Concepts

- 1.A.1. A forest is an ecosystem dominated by trees, and includes a variety of other organisms. The trees in a forest may differ in species, age and size.
- 1.B.1. A tree is a woody perennial plant, usually more than 12 feet (4 meters) tall at maturity, with a single main stem and a more or less distinct crown of leaves or needles.

Materials

- Woodland stick (available from Oregon State University's [Forestry & Natural Resources Extension Program](http://forestry.oregonstate.edu) at forestry.oregonstate.edu)
- String
- Measuring tape or ruler
- “Measuring Trees” student page
- Diameter tape (optional)
- Lab notebooks (optional)

Background Information

See the “Measuring Trees” student page for information about measuring trees. Depending on the materials you have available for measuring, decide which methods your students will use to measure tree diameter and height.

Key Vocabulary

Biltmore stick (or woodland stick)

calipers

clinometer

diameter at breast height (DBH)*

diameter tape

**included in Glossary*

Preparation

Make copies of the student page or provide on-screen access to it.

Procedure

1. Ask students, “If you were a forester, what are some things you might like to know before making decisions about trees?”
2. Using information from the student page, explain why tree diameter and tree height are important measurements. Demonstrate how to use the woodland stick (or other tools available) to take these measurements.
3. Divide the class into pairs or small groups, and give each a copy of the student page or provide on-screen access to it.
4. Direct students to practice measuring the diameter and height of trees on your school grounds or other site. If you do not have suitable trees to measure, students may practice with utility poles or field lights. They may record their measurements in their lab notebooks.

Assessment

Ask students to write (in their own words) a set of pointers for measuring tree height and diameter.

Extension Ideas

- Have students calculate tree volumes from tree height and diameter. See the bulletin [Measuring Your Trees](https://catalog.extension.oregonstate.edu) by Steve Bowers (available at catalog.extension.oregonstate.edu) for details. If possible, consider inviting a forester to explain how and why forest landowners calculate tree volume.
- Determine board foot volume by using the FFA Forestry Career Development Event sheets “Bd Feet Volume Estimation Worksheet” and “Doyle Log Rule” (on pages 13 and 14 of [Forestry CDE Handbook, 2017-2021](https://www.ffa.org/forestry-cde-handbook), available at [ffa.org](https://www.ffa.org)).
- Calculate the value of the trees measured in the lesson using the website treebenefits.com.
- Use a relascope to measure tree height, tree diameter and basal area. A relascope is a multi-use instrument for inventorying trees. Basal area is the area of a cross-section of a tree trunk at its base. Foresters use basal area to describe the area of land occupied by tree trunks, and it is generally expressed as square feet per acre (or square meters per hectare).
- Use a clinometer to measure tree height as described in the following box. Basically, by measuring the angle between you and the tree’s top, a clinometer lets you estimate the tree’s height. The bigger the angle is, the taller the tree.

Measuring Tree Height with a Clinometer

1. You must first know the horizontal distance from the tree to where you are standing. It doesn't matter what this distance is, as long as you know it.
2. Looking at the top of the tree with one eye and through the clinometer with the other eye, line up the marker in the clinometer with the top of the tree. Read the value on the percent scale.
3. Repeat step 2 for the bottom of the tree.
4. Subtract your top measurement from your bottom measurement. If the bottom is a negative, then add the two numbers.
5. Convert the percent to a decimal number and multiply by the horizontal distance between you and the tree. You now have the tree's height.

Formula

Tree height = (top of tree reading – bottom of tree reading) x distance from tree in feet

Example

Measurements:

- Distance from tree = 100 feet
- Top of tree reading = +90%
- Bottom of tree reading = -5%

Since the bottom reading is negative, you add the two tree readings.

Calculation:

Tree height = (90% + 5%) x 100 feet = 0.95 x 100 feet = 95 feet

Measuring Trees

One of the most important things foresters need to know about trees is their size. Knowing trees' diameter and height enables foresters to monitor tree growth, calculate tree volume in a given forest area, and make informed management decisions. Foresters often use tree measurements to estimate the amount of marketable timber that could be harvested from a forest stand – a process that is called timber cruising.

The diameter is the distance from one side of a circle, passing through the center, to the other side. A tree's diameter is basically the width of its trunk. A tree's height is how tall it is from the ground to its very top.

Determining Tree Diameter

Because tree trunks can be wider or narrower at the base, foresters measure tree diameter at a standard height above ground level. Known as “diameter at breast height,” or DBH, this measurement is taken at a height of four and a half feet above ground level. If the tree is on a slope, it is measured on the uphill side of the tree.

When foresters need an accurate DBH measurement, they may use calipers or a special diameter tape that, when placed around the tree, shows the conversion of tree circumference to diameter. Following are two different methods you can use to measure diameter.

Woodland Stick Method

A convenient way to measure the diameter is with a special stick, called a woodland stick or Biltmore stick, which contains built-in formulas for measuring diameter. While not the most accurate method, it does provide a good, quick estimate.

1. To use the woodland stick, hold it against the tree 4.5 feet above the ground. Stand so that your eye is 25 inches from the stick.
2. Without moving your head, line up the zero end of the stick with one edge of the tree, then read the tree's diameter at the other edge of the tree using the scale printed on the stick.

String Method

Another way to measure the diameter involves string and a tape measure or ruler. For this method, you first find the tree's circumference (the distance around the trunk).

1. Take the string and wrap it around the tree at 4.5 feet above the ground, making sure that the string stays level all the way around the tree.
2. Hold or mark the place where the string matches up with the beginning end of the string, then use a tape measure or ruler to determine the inches of circumference.
3. Divide this number by 3.14 (or π) to find the tree's diameter.

(Note: You may also measure the circumference directly using a tape measure. A diameter tape or D-tape measures circumference and reads it out as diameter.)

Determining Tree Height

It's surprisingly difficult to accurately measure the height of a tree, particularly when it is on a slope or surrounded by other trees or objects. The most accurate way involves climbing to the top of the tree and dropping a measuring tape to the ground. This method is used primarily by professional tree researchers or arborists, especially to measure the height of record-breaking trees. (Safety note: This method should be used only by experienced professionals with the relevant training and equipment. Do not attempt this method yourself!)

Professionals may also use laser rangefinders and other digital equipment to estimate tree height. A couple lower-tech options involve a woodland stick or a simple pencil.

Woodland Stick Method

The woodland stick or Biltmore stick contains lines and formulas for helping you determine tree height.

1. Using a woodland stick, position yourself 100 feet from the tree with your eye approximately level with the bottom of the tree.
2. Hold the stick 25 inches from your eye and align the bottom of the stick with the bottom of the tree.
3. Without moving the stick or your head, read the measurement that lines up with the top of the tree.

Pencil Method

An easy way to estimate tree height uses a pencil and a measuring tape.

1. Working with a partner, take a pencil and stand away from the tree.
2. Outstretch your arm and hold the pencil so that you can line it up with the trunk of the tree.
3. Close one eye and move the pencil until one end looks even with the top of the tree.
4. Place your thumb on the pencil where it matches the base of the tree.
5. Turn the pencil by 90 degrees, keeping your thumb in place.
6. Direct your partner to mark the place on the ground where it looks like the end of the pencil lies.
7. Use a measuring tape to measure the distance from that point to the tree. This is the approximate height of the tree.

INSIDE OREGON'S FORESTS

A high school forestry curriculum



ENVIRONMENTAL IMPORTANCE OF OREGON'S FORESTS

- 1: Forests and Drinking Water
- 2: Watershed Survey
- 3: Forests as Habitat
- 4: Habitat Edges
- 5: Forests and Carbon



Oregon Forest
Resources Institute

ENVIRONMENTAL IMPORTANCE OF OREGON'S FORESTS

1: 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

Oregon Science Standards

- Science and Engineering Practice – Analyzing and Interpreting Data. Evaluate the impact of new data on a working explanation and/or model of a proposed process or solution.

Oregon Mathematics Standards

- Mathematical Practice – MP.2. Reason abstractly and quantitatively.
- Mathematical Practice – MP.4. Model with mathematics.

Oregon Forest Literacy Plan Concepts

- 1.C.2. Forest ecosystems include processes such as photosynthesis, energy flow and the cycling of nutrients, water, carbon and other matter. Energy and matter are transferred between producers, consumers and decomposers.
- 2.A.1. Forests improve air and water quality, and help stabilize soil.
- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., 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
- Technology for showing video(s)
- Materials for each soil filtration model, one per group¹ (see Preparation below for details):
 - 2-liter plastic bottle
 - 6-oz can taller than wide
 - Stopwatch (or stopwatch app for smartphone or tablet)
 - Clear plastic cups or other containers
- Materials for soil filtration model, per class:
 - A variety of soil materials (for example, fine-grained sand, bark chips, topsoil, clay, mulch, dried leaves, pieces of sod)
 - Graduated cylinders
 - Utility knife
- “Soil Filtration Investigation” student page

Background Information²

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.

¹ Alternatively, you may use stream tables or runoff models. For larger models, adjust the size of can and water used accordingly.

² Source: [Forest Fact Sheet: Do Forests Affect Our Drinking Water?](#). Oregon Forest Resources Institute. learnforests.org. Accessed December 2022.

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.
 - Label each group's model with a unique number.
 - Place a collecting cup near the mouth to capture any runoff.
 - Fill the model with materials according to the Procedure below.

Procedure

1. To introduce the lesson, show students the brief 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=fully 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:
 - a. Which model had the highest and which the lowest percent runoff?
 - b. Which had the cleanest water?
 - c. Which model is most like a forest?
 - d. What does this investigation indicate about soils?
 - e. 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.

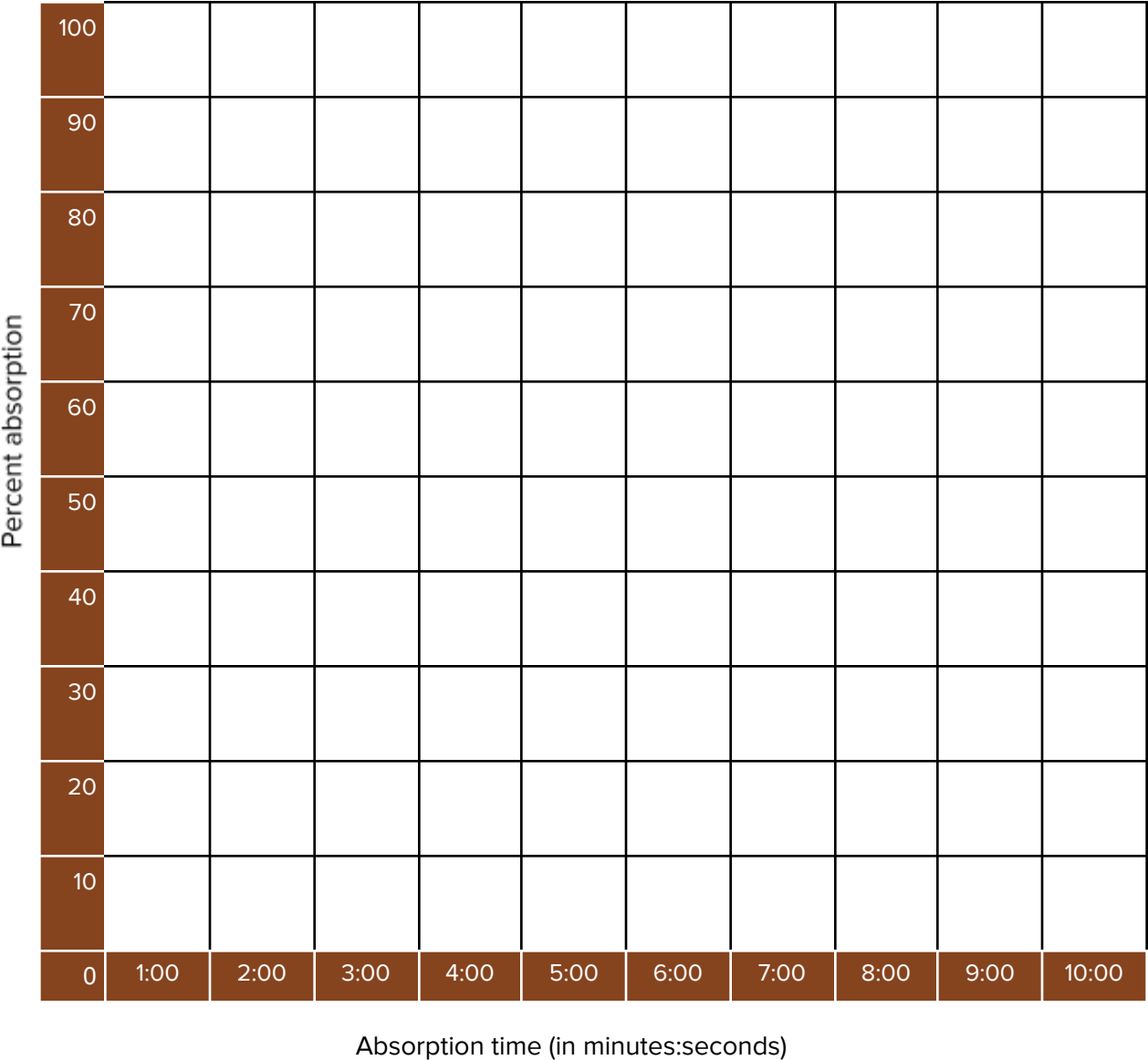
Model #	Soil Material	Water Added (in ml)	Amount of Runoff (in ml)	Percent Runoff	Percent Absorption	Absorption Time	Water Clarity (10=clear, 0=opaque)
<i>Example</i>	<i>Clay with leaf cover</i>	<i>150</i>	<i>85</i>	<i>57%</i>	<i>43%</i>	<i>4:25 minutes</i>	<i>6</i>

Percent Runoff = $\frac{\text{Water Added (in ml)} - \text{Amount of Runoff (in ml)}}{\text{Water Added (in ml)}} \times 100\%$

Percent Absorption = $100\% - \text{Percent Runoff}$

Percent Absorption Over Time

Plot the results of the experiment from all the models.



Water Clarity Over Time

Water clarity (10=clear, 1=opaque)	10										
	9										
	8										
	7										
	6										
	5										
	4										
	3										
	2										
	1										
	0	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00

Absorption time (in minutes:seconds)

What patterns do you notice?

2: Watershed Survey³

Overview

Students use mapping imagery to investigate the land use around waterways in their community or 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

Oregon Science Standards

- Science and Engineering Practice – Analyzing and Interpreting Data. Evaluate the impact of new data on a working explanation and/or model of a proposed process or solution.

Oregon Mathematics Standards

- Mathematical Practice – MP.2. Reason abstractly and quantitatively.
- Mathematical Practice – MP.4. Model with mathematics.

³ 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.

Oregon Forest Literacy Plan Concepts

- 1.C.2. Forest ecosystems include processes such as photosynthesis, energy flow and the cycling of nutrients, water, carbon and other matter. Energy and matter are transferred between producers, consumers and decomposers.
- 2.A.1. Forests improve air and water quality, and help stabilize soil.
- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., recreation and tourism).

Materials

- Remote mapping and imaging program (Google Earth or NASA's WorldWind – see Background Information below) ⁴
- Internet access
- “Online Watershed Survey” student page
- Blank paper

Background Information⁵

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 a 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.

Google Earth is available for free download at earth.google.com. NASA WorldWind is open-source software that can be downloaded for free at worldwind.arc.nasa.gov. Both provide high-resolution aerial and satellite imagery and include layers such as elevation, terrain and other features, but WorldWind requires more programming expertise.

⁴ 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.

⁵ Source: Adapted from “Impact of Land Use on Water Quality,” in *Watershed Evaluation* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

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 for them 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 impact 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:
 - a. What percentage of each type of land use did you find along the waterway?
 - b. 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 the river and document actual land uses and direct and indirect impacts. Compare findings to class predictions.

Online Watershed Survey⁶

- Using the mapping program, either follow the coordinates provided by your teacher or enter the name of the river you'll be studying.
- 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?
- 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.
- Draw the approximate shape of the watershed boundaries on a blank sheet of paper. Include the river in your drawing.
- Look for the following major land uses along the length of the river you're studying:
 - forest (F)
 - agricultural (A)
 - urban (U)
 - residential (R)
 - industrial (I)
 - disturbed (for example, clearcut, mine or new excavation) (D)
- 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.)
- 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.

⁶ Source: Adapted from "Impact of Land Use on Water Quality," in *Watershed Evaluation* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

- For each land use, predict the potential impacts on the water quality of the river by entering one of the following values in each cell. See below for a description of the different land uses identified in the table.

0 = no negative impact

2 = moderate impact

X = unable to determine

1 = minor impact

3 = major impact

Potential Impacts of Various Land Uses on Water Quality

	% of River	Heated Effluent	Volume Extraction	Solid Waste Dumping	Industrial Effluent	Increased Temperature	Stream Channelization	Fertilizer or Pesticide Runoff	Livestock Manure Runoff	Sediment Runoff
Forest										
Agricultural										
Urban										
Residential										
Industrial										
Disturbed										

Description of land uses (in 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 a 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 a 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 a river).
- Sediment Runoff – observed/inferred runoff from disturbed lands resulting in decreased clarity.

3: 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 signs.
- Inventory a study site for animal signs.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS2.C. Ecosystem Dynamics, Functioning, and Resilience. 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 – 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.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – 11-12.RST.7. Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

Oregon Forest Literacy Plan Concepts

- 1.B.5. As part of the forest ecosystem, trees have many roles (e.g., supplying oxygen, providing habitat and food, holding soil, moderating temperature, capturing and storing carbon, and cycling water and nutrients). They may have different roles at different life stages.
- 2.A.2. Forests provide habitat for fish and wildlife. Many species depend on forest habitats for their survival.

Materials

- [Forest Fact Break: Wildlife](#) video (1:31 minutes), available at learnforests.org
- [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
- Technology for showing video(s)
- [A Guide to Priority Plant and Animals Species in Oregon Forests](#) (for Preparation), available at oregonforests.org
- “Wildlife Signs” student page
- “Wildlife Inventory” student page
- Large master map or sketch of study site (see Preparation below)
- 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

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 the age of the forest 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 (see Preparation above), 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 another 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.
- Watch the OPB *Oregon Field Guide* special on wolves titled “[Living with America's Most Iconic Predator](#),” (available at watch.opb.org). Conduct a debate on the pros and cons of an increasing wolf population.
- Invite a member of one of Oregon’s 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 the following species. They are available from OFRI’s publication library at oregonforests.org/publications.
 - [American Beaver](#)
 - [Deer and Elk](#)
 - [Early Seral-Associated Songbirds](#)
 - [Fish Habitat and Passage](#)
 - [Fisher and Humboldt Marten](#)
 - [Stream-Associated Amphibians](#)

Students may also check out the [Wildlife in Managed Forests: Species Reference Series](#) for fact sheets about different forest wildlife species.

Possible Answers to “Wildlife in Oregon’s Forests – Questions” Fisher and Humboldt Marten 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.
8. Possibilities: deer mouse, striped skunk, common nighthawk, American goldfinch.
9. Marbled murrelet, red tree vole, Oregon slender salamander.

Wildlife in Oregon's Forests⁷

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.

⁷ 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 Short Course*.

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-age forests and some of the wildlife associated with them.

Young Open Stands

This condition occurs within a short time (two 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 the deer mouse, striped skunk, common nighthawk and American goldfinch.

Middle-Age 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 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 that 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 – Questions⁸

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 of 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.

⁸ Source: *Exploration of Oregon Forests: Module 6 – Woodland Wildlife*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

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 Inventory⁹

Inventory beginning time _____ a.m./p.m. Ending time _____ a.m./p.m.

Current temperature _____

Current weather (check all that apply):

- ☐ clear
- ☐ scattered clouds
- ☐ complete cloud cover
- ☐ rain

Wind:

- ☐ calm
- ☐ breezy
- ☐ gusty
- ☐ windy

⁹ Source: Data sheet adapted from “Schoolyard Biodiversity Wildlife Survey,” *Schoolyard Biodiversity Investigation Education Guide*, Association of Fish & Wildlife Agencies, 2011.

Wildlife Seen or Heard

Type	Species (if known)	Description of Animal's Activity (passing through, eating, hanging out, etc.)	Number Observed
Birds			
Mammals			
Reptiles or amphibians			
Invertebrates (insects, spiders, etc.)			
Other			

Signs of Wildlife

Sign	Species (if known)	Description (What does it look like? Where was it found? Other observations?)	Number Observed
Scat			
Tracks			
Feathers			
Fur			
Nests			
Chewed leaves, branches, etc.			
Other			

4: Habitat Edges¹⁰

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 between two 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

Oregon Science Standards

- HS.LS2.2. Ecosystems: Interactions, Energy, and Dynamics. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- Disciplinary Core Idea – HS.LS2.C. Ecosystem Dynamics, Functioning, and Resilience. 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 – Planning and Carrying Out Investigations. Plan and conduct an investigation individually and collaboratively to produce data to serve as the

¹⁰ 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.

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

- 1.C.6. Forests are interconnected with other terrestrial ecosystems (e.g., grasslands, meadows and agricultural lands) and aquatic ecosystems (e.g., estuaries, riparian areas and wetlands).
- 2.A.2. Forests provide habitat for fish and wildlife. Many species depend on forest habitats for their survival.

Materials

- A study site (see Preparation below)
- Optional: 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
 - Thermometers – to measure air temperature
 - Armored field thermometers – to measure soil temperature
 - Thermohygrometers – to measure relative humidity and air temperature
 - Light meters, or a light meter app for smartphones or tablets – to measure solar radiation
 - Digital anemometer, or a wind meter device and app for smartphones or tablets – to measure wind velocity
 - Compasses, or an app for smartphones or tablets – to measure wind direction
 - Measuring tape – to measure distances
- Data sheets (designed by students in Part 1)
- Measuring tape
- Flagging
- Optional: transect lines (ropes marked at one meter, five meters or another distance along their length)
- Graph paper (or access to a spreadsheet program for tables and graphs)

Background Information¹¹

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.

¹¹ Source: Adapted from “Edge Effect One,” in *Environmental Science I* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Key Vocabulary

dependent variable

edge effect

edge species

independent variable

transect

Preparation

Choose a study site that illustrates a distinct ecological edge between habitats and 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 timberland, 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’ve 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’ll 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’ll measure each variable in the field. All measurements should be in metric units.

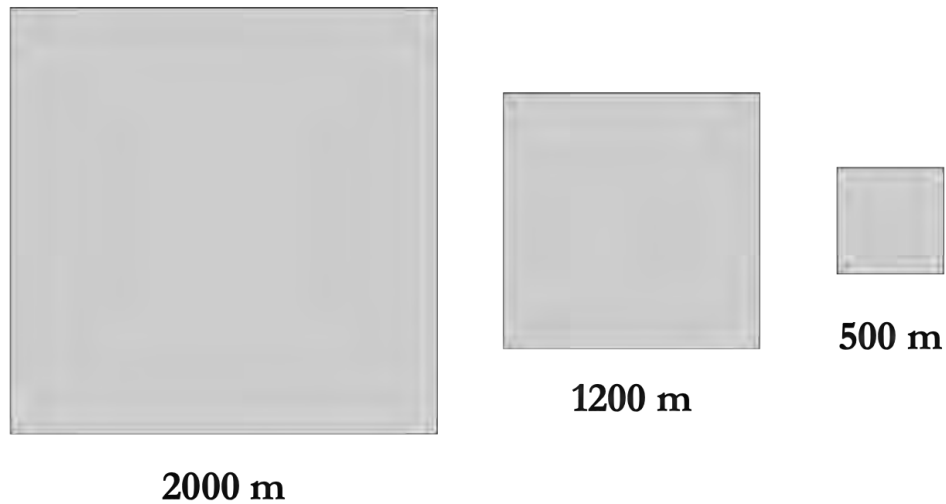
D. Data Sheet Design

You've decided what information your group will collect and how you'll 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’ve 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 the forested stands below, assume that each is surrounded by clearcuts, and the “edge effect” penetrates 200 meters into the interior forest. For each stand, calculate the total area of edge habitat and the percent of total area in edge.



7. What conclusions can you draw?
8. Overall, does the edge effect have a positive or negative influence on ecosystem health and stability? Explain.

5: 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 5: Climate Change and Oregon's Forests in the "Forest Management Issues" module.

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

Oregon Science Standards

- HS.LS2.5. Ecosystems: Interactions, Energy, and Dynamics. 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 – HS.LS2.B. Growth and Development of Organisms.
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 – 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

- 1.A.1. A forest is an ecosystem dominated by trees, and includes a variety of other organisms. The trees in a forest may differ in species, age and size.
- 2.A.3. Forests sequester carbon from the atmosphere and are an essential component of the global carbon cycle.
- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., 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](#)
- Technology for showing videos
- Copies of the [Tree Carbon Tape](#) (printed at actual size on 8½" x 11" paper), available at [learnforests.org](#)
- Scissors
- Glue, stapler or tape
- "Plant Food" student page
- "How Much Carbon?" student page
- "The Carbon Cycle Poster" student page (or print copies of [Where's All the Carbon?](#) posters from [learnforests.org](#))

Background Information¹²

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.

¹² Sources: "[Forests, Carbon and Climate Change](#)." Oregon Forest Resources Institute, [oregonforests.org](#).

"[Forest Fact Sheet: How Are Forests, Carbon and Climate Change Related?](#)" Oregon Forest Resources Institute, [learnforests.org](#).

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. While the chemical composition of wood varies from species to species and even from one part of a tree to another, wood is generally made up of approximately 50 percent carbon, 44 percent oxygen and 6 percent hydrogen, with trace amounts of metal ions.

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 U.S. 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.

Most of the carbon sequestered in a tree stays out of the atmosphere, even after the tree is harvested and the wood is used to build something. About half the dry weight of wood is carbon, which remains stored in wood products used to construct houses, apartments and office buildings, and helps offset carbon emissions that are contributing to climate change

To compare the amount of sequestered carbon to carbon from emissions, scientists use a term called carbon dioxide equivalent, or CO₂e. For any quantity and type of greenhouse gas, CO₂e signifies the amount of CO₂ that would have the equivalent global warming impact.

Key Vocabulary

carbohydrate

carbon cycle*

carbon sequestration*

global climate change*

photosynthesis*

**included in Glossary*

Preparation

- Make copies of student pages and the Tree Carbon Tape. (Instead of copying “The Carbon Cycle Poster” student page, you may choose to provide on-screen access to it. You may also order print copies of [Where’s All the Carbon?](http://learnforests.org/where-all-the-carbon/) posters from learnforests.org.)
- Find an outdoor area that has several trees for students to measure.

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.¹³)
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:



Where: CO₂ = carbon dioxide, H₂O = water, C₆H₁₂O₆ = glucose (sugar) and O₂ = 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

¹³ The exercise is adapted from Keeley, Page, et al. “Is It Food for Plants?” from *Uncovering Students’ Ideas in Science*, Volume 2. National Science Teachers Association, 2007.

wood varies from species to species, it is approximately 50 percent carbon, 44 percent oxygen, and 6 percent hydrogen.

2. Show the two-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. Give each group of students a copy of the Tree Carbon Tape. Direct them to cut out all 12 sections of the tape and then glue, staple or tape the sections together as indicated on the student page. The finished tape should be 72 inches long.
4. Take students to an outdoor area that has several trees. Invite students to use the Tree Carbon Tape to measure the circumference of five different trees, and to estimate the pounds of carbon dioxide equivalents (CO₂e) stored in them. Have them record their findings on the “How Much Carbon?” student page.
5. Discuss questions such as: What role does photosynthesis play in capturing carbon from the atmosphere? How does the size of a tree affect the amount of carbon it stores? What happens to a tree’s carbon if the tree is cut down?
6. 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.
7. 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.
8. 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

- Explore other benefits of individual trees using the tool [MyTree](https://mytree.itreetools.org), available for free at mytree.itreetools.org. Students will need to enter details about the tree’s location, species, trunk size (either diameter or circumference at chest height), proximity to a building and sun exposure. The tool will estimate the carbon sequestered, rainfall

intercepted, runoff avoided, air pollution removed and energy avoided from the tree. See [i-Tree](http://itreetools.org) at itreetools.org for more information about this and other tree benefits tools.

- 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.

Plant Food¹⁴

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.

¹⁴ Source: Adapted from Keeley, Page, et al. "Is It Food for Plants?" from *Uncovering Students Ideas in Science*, Volume 2. National Science Teachers Association, 2007.

How Much Carbon?

1. Identify five trees to measure using the Tree Carbon Tape.
2. Determine the circumference of each tree: Hold the tape at chest height (about 4.5 feet, or 1.4 meters) from the ground and wrap it once around the tree trunk. Find the measurement to the nearest 3 inches, and record the result below.
3. Use the tape to find the approximate carbon dioxide equivalent (CO₂e) contained in each tree. Record below.
4. Use the tape to find the approximate number of miles in a car that would emit the same amount of carbon as there is stored in the tree. In growing to that size, the tree can “offset” the emissions from driving that number of miles.

Tree location	Circumference at chest height (in inches)	Approximate carbon dioxide equivalent of tree (pounds CO ₂ e)	Approximate car miles offset by tree



INSIDE OREGON'S FORESTS

A high school forestry curriculum

A woman with short blonde hair and glasses, wearing a grey hoodie and blue jeans, stands in a large warehouse. She is holding a clipboard in her left hand and a handheld device in her right hand. She is smiling at the camera. Behind her are tall stacks of lumber, some labeled with 'Murphy'. The warehouse has a high ceiling with exposed wooden beams and skylights.

ECONOMIC IMPORTANCE OF OREGON'S FORESTS

- 1: Oregon's Forest Economy
- 2: Oregon's Wood Products
- 3: Biomass Energy from Oregon's Forests
- 4: Forestry Careers – Find Your Path



Oregon Forest
Resources Institute

ECONOMIC IMPORTANCE OF OREGON'S FORESTS

1: Oregon's Forest Economy

Overview

Students read about the economic importance of forests in Oregon (or listen to a lecture about it) and discuss the importance of forests to Oregon's economy. They then analyze county-level economic fact sheets to see how the forest sector impacts each of Oregon's 36 counties.

Time Considerations

Preparation: 15 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Articulate the benefits of and current challenges to the forest sector within Oregon's economy.
- Analyze and interpret county-level information about forest ownership, timber harvest levels and forest sector employment.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
- Science and Engineering Practice – 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.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – 11-12.RST.1. Analyze what science and technical texts say explicitly as well as inferentially, citing evidence to support the analysis, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Oregon Forest Literacy Plan Concepts

- 2.B.2. Oregon’s forest sector is one of the state’s largest economic sectors. It provides living-wage employment that is important for all communities, particularly in rural areas of Oregon.
- 2.B.3. Forests and forest products are important components of Oregon’s green economy, which supports sustainable and efficient resource use. Forests are a renewable resource, and forest products store carbon and are also reusable and recyclable.

Materials

- “Oregon’s Forest Economy” student page
- [County Economic Fact Sheets](#), available at oregonforests.org

Background Information

See the “Oregon’s Forest Economy” student page for an overview of Oregon’s forest sector. For more specifics on the economic picture of forests in Oregon, see [Oregon Forest Facts](#) (available at learnforests.org) and [Oregon’s Forest Economy](#) (available at oregonforests.org).

Key Vocabulary

economic benefit*

**included in Glossary*

Preparation

- Make copies of the “Oregon’s Forest Economy” student page or provide on-screen access to it. (As an alternative, you may choose to prepare a brief lecture based on the material.)
- Review the County Economic Fact Sheets and decide how many and which counties students will analyze. For example, you may choose to have all students analyze just your

county's profile, or give different individuals or groups different county profiles to examine and compare.

Procedure

1. Introduce the activity and the lesson by reviewing the historical and environmental importance of Oregon forests and asking students why Oregon's forests might be important economically.
2. Provide copies or online access to the "Oregon's Forest Economy" student page and allow time for students to read the material (or, alternatively, present the lecture you have prepared on the material).
3. Discuss the reading:
 - a. What economic benefits do Oregon's forests provide?
 - b. Who benefits from Oregon's forests?
 - c. What challenges are facing Oregon's forest sector today?
 - d. What can Oregonians do to get the most economic benefit from our forests?
4. Provide students access to the County Economic Fact Sheets. Invite them to analyze their county using the "Analyzing County Fact Sheets" student page and compare it to the statewide data in the "Forestry & Wood Products in Oregon" fact sheet at the beginning of the collection. They can then compare their county to another county in a different part of the state.
5. Discuss students' findings and the conclusions they can draw from them.

Assessment

Have students create a T-chart showing the benefits of and current challenges to the forest sector within Oregon's economy. The chart should include specific examples from the reading or county fact sheets.

Extension Ideas

- Use information in [Oregon Forest Facts](https://learnforests.org/) (available at learnforests.org) to graph economic data on Oregon's forests. For example, the 2023-24 edition presents data on timber harvest levels as well as forest sector wages and employment.
- Analyze data on [log prices](https://data.oregon.gov/) in Oregon (available from Oregon Department of Forestry at <https://data.oregon.gov/>) to look for economic patterns or trends.

Oregon's Forest Economy¹

Oregon's forestlands are some of the most productive in the world. The state's mild climate, deep soils and abundant rainfall make it one of the best places to grow trees. A strong social climate helps support our forestlands as well.

As Oregonians, we enjoy:

- Widespread public support for the economic, environmental and social contributions of a stable forest sector.
- Solid educational and research institutions, such as the Oregon State University College of Forestry and the USDA Pacific Northwest Research Station, which keep the sector at the vanguard of best practices.
- Strong forest protection laws under the Oregon Forest Practices Act that ensure landowners employ sound forest management practices.

As a result, by internationally recognized standards of sustainability Oregon is a world leader in timber production, wood product manufacturing and sustainable forestry.

Jobs and Community

According to 2021 data, forestry products and services employ about 62,000 people in Oregon. These jobs are particularly critical to rural communities, where wood product manufacturing can account for more than 50% of all manufacturing jobs.

Oregon's forest sector provides:

- About 62,000 Oregon jobs.
- 3% of all jobs in Oregon.
- An average yearly wage of \$68,200.

Growing Oregon's Forests

The total acreage of Oregon's forestland has remained mostly unchanged – at about 30 million acres – for nearly 100 years. It's estimated to have been about 30 million acres in the 1600s, as

¹ Sources: [Oregon Forest Facts, 2023-24](#), Oregon Forest Resources Institute, oregonforests.org. "Christmas Trees." Oregon Agriculture in the Classroom, oregonaitc.org.

well. Yet since 1953, Oregon has produced more than 450 billion board feet of timber, without a reduction in the size and volume of the state's forestland.

Oregon forests grow about 2.8 billion cubic feet of new wood each year. Overall, about 39% is harvested, 25% is in trees that end up dying from natural causes, and 36% adds to growing trees, which means Oregon grows more wood per year than it harvests.

Today, approximately 76% of Oregon's timber production comes from forestlands owned by companies, families and Native American tribes. On private forestland, the harvest represents about 77% of the new growth being added to the forests each year; on federal forestland, the harvest represents only about 8% of new growth.

Oregon leads the nation in:

- softwood lumber production
- plywood production
- engineered wood product development

Deck the Halls with Oregon Christmas Trees

In addition to growing timber for wood and paper products, more than 1,000 tree farms around the state have made Oregon the country's leading producer of Christmas trees. Each year, Oregon tree farmers harvest more than 4 million Christmas trees — nearly twice as many as any other state, and about 31% of the country's total. In 2020, Christmas tree farms contributed \$107 million to Oregon's economy.

Some 92% of all Oregon Christmas trees are exported out of the region, bringing holiday cheer to California, Hawaii, Alaska and other states, and to foreign markets including Mexico, China, Japan and the Philippines.

Tourism: Oregon's Natural Attraction

Oregon attracts tourists from around the world, and many of them come to enjoy the natural beauty of our forests and abundant recreational opportunities in the outdoors. A survey by the US Forest Service estimated that more than 11 million recreational tourists visit Oregon's national forests each year, sustaining nearly 15,000 jobs and contributing an estimated \$440 million to the economy.

Analyzing County Economic Fact Sheets

Using the [County Economic Fact Sheets](#) and the “Forestry & Wood Products in Oregon” fact sheet at the beginning of the collection, answer the following questions to assess the economic importance of Oregon’s forests. Compare your county to the statewide information, and then compare your county to another county in another part of the state. Provide evidence for your responses from the fact sheets.

Your county: _____

1. How does the forestland ownership in your county compare to Oregon’s overall forestland ownership?
2. How does the timber harvest in your county compare to Oregon’s overall timber harvest?
3. How significant are forest sector jobs in your county?
4. How many wood processing facilities does your county have? What percentage of the state’s overall wood processing facilities does this represent?

Other county analyzed: _____

5. How does this county compare to your county in terms of forestland, timber harvest, forest sector jobs and wood processing facilities?
6. What conclusions can you draw from your findings?

2: Oregon's Wood Products

Overview

Students watch a brief video on Oregon wood products and read how engineered wood products are helping build a more sustainable future for Oregon and beyond. They then research and report on different products made from Oregon trees.

Time Considerations

Preparation: 30 minutes

Procedure: Two 50-minute class periods, with time between for student research

Learning Objectives

Students will be able to:

- Articulate the importance of wood products for Oregon's economy.
- Conduct research on several different products made from Oregon trees.
- Summarize their research.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.7 and 11-12.WHST.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- Writing History, Science, and Technical Subjects – 9-10.WHST.9 and 11-12.WHST.9. Draw evidence from informational texts to support analysis, reflection, and research.

Oregon Forest Literacy Plan Concepts

- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., recreation and tourism).
- 2.B.3. Forests and forest products are important components of Oregon’s green economy, which supports sustainable and efficient resource use. Forests are a renewable resource, and forest products store carbon and are also reusable and recyclable.

Materials

- An assortment of items made from trees (for example, a piece of paper, a swatch of rayon fabric, a piece of cellophane, a disposable diaper and a bottle cork)
- [Forest Fact Break: Wood Products](#) video (1:31 minutes), available at learnforests.org
- Technology for sharing the video
- “Engineered Wood for a More Sustainable Future” in [Forest Essays \(Level 7-12\)](#), available at learnforests.org
- “Wood Products Made from Oregon Trees” student page

Background Information²

Wood products make up 47% of all raw materials used in manufacturing in the United States. Nearly 100% of a harvested log can be used to make wood and other products we use every day — most of which are completely recyclable.

Products from Oregon’s forests include:

- Structural lumber – Dimensional lumber, beams, joists, laminated veneer lumber and engineered structural softwood.
- Millwork – Doors, windows, cabinets, furniture, siding, flooring, moldings and fencing.
- Plywood and paneling – Veneer or other composite panels such as particleboard, hardboard and fiberboard.
- Posts, poles and timbers – Utility poles, fence posts, pilings, treated timbers, cross-arms and railroad ties.
- Pulp and paper products – Packaging, printing paper, newsprint, tissue, toweling, absorbents, adhesives, fluff pulp and cellulose products such as rayon, cellophane, food additives and pharmaceuticals.
- Biomass energy – Many Oregon mills burn wood waste to generate heat and electricity for manufacturing.

² Source: “[Oregon’s Forest Economy](#).” Oregon Forest Resources Institute, oregonforests.org.

Key Vocabulary

biomass energy
dimensional lumber
fiberboard
hardboard
particleboard
reconstituted wood
veneer

Preparation

- Gather an assortment of items made from trees.
- Make copies of the *Forest Essays* reading and student page, or provide on-screen access to them.

Procedure

1. Introduce the lesson by showing students the assortment of items you have collected and asking them which are made from trees. After they have had time to consider the items, ask whether they would be surprised to hear that all of them come from trees.
2. Show the 90-second video *Forest Fact Break: Wood Products* and discuss the importance of wood products to Oregon's economy.
3. Provide copies of "Engineered Wood for a More Sustainable Future" or have it available for students to access online. Allow time for students to read the story and answer the questions. Ask students what other wood products might be important in Oregon, and begin a list on the board.
4. Give students copies of the "Wood Products Made from Oregon Trees" student page. Direct students to choose a number of the wood products to research, or you may assign students particular products to explore. (Assign a number of products for each student to research that takes into account your time, learning objectives and the size of your class.)
5. Allow time for students to conduct quick research on each product, focusing on the questions listed in the Task section of the student page. Students should write a brief report (one to two paragraphs) about each product, describing what they learned.

Assessment

Use students' brief reports to assess what they learned about the wood products and their importance to Oregon's economy.

Extension Ideas

- Explore two careers associated with wood products in Oregon. Show the 5-minute [Find Your Path: Mill Operator](#) and [Find Your Path: Procurement Forester](#) videos, available at learnforests.org, and have students compare the two careers portrayed.
- Learn about Oregon wood products used to frame high-rise buildings. See [Wood Stands Tall](#), available at oregonforests.org.
- Visit a mill.
- Explore the production and sale of non-timber forest products, using resources from "[Non-Timber Forest Products](#)" at knowyourforest.org.

LESSON 2

Wood Products Made from Oregon Trees

Lumber

- Dimensional lumber
- Solid beams
- Laminated beams
- Joists
- Laminated veneer lumber
- Finger-jointed lumber

Plywood

Reconstituted Wood

- Particleboard
- Hardboard
- Fiberboard
- Heating pellets

Posts, poles and timbers

- Utility poles
- House logs
- Fence posts
- Pilings
- Treated timbers, cross-arms and railroad ties

Pulp and paper products

- Packaging
- Printing paper
- Newsprint
- Tissue

- Paper towels

- Absorbents

- Adhesives

- Fluff pulp

Cellulose products

- Rayon

- Cellophane

- Food additives

- Pharmaceuticals

- Biomass energy

Millwork

Lumber for products

- Doors

- Windows

- Cabinets

- Furniture

- Siding

- Flooring

- Moldings

- Fencing

- Pallets

- Lath

- Pencils

- Musical instruments

Cross-laminated timber (CLT)

Task

As directed by your teacher, select a number of items from the list of wood products. For each product, research and answer the following.

- ☐ Product: _____
- ☐ What is it? How would you define it?
- ☐ What is it used for?
- ☐ How is it made? What raw materials are required to make it?
- ☐ What are the potential environmental, economic and social impacts of this product for Oregon?
- ☐ What sources did you consult?

3: Biomass Energy from Oregon's Forests³

Overview

Students explore renewable energy from forests by generating biomass gas and investigating its potential as a fuel.

Note: For non-lab classes, introduce the topic with the suggested video and then explore further using one or more of the Extension Ideas.

Safety Notes

- The procedures provided in this lesson are intended as suggestions.
- Be sure to follow all lab safety guidelines set out by your school or district.
- Have students wear safety goggles throughout the lab.
- Be mindful of open flames. Use a hood, if possible.

Time Considerations

Preparation: 30 minutes

Procedure: One to two 50-minute class periods, with the lab (steps 3-4) conducted during one period

Learning Objectives

Students will be able to:

- Explain the pros and cons of using biomass gasification to produce energy.
- Use proper lab techniques to generate and collect biomass gases.
- Carry out a scientific investigation using the biomass gases.
- Analyze their data and draw conclusions.

³ The lab was adapted from "[Investigating and Using Biomass Gases](#)" by Eric Benson and Melissa Highfill. National Renewable Energy Laboratory, U.S. Department of Energy.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Oregon Forest Literacy Plan Concepts

- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., recreation and tourism).

Materials

- “[Powered by Oregon](#)” video (9:02 minutes), available on the OFRI YouTube channel
- Optional: “[Energy Basics: Biomass](#)” video (3:22 minutes), available at nrel.gov
- “Syngas Lab” student page
- Lab equipment, per group:
 - Safety goggles
 - Lab coats
 - Latex or nitrile gloves
 - Fume hood (if possible)
 - 35-55 mL test tube with matching one-hole rubber stopper
 - Two ring stands with metal test tube clamp and clamp for Erlenmeyer flask
 - Three pieces stainless steel or glass tubing, each approximately 5 cm long
 - 250 mL Erlenmeyer flask with matching two-hole stopper
 - Three pieces rubber or Tygon tubing, two approximately 60 cm long and one just shorter than the Erlenmeyer flask
 - Bunsen burner and lighter
 - Sink with faucet connection for tubing
 - Wood pellets (enough to fill test tube approximately 3/4 full)
 - Regular-size marshmallow (not mini-size)
 - Skewer for roasting marshmallow
 - One large sealable bag for test tube disposal

- Lab equipment, per class
 - One pair leather gloves
 - Acetone (optional, for cleanup)
 - Additional marshmallows

Background Information⁴

Oregon produces millions of tons of wood byproducts every year, from logging slash to sawdust to small trees from US Forest Service thinning projects. This material, known as biomass, contains stored solar energy – enough to power hundreds of thousands of homes, businesses and public buildings.

Humans have been using biomass energy since they first discovered fire. Wood fires are, of course, still used for heating and cooking around the world. In addition to wood, people use corn stover (dried leaves and stalks of maize plants), other crop wastes, manure and other once-living materials for fuel.

Woody biomass includes branches, tree tops and other slash left over from logging, as well as bark, sawdust, chips and other residuals from sawmills. Biomass can be used for fuels, to produce power and to manufacture products that would otherwise be made from fossil fuels. It is currently used in Oregon to heat schools and hospitals, and to generate electricity. Entrepreneurs and scientists are also working to develop biomass fuel to power cars, trucks and airplanes, as well as other practical uses for wood byproducts.

There are generally three types of biomass energy technologies:

- **Biofuels** are transportation fuels, such as ethanol and biodiesel, created by converting biomass into liquid fuels.
- **Biopower** includes technologies that convert renewable biofuels into heat and electricity through burning, bacterial decay, or conversion to gas or liquid fuel.
- **Bioproducts** include technologies that convert biomass into chemicals for making plastics and other products typically made from petroleum.

The conversion of woody biomass to energy in Oregon presents a unique opportunity to simultaneously address three challenging needs: restoring forest health, fire resiliency and

⁴ Sources: [Biomass Energy and Biofuels from Oregon's Forests](#). Oregon Forest Resources Institute. "[Biomass Energy Basics](#)." National Renewable Energy Laboratory, nrel.gov.

wildlife habitat; finding renewable energy alternatives; and revitalizing rural economies by providing jobs and a market for wood byproducts.

The use of biomass energy is also an important way to help mitigate climate change. In addition to being renewable, biomass energy can help reduce greenhouse gas emissions. While it's true that burning biomass releases about the same amount of carbon dioxide as burning fossil fuels, there is a key difference between the two energy sources. Fossil fuels release carbon dioxide captured by photosynthesis millions of years ago — adding to greenhouse gas levels with essentially “new” carbon dioxide, while biomass releases carbon dioxide that was recently captured from the atmosphere in its own growth, and so is essentially carbon-neutral.

In this lab, students will synthesize and use syngas, a gaseous fuel made from biomass. If the biomass is heated at high temperatures, gasification occurs, producing syngas. The main components of syngas are hydrogen, methane, carbon monoxide and carbon dioxide. It can be burned directly to power a turbine and generate electricity.

Key Vocabulary

biomass energy

gasification

syngas

woody biomass

Preparation

- Before the lab, push two of the pieces of 5-cm long tubing into the two holes of the Erlenmeyer flask stopper, and one into the hole of the test tube stopper.
- Make copies of the student page.

Procedure

1. Introduce the lesson by asking students what they think biomass is. What are common forms of biomass? How is it used as energy?
2. Show the 9-minute video “Powered by Oregon” and discuss the benefits of woody biomass as a source of fuel. Point out that researchers are working to develop wood-based liquid fuel and other forms of energy from wood. You might also show the video “Energy Basics: Biomass” for more background.

3. Divide the class into lab groups to create a biomass gas called syngas. Give each group a copy of the “Syngas Lab” student page. Note that although the gases produced are trapped in the flask, it is advisable to conduct the lab in a fume hood, if possible.
4. As lab groups complete step 10 of the lab procedure, disconnect each group’s test tube tubing from their Erlenmeyer flasks and – using leather gloves – move the hot tubing out of the way.
5. After students have completed the lab, discuss the results:
 - a. What did you observe during the lab?
 - b. What do you think the gas you synthesized is made of? (Explain that the gas is a mixture of methane, hydrogen, carbon monoxide and carbon dioxide. The methane, carbon dioxide and hydrogen are the components of the gas that actually burn.)
 - c. What was the purpose of roasting the marshmallow?
 - d. How might this experiment compare with actual gasification? (This experiment is at a much lower temperature than commercial gasification and produces more pyrolysis oils than gas.)
 - e. What might be the environmental and economic impacts for Oregon – both positive and negative – of biomass gasification or other forms of woody biomass?
6. Lab cleanup: Once the test tubes are cool to the touch (this may be after the class period is over), remove them from the clamps and place the tubes and their contents in the sealable bags. Seal the bags – as the tubes will be very stinky – and dispose in the trash. Wash the dirty tubing and flask in hot soapy water to remove any oils. If oils remain, rinse with acetone.

Assessment

Have students write a short essay summarizing what they learned from the lab. The essay should include relevant terminology, a summary of gas collection procedures, and the implications of large-scale gasification as a source of renewable energy.

Extension Ideas

- Using the same procedure as described in the lab, challenge students to compare different biomass materials to determine which is the best energy source. Sources of biomass could include wood pellets or splints, dried grass, nut shells, manure and corn stover (leaves and stalks of maize plants). Students could set their own parameters for what the “best” means, but one possibility is the volume of gas produced by one gram of material.

- Have students calculate their average home energy use over four months and compare it to biomass energy. Electricity usage is stated in terms of kilowatts (KW), while gas usage is in therms (one therm = 100,000 British Thermal Units, or BTUs).⁵ In general, one kilogram of dry wood or other biomass can produce about one kilowatt (KW) of electricity, and one liter of syngas contains 13.4 BTUs of energy. How much wood and syngas would students' households need to meet their current energy usage?
- Investigate the possibility of using biomass fuels for your school, like the school featured in the 4-minute video "[Biomass Success in Burns](#)" (available on the Oregon Department of Forestry YouTube channel). See [Oregon's Energy Efficient Schools Program](#) at oregon.gov/energy as a place to start.
- Visit a biomass energy plant, or research bio-energy or co-energy plants in Oregon.

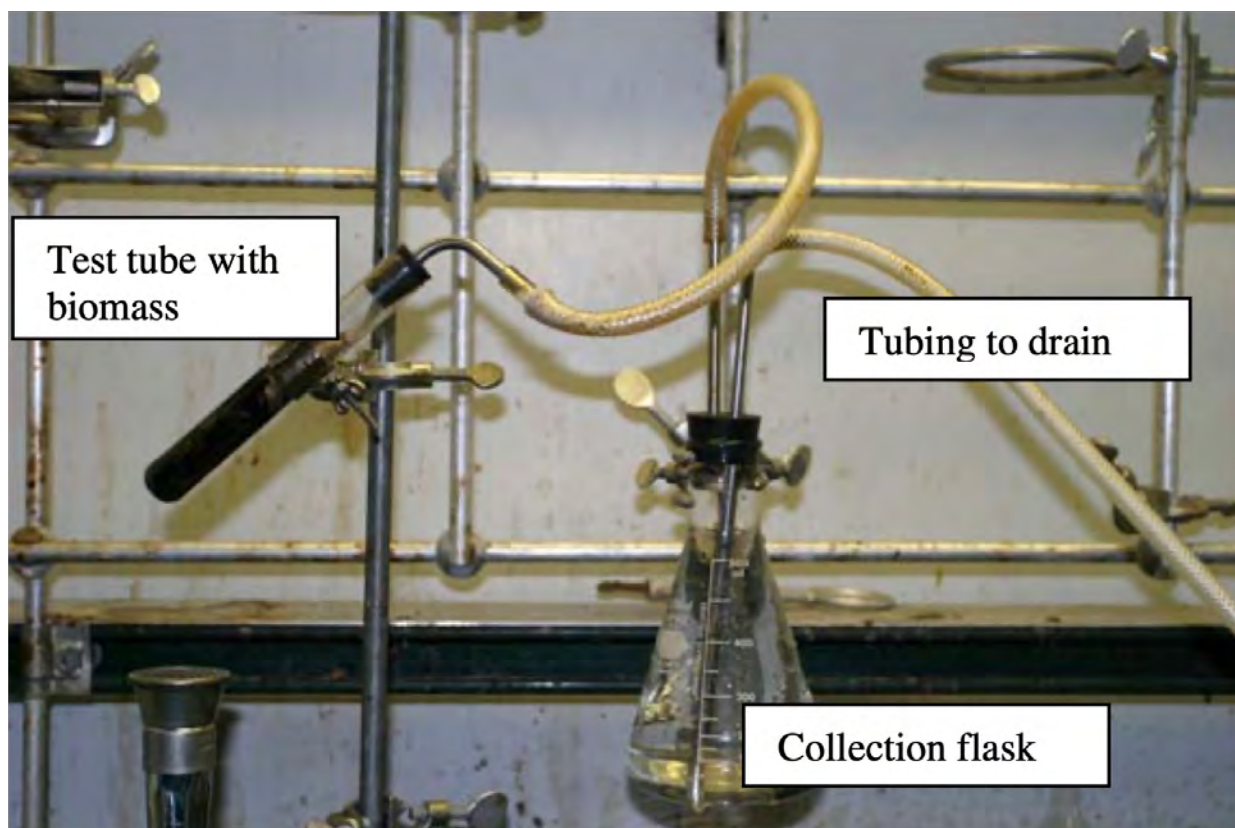
⁵ One BTU is the amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit.

Syngas Lab⁶

Procedure

1. Fill test tube 3/4 full with wood pellets.
2. Clamp the test tube to the ring stand using the metal clamp. Adjust the height of the tube relative to the Bunsen burner. The bottom of the test tube should be at least 3 centimeters above where the flame will be.
3. Insert the one-hole stopper with tubing into the test tube.
4. Attach the rubber tubing to one of the tubes in the two-hole stopper. The rubber tubing should come from the bottom of the stopper.
5. Fill the Erlenmeyer flask full of water and insert the two-hole stopper with the tubing going into the water. The tube should almost touch the bottom of the flask.
6. Connect the test tube and the Erlenmeyer flask with the piece of rubber tubing from step 3.
7. Connect the last piece of rubber tubing to the top of the two-hole stopper and place the other end into the sink. Check the figure to ensure your setup is correct.
8. Light the Bunsen burner and begin heating the test tube. Make sure the flame is at least 3 centimeters away from the test tube so the tube does not melt.
9. Record observations while the tube is being heated.
10. After a few minutes gas will be evolved and will begin to displace the water in the Erlenmeyer flask. Continue heating until all the water has been displaced.
11. At this point have your teacher disconnect the hot test tube tubing from the Erlenmeyer flask and move the hot test tube out of the way.
12. Connect the drain tubing to the faucet.
13. Slowly turn on the water and light the gas flowing from the end of the glass tubing. Adjust water flow rate to maintain a constant flame.
14. Roast a marshmallow on the flame (but don't eat it, as it may have a little tar on it). Record your observations below.

⁶ Source: "[Investigating and Using Biomass Gases](#)" by Eric Benson and Melissa Highfill. National Renewable Energy Laboratory, U.S. Department of Energy.



Equipment setup for syngas lab.

Observations

Lab Step	Time	Observations
Heating test tube		
Turning on water		
Lighting gas		
Roasting marshmallow		

4: Forestry Careers: Find Your Path

Students learn about different forest sector careers in Oregon, articulate which careers appeal to them, and identify what education, skills, experience and personal qualities it takes to succeed in a particular career.

Learning Objectives

Students will be able to:

- Explain that Oregon's forest sector is an important source of jobs in the state.
- Identify what it takes to succeed in different forest sector careers.
- Articulate which forest sector careers appeal to them and why.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.7 and 11-12.WHST.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Oregon Forest Literacy Plan Concepts

- 2.B.1. Forests provide multiple economic benefits, including jobs, a source of forest products and business opportunities (e.g., recreation and tourism).
- 4.B.5. We need a variety of professionals and skilled workers to sustain our forests, including foresters, scientists, engineers, lawyers, information technology professionals, land managers, investors, educators, communications specialists, fire fighters, loggers,

tree planters, truck drivers, mechanics and wood products manufacturers. Resources are available to learn about these valuable and rewarding careers.

Materials

- [Forest Essays \(Level 7-12\)](#) booklet, available at learnforests.org
- [Find Your Path](#) videos, available at learnforests.org
- Technology for sharing videos
- “What Does It Take?” student page

Background Information⁷

Oregon’s forest sector – the part of Oregon’s economy derived from forests – represents about 61,500 jobs for our state. This sector encompasses forest management, tree harvesting, and converting wood into consumer and construction products such as lumber, plywood, poles, paper and energy. It also includes careers in forestry, science and engineering, trucking and equipment, manufacturing, energy, recreation, government and forest support.

Find Your Path is a booklet produced by OFRI that explores a variety of careers in the forestry sector. It includes profiles of 19 different Oregonians working in the following forest-related careers:

- Field Forester
- Forest Manager
- Wildlife Biologist
- Forest Engineer
- Natural Resource Ecologist
- Recreation Unit Manager
- Road and Right-of-Way Specialist
- Research Economist
- Logging Crew
- Harvester Processor Operator
- Log Truck Driver
- Field Technician / Service Mechanic
- Wildland Firefighter / Base Manager
- Nursery Manager
- Mill Operator

⁷ Source of information in first paragraph: [Oregon Forest Facts, 2023-24](#). Oregon Forest Resources Institute, learnforests.org.

- Shipping and Sales Coordinator
- Vice President of Manufacturing
- Millwright
- Vice President of Timberlands

In addition to the booklet, OFRI has also created a series of short “*Find Your Path*” videos, each highlighting a particular forest career by capturing the voice and perspective of a real person in that career. Currently, the videos profile an Electrician, Field Forester, Fish Biologist, Forest Engineer, Forest Hydrologist, Forest Logging Crew, Forestry Teacher, Maintenance Manager, Mill Operator, Procurement Forester, Recreation Manager, Seedling Nursery Manager, Stewardship Forester, Wildland Firefighter and Wildlife Biologist.

Preparation

Make copies of the student page.

Procedure

1. Show one or more of the “*Find Your Path*” videos to begin a discussion about Oregon forest sector careers. Ask students to describe the education, skills, experience and personal attributes necessary to be successful in each career. Discuss: What does or doesn’t appeal to you about that career? What might be challenging about that career?
2. Give students copies of the “*Find Your Path*” booklet (or online access to it), and a copy of the “What Does It Take?” student page.
3. Direct students to choose three (or more) careers in the booklet to examine in depth. For each career, they should describe the job involved, as well as the education, skills, experience and personal attributes someone would need to be successful in that career. They should also write a brief paragraph about whether or not that particular job appeals to them, and why.

Assessment

Use students’ responses to the “What Does It Take?” student page to assess their learning.

Extension Ideas

- Students conduct research on a different forest-related career to find out what education, experience, skills and personal qualities are required (see Forestry Works at

<https://www.forestryworks.com> for a list of possibilities). Then they create an online poster or other visual to share what they learned.

- Create a “dichotomous key” to forest sector careers that can help others determine which might be best suited to them. The key would be a series of paired questions or attributes users respond to. It might include such attributes as indoor versus outdoor, high school education versus college education, urban setting versus rural setting and so on, to organize the career options.
- Invite someone from the forest sector to come in and talk to students about a range of careers.
- Share the [Find Your Path: Recreation Manager](#) video, available at learnforests.org, and explore recreation careers related to forests, including opportunities, safety, regulations and OHV (off highway vehicle) use.
- Have students explore their interests and skills related to future careers using various assessment tools available on the Oregon Career Information System website, oregoncis.uoregon.edu.

Inspiring Career Stories

Inspire students to pursue forest and conservation careers through the stories of Black Americans who have taken this career path and who have advice and resources to share. Project Learning Tree’s [Black Faces in Green Spaces: The Journeys of Black Professionals in Green Careers](#) profiles the career pathways of 22 Black American forestry professionals. It aims to

- make youth and young professionals aware of and excited about the many jobs in the forest and natural resources sector
- advance representation through inspiring stories from historical and current environmental heroes
- highlight the green career opportunities that abound for all

See plt.org for free download or to purchase a hard copy.



What Does It Take?

For each forest-related career, identify what education, skills, experience and personal qualities are required. Then, write a paragraph telling whether that career appeals to you and why (or why not).

Job Title:

Job description:

Education:

Skills:

Experience:

Personal qualities:

Does this career appeal to you? Explain why or why not.

Job Title:

Job description:

Education:

Skills:

Experience:

Personal qualities:

Does this career appeal to you? Explain why or why not.

Job Title:

Job description:

Education:

Skills:

Experience:

Personal qualities:

Does this career appeal to you? Explain why or why not.

INSIDE OREGON'S FORESTS

A high school forestry curriculum

FOREST MANAGEMENT

1: What Is Forest Management?

2: Surveying a Forest Tract

3: Analyzing Forest Soil

4: Forest Density Lab

5: Forest Thinning

6: Harvesting

7: Reforestation

8: Silviculture Tour

9: Developing a Forest
Management Plan



Oregon Forest
Resources Institute

FOREST MANAGEMENT

1: What Is Forest Management?

Overview

Students watch a brief video exploring the concept of forest management and then consider what forest management might mean for particular management goals.

Time Considerations

Preparation: 15 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Develop a working definition of the concept of forest management.
- Identify activities that may be involved in forest management.
- Compare different forest management strategies for a forest, depending on management goals.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – 11-12.RST.1. Analyze what science and technical texts say explicitly as well as inferentially, citing evidence to support the analysis, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Oregon Forest Literacy Plan Concepts

- 3.B.1. Forest management is a long-term process that can lead to changes in tree species composition, size and age, as well as in forest health and resilience.
- 3.B.2. From time immemorial, Indigenous people of Oregon have used fire and other practices such as girdling trees and land clearing to manage the forest. Their traditional ecological knowledge of Oregon's forests informs forest management practices that sustain forests.
- 3.B.3. Forest management ranges from active management (e.g., planting, thinning and harvesting) to passive management (e.g., reserves and wilderness areas) to grow, restore, maintain, conserve or alter forests.
- 3.B.4. Forest management includes using natural processes and goal-oriented decisions and actions to achieve a variety of desired outcomes, including environmental (e.g., wildlife habitat and carbon sequestration), economic (e.g., timber production) and social (e.g., recreation) outcomes. Many of these outcomes are interrelated and can be managed for simultaneously, while others may be incompatible.

Materials

- [Forest Fact Break: Forest Management](#) video (1:53 minutes), available at learnforests.org
- “Managing Forests for Specific Goals” student page

Background Information¹

How do you ensure that a forest is sustainable for the long run? Forest management is the practice of giving forestlands the proper care so that they remain healthy and vigorous, and so that they provide the products and amenities the landowner wants.

Many people believe that the best way to protect a forest is to leave it alone. But generations of forest management and harvesting experience show that most forests do better with some form of management to ensure their health and sustainability.

This does not mean that all forests are managed the same way. Oregon's forests generally fall into one of three management classifications:

- Reserve – managed primarily for environmental attributes, such as old-growth habitat
- Multi-resource – managed for multiple uses including recreation, water, wildlife habitat and some timber production

¹ Source: Adapted from “[Sustainable Forest Management Is Key](#).” Oregon Forest Resources Institute, oregonforests.org.

- Wood production – managed primarily for timber production, while protecting water quality and habitat

Forest management helps balance a forest’s environmental, social and economic values, providing the wood products and recreational access that society desires. It involves planning how to address the well-being of wildlife, the quality of watersheds, the health of the trees and plants, and the reduction of fires, insect infestations and diseases. It may include planting, thinning, prescribed burning, harvest and replanting.

This lesson introduces the concept of forest management as students consider what it might involve for a particular forest. In the next eight lessons, students will examine in depth specific management skills and strategies.

Key Vocabulary

carbon sequestration*

forest management*

forest reserves

management strategies

recreation

sustainability

timber production

watershed protection

**included in Glossary*

Procedure

1. Ask students what they think of when they hear the term “forest management.” Have students call out words or phrases, and write them on the board.
2. Show the brief video *Forest Fact Break: Forest Management* and discuss with students how the video’s description of forest management compared with their ideas.
3. Point out that the management of a specific forest depends on the amenities and products that the landowner wants (or that society expects) the forest to provide. Ask students what some of the goals people might have for forests are, and create a list of the goals on the board. (Possibilities include timber production, watershed protection, wildlife habitat, recreation, forest reserves and sequestering carbon.) Discuss the value of each goal.

4. Ask students for their ideas of management activities that landowners might undertake to meet their goals, and create a separate list of these on the board. (Possibilities may include planting, thinning, prescribed burning, harvest and replanting, among many others.)
5. Divide the class into small groups and give each group one of the goals on the list from step 3. Their job will be to identify how they might manage a 100-acre forest based on their goal.
6. Give each group a copy of the student page and allow time for them to work through the questions.
7. Have groups share their main management strategies based on their goal. As a class, compare and contrast the management strategies presented. Discuss:
 - a. What activities does forest management include?
 - b. In what ways do forest management strategies differ depending on the management goal?
 - c. Is there a management activity or outcome that all forest management goals share?
 - d. Are there any scenarios for which the best forest management strategy is to do nothing?
 - e. How is forest management similar to or different from farm management?
 - f. In what ways does forest management ensure the sustainability of forests?

Assessment

Ask students to write two paragraphs defining forest management and how it might differ for different goals.

Extension Ideas

- Explore the Coquille Indian Tribe's approach to forest management using a Tribe-created student lesson (see box).
- Discuss how forest management might change over time with changes in laws or values, or with environmental changes.

Coquille Indian Tribe's Approach to Forest Management

The Coquille Indian Tribe has lived in southwest Oregon for thousands of years and continues to thrive there. Generations of experience by the Coquille and other tribes has led to traditional ecological knowledge that has proved that most forests do very well with some form of human management to sustain the health of the ecosystem and the various resources that humans draw from the environment.

The Tribe's unique approach to forest management has become a model for federal, state and private forest managers, and serves as an example of how humans can act in sync with the ecosystem to meet a complex mix of economic, social and cultural needs while maintaining healthy forestlands.

Explore the Tribe's approach with your students through a Grade 10 lesson, [Forest Management](#), created by the Tribe and available at coquilletribe.org. Discuss with students:

- In what ways do the Coquille Indian Tribe's forest management methods reflect scientific practices for effectively balancing human interests with a healthy ecosystem?
- In what ways do the Coquille Indian Tribe's methods serve as a model for how to reduce the impact of human activities on the environment and promote biodiversity?

Managing Forests for Specific Goals

Imagine that your group owns and manages 100 acres of forest that consists primarily of same-age conifer trees.

1. What is your goal for this forest?
2. How would you know that your goal is being met?
3. What natural forest processes can you build on to meet your goal?
4. What things might you do in the short term to further your goal?
5. What things might you do in the long term to further your goal?
6. What management activities, assessments and strategies might you undertake to ensure that your forest remains healthy and vigorous in the long run, while also meeting your goal?

2: Surveying a Forest Tract²

Overview

Students learn some skills that forest managers use to survey forestland: pacing to measure horizontal distance, using compasses to find direction, map reading, and creating a map of a forest stand (or other site).

Time Considerations

Preparation: 30 minutes

Procedure: Two to four 50-minute class periods

Learning Objectives

Students will be able to:

- Identify ways that pacing, using a compass and mapping are useful in survival and forest management.
- Determine their average pace and measure distances between two points using pacing.
- Accurately use a compass to determine direction.
- Combine compass and pacing skills to follow an “orienteering” course.
- Identify common symbols on a topographic map.
- Use pacing and compass skills to create a simple forest map.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Using Mathematics and Computational Thinking. Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

² This lesson was adapted from *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources. Chemeketa Community College.

Oregon Mathematics Standards

- Number and Quantity – HS.NQ.B.3 Use reasoning to choose and interpret measurement units consistently in formulas, graphs, and data displays, as a way to understand problems and to guide the solution of multi-step problems.

Oregon Forest Literacy Plan Concepts

- 3.A.4. Oregon’s forests are managed under private (e.g., family and industrial), public (e.g., state and federal) and tribal ownership. Each type of ownership may have different management objectives, and is subject to different protection laws and policies. Management objectives may even differ within classes of ownership.

Materials

- “Pacing” student page
- 100-foot measuring tape
- Stakes, flags or other markers for the course
- Orienteering compasses, one per pair of students
- “Compass and Pacing Instruction Cards” teacher page, copied and cut apart (two cards per student pair)
- Topographic maps of a nearby forest, available for free download from U.S. Geological Survey, store.usgs.gov (either printed, or accessible on-screen as PDFs)
- Graph paper (or gridded lab notebook)

Background Information

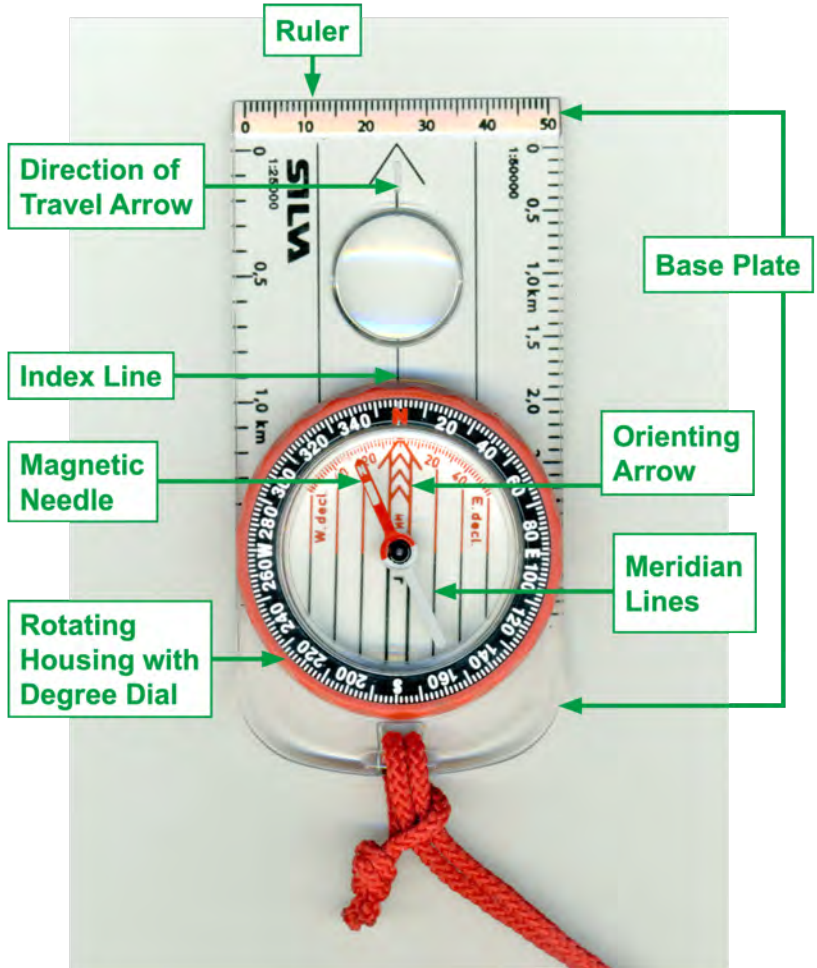
Pacing is a useful technique for measuring distance in the field, as it requires no equipment. In ancient Rome, one pace was measured as two natural steps, from the heel of one foot striking the ground to the heel of that same foot striking the ground. Today, while many people measure one-step paces (from the heel of one foot to the heel of the other), foresters and ecologists generally use two-step paces.

The average length of a pace will vary between people, and will also vary across different types of terrain. Most people have a one-step pace of about 30 inches and a two-step pace of about 60 inches.

The map symbols introduced in Part 3 of the lesson are those required for the FFA Forestry Career Development Event’s map reading. More symbols may be found in the USGS publication [Topographic Map Symbols](https://pubs.er.usgs.gov), available at pubs.er.usgs.gov.

Using a Compass to Follow a Bearing

1. Turn the dial on your compass until the degree you want matches up with the index line.
2. Hold the compass flat in your hand so the direction-of-travel arrow points directly away from you.
3. Turn your entire body until the north (red) end of the needle rests squarely in the orienting arrow.
4. You are now facing your bearing. Step forward in that direction to follow that bearing.



Key Vocabulary

bearing*

compass

contour*

pacing*

topographic map*

**included in Glossary*

Preparation

- For Part 1 of the lesson, you will need to set up four different courses. Two of the courses should be 300 feet long, or a similar, same-size length – one on an uneven or irregular surface (such as a field) and one on a smooth surface (such as pavement or sidewalk). In addition, measure and set up two “mystery” courses of different lengths (A and B) for students to measure using pacing.
- For Part 2 of the lesson, you will need to set up a compass course that consists of 20 markers placed five feet apart in a straight line running from magnetic west to magnetic east. Number the most westerly marker “1” and consecutively number the markers moving east until all 20 markers are numbered.
- Copy the student page. Copy the “Compass and Pacing Instruction Cards” teacher page, and cut apart.
- For Part 4 of the lesson, identify a suitable forest stand or other site near your school for students to map.

Procedure

Part 1 – Pacing

1. Ask students how measuring distances, using a compass and mapping might be useful for survival and for forest management.
2. Explain that students will be learning some skills that forest managers may use to survey their forestland. First, they will learn a technique for measuring horizontal distances called pacing. With this technique, individuals use their own natural pace to estimate distances.
3. Show them the two 300-foot courses, and direct them to pace the two courses – two times per course – to compute their pace length. Give them copies of the “Pacing” student page to record their results.
4. Challenge students to use their pace length to estimate the length of the two “mystery” courses, recording their estimates on the student page.
5. Discuss student findings. First, get a show of hands to find out their estimates for the two mystery courses. Then share the actual distances with them. How close were their estimates? What factors might affect the accuracy of this method? (Examples include ground cover, weather, footwear, ground surface and time of day.) In what situations might this method be useful for forest landowners?

Part 2 – Using a Compass

- Show students how to use a compass to follow a bearing (see “Using a Compass to Follow a Bearing” in the Background Information). Give them practice following various degree bearings such as 225 degrees, 120 degrees, due north, due east and so on.
- Show students the course you have set up (see Preparation). Explain that each pair of students will get one of the “Compass and Pacing Instruction Cards” that has a starting point marker number and directions to follow.
- Pairs should start at the marker number indicated on their card and follow the steps described. All routes lead back to a marker number on the starting line. After they’ve followed the instructions, students should note the number of the nearest marker.
- When students have completed the instructions on one card, give them a different instruction card to follow.

“Compass and Pacing Instruction Cards” Answer Key

Starting Point	Destination Point
1	7
2	19
3	2
4	8
5	16
6	8
7	8
8	9
9	15
10	19

Part 3 – Reading Forest Maps

- Divide the students into pairs, and give each a copy of the topographic map (or access to viewing on-screen).
- Introduce or review some or all of the map symbols identified on the “Topo Map Symbols” student page.
- Challenge students to find as many of the symbols as possible on their maps, marking them with sticky notes or highlighter (either real or virtual).

Part 4 – Creating a Forest Map

- Take students to a forest stand or other site on or near your school (see Preparation). As a class, identify the boundaries of a rectangular study area at the site and, using a steel measuring tape, measure the length and width of the area.
- Direct students to make a rough scale drawing of the perimeter on graph paper or in their lab notebooks, using as much of the space available as possible.
- Have students work in pairs and, using hand compasses and their pace, measure and draw in the important features encountered at the study site, such as paths, ridges, valleys, vegetation boundaries, and so on. Students should sketch these features and include data on pacing and compass direction.
- Back in the classroom, allow students time to create scale maps of the area, using the information they recorded in the field and some of the map symbols they explored in Part 3.

Assessment

Use students' forest maps as an assessment of their surveying skills. Based on your particular situation, develop a rubric for assessing the maps with criteria such as number and quality of important features, accuracy of location, number of map symbols and so on. You may also want to create a map transparency of the study site to use in assessing student maps.

Extension Ideas

- The FFA Forestry Career Development Event requires participants to determine the degree reading between each of a set of stakes. Practice determining compass bearings as follows.
 - Face the stake or other object.
 - Hold the compass flat in your hand with the direction-of-travel arrow pointing out toward the stake. Do not hold the compass near metal belt buckles.
 - Turn the dial until the north (red) end of the needle rests squarely in the orienting arrow.
 - Read the number at the index line. That number is the bearing for your stake.
- Practice reading the information available on maps of forested areas. For online interactive GIS maps of Oregon, see the Oregon Department of Forestry's [LocatOR](https://gisapps.odf.oregon.gov/LocatOR) application, available at gisapps.odf.oregon.gov/LocatOR. Work in small groups to design geocaching trails to share with another group.

Pacing³

Pacing is a useful skill for measuring forest stands or other distances in the field. It involves using your natural walking pace to estimate a distance. For this exercise, count two steps as one pace: that is, from the heel of one foot striking the ground to the heel of that same foot striking the ground again.

1. To determine your pace, walk a measured course, counting the number of paces you take. Then, divide the length of the course by that number. For accuracy in the field, find your average pace on both smooth and uneven surfaces.

Smooth Surface

Trial 1:

Course Length: _____

Number of Paces in Course: _____

Pace Length = Course Length ÷ Number of Paces: _____

Trial 2:

Course Length: _____

Number of Paces in Course: _____

Pace Length = Course Length ÷ Number of Paces: _____

³ Source: Adapted from *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources. Chemeketa Community College.

Uneven Surface

Trial 3:

Course Length: _____

Number of Paces in Course: _____

Pace Length = Course Length ÷ Number of Paces: _____

Trial 4:

Course Length: _____

Number of Paces in Course: _____

Pace Length = Course Length ÷ Number of Paces: _____

Average Pace Length = (Trial 1 Pace Length + Trial 2 Pace Length + Trial 3 Pace Length + Trial 4 Pace Length) ÷ 4 = _____

2. Use your average pace length to measure unknown distances.

Mystery Course A

Number of Paces in Course: _____

Course Length = Average Pace Length x Number of Paces in Course = _____

Mystery Course B

Number of Paces in Course: _____

Course Length = Average Pace Length x Number of Paces in Course = _____

Compass and Pacing Instruction Cards⁴

(Copy and cut cards apart)

<p>Starting Point: 1 Go 36 degrees for 122 feet Then 149 degrees for 58 feet Then 235 degrees for 86 feet Destination number: _____</p>	<p>Starting Point: 6 Go 03 degrees for 100 feet Then 132 degrees for 74 feet Then 225 degrees for 69 feet Destination number: _____</p>
<p>Starting Point: 2 Go 17 degrees for 104 feet Then 150 degrees for 52 feet Then 142 degrees for 64 feet Destination number: _____</p>	<p>Starting Point: 7 Go 34 degrees for 119 feet Then 186 degrees for 50 feet Then 228 degrees for 74 feet Destination number: _____</p>
<p>Starting Point: 3 Go 38 degrees for 125 feet Then 237 degrees for 90 feet Then 186 degrees for 50 feet Destination number: _____</p>	<p>Starting Point: 8 Go 346 degrees for 102 feet Then 129 degrees for 78 feet Then 211 degrees for 58 feet Destination number: _____</p>
<p>Starting Point: 4 Go 36 degrees for 122 feet Then 174 degrees for 50 feet Then 228 degrees for 74 feet Destination number: _____</p>	<p>Starting Point: 9 Go 346 degrees for 102 feet Then 129 degrees for 78 feet Then 186 degrees for 50 feet Destination number: _____</p>
<p>Starting Point: 5 Go 22 degrees for 107 feet Then 158 degrees for 54 feet Then 186 degrees for 50 feet Destination number: _____</p>	<p>Starting Point: 10 Go 343 degrees for 104 feet Then 141 degrees for 64 feet Then 145 degrees for 61 feet Destination number: _____</p>

⁴ Source: *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

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LESSON 2

Topographic Map Symbols⁵

Map symbols are an important part of map reading. They can depict various features including roads, boundaries, buildings, landmarks, places of interest, water supplies and mines. Following is a list of some common symbols used in topographic maps.

Building	
Cemetery	
Quarry or open pit mine	
Gravel, sand, clay, or borrow pit	
School; house of worship	
Perennial stream	
Perennial river	
Intermittent stream	
Perennial lake/pond	
Spring or seep	
Highway or road bridge; drawbridge	

ROADS AND RELATED FEATURES

Please note: Roads on Provisional-edition maps are not classified as primary, secondary, or light duty. These roads are all classified as improved roads and are symbolized the same as light duty roads.

Primary highway	
Secondary highway	
Light duty road	
Light duty road, paved*	
Light duty road, gravel*	
Light duty road, dirt*	
Light duty road, unspecified*	
Unimproved road	
Unimproved road*	
Trail	
Power transmission line; pole; tower	
Standard guage railroad, single track	
Standard guage railroad, multiple track	

CONTOURS

Topographic

Index	
Approximate or indefinite	
Intermediate	
Approximate or indefinite	

⁵ Symbols adapted from "[Topographic Map Symbols](https://pubs.usgs.gov/topographic/symbols/)," US Geological Survey, pubs.usgs.gov.

3: Analyzing Forest Soil⁶

Overview

Students participate in a lab comparing soils from two or more different sites, looking at organic composition, pH, macronutrients, soil texture and the presence of soil invertebrates, to learn more about this important element in forest management.

Safety Notes

- Be sure to follow all lab safety guidelines set out by your school or district.
- Have students wear safety goggles throughout the lab.
- Be mindful of open flames for the organic component procedure.
- Be aware of the possibility of chemical contact with skin while using the soil test kit.
- Follow the test kit guidelines for disposing of spent chemicals.
- Be sure that students follow rules for the safe and ethical treatment of living things.

Time Considerations

Preparation: 30 to 60 minutes (with time enough in advance to dry soil samples)

Procedure: One to three 50-minute class periods

Learning Objectives

Students will be able to:

- Describe some chemical and physical components of soil (organic composition, pH, soil macronutrients and texture).
- Use a dichotomous key to identify soil invertebrates.
- Compare two or more different soil samples.
- Explain the importance of soils in forest management, based on evidence from their investigation.

⁶ Source: This lesson was adapted from “Soils: Physical and Biological Analysis,” in *Environmental Science II* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Standards Connections

Oregon Science Standards

- HS.LS2.2. Ecosystems: Interactions, Energy, and Dynamics. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS.ESS3.1. Earth and Human Activity. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- Science and Engineering Practice – Using Mathematics and Computational Thinking. Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.2 and 11-12.WHST.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Oregon Mathematics Standards

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

Oregon Forest Literacy Plan Concepts

- 1.C.7. Oregon's regions vary in soil types, elevation, topography, temperature, wind and rainfall patterns. These variations create the different forest types and species composition that, together with disturbance histories, contribute to the region's biodiversity.
- 4.B.5. We need a variety of professionals and skilled workers to sustain our forests, including foresters, scientists, engineers, lawyers, information technology professionals, land managers, investors, educators, communications specialists, fire fighters, loggers, tree planters, truck drivers, mechanics and wood products manufacturers. Resources are available to learn about these valuable and rewarding careers.

Materials

For the class:

- 12” soil core samples from two or more sites, dried (see Preparation)
- Leaf litter samples from the same sites (see Preparation)
- One-gallon sealable bags and garbage bags (for soil and leaf litter samples)
- Asbestos gloves
- Tongs (for lifting crucibles)
- Digital balance

For each lab group:

- Safety goggles
- Porcelain crucible with cover (for heating core samples)
- Needle probe (for stirring core sample)
- Bunsen burner
- Ring stand and clamp (for crucibles)
- Matches
- Asbestos pads
- Soil test kit (for testing pH, nitrogen, phosphorous and potassium levels)
- Large aluminum tray
- Screw-cap vial (for soil invertebrates)
- Tweezers or forceps (for soil invertebrates)
- “Soil Lab Procedures” student page
- “Soil Lab Data Sheet” student page
- “Key to Soil and Leaf Litter Invertebrates” student page

Background Information

Soils are complex systems of organic and inorganic components. Soil composition greatly influences plant and animal communities, as well as the potential human uses for a given site. Land management decisions are fundamentally tied to soil types – whether it is forestry, agriculture, building/construction or other land use. In this lesson, students examine various physical and biological characteristics of soil. For more details, see the soil lab student pages.

Key Vocabulary

clay

invertebrate*

leaf litter*

loam

macronutrient*

nutrient*

organic*

soil*

soil pH*

**included in Glossary*

Preparation

- Choose two or more sites that are likely to have different soil types for collecting soil samples – either on your school grounds or from nearby locales. Possible sites might include a grassy area, a treed area, a timber production tree farm, a wildlife refuge slough area, a pastureland or a forest with trees 50 to 70 years old or older. Wherever you collect the samples, be sure you have permission from the landowner or manager to do so.
- At each site, collect a 12-inch core sample, placed in a one-gallon sealable bag, as well as the litter layer from a 1-m² area, placed in large plastic bags. Dry the core samples in aluminum pans in a drying oven at 55 C° for four days.
- Set up soil analysis kits and other equipment for each group on lab benches. Make copies of the student pages.

Procedure

- Discuss: What is soil? Why is it important? What might forest managers want to know about the soil in the forests they manage?
- Divide the class into pairs or small groups. Give them copies of the “Soil Lab Procedures” student page, and explain the various tests students will conduct.
- Give each group a soil sample and matching leaf litter to analyze. Have them use the equipment provided to follow the lab procedures, recording their results on the “Soil Lab Data Sheet” student page. They will also need a copy of the “Key to Soil and Leaf Litter Invertebrates” page to identify the organisms they find.

- Lead a class discussion about students' findings:
 - What differences did the groups find between the sites' soil organic content, pH, macronutrient levels, soil texture and soil invertebrates? What might these differences say about each of the sites?
 - Given the findings for a particular site, would this site be suitable for the commercial production of trees? What might be major forest management concerns for this site?
 - Which sites might be suitable for recreational activities? What soil characteristics may limit the type of recreation that occurs at each site?

Assessment

Give students the following writing prompt: Assume that your sample was taken from a 100-acre plot of land that you have just inherited. Prepare a one- to two-page narrative that describes what you have learned about this land. Taking into account the characteristics of the soil, describe what you might do with this land. Include the evidence that supports your choices.

Extension Ideas

- Construct food webs representing the energy flow in the soil samples.
- Find out more about your area's soil by checking out Natural Resources Conservation Service's [Web Soil Survey](http://websoilsurvey.nrcs.usda.gov) website at <http://websoilsurvey.nrcs.usda.gov>, which includes a soil survey for every county in the United States with soil descriptions and characteristics, aerial photographs and other soil resources.
- Compare soils in Oregon with other regions of the world.

Soil Lab Procedures⁷

Safety Note: Wear goggles during this lab, and follow any other safety instructions provided by your teacher.

Organic Content

Organic material increases the water-holding ability and aeration of soil. As decaying plants decompose, they add important nutrients and influence the soil's pH. Thus, the amount of organic material in soil is an important consideration.

Organic matter burns at high temperature and decomposes to CO₂ and H₂O. In general, the inorganic components of the soil do not decompose at high temperatures. Therefore the loss in weight of a soil sample after burning can be used to estimate organic content.

Procedure

1. Weigh a glazed porcelain crucible (without the cover) to the nearest 0.01 gram:
_____.
2. Fill the crucible approximately two-thirds full with an oven-dried sample of soil.
3. Reweigh the sample plus the crucible to the nearest 0.01 gram: _____.
4. Subtract the weight of the crucible. This is the "dry sample weight": _____.
5. Place the uncovered crucible over a flame (Bunsen burner) and cook for 15 minutes. While cooking, stir with a probe, but be careful not to remove any soil in the process.
6. Ask the teacher to use tongs and asbestos gloves to remove the crucible from the flame. Cover it and allow it to cool on a heat-proof pad.
7. After about 5 minutes, when it's cool enough to weigh, remove the cover and reweigh the sample to the nearest 0.01 gram. This is the "cooked sample weight": _____.
8. Calculate the percent (%) of organic matter in the soil sample using the formula:
Percent Organic Matter = (Dry Sample Weight – Cooked Sample Weight) x 100 Dry Sample Weight
9. Record the percent of organic matter for your sample on the data sheet.

⁷ Source: Adapted from "Soils: Physical and Biological Analysis," in *Environmental Science II* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

pH

A soil's pH is a measure of its acidity. The pH scale runs from 0 to 14, with 7 being neutral. Values below 7 are progressively more and more acidic, while values above 7 are progressively more and more alkaline, or basic.

Plants often have specific soil pH requirements. Crops such as blueberries and strawberries, for example, prefer more acidic soils, while most vegetable crops require somewhat more alkaline soils. Soils closely associated with Douglas-fir and other cone-bearing trees are often acidic. That's because tannic acid accumulates as a result of decomposition of conifer needles and branches.

Interpretation of Soil pH Levels

pH 4.0 – strongly acidic
pH 5.0 – moderate to strong acidity
pH 6.0 – slight to moderate acidity
pH 7.0 – neutral (neither acidic nor alkaline)
pH 8.0 – slight to moderate alkalinity
pH 9.0 – moderate to strong alkalinity

Procedure

1. Use soil from your soil core sample.
2. Follow the instructions that come with the soil test kit to determine the soil's pH.
3. Record your measurements on the data sheet.
4. Clean and dry the soil kit components and pack them neatly back in the case.

Macronutrients

Macronutrients are chemical elements that plants need for growth and development. Three primary macronutrients in soil that plants use are nitrogen (N), phosphorus (P) and potassium (K). A measure of these three components provides a good picture of soil fertility. Most commercial fertilizers contain varying amounts of these three macronutrients, which are often shown on fertilizer labels. A label of "15-30-10," for example, indicates 15 percent by weight for N, 30 percent for P and 10 percent for K.

Procedure

1. Use soil from your soil core sample.
2. Follow the instructions that come with the soil test kit to determine the soil's nitrate-nitrogen level.
3. Follow the instructions to determine the phosphorus level.
4. Follow the instructions to determine the potassium level.
5. Record all the values for soil macronutrients on the data sheet.
6. Clean and dry the soil kit components and pack them neatly back in the case.

Soil Texture

Soil texture is a physical property determined by the size of mineral particles in the soil. Soils are generally made up of larger fragments of sand or gravel embedded in microscopic silt or clay particles. Soil texture is very important, because it affects a plant's ability to get nutrients, water and air at the root level.

Mineral Particles in Soil

Gravels – 2.0 mm in diameter or greater

Sands – 0.02 mm – 2.0 mm in diameter

Silts – 0.002 mm – 0.02 mm in diameter

Clays – less than 0.002 mm in diameter

Most soils contain a mixture of sand, silt and clay. Soils that are predominantly sand have few nutrients, don't hold water and are prone to drought. Soils that are predominantly clay contain nutrients and hold water well, but do not allow movement of air or water, and don't drain well. The best soils for most plants contain a relatively even mixture of sand, silt and clay, and are called loam.

Procedure

Conduct a simple field test using the sense of touch to approximate soil texture:

- Place a small handful of dry soil (about the size of a marble) on the palm of your hand.
- Add a few drops of water to moisten it to the point that it can be worked with the fingers.

- Knead the soil between your thumb and fingers, breaking up clumps. Remove any sticks, gravel or pebbles.
- Squeeze the soil between your thumb and fingers. Use the following chart to determine the approximate soil type.
- Record your findings on the data sheet.

Soil Type	Characteristics of Squeezed Moist Soil ⁸
Sand	Feels gritty and does not hold a ball shape.
Sandy Loam	Can be molded into a ball, but the ball breaks up easily.
Silt	Has silkiness like flour (not gritty; can be molded into a ball, but is easily deformed).
Loam	Can be molded into a ball that can be handled without breaking or deforming.
Clay Loam	Can be formed into a long thin “ribbon” that easily breaks.
Clay	Feels sticky, and can easily be formed into a long thin “ribbon.”

Soil Invertebrates

Soil invertebrates play critical roles in the long-term stability and fertility of soils. Their activities aerate the soil, speed up decomposition of organic materials and distribute important nutrients.

Procedure

1. With your leaf litter in a large tray, use tweezers to collect any invertebrates you see, placing them in a vial.
2. Use the “Key to Soil and Leaf Invertebrates” page to identify the organisms you found.
3. Record your findings on the data sheet.

⁸ Adapted from Project Learning Tree, “Monitoring Forest Health” in *Exploring Environmental Issues: Focus on Forests*.

Soil Lab Data Sheet

Soil Characteristics

	Site #1	Site #2	Site #3	Site #4
% Organic matter				
pH				
Nitrate N (lbs/acre)				
Phosphorus P (lbs/acre)				
Potassium K (lbs/acre)				
Soil texture				

Soil Invertebrates

	Site #1	Site #2	Site #3	Site #4
Springtails				
Earthworms				
Roundworms				
Beetles				
Beetle larvae				
Slugs				
Snails				
Flies				
Fly larvae				
Millipedes				
Proturans				
Pseudoscorpions				
Spiders				
Sowbugs				
Mites				
Ants				
Caterpillars				
True bugs				
Harvestmen				
Other: _____				
Other: _____				
Miscellaneous				
Total # Individuals				
Total # Species				

STUDENT PAGE

LESSON 3

Key to Soil and Leaf Litter Invertebrates⁹

For each organism you find, start with #1 and, depending on whether legs are present or not, go to the question number indicated. Continue until you determine the type of organism. Please note that some immature insects such as fly larvae, beetle larvae and moth larvae may not be accurately identified with this key.

1	Legs present	4
	Legs absent	2
2	Body spindle-shaped, smooth, unsegmented, slender, usually light-colored, minute (approx. 0.5-1.5 mm long)	Phylum Nematoda (roundworms)
	Body not spindle-shaped, or if spindle-shaped, animal is segmented, usually darker in color and 1.5 mm long	3
3	Body distinctly segmented and worm-like, shell absent	Phylum Annelida (earthworms)
	Body not segmented, soft and smooth, with or without shell	Phylum Mollusca (snails and slugs)
4	Three pairs of legs present	5
	More than three pairs of legs present	14
5	With functional wings	6
	Without functional wings	10
6	With only one pair of wings; second pair of wings replaced by a pair of short, pin-like structures (halteres)	Order Diptera (flies)
	With two pairs of wings	7
7	Front and hind wings similar in texture and thickness	8
	Front and hind wings unlike in texture; front wings may be horny or leathery	9

⁹ Source: "Soils: Physical and Biological Analysis" in *Environmental Science II* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources. Chemeketa Community College.

8	Wings usually covered with scales; sucking mouthparts	Order Lepidoptera (moths and butterflies)
	Wings transparent; chewing or sucking mouthparts	Order Hymenoptera (wasps)
9	Front wings horny or leathery and usually meeting in a straight line down the back, forming a veinless sheath over the abdomen; hind wings folded under front wings when not in use; chewing mouthparts	Order Coleoptera (beetles)
	Front wings thickened and leathery at base and membranous at tip; mouthparts, a piercing-sucking beak arising from the anterior portion of the head	Order Hemiptera (true bugs)
10	Abdomen terminating in two or three tail-like appendages (cerci); long antennae, chewing mouthparts	Order Thysanura (silverfish)
	No cerci at end of abdomen or, if cerci-like appendages are present, they are pointed in an anterior direction (i.e., the springs of springtails)	11
11	Narrow-waisted; chewing mouthparts	Order Hymenoptera (ants)
	Not narrow-waisted	12
12	Ant-like, but broad-waisted and usually light-colored	Order Isoptera (termites)
	Not ant-like	13
13	Small, delicate insects with long, usually double appendages on underside of abdomen; chewing mouthparts (very common in litter samples!)	Class Collembola (springtails)
	Small, soft-bodied, plump insects with two short tubes at end of abdomen; piercing mouthparts in a beak that arises from back of head	Order Homoptera (aphids)
14	Four pairs of walking legs present; head and thorax fused to form cephalothorax (Class Arachnida)	15
	More than four pairs of walking legs present	18
15	First pair of appendages (pedipalps) with large pincer-like claws; abdomen distinctly segmented; generally less than 10 mm long	Order Pseudoscorpionida (pseudoscorpions)
	First pair of appendages not usually highly modified; abdomen not distinctly segmented; length variable	16
16	Tiny, total length less than 2 mm; body generally oval or shield-like	Order Acari (mites)
	Larger, total length greater than 2 mm; body shape variable	17

17	Cephalothorax distinct from abdomen; leg length less than 3x body length	Order Araneae (spiders)
	Cephalothorax not distinct from abdomen; leg length greater than 3x body length	Order Opiliones (harvestmen, daddy-long-legs)
18	Two pairs of appendages per abdominal segment	Class Diplopoda (millipedes)
	One pair of appendages per abdominal segment	19
19	Thorax composed of eight overlapping segments, abdomen composed of six segments; seven pairs of legs plus one pair of maxillipeds (anterior)	Order Isopoda (sowbugs)
	Thorax and abdomen variable; more than seven pairs of legs	20
20	Antennae with three distinct prongs, nine pairs of legs	Class Pauropoda
	Antennae not as above, more than nine pairs of legs	21
21	Minute, total length less than 10 mm; 10 to 12 pairs of legs, poison claws absent on first trunk segment	Class Symphyla
	Larger, total length generally more than 10 mm; generally more than 12 pairs of legs, poison claws present on first trunk segment	Class Chilopoda (centipedes)

4: Forest Density Lab¹⁰

Overview

Students use Lego® bricks to model forest density and “build” forest stands with optimal spacing.

Time Considerations

Preparation: 30 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Define forest stand density.
- Model different forest stands to compare their density and spacing.
- Determine the optimal spacing and size class distribution for a particular stand.

Standards Connections

Oregon Science Standards

- HS.LS2.2. Ecosystems: Interactions, Energy, and Dynamics. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- Disciplinary Core Idea – HS.LS2.C. Ecosystem Dynamics, Functioning, and Resilience. 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 – 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.
- Science and Engineering Practice – 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.

¹⁰ Source: Adapted from “Lego® Forest Density Lab” in *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Oregon Forest Literacy Plan Concepts

- 3.B.3. Forest management ranges from active management (e.g., planting, thinning and harvesting) to passive management (e.g., reserves and wilderness areas) to grow, restore, maintain, conserve or alter forests.
- 3.B.4. Forest management includes using natural processes and goal-oriented decisions and actions to achieve a variety of desired outcomes, including environmental (e.g., wildlife habitat and carbon sequestration), economic (e.g., timber production) and social (e.g., recreation) outcomes. Many of these outcomes are interrelated and can be managed for simultaneously, while others may be incompatible.

Materials

- 16x16-stud Lego® baseplates, one per individual or pair
- Assortment of different-sized Lego® bricks: one-stud,¹¹ two-stud, four-stud, six-stud and eight-stud bricks (if possible, it is helpful if the bricks of each size are the same color)
- “Forest Stand Density” student page
- Camera (optional)

Background Information¹²

Stand density is an important concept in forest management. It is a measure of how many trees are growing per unit area. The density of a stand of trees affects a number of factors: tree size (and therefore tree value), tree and stand growth, branch and crown size, wood quality (such as presence of knots) and certain attributes of wildlife habitat. Land managers can directly influence stand development by manipulating stand density.

Forest managers use a variety of measures such as trees per acre (TPA), basal area per acre (BA/A), Reineke’s Stand Density Index (SDI), volume (board feet) and Relative Density (RD) to determine density. In this lesson, students calculate the trees per acre and use Stand Density Index and Relative Density to observe the spacing of trees within stands.

A stand’s SDI is equal to the number of trees averaging 10 inches in diameter (DBH) present in the stand. A site’s maximum SDI is both site- and species-specific, and describes the maximum

¹¹ The “studs” are the extensions on the bricks or platform that enable them to hold together. The number of studs denotes brick size.

¹² Source: “Lego® Forest Density Lab” in *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

number of 10-inch-diameter (DBH) trees that the stand could support before natural thinning would occur. RD is calculated by dividing the measured SDI by the maximum SDI. Thus,

$$RD = \text{Measured SDI} \div \text{Maximum SDI}$$

Each species has a different maximum Stand Density Index as well as optimal Relative Densities. Decades of research and empirical data have yielded some general rules for tree vigor and growth rates of coastal Douglas-fir in the Pacific Northwest. The tree-growth zones shown below have been established for Douglas-fir.

Note that the Coast Range is very productive, so Douglas-fir's maximum SDI is higher than it may be in other areas. In the Willamette Valley, for instance, the maximum SDI will vary between 510 and 550, depending on site quality. Also, remember that each species has a different maximum SDI value.

Table: Growth Zones for Coastal Douglas-Fir¹³

Zone	Description	SDI (per acre)	RD
Maximum Density Zone	The biological maximum of 10-inch-diameter trees that could possibly grow in an acre in this area.	600	1.0 (100%)
Mortality Zone	Some trees will begin to die due to tree-to-tree competition.	330-600	.55-1.0
Healthy Zone	Trees are vigorously growing, optimally using site resources.	210-330 ¹⁴	.35-.55
Diversity Zone	This density allows for differentiation of crown positions in the canopy.	120-240 ¹⁵	.20-.40

¹³ Source: "[Using Lego® Blocks to Demonstrate Concepts of SDI and Relative Density](#)" by Monica Spicker. Spokane Community College. Available at ir.library.oregonstate.edu.

¹⁴ This is the well-accepted thinning zone; allowing the stand to grow to 330 SDI and then thinning back to 210 SDI optimizes site resource utilization without allowing competition-induced mortality.

¹⁵ Thinning back to these levels of SDI should promote growth of understory vegetation or regenerated trees.

In this lesson, each two-stud Lego® brick represents a 10-inch-diameter (DBH) Douglas-fir tree growing in Oregon’s Coast Range. The two-stud brick has an SDI of 1, a one-stud brick represents 0.5 SDI, a four-stud brick presents 2 SDI, and so on. A Lego® baseplate of 16x16 studs has a total SDI of 128, and represents ¼ acre of forestland. The following table shows the brick sizes, their comparable tree size and SDI, as well as the number of bricks that would be needed for even SDI distribution among the five sizes at various relative densities.

Table: Number of Bricks Needed for Even SDI Distribution at Different Relative Densities (RD) for a 16x16 Baseplate

Brick Size	Comparable Tree Size (DBH)	Stand Density Index (SDI)	Relative Density (RD)		
			RD = 0.15	RD = 0.35	RD = 0.55
1-stud	6.5 inches	0.5	8	18	28
2-stud	10.0 inches	1	4	9	14
4-stud	15.4 inches	2	2	4	7
6-stud	19.9 inches	3	1	3	5
8-stud	23.8 inches	4	1	2	4

Key Vocabulary

basal area

diameter at breast height (DBH)*

Relative Density (RD)

stand density

Stand Density Index (SDI)*

tree size class

trees per acre (TPA)

**included in Glossary*

Preparation

Gather the materials. Make copies of the student page.

Procedure

1. Ask students: What might be the consequences of forest trees growing very close together or very far apart?
2. Point out that forest density is an important measure of a forest's health. Using information from the Background Information, introduce the concepts of trees per acre (TPA), Stand Density Index (SDI) and Relative Density (RD).
3. Give each individual or pair a 16x16-stud Lego® baseplate, an assortment of different-sized Lego® bricks and a copy of the “Determining Stand Density” student page. Direct them to follow the directions on the student page to build three different forest stands with different characteristics. You also may have students take pictures of each of their stands to compare later.
4. When students have completed the lab, lead a class discussion about what they learned, asking such question as
 - a. What distribution of tree sizes enabled you to best achieve the optimal density?
 - b. How did your mixed-age stand model compare with your optimal stand density model?
 - c. What does your modeling tell you about stand densities in a real forest?

Assessment

- Have students write a paragraph describing what they observed in the modeling exercise and what they learned from it.

Extension Idea

- Use the data from the activity to determine Basal Area (BA) for each of the stands. Basal Area describes the average amount of an area (usually an acre) occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height, and expressed as per unit of land area (typically square feet per acre). For this exercise, students calculate the area of each class of trees at breast height and then add together all the areas of all the trees, multiplying by four to express square feet per acre.

Determining Stand Density

Use Lego® bricks to model a forest stand, with each brick size representing a different size Douglas-fir tree and the 16x16-stud baseplate representing a quarter acre.

Stand 1: Place “trees” on the 16x16 baseplate in any array you choose. Then determine the Trees per Acre (TPA), Stand Density Index (SDI) and Relative Density (RD) for your stand, using the table below.

Brick Size	Comparable Tree Size (DBH)	Stand Density Index (SDI) per Tree	Number of Trees in Size Class (N)	SDI for Size Class (SDI x N)
1-stud	6.5 in	0.5	i:	a:
2-stud	10.0 in	1	ii:	b:
4-stud	15.4 in	2	iii:	c:
6-stud	19.9 in	3	iv:	d:
8-stud	23.8 in	4	v:	e:
TPA (sum of i-v above) x 4:				
Stand SDI (sum of a-e above):				f:
Stand SDI per Acre (f x 4):				g:
Relative Density (RD) = Stand SDI per Acre ÷ Maximum Stand SDI (g ÷ 512)				h:

Stand 2: Place trees on the 16x16 baseplate to build a forest stand with a Stand SDI of 240 per acre, the optimal density for Douglas-fir trees growing in the Coast Range. Be careful not to crowd trees (crowding is when one brick touches another brick at more than one stud).

Brick Size	Comparable Tree Size (DBH)	Stand Density Index (SDI) per Tree	Number of Trees in Size Class (N)	SDI for Size Class (SDI x N)
1-stud	6.5 in	0.5	i:	a:
2-stud	10.0 in	1	ii:	b:
4-stud	15.4 in	2	iii:	c:
6-stud	19.9 in	3	iv:	d:
8-stud	23.8 in	4	v:	e:
TPA (sum of i-v above) x 4:				
Stand SDI (sum of a-e above):				f:
Stand SDI per Acre (f x 4):				g:
Relative Density (RD) = Stand SDI per Acre ÷ Maximum Stand SDI (g ÷ 512)				h:

Stand 3: Create a mixed-age stand with a Relative Density of .35 per acre by choosing three or more different tree sizes and placing enough of each in the stand so that the total SDIs for each size class are about the same. Be careful not to crowd trees.

Brick Size	Comparable Tree Size (DBH)	Stand Density Index (SDI) per Tree	Number of Trees in Size Class (N)	SDI for Size Class (SDI x N)
1-stud	6.5 in	0.5	i:	a:
2-stud	10.0 in	1	ii:	b:
4-stud	15.4 in	2	iii:	c:
6-stud	19.9 in	3	iv:	d:
8-stud	23.8 in	4	v:	e:

TPA (sum of i-v above) x 4:	
Stand SDI (sum of a-e above):	f:
Stand SDI per Acre (f x 4):	g:
Relative Density (RD) = Stand SDI per Acre ÷ Maximum Stand SDI (g ÷ 512)	h:

5: Forest Thinning¹⁶

Overview

In this field investigation, students determine the trees per acre of a forest plot and then make recommendations for thinning it to a given density, including which trees they would remove.

Time Considerations

Preparation: 30 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Determine the trees per acre of a given forest plot.
- Calculate the number of trees that should be removed to reach a given optimum density.
- Recommend which trees to remove based on their location, size, live crown ratio, health and form.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Constructing Explanations and Designing Solutions. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Oregon Mathematics Standards

- Mathematical Practice – MP.2. Reason abstractly and quantitatively.
- Number and Quantity - HS.NQ.B. Attend to units of measurement needed to solve problems through quantitative reasoning and mathematical modeling.

¹⁶ Source: Lesson was adapted from *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Oregon Forest Literacy Plan Concepts

- 3.B.1. Forest management is a long-term process that can lead to changes in tree species composition, size and age, as well as in forest health and resilience.
- 3.B.3. Forest management ranges from active management (e.g., planting, thinning and harvesting) to passive management (e.g., reserves and wilderness areas) to grow, restore, maintain, conserve or alter forests.

Materials

- Flagging tape
- Stakes
- “Forest Thinning Tally Sheet” student page
- Measuring tapes
- Optional: calculators or calculator app

Background Information¹⁷

The most common tool used in silviculture is thinning, which means removing some trees so that the remaining trees have more light and other resources to grow. All plants have a predetermined size-density relationship, meaning that at a given density (trees per acre) individual plants can only grow to a certain size. To get larger, they need more space.

This relationship has been well researched by foresters, so they know the optimal spacing for tree growth. Managing tree growth with thinning requires staying above a minimum spacing and far enough above the optimal spacing to allow for growth until the next thinning.

A general rule for Douglas-fir, for example, says that minimum adequate spacing can be estimated by the number of inches of diameter measured at breast height (DBH, 4.5 feet above ground on uphill side of tree). Using this method, a 12-inch-diameter tree would need a minimum of 12 feet to

Optimal spacing for various tree species

Species	Optimal spacing (in feet) at		
	6" diameter	10" diameter	16" diameter
Douglas-fir	8	12	17
Western hemlock	6	10	14
Western redcedar	7	11	16
Grand fir	8	12	18

¹⁷ Source: “Tending Your Trees,” in *Establishing and Managing Forest Trees in Western Oregon*. Oregon Forest Resources Institute.

the nearest 12-inch-diameter tree, while a 20-inch tree would need 20 feet. If you were thinning a forest you would want to provide for future growth, so Douglas-fir forests are commonly thinned to spacings of diameter plus 4 or 5 feet. The chart below indicates the optimal spacing of various Oregon forest tree species.

In deciding which trees to remove in thinning, foresters will take into account the health of the individual trees, including whether they are alive, show any deformities (such as the top missing) or have signs of poor health (such as fungus or evidence of insect damage).

Another factor they may consider is a tree's "live crown ratio." This is the percentage that the crown represents of the total tree height. Determining live crown ratio involves measuring or estimating the vertical distance from the top of the tree to the lowest live branch and dividing that measurement by the total height of the tree. For Pacific Northwest conifers, a live crown ratio of 30 percent or more is considered healthy. Trees with less than 30 percent may be good candidates for thinning.

Key Vocabulary

live crown ratio*

plot density

target density

thinning

**included in Glossary*

Preparation

Identify a suitable forest study area. It should include space for 0.05-acre (1/20 of an acre) circle plots for each student group. At 0.05 acres, each circle plot will have a radius of 26.3 feet.

You may mark the circle plots in advance, with a stake at the center and stakes or flags around the perimeter, or have students do that as part of the lab.

Procedure

1. Ask students what happens if the trees in a forest stand grow too close together. Discuss the importance of thinning as a way to maximize tree growth.
2. Give students the following scenario: You are in charge of managing a 4-acre forest plot for maximum wood production. Foresters have determined that the optimal stand density for this forest is 200 trees per acre (for westside forests) or 100 trees per acre (for

eastside forests). Your job will be to determine how many trees you would need to reduce, and which specific trees you would cut or thin, to reach the target.

3. Point out that each team will look at a 0.05-acre sample plot within the stand – a circle plot, with a radius of 26.3 feet – and mark the trees they would thin with flagging tape. Ask students what characteristics they might consider to determine which trees to thin.
4. Hand out copies of the student page. Explain live crown ratio and answer any other questions about the task.
5. Take students to the study area, and divide them up into lab groups of two to four students. If you haven't already marked the plots, have groups measure and mark their 0.05-acre plots.
6. Direct groups to count the number of trees in their plot, calculate the trees per acre (as shown on the student page), determine how many trees they would need to thin to reach the target density, and identify (on the student page and with flagging tape) which trees they would recommend removing. Point out that every tree larger than 2" DBH should be identified and recorded on their student pages.
7. When groups finish up their task, have them share with another group their findings and which trees they recommend thinning.

Assessment

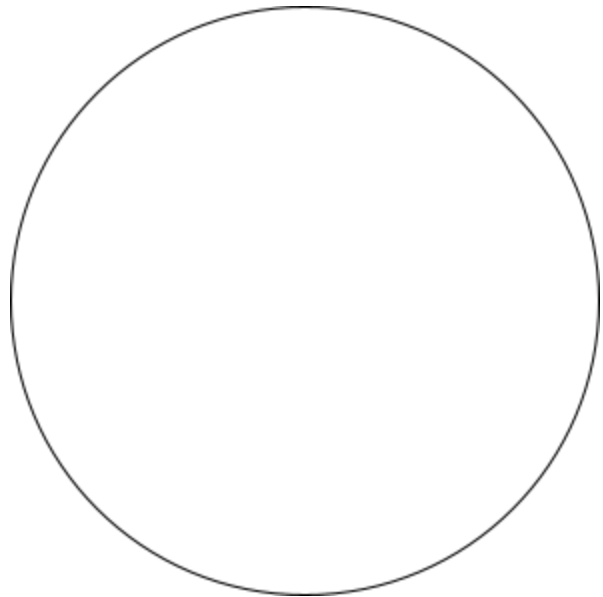
Ask students to write a few paragraphs describing their lab experience, including their method and reasoning for determining how many and which trees to thin.

Extension Ideas

- Enter the data collected from the lesson into a modeling program to estimate tree growth and visualize other forest processes. The [Landscape Management System](http://landscapemanagementsystem.org) at landscapemanagementsystem.org is a free software program developed by University of Washington, College of Forest Resources, Silviculture Laboratory; Yale University School of Forestry and Environmental Studies; The Cradle of Forestry in America; and the U.S. Forest Service.
- Watch an 8-minute OPB Oregon Field Guide segment on forest thinning: [Oregon Field Guide, Season 21, Episode 5](http://opb.org), available at opb.org.
- Explore forest thinning using resources from OSU Forestry and Natural Resources Extension, which can be found on the "[Thinning](http://knowyourforests.org)" webpage at knowyourforests.org.

Forest Thinning Tally Sheet¹⁸

1. Mark in the circle the locations of each of the trees in the circle plot. Give each tree a number.



2. For each tree in your circle plot, determine the following.

Tree Number	Species	DBH	Height	Live Crown Ratio	Health	Thin?

¹⁸ Source: Adapted from *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

3. Calculate the plot density (in trees per acre) using the following formula.

Plot Size: 0.05 acres (1/20 of an acre)

Number of Trees (larger than 2" diameter at breast height) in Plot: _____

Plot Density = Number of Trees in Plot x 20 = _____ Trees per Acre

4. Determine the thinning requirement for the plot by finding the difference between the Plot Density and the Target Density.

Target Density (trees per acre): _____

Plot Density (trees per acre): _____

Difference between Target Density and Plot Density: _____

Number of Trees to Thin = Difference in Density x Plot Size = _____

6: Harvesting

Overview

Students learn about the Oregon Forest Practices Act and its general requirements for harvesting and reforestation. They then compare six different timber forest harvest systems and choose the most appropriate system for a specific scenario.

Time Considerations

Preparation: 15 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Describe the key features of the Oregon Forest Practices Act.
- Compare different timber harvest systems.
- Given a real-life scenario, choose the best harvest system or systems for it.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Oregon Forest Literacy Plan Concepts

- 3.B.3. Forest management ranges from active management (e.g., planting, thinning and harvesting) to passive management (e.g., reserves and wilderness areas) to grow, restore, maintain, conserve or alter forests.
- 3.B.4. Forest management includes using natural processes and goal-oriented decisions and actions to achieve a variety of desired outcomes, including environmental (e.g., wildlife habitat and carbon sequestration), economic (e.g., timber production) and social (e.g., recreation) outcomes. Many of these outcomes are interrelated and can be managed for simultaneously, while others may be incompatible.

Materials

- “Timber Harvest Systems” student pages
- “Timber Harvest Systems Compared” student page

Background Information¹⁹

In forest management, trees are harvested for a variety of reasons. They may be harvested to improve the health of the forest; to control the types of trees that grow on the site; to attract certain wildlife species; to provide a source of income for the landowner; to produce paper, lumber and numerous other forest products; or to improve access to the area for hikers, hunters and other recreational users.

Oregon has strict laws for protecting forests, some of which have been in place since 1941. Oregonians recognize that ensuring the abundance of our forest resources helps everyone, and that keeping them economically viable prevents their conversion into non-forest use. These laws have been developed and updated as an ongoing collaboration between scientists, landowners, elected officials and the general public. They help ensure that all Oregon forests operate under a unified set of guidelines and practices so that we sustain our forestlands for generations to come. These laws provide protection for soil, air, water, fish, wildlife and forest resources.

In 1941, Oregon adopted the Oregon Forest Conservation Act to address reforestation and fire protection. In 1971, Oregon became the first state to implement a comprehensive set of laws governing forest practices with the Oregon Forest Practices Act (OFPA). Leaders from the forest sector helped develop these laws to guide pre-operation planning, education for operators, and cooperative efforts among landowners and government.

Some of the requirements in the Oregon Forest Practices Act include:

- Reforestation: Landowners must complete replanting within two years after harvest. Within six years, the harvest area must be a healthy stand of trees that can outgrow competing grass and brush.

¹⁹ Sources: Information about Oregon Forest Practices Act: “[Oregon’s Forest Protection Laws](#).” Oregon Forest Resources Institute, [oregonforests.org](#).

“[Are There Laws that Protect Our Forests?](#)” Oregon Forest Resources Institute, [learnforests.org](#).

Information about timber harvest systems: “Common Types of Timber Harvest Systems.” [Oregon Forest Protection Laws: An Illustrated Manual](#). Oregon Forest Resources Institute, [oregonforests.org](#).

- Protection of water sources: Timber harvesting, road building and chemical use are restricted close to streams, to protect fish and drinking water.
- Protection of wildlife habitat: Live trees, snags and fallen logs must be left after harvest to provide structure for wildlife habitat.
- Limits on clearcuts: A clearcut cannot be more than 120 acres. Clearcuts within 300 feet of each other cannot total more than 120 acres on the same ownership.

Since 1971, Oregon has adopted additional rules that help protect forests, water quality and wildlife habitat. The OFPA is periodically updated to reflect new scientific data, new operating technology and new forestry practices, to ensure our forest resources are properly protected.

Common Types of Timber Harvest Systems

Cutting trees, moving logs to a landing and loading logs for transport to a mill all are part of a timber harvest system. There are different timber harvest systems. Each one has advantages, which are described on the student pages. Modifications can make them even more versatile. The systems include conventional chainsaw and tractor skidder harvest, cable logging, shovel logging, cut-to-length harvesting, whole-tree harvesting and helicopter harvesting.

The terrain of the forest area will influence the choice of logging system. On gentle terrain, tree processors and forwarders, excavators, tractors and skidders (explained in the student pages) and even horses can be logical choices. On steep terrain, the choice shifts to cable or helicopter systems.

Key Vocabulary

cable logging

cut-to-length harvesting

helicopter harvesting

shovel logging

timber harvest*

timber harvest system

tractor/skidder harvest

whole-tree harvesting

**included in Glossary*

Preparation

Make copies of the student pages, or provide on-screen access to them.

Procedure

- Remind students of the many different products that come from Oregon forests. Ask them what might happen if forest owners were able to harvest trees on their land whenever and however they wanted.
- If students are not aware of it, provide a brief overview of the Oregon Forest Practices Act, using ideas from the Background Information. Point out that this law is designed to protect Oregon's forests.
- Discuss how harvesting timber might compare to harvesting agricultural crops such as lettuce or pears. (For example, lettuce or pears could be harvested by hand in the field, but since trees are so massive, harvesting requires large equipment to cut, move and load the logs. In both types of harvest, care must be taken not to compact the soil or disturb the landscape.)
- Give students copies of the "Timber Harvest System" student pages. Direct them to read about each system and, using the "Timber Harvest Systems Compared" student page, make notes about which system is best for which situation.
- Ask students to work in pairs or groups and write a scenario to describe a particular forestland area. They should include in their description its size, how sloped or flat it is, how large or dense, and the forest landowner's goal for harvesting it.
- Invite students to swap scenarios with another pair or group to determine the best harvesting method for the scenario they are given. Pairs or groups should be able to give their reasoning to defend their choice.

Assessment

- Have students use presentation software (such as PowerPoint or Prezi) to describe the Forest Practices Act and its requirements for timber harvest.

Extension Ideas

- Show students the video [Inquiry at Hinkle Creek: Doing Science in Our Forests](#) (16:59 minutes, available at [learnforests.org](#)), and discuss what the investigation revealed about management methods in the two watersheds.
- Share with students the [Find Your Path: Logging Crew](#) video (2:20 minutes, available at [learnforests.org](#)), and arrange for students to visit an active logging site in your area.

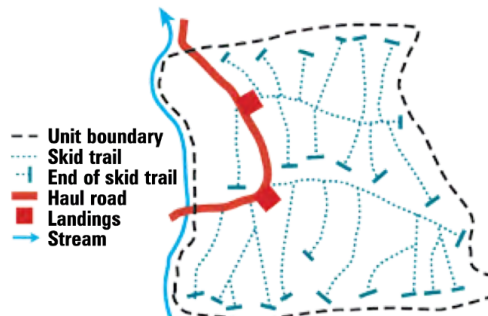
Timber Harvest System: Conventional Chainsaw and Tractor/Skidder Harvest

Hand-operated chainsaws are used to cut, delimb and buck trees into logs at the stumps. Skidders or crawler tractors (dozers) drag the logs to landings, where they are loaded onto trucks.



Tree felling, limbing and bucking are done with chainsaws.

Typical harvest layout. Skid trails should be planned and marked in advance. They often follow parallel branching patterns as shown (see Page 60). By winching logs across greater distances, skid trails can be located farther apart, reducing the area of skid trails and soil impacts from vehicle traffic.



Advantages

- adaptable to smaller harvest locations
- generally less costly equipment

Equipment used

- chainsaw
- log skidder or crawler tractor (dozer)
- log loader or self-loading log truck

Topography considerations

- normally restricted to slopes less than 35 percent
- haul roads usually located at the bottom of the logging unit

Soil considerations

- use of designated skid trails keeps machines on planned routes to help reduce soil disturbance
- on weaker soils, heavy traffic may result in trail ruts that require more water bars after logging
- soil disturbance can be reduced with widely spaced trails and pulling a winch line farther to logs – synthetic lines and other equipment features can make this task easier
- tractors and skidders should lift the front end of logs to reduce soil gouging

Forest stand considerations

- provides much flexibility with a variety of stand management goals

Slash disposal considerations

- lop and scatter possible with light accumulations of slash
- pile and burn is an option but requires additional steps and costs
- chipping and biomass energy utilization may be possible

Reforestation considerations

- yarding traffic or post-logging treatment can scarify ground and create areas for natural regeneration or hand-planting
- some advance regeneration may be lost or damaged by vehicle traffic

Economic considerations

- often more labor intensive
- generally, more roads are necessary
- least expensive method if road construction is not needed or is budgeted separately

Left: Skidders or dozers drag logs from the forest to the log landing. To reduce soil disturbance, rubber-tired skidders or crawler tractors are kept on skid trails. Winch line and chokers pull logs to the machine. **Right:** At the landing, a log loader moves logs onto trucks for delivery to the mill.



Timber Harvest System: Cable Logging

On steep terrain, this system uses a steel cable to carry either whole trees or logs to a landing after trees are felled with chainsaws.

Advantages

- allows for harvesting on steep ground and other sensitive terrain
- eliminates the need for skid trails
- can reduce construction and less favorable locations of roads

Equipment used

- chainsaw
- cable yarder
- delimber and log loader

Topography considerations

- well-suited for slopes of 35 percent and greater
- concave slopes allow more cable deflection and greater system efficiency
- intermediate supports allow for log lift in uneven terrain
- haul roads usually located at the top of the logging unit

Soil considerations

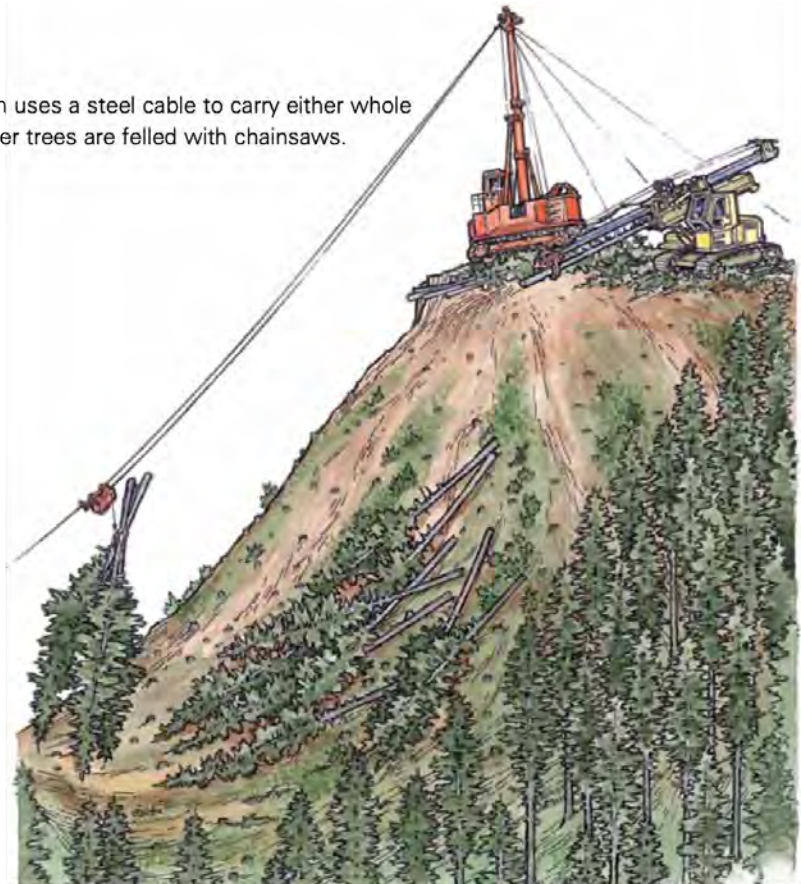
- can significantly reduce soil compaction and disturbance if logs are properly lifted
- heavy equipment is confined to roads and landings

Forest stand considerations

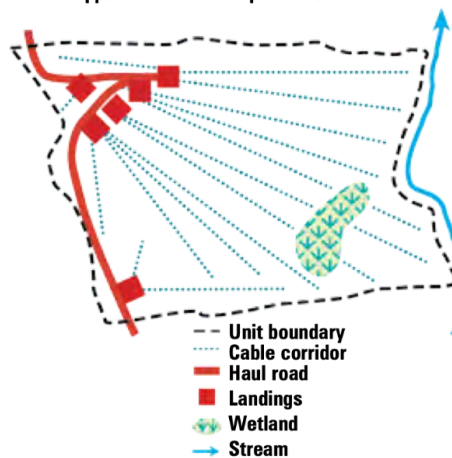
- primarily used with clearcuts and some partial cuts
- a more difficult method for thinning, with potential damage to residual stems

Slash disposal considerations

- if whole trees are brought to the landing, in-unit slash is minimized



Cable yarding systems can reach out 2,500 feet or more, especially with intermediate cable supports. This can help limit road construction needs.



Typical cable harvest layout. Generally logs are pulled uphill, but can also be moved downhill. With a strategic layout, logs can be lifted over streams, wetlands and canyons (see page 63).

- heavy slash piles at the landing must be treated or utilized
- if whole tree yarding is not used, prescribed burning of slash may be needed (see pages 69-72)

Reforestation considerations

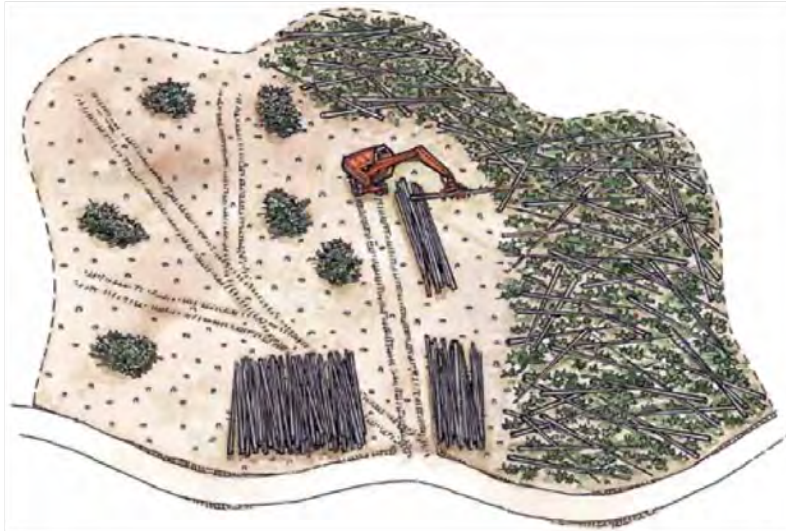
- may expose fewer spots for easier planting or natural seeding
- brush control needs also may be greater when scarification is reduced

Economic considerations

- can be more costly and specialized than ground-based systems
- small-scale systems can be competitive in some situations

Timber Harvest System: Shovel Logging

This ground-based harvest system uses a log loader (also called a shovel) to move logs rather than a skidder, tractor or forwarder. The shovel moves logs across the unit to locations near the road where they can be loaded onto log trucks. Logs are often picked up and moved ("swung") several times before reaching the road.



The shovel starts at the nearest access point and moves logs until they are within reach of the road. From there they can be loaded on trucks.

Below: Excavators equipped with grapples are common choices for handling logs and doing other useful tasks.



Advantages

- requires few people and machines
- few or no skid trails needed; existing roads may be adequate
- brush can be piled during harvest operations.

Equipment used

- chainsaw
- tracked excavator equipped with a grapple to grip and move logs

Topography considerations

- limited by slope due to machine instability on steep side hills
- may allow for harvest of some sensitive areas, with less disturbance than other systems

Soil considerations

- less compaction and disturbance if machine passes are limited

Forest stand considerations

- used primarily in clearcuts or partial cuts
- requires clearing of roadsides for log decks

Slash disposal considerations

- while moving logs, the excavator can pile heavy concentrations of slash for burning, chipping or other utilization

Reforestation considerations

- while or after moving logs or slash, the excavator can prepare the site for planting or seeding

Economic considerations

- small crew size
- one machine for multiple tasks can reduce costs
- efficiency improves with shorter yarding distances

Timber Harvest System: Cut-to-Length Harvesting

This ground-based system uses a mechanized harvester (tree processor) and a forwarder. The harvester severs, de-limbs and cuts each tree into logs and stacks them in the forest. The forwarder follows, picking up the logs and carrying loads to log trucks. It is also called a harvester-forwarder system.



A single grip processor can reach out 30 feet, cut a tree, strip the limbs, cut the stem into pre-programmed lengths and lay the logs on the ground, all in less than a minute. Ideally, they travel over the tree tops and limbs they leave.



A forwarder follows the harvester, picking up logs and delivering them to log trucks. They can travel long distances, reducing the need for log truck roads.



Logs are offloaded from the forwarder directly to log trucks.

Advantages

- leaves slash (tree branches and tops) in the forest
- reduces the need for log landings and access roads

Equipment used

- harvester/processor (tracked or wheeled)
- forwarder (often wheeled)

Topography considerations

- normally limited to slopes less than 35 percent

Soil considerations

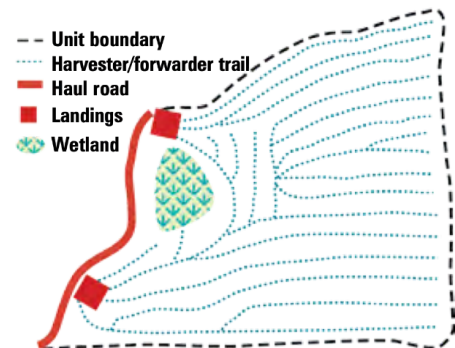
- can reduce compaction and disturbance, especially if the processor moves over duff and slash and if forwarders stay on slash-covered, designated skid trails
- slash left in the harvest unit will recycle nutrients and organic matter

Forest stand considerations

- an efficient method for commercial thinning
- typically used to move short logs out of the forest rather than long logs
- processor efficiency in dense stands is useful for forest health and fuels treatments

Slash disposal considerations

- by traveling over and compacting the slash, the system can reduce wildfire hazards and may meet slash hazard control requirements with no further treatment
- equipment can be used for slash piling for burning, chipping or other utilization



Typical harvest layout. Designated harvester/forwarder trails are about 60 feet apart and often follow parallel patterns across the harvest units.

Reforestation considerations

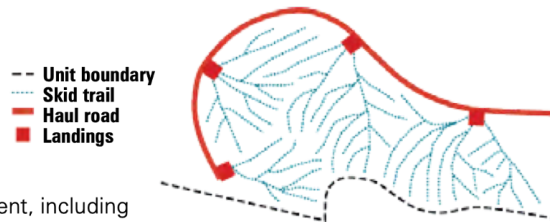
- common for thinnings where residual stocking does not trigger reforestation requirements
- if used for heavier cuts and slash loads, extra steps could create spots for planting or seeding

Economic considerations

- may not require new or improved roads
- relatively expensive and specialized machinery and operators
- may require larger volumes or higher quality timber for efficient use

Timber Harvest System: Whole-Tree Harvesting

This harvest system brings the entire tree, limbs and tops attached, to the landing or roadside. It can be used for both ground-based and cable applications. When used in ground applications, a feller-buncher often is used to cut and pile bundles of trees in the forest. Then a tractor or skidder drags the tree bundles to the landing or roadside. Finally, a delimber converts the trees to logs.



Advantages

- can be relatively efficient, including use of smaller material
- slash is brought to the landing or roadside where it can be burned, chipped or otherwise utilized

Equipment used

- feller-buncher
- crawler tractor or skidder with grapple
- stroke-boom delimber
- log loader

Topography considerations

- normally limited to slopes less than 35 percent
- with ground-based harvest, haul roads are usually at the bottom of the logging area

Soil considerations

- vehicles travel over a larger portion of the area as they cut, stack, gather and drag whole trees
- potential for more soil disturbance and compaction than other ground-based systems
- removal of tops and limbs does not recycle nutrients and organic matter near its source

Forest stand considerations

- efficient harvest and stand conversion when using a clearcut,
- can be used when thinning, but damage to remaining trees can be a problem.



A feller-buncher severs trees and lays them in bunches with limbs and tops attached. Bunches are oriented with tree trunks facing downhill.

Slash disposal considerations

- slash can be piled and later burned, chipped or otherwise utilized
- slash returned to the harvest area can recycle nutrients and organic matter (see pages 67-69)

Reforestation considerations

- widespread traffic and large tree bundles may damage advance regeneration
- dragging tree bundles can expose areas for planting or seeding

Economic considerations

- costs can increase on steeper ground or with longer skid distances
- bunching trees can help reduce the cost of handling small diameter trees.

Typical harvest layout. The feller-buncher and grapple skidder travel over most of the unit. Confining multiple trips to primary skid trails can reduce soil disturbance.



A crawler tractor or skidder with a grapple picks up bunched trees and drags them to a landing or roadside. Some grapples can swing 180 degrees, making it easier to operate in tight spaces.



The stroke-boom delimber operates at the landing or roadside, removing tree limbs and top, cutting the stem into logs and stacking them.



The loader serves two needs: loading trucks and piling tops, branches and log chunks for later burning, chipping or other utilization.

Timber Harvest System: Helicopter Harvesting

This harvest system was once used exclusively for large, high-value timber. Helicopter harvest remains a higher-cost alternative, but it can be used for smaller logs when timber volumes and quality are adequate.

Advantages

- can harvest visually sensitive, inaccessible or other areas where other systems are unsuitable
- useful option for locations with high recreational use, special wildlife habitat, riparian/wetlands or geologic hazards
- may reduce or avoid new road construction, including hazardous/sensitive locations

Equipment used

- chainsaw
- logging helicopter
- helicopter maintenance and fueling equipment
- log loader

Topography considerations

- can be used on any type of terrain with suitable landing and helicopter service area locations (i.e., adequate size, safety and efficiency)

Soil considerations

- minimizes in-unit soil disturbance and compaction because logs are fully suspended
- large landings and service areas may require extra drainage or other treatment

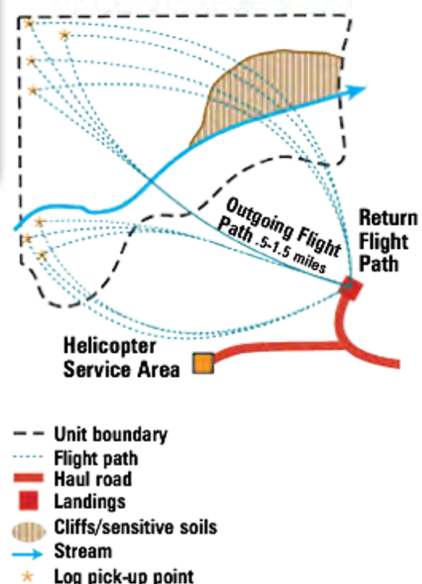
Forest stand considerations

- offers efficient, but costly method for commercial thinning
- large landings and service areas can locally impact forest stands.



This helicopter has a payload capacity of 6,000 pounds. Flight distances are kept to one-half to 1.5 miles. Longer distances are more costly. Planning to achieve optimum payloads for each trip helps make the operation economic.

Typical harvest layout



Slash disposal considerations

- lop-and-scatter methods typically are used to reduce fire hazards
- if further treatment is needed, it can be costly where road access is limited

Reforestation considerations

- slash left on-site and limited yarding disturbance result in fewer exposed spots for easy planting or natural seeding

Economic considerations

- typically the most expensive logging system
- equipment and crew needs can result in costs three to four times those of ground-based systems
- reduced road construction needs may help offset high costs
- without adequate volume of higher value logs, harvest costs may exceed timber revenues

LESSON 6

Timber Harvest Systems Compared

Good for...	Conventional Chainsaw and Tractor/Skidder Harvest	Cable Logging	Shovel Logging	Cut-to-Length Harvesting	Whole-Tree Harvesting	Helicopter Harvesting
Smaller harvest or thinning?						
Clearcuts or partial cuts?						
Level land (less than 35% slope)?						
Sloped land (35% slope or greater)?						
Minimizing the number of skid trails needed?						
Areas with special wildlife habitat?						
Minimizing soil disturbance?						
Minimizing cost?						

7: Reforestation

Overview

Students read about and answer questions on techniques for successful reforestation, and then calculate the number of seedlings that would be required to reforest a given area.

Time Considerations

Preparation: 15 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Describe the key features of the Oregon Forest Practices Act.
- Explain the steps involved in successful reforestation.
- Calculate the number of seedlings that would be required to reforest a given tract of land.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Using Mathematics and Computational Thinking. Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Oregon Mathematics Standards

- Mathematical Practice – MP.4. Model with mathematics.

Oregon Forest Literacy Plan Concepts

- 3.B.1. Forest management is a long-term process that can lead to changes in tree species composition, size and age, as well as in forest health and resilience.

- 3.B.3. Forest management ranges from active management (e.g., planting, thinning and harvesting) to passive management (e.g., reserves and wilderness areas) to grow, restore, maintain, conserve or alter forests.

Materials

- [Forest Fact Break: Reforestation](#) video (1:22 minutes), available at learnforests.org
- Technology to share video
- “Reforestation in Oregon” student page
- “Reforestation in Oregon – Questions” student page

Background Information²⁰

Reforestation is Oregon law. But even before these laws were in place, forest landowners – much like farmers – replanted after every harvest. Because of landowners, Oregon is a national reforestation leader, planting about 40 million new seedlings each year, according to the Oregon Department of Forestry.

Reforestation is an essential part of active forest management. Before harvest, foresters determine the best plan of action to ensure the regrowth of a healthy forest. Sometimes this means immediate replanting, while other times it means leaving trees as seed sources. When appropriate, seedlings of several different tree species are planted to maintain diversity in a working forest.

The land needs to be prepared to improve the growth and health of young trees. This requires clearing away post-harvest debris through a few different methods:

- Controlled and contained burning
- Using herbicides within the rules and regulations of the Environmental Protection Agency and Oregon Department of Forestry to control weeds and other vegetation that compete with young trees
- Using machines to clear excess logging debris to allow planting of seedlings

Seedlings are planted while they are dormant so they can take advantage of cool, wet weather conditions that promote good root development. This means seedlings are typically planted from winter into early spring. In Oregon, seedling survival typically surpasses 95 percent.

Through consistent and responsible reforestation, Oregon can keep its forests healthy and sustainable.

²⁰ Source: “[Reforestation Is Oregon Law](#).” Oregon Forest Resources Institute, oregonforests.org.

Key Vocabulary

artificial regeneration

bare root stock

container stock

free to grow*

reforestation*

regeneration*

**included in Glossary*

Preparation

Copy the student pages or provide on-screen access to them.

Procedure

1. Ask students to jot down what they think reforestation means. What might be the purpose of reforestation?
2. Show students the 90-second video *Forest Fact Break: Reforestation*. Discuss: How did the information in the video compare to what students wrote down?
3. Give students copies of the “Reforestation in Oregon” student page.
4. After allowing time for students to read, give them copies of the “Reforestation in Oregon – Questions” student page and have them discuss the questions in pairs or small groups.
5. Have students work in pairs to solve the following problem:

You are the manager of eight acres of forestland that have just been completely cleared and need to be reforested. After talking with foresters in your area, you have decided to plant Douglas-fir seedlings spaced 12 feet apart, as this would be the optimal spacing for your site. Your task now is to determine how many Douglas-fir seedlings you would need to reforest the entire area, with the seedlings spaced 12 feet apart.

You may choose to have students look up the area of an acre as part of their problem-solving, or tell them that an acre is equivalent to 4,840 square yards or 43,560 square feet.

6. Have students share their responses, explaining how they got their answer. (The correct answer is in the following box.) Discuss how the number would change if the trees were planted 6x6 feet or 10x10 feet apart, and why someone might choose to plant the seedlings closer or farther apart.

Spacing and Number of Trees per Acre – Answer

To determine the number of trees needed to plant one acre, you must divide 43,560 square feet (the area of an acre) by the number of square feet each tree needs. For 12x12 spacing, $43,560 \text{ square feet per acre} \div 144 \text{ square feet per tree} = 302 \text{ trees per acre}$. For eight acres, multiply the trees per acre times eight ($302 \text{ trees per acre} \times \text{eight acres} = 2,416 \text{ trees}$).

Spacing (feet)	Square Feet per Tree	Trees per Acre	Trees for Eight Acres
12x12	144	302	2,416
10x10	100	436	3,488
6x6	36	1,210	9,680

Assessment

To assess student understanding, direct them to write a report describing their reforestation plan for the forestland described in the activity – including why they are reforesting the land and how they determined the number of trees required.

Extension Ideas

- Have students participate in a tree planting or reforestation effort. For information on how to plant trees, see [Establishing and Managing Forest Trees in Western Oregon](http://oregonforests.org), available at oregonforests.org. See Lesson 3: Service-Learning Project in the “Our Responsibility to Oregon’s Forests” module for ideas for developing this as a service-learning activity.
- Visit a forest seedling nursery to learn firsthand how seedlings are grown. See “[Sources of Native Forest Nursery Seedlings](http://oregon.gov/odf),” available at oregon.gov/odf, for a possible nursery in your area.

Possible Answers to “Reforestation in Oregon – Questions” Student Page

1. Besides being the law in Oregon, reforestation provides multiple benefits, including wood products, watershed protection, fish and wildlife habitat, and recreational opportunities, as well as providing shade and absorbing greenhouse gases.

2. Planning and evaluating the site; preparing the site; selecting proper species and stock-type; planting at the optimal time for the location; maintaining the seedlings until they are “free to grow.”
3. Bare root seedlings – packaged in bags, with roots exposed. Container seedlings – come in a container, often made of Styrofoam.
4. Ponderosa pine.
5. Possible answers: western hemlock, western redcedar.
6. Planted in rich planting soil; at the proper depth; with no air pockets; with roots directed down into the soil with space between them; and with the main stem upright.

Reforestation in Oregon²¹

Replanting a forest after it has been harvested, known as reforestation, is important. For one thing, it's the law in Oregon. Beyond the law, however, reforesting makes good sense for the environment and for the economy. Since nearly half of the state's land area grows trees, forests can provide multiple benefits, including wood products, watershed protection, fish and wildlife habitat, and recreational opportunities. Our forests can even make an impact beyond our borders, since trees provide cool shade and absorb greenhouse gases that contribute to climate change.

Oregon was the first state in the nation to pass laws to ensure continuous harvest of timber on private lands while safeguarding soil, air, fish and wildlife resources. In 1971, Oregon enacted the Oregon Forest Practices Act, which regulates many activities conducted on forestland, including reforestation. Oregon law requires reforestation when timber harvesting reduces the number of trees below specific stocking levels. Landowners must complete reforestation within 24 months after harvesting. Depending on site productivity, at least 100 to 200 seedlings per acre must be established. However, most landowners plant 300 to 400 trees per acre.

Today, about 40 million trees are planted every winter and spring in Oregon. These tree seedlings are carefully planted on public, industrial and family forestlands. It takes good planning and follow-through to ensure success in this labor-intensive and expensive work.

Planting is the most common way to ensure a fully stocked young forest. This is known as artificial regeneration and is often used in heavily managed stands. Advantages to artificial reforestation include quick, uniform regeneration, less susceptibility to environmental factors (e.g., natural seed dispersal, poor seed years, etc.), a head start over brush and selecting seedlings from superior genetic stock. Natural regeneration, by comparison, may take longer and result in spotty regeneration.

²¹ Source: *Exploration of Oregon Forests: Module 4 – Forest Management 1 – Cycles and Reforestation*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

The Five Steps to Reforestation:

STEP 1:

Carefully plan, evaluate and prepare the site. Consider the condition of the planting site: vegetation present, soil type, aspect (direction the slope faces), wildlife and pests. Site characteristics affect critical site resources necessary for seedling survival and growth, including water, sunlight, temperature and nutrients.

STEP 2:

Choose an appropriate site preparation method or combination of methods. Several methods are available to prepare sites for planting. These methods include mechanical, manual and chemical. Costs depend on site conditions, methods used, existing vegetation and the amount of logging debris or slash.

STEP 3:

Select the proper species and seedling stock-type for the site. Different tree species are adapted to different site conditions. Choose seedlings specifically for the seed zone and elevation. Obtain tree seedlings by encouraging natural seeding, by transplanting seedlings growing in the wild or by purchasing nursery-grown seedlings.

STEP 4:

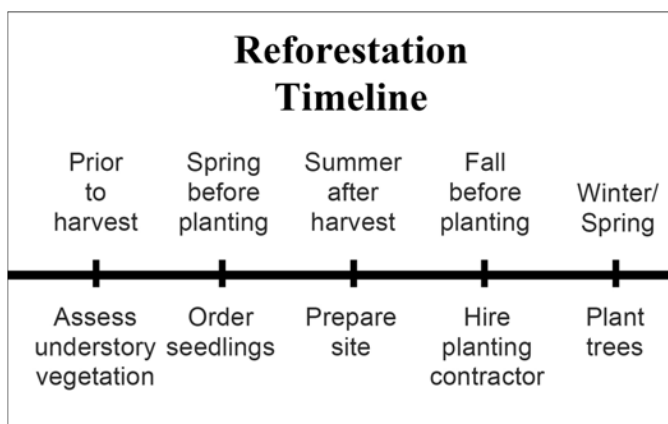
Plant conifer seedlings in western Oregon from January through March. In higher elevations or in eastern Oregon, plant as soon as possible after snow melts and the ground thaws, generally late March through April. Keep seedlings cool (34 to 40 degrees F) and moist, and handle them gently at all times. Site conditions dictate the spacing and density of trees. In western Oregon, typical spacing is 10' x 10'. In eastern Oregon, trees are generally spaced at 12' x 12'. Select good planting spots such as areas of exposed mineral soil that are free of weeds.

STEP 5:

Once seedlings are planted, additional maintenance often is needed to ensure their continued survival and growth. The first two years following planting are critical for survival. New seedlings may require protection from animals, weeds or drought. According to Oregon laws, by the sixth year, the new stand must be “free to grow” (able to out-compete surrounding grasses and brush).

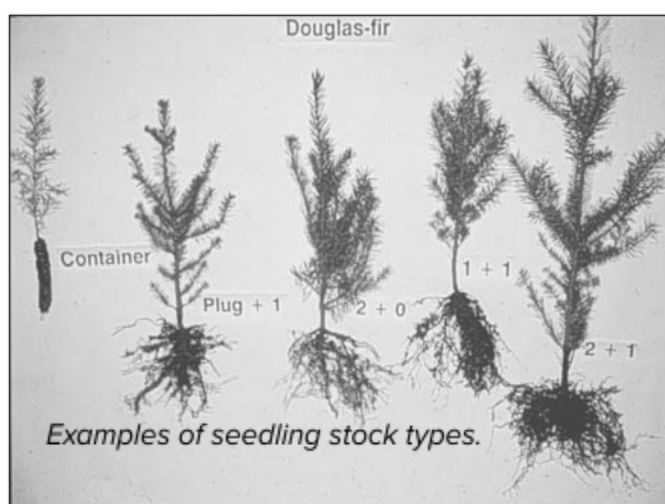
Timing

Although planting is only done in winter and early spring, reforestation is an effort that takes place year-round for most landowners. The figure to the right outlines typical reforestation timeline.



Nursery Stock

Nursery stock used for planting includes bare root and container stock. Bare root is just as it sounds: the trees are packaged, usually in bags, but their roots are exposed. Bare root seedlings are usually less expensive than container stock. Container stock comes in a container, usually made of Styrofoam. Although it is usually more expensive, this method avoids the damage associated with uprooting the trees before transport, as the seedlings are planted along with the soil from the container.



The following figure illustrates examples of seedling stock types. The names can be a bit confusing, but the numbers are associated with how many years the tree spent in a container and in the ground as a bare root. For example, “Plug + 1” means that the tree spent one year in a container, or “plug,” and one year in the ground as a bare root.

Planting Seedlings

Planting should occur when the seedlings are dormant and the soil is moist, and when subsequent rains will water the plants. This generally means mid-December to mid-March.

Matching Species to Site

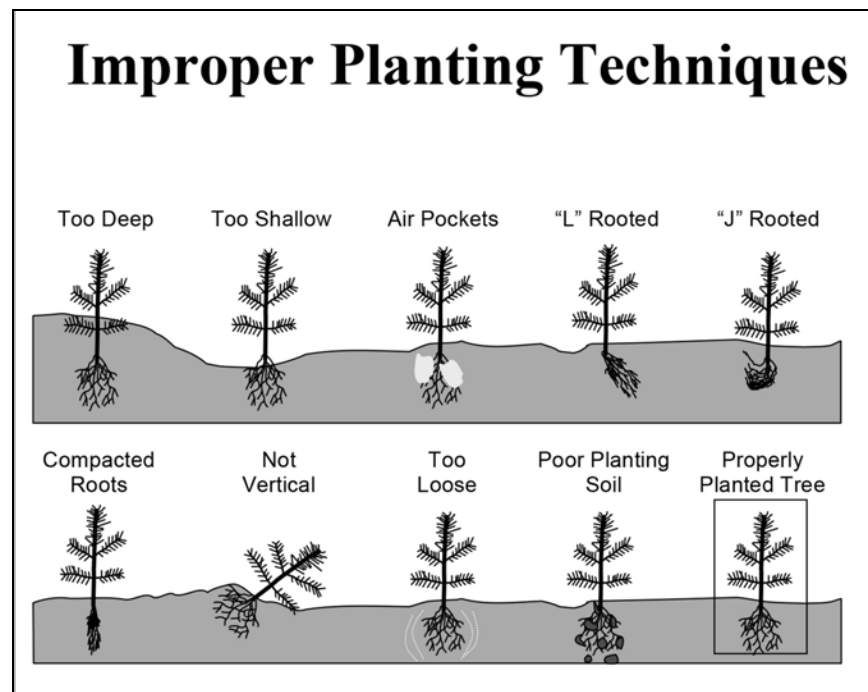
Species	Shade	Wet Soil	Drought	Frost	Browse
Alder	1	4	1	2	2
P. Pine	1	4	5	5	4
Douglas-fir	2	2	2-3	4	2
Grand Fir	4	3	2	3	4
W. Hemlock	5	3	1	1	4
W. Redcedar	5	4	1	2	1

(1=not tolerant, 5=tolerant)

Species of seedlings to plant should be determined by soil type, native species and existing vegetation, and seeds must be from the correct seed zone.

When planting seedlings, it is also important to ensure trees have enough space to grow and meet the landowner's long-term objectives. Another important component is properly matching tree species with site

conditions. The figure above briefly summarizes common Oregon tree species and their tolerance to specific site conditions.



Tree planting requires time and practice. Proper tree planting techniques are important to successful reforestation and long-term tree survival. See the diagram "Improper Planting Techniques" at right for conditions that often lead to seedlings dying.

Summary

Replanting trees after harvest, or reforestation, is required by the Oregon Forest Practices Act. Beyond the letter of the law, replanting also makes environmental and economic sense. But this labor-intensive and expensive work requires good planning and follow-through, including the choice of timing, nursery stock, tree species and planting technique. Today, about 40 million trees are planted every winter and spring in Oregon on public, industrial and family forestlands.

Reforestation in Oregon – Questions²²

1. Why is reforestation important?
2. What steps are involved in reforesting an area?
3. Explain the differences between bare root and container seedlings.
4. Name an Oregon tree species that tolerates drought conditions well.
5. Name an Oregon tree species that tolerates shade well.
6. Describe a properly planted seedling.

²² Source: *Exploration of Oregon Forests: Module 4 – Forest Management 1 – Cycles and Reforestation*. Developed by Julie Woodward based on the Oregon State University Forestry Extension's *Basic Forestry Short Course*.

8: Silviculture Tour²³

Overview

Students visit a forest site to learn about management techniques and strategies, and then create a written report or other documentation of the visit. (As an alternative to a field trip, a forest management representative may be invited to give an in-class presentation.)

Time Considerations

Preparation: 30 to 60 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Describe the management objectives of a particular forest site or forest owner.
- Explain the silvicultural techniques used to manage the forest to meet the objectives.
- Write a detailed report describing what they learned.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Obtaining, Evaluating, and Communicating Information. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

²³ This lesson was adapted from “Silviculture Tour” in *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.4 and 11-12.WHST.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Oregon Forest Literacy Plan Concepts

- 3.B.3. Forest management ranges from active management (e.g., planting, thinning and harvesting) to passive management (e.g., reserves and wilderness areas) to grow, restore, maintain, conserve or alter forests.
- 3.B.4. Forest management includes using natural processes and goal-oriented decisions and actions to achieve a variety of desired outcomes, including environmental (e.g., wildlife habitat and carbon sequestration), economic (e.g., timber production) and social (e.g., recreation) outcomes. Many of these outcomes are interrelated and can be managed for simultaneously, while others may be incompatible.

Materials

- [*K-12 Forest Education Opportunities: A Guide to Forestry Education Programs and Materials Available to You and Your Students*](#), available at learnforests.org
- “Silviculture in Practice” student page

Background Information²⁴

Silviculture is the practice of growing and managing forests and forest stands to increase their productivity. The name comes from the Latin “silvi-“ (forest) + “culture” (as in growing). Silviculture attempts to create and maintain the composition and structure of a forest that will best meet the objectives of the landowner. These objectives vary greatly among owners, but may include:

- Controlling stand structure – A stand’s shape or structure may be modified for aesthetic reasons, to facilitate treatments and harvest, to control animal pests or improve wildlife habitat. Its structure may be modified to select for certain age classes, arrangements of canopy levels/layers of vegetation, or distribution of diameter classes.
- Controlling composition – The types and quality of various species in the forest define the forest composition. Composition is controlled to limit undesirable species or poorly

²⁴ Adapted from “Silviculture Tour” in *Forest Surveying and Silviculture* by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

formed trees, and is achieved by site preparation; cutting, burning or applying herbicides to unwanted species; or introducing desired species.

- Restocking unproductive areas – Areas capable of growing trees but not fully stocked because of fire, logging, disease or animal damage may be restocked by planting seeds or seedlings.
- Protecting and reducing losses – Forest losses from fire, diseases, insects, wind or competition may be reduced by applying silvicultural methods such as thinning and salvage logging.
- Controlling rotation length – The number of years required to grow a stand to a specified condition of economic maturity (i.e., rotation length) may be modified to achieve different goals. Douglas-fir, for example, is commonly grown on a 40- to 60-year rotation to produce sawtimber in western Oregon, but landowners may carry it longer for improving wildlife habitat and having larger trees to market.
- Facilitating harvesting – Planning operations may include management activities that make harvesting efficient, economical and predictable.
- Conserving site quality – Silviculturists, like farmers, must conserve resources (particularly soils) on a site to preserve future productivity. Silvicultural practices also have a great deal of influence on site microclimate. If site quality is conserved, renewable resources such as trees can replace themselves. Soil erosion is considered the least reparable of disturbances. Nutrients and applied chemicals can be lost through surface runoff and leaching.

Note that forests are managed for different purposes and may serve very different societal needs. Research in social science and economics – as well as in the natural sciences – may be used to inform forest management decisions.

Field trips to actual silvicultural operations are valuable for seeing how things are done in the “real world.” This lesson provides an opportunity for students to ask questions of the forest manager and to gain insight into the day-to-day challenges and issues facing this type of operation.

Key Vocabulary

converting species

cost/benefit analysis

density diagram

silviculture*

**included in Glossary*

Preparation

- Arrange a visit to a forest site where silviculture is being practiced. Use [Find a Forester](#) on the www.oregon.gov/odf website to contact a stewardship forester in your area, or check with your local [Forestry and Natural Resources Extension](#) agent, listed at forestry.oregonstate.edu. For possible field-trip locations and activity ideas, see the [K-12 Forest Education Opportunities](#) guide (available at learnforests.org), which lists many of the diverse forestry education programs offered throughout Oregon. If a field trip is not possible, seek out and invite a forest manager to visit your class. In either case, students may use the student page to record their findings and form the basis of their reports.
- When arranging the field trip or class visit with the forest manager, share the student page questions so that he or she can plan a presentation that is as relevant as possible to the lesson's learning objectives.

Procedure

1. Discuss the meaning of the term “silviculture.” Talk about some of the forestland objectives that may be met through silviculture techniques. (See the Background Information for possibilities.)
2. Explain that students will have a chance to learn more about silviculture from someone in the field.
3. Either on the field trip or in the classroom with a forest manager, encourage students to use the “Silviculture in Practice” student page to ask questions and record their answers.
4. After the field trip or presentation, direct students to use their notes to develop a report on their findings. Establish criteria for the report, such as:
 - a. Write a two- to four-page report (double-spaced, 12-point font) describing the field-trip site (or class visitor).
 - b. Include a title with the name and location of the silvicultural operation and the date of the visit.
 - c. Use the headings topics from the “Silviculture in Practice” student page as a template for the body of the report, using the pertinent sections.
 - d. Describe concisely, yet thoroughly, the processes involved in the organization's silvicultural process.
 - e. Write the report in coherent paragraphs, not just bullet points.

Assessment

Use students' reports to assess both what they learned about silviculture practices and their ability to communicate scientific information.

Silviculture in Practice

While on the field trip, find out as many of the following items as you can:

Ownership and personnel

- ☐ Who is the landowner?
- ☐ Who decides what management activities will be done?
- ☐ Who actually implements the activities done to this forest?

Management objectives

- ☐ What are the main management objectives for this forest?
- ☐ What “rules of thumb” are used to determine management strategies?
- ☐ What other planning tools are used (such as density diagrams, cost/benefit analysis or other)?

Information about the forest

- ☐ What pressures or impacts does this forest face?
- ☐ What wildlife habitat does it support?
- ☐ What opportunities does this forest offer for the future?

Management activities

What methods are used for:

- ☐ Thinning?
- ☐ Pruning?
- ☐ Planting?
- ☐ Fertilizing?
- ☐ Converting species?
- ☐ What challenges do these activities present?

9: Developing a Forest Management Plan

Overview

Students use an Oregon forest management plan template to describe a tract of forestland and to consider different ecological, economic and social outcomes for it.

Time Considerations

Preparation: 30 minutes

Procedure: One 50-minute class period up to several weeks, depending on how involved students become in the plan development

Learning Objectives

Students will be able to:

- Explain the purposes of a forest management plan.
- Use a forest management plan template to describe and plan for a specific forestland.

Standards Connections

Oregon Science Standards

- HS.ESS3.3. Earth and Human Activity. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
- Disciplinary Core Idea – HS-ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Constructing Explanations and Designing Solutions. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.2 and 11-12.WHST.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Oregon Mathematics Standards

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

Oregon Forest Literacy Plan Concepts

- 3.C.4. Oregon foresters and forest managers prepare forest management plans based on landowner goals and objectives, capacities of the forest site, laws and available management tools (e.g., planting, harvesting and using prescribed fire). The plans guide management decisions, and are often required for funding applications or documentation for forest certification.
- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and diversity, and maintaining a forested land base for the needs of present and future generations.

Materials

- “[Oregon’s Forest Management Plan Template](#),” available at oregonstate.edu
- “[Forest Management Planning System Guidelines](#),” available at oregonstate.edu
- Optional: [Establishing and Managing Forest Trees in Western Oregon](#), available at oregonforests.org
- Optional: [Understanding Eastside Forests](#), available at oregonforests.org
- Additional materials and information needed to complete the management plan (optional; see Preparation)

Background Information²⁵

Forest management plans are overarching, long-range plans that guide the annual management of forestlands. Federal, state and private forest managers develop plans to meet regulations and guide on-the-ground operations.

Even individual forest landowners should have a written forest management plan for an increasing number of reasons, including tax and business needs, land use actions and forest certification. But perhaps the most important reason to develop a management plan is so that the landowners can learn about their forest, describe how it looks today and how they want it to look in the future, and develop or refine a course of action. A plan is also a good way to let heirs and others know the landowners' vision for the future of the forest and the steps they have taken to achieve that vision.

A management plan helps ensure that the forest will be managed so that its many resources are available for generations to come. It may incorporate social, economic and environmental considerations. Plans typically include:

- Property information, including the location, size, ownership, history and other details
- Goals and objectives
- Maps and photos
- Property resource information, with details about the wood, water, wildlife and other resources on the site
- Recommendations for future action
- Business and operations information, such as tax, management and liability matters

For this lesson, students will be using a forest management template designed specifically for individual forest landowners in Oregon.²⁶ It includes sections on the history and description of the property, landowner goals, planned actions for improving the property and where to get help.

²⁵ Source: Adapted from "[About Forest Management Planning](#)," *Oregon Forest Management Planning*. Oregon State University.

²⁶ Oregon's Forest Management Plan Template reflects the work of the Uniform Resource Planning and Endorsement System project, which is a collaboration of 10 different organizations. The template is designed to further communicate the necessary information needed to meet Oregon Forest Management Plan guidelines.

Key Vocabulary

forest management plan

Preparation

Decide what forest area students will use as the basis for their management plan. For example, they may develop a plan for a forest they have studied in the other lessons, or they may create a draft plan for a particular forest landowner in your community.

Depending on your time and student interest, determine how in-depth you want students to go in their management planning. For a brief introduction to forest management plans, groups might simply fill out the template as much as possible from what they know. For a more thorough study, or as a culminating activity, groups might develop full-blown plans by interviewing the landowners for details about the land's history and their vision for its future, researching maps and images, surveying and inventorying the forestland, and determining recommended actions.

See "[Forest Management Planning System Guidelines](https://oregonstate.edu/forest-management-planning-system-guidelines)," available at oregonstate.edu, for suggestions for completing the forest management template.

Procedure

1. Ask students what they think the value of having a forest management plan might be. What might a plan include?
2. Explain that students will gain experience developing a management plan for the selected forest area.
3. Introduce students to the "Oregon's Forest Management Plan Template," pointing out the different sections and discussing which ones students will be responsible for completing. You may want to refer students to the "Forest Management Planning System Guidelines" for more detailed directions and explanations for each section.
4. Ask students what goals they would see for this forestland and what actions would support those goals. Encourage them to consider environmental, economic and social aspects.
5. Direct students to work in pairs or small groups to fill in the details of their management plans. You might have on hand forest management resources for them to draw on, such as *Establishing and Managing Forest Trees in Western Oregon* or *Understanding Eastside Forests*.

Assessment

Ask students to present their plans to the class, pointing out their key features and recommendations.

Extension Idea

Invite a forestland manager to your class to share features of their management plan.

INSIDE OREGON'S FORESTS

A high school forestry curriculum



FOREST MANAGEMENT ISSUES

- 1: Fire in Oregon's Forests
- 2: Assessing Wildfire Safety
- 3: Evaluating Articles on Forest Issues
- 4: Forest Pests
- 5: Climate Change and Oregon's Forests
- 6: Community Views on Forest Management Issues



Oregon Forest
Resources Institute

FOREST MANAGEMENT ISSUES

1: Fire in Oregon's Forests

Overview

Students compare the forests of eastern and western Oregon in terms of historical fire behavior, current fire risks and approaches to fire management.

Time Considerations

Preparation: 30 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Explain why fires behave differently today than they did historically.
- Compare eastern and western Oregon forests in terms of fire behavior and fire risk.
- Identify solutions for making eastern and western Oregon forests more fire-resilient.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Oregon Forest Literacy Plan Concepts

- 3.C.3. The type and intensity of forest management, including harvest, is dependent on the purposes for which the forest is managed, as well as forest type, ownership, size and location.
- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and diversity, and maintaining a forested land base for the needs of present and future generations.

- 3.D.2. Forestry practices can be controversial, because of diverse perspectives as well as the complex nature of forest ecosystems.
- 3.D.4. Current issues related to forest management include the effects of timber harvest, wildfire, climate change and land uses, as well as the perception of these effects.

Materials

- Optional: [State of Fire](#) video (12 minutes), available at oregonforests.org
- Optional: [State of Fire](#) report
- Technology for showing video
- “Fire: Comparing Oregon Forests” student page

Background Information¹

Fire is a natural part of forest ecosystems in Oregon. Historically, fires in the dry pine and mixed-conifer forests of eastern and southwestern Oregon occurred every five to 40 years. Fires in the wetter, Douglas-fir and western hemlock forests of western Oregon burned every 100 to 450 years. As humans have actively fought fire over the past century, the “housekeeping” that fire provides hasn’t happened at these natural intervals. With no matching level of fuel removal, many of these forests have become unnaturally dense, particularly in Oregon’s dryer forests.

Although fire can provide benefits, a wildfire or a fire that’s out of control causes significant damage to forest values of timber, watersheds, wildlife habitat and homes. Treatments that can reduce fire severity and promote fire-resiliency – particularly in Oregon’s dryer forests – include:

- **Thinning.** Thinning subordinate trees mimics natural stand mortality by removing trees that would naturally die from competition or from natural surface fires, leaving the more dominant trees and eliminating “fuel ladders.” The remaining dominant and co-dominant trees are more fire-resistant, because their bark is thicker and their crowns are much higher.
- **Pruning.** Pruning is removing tree limbs to improve wood quality, aesthetics and fire resistance. Pruning improves fire resistance by raising the tree canopy so fire will be less likely to climb into the crowns. The branches need to be removed from the site, or burned or chipped.
- **Mowing.** Mowing is one tool used in central Oregon to remove flammable shrubs such as bitterbrush, which contains volatile oils that can produce flames 15 feet or higher. Mowing reduces the surface fuel and often is used adjacent to developments where prescribed burning might be risky and produce unwelcome smoke.

¹ Source: Adapted from [Forest Fact Sheet: Why Are Some Forest Fires More Intense?](#) Oregon Forest Resources Institute, learnforests.org.

- Prescribed fire. Prescribed fire is the purposeful and controlled application of fire to rid the understory of fuels. Prescribed fire also helps control insects and disease, improves the quality of grass for animals, prepares a seedbed for regeneration, removes undesirable older shrubs, improves access, and allows more nutrients, water and space for remaining trees. Sometimes a naturally occurring fire, such as one started by lightning, can be managed to achieve the goals of a prescribed burn.

Fire Basics²

Wildfires are ignited by either lightning or humans. Human activities that can cause wildfires include debris burning, campfires, equipment fires, smoking and arson.

To sustain a fire, three elements are needed: heat or an ignition source, oxygen and fuel. Together, these elements are known as the “fire triangle.” Take away one of these things, and the fire will go out or won’t start. For example, constructing a fire line down to the mineral soil removes fuel from the forest floor.

Fires differ in terms of how fast they spread, how high their flames are, and how hot they burn (their intensity). Once a fire ignites in forestland or rangeland, the manner in which it reacts to local conditions is known as its behavior. The “fire behavior triangle” includes three elements: the amount and arrangement of fuel, the topography and the weather conditions. A change in any one factor during the fire alters its behavior and type (whether it’s a ground, surface or crown fire).

There’s not much people can do about weather and topography. The one element in both of these triangles we can do something about is fuel. Fuels include grass, shrubs, litter and slash. By reducing the amount of fuel and changing its arrangement, we can influence a fire’s behavior.

Key Vocabulary

fire intensity

fuel

fire suppression*

ignition

fire triangle

prescribed fire*

**included in Glossary*

² Source: Adapted from *Chapter 9: Fire in the Forest* online course draft, which was adapted for high school students by Rod Bardell from the Oregon State University Forestry Extension’s *Basic Forestry Short Course*.

Preparation

- Plan whether you will use the *State of Fire* video or report, or both, or have students do their own research, to compare forest conditions in different parts of Oregon as they relate to wildfire.
- Plan how students will access the *State of Fire* report.
- Make copies of the student page.

Procedure

1. Explain to students that over the next few lessons they will be exploring some of the challenges and issues that face Oregon's forest managers. Ask them what they think some of those might be.
2. If they don't mention it, point out that fire is one of the topics they will explore. With a show of hands, ask students whether they think forest fires are good for forests, bad for forests, or neither good nor bad for forests. Have a few students explain their thinking.
3. Using information from the Background Information, introduce or review the fire triangle (the three elements needed for a fire to ignite or burn), as well as the fire behavior triangle (the three factors that influence the fire's rate of spread and intensity).
4. Ask students how fire might be different in western Oregon than in eastern and southwestern Oregon.
5. Have students view the *State of Fire* video, read the *State of Fire* report or conduct their own research to take notes on the "Fire: Comparing Oregon Forests" student page about the differences among western, eastern and southwestern Oregon forest fires. (Note that the film mostly discusses western and eastern Oregon forests, while the report differentiates among all three.)
6. Lead a discussion about students' findings:
 - a. What role has fire played in Oregon's landscape, both historically and recently?
 - b. In what ways have people's views of wildfire changed over time?
 - c. What differences between eastern and western Oregon forests influence our approach to wildfires in these regions?

Assessment

Ask students to use the information from the student page to write a paragraph describing one or more fire-related issues in Oregon.

Extension Ideas

- Visit FireAmongUs.org, an illustrated microsite specifically for youth, in which characters of the forest walk them through the basics of fire science, and how to make smart choices with fire in and around a forest.
- Practice properly and safely using hand tools to construct a fuel break or trail in the field. Discuss with students the importance of gas-powered equipment operating with a spark arrester and off-road vehicles having proper exhaust systems to minimize fire hazard. You can get more information about fire prevention from [Keep Oregon Green](http://KeepOregonGreen.org) at keeporegongreen.org.
- Learn more about fire behavior using matchsticks (see box).
- Research to learn about Indigenous people's use of fire as a tool for managing Oregon's forests. One place to start is [*Indians, Fire, and the Land in the Pacific Northwest*](#), edited by Robert T. Boyd.

Matchstick Forest Demonstration

For a very visual exploration of how slope and tree density affect fire behavior, do a classroom demonstration with “forests” made out of matchsticks. Using roasting pans or boards at different angles, or with matches placed at different densities, students can evaluate how fire behavior changes over multiple experiments. See “A Matchstick Forest” in the Bureau of Land Management's [Exploring Wildland Fire Educator Guide](#), available at blm.gov, for a sample procedure.

Fire: Comparing Oregon Forests

Describe the differences related to fire among Oregon's broad forest types.

	Western Oregon	Eastern Oregon	Southwestern Oregon
Climate			
Forest Type			
Land Ownership			
Historical Fire Frequency			
Historical Fire Intensity			
Recent Fire History			
Management Solutions			

2: Assessing Wildfire Safety

Overview

Students do a wildfire safety assessment of their home or school, and make recommendations for increasing wildfire safety.

Time Considerations

Preparation: 30 minutes

Procedure: Two 50-minute class periods, with time between to conduct the assessment

Learning Objectives

Students will be able to:

- Define the term “wildland urban interface.”
- Identify strategies for reducing the risk of damage to their homes and communities from wildfire.
- Conduct a wildfire safety assessment at their home or school, or in their community, and make recommendations for increasing wildfire safety.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Obtaining, Evaluating, and Communicating Information. Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Oregon Forest Literacy Plan Concepts

- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and

diversity, and maintaining a forested land base for the needs of present and future generations.

Materials

- “Oregon Wildland Urban Interface, 1990” teacher page
- “Oregon Wildland Urban Interface, 2020” teacher page
- Technology for sharing teacher pages
- “Wildfire Safety Checklist” student page

Background Information³

In Oregon, more and more people are living in what is known as the wildland urban interface — or WUI — where homes and other structures are built in or near woodlands or forests. While residents in these areas enjoy the beauty of the environment, they also face the very real danger of wildfire.

The WUI is composed of both intermix and interface communities. Intermix communities are places where housing and wildlands intermingle. In the intermix, wildland vegetation is continuous and more than 50 percent vegetation. Interface communities are next to or very near wildlands. These areas are defined as having less than 50 percent vegetation, but being within 1.5 miles of a large area with more than 75 percent vegetation.

For those fortunate enough to live nestled in or near forests, planning and preparation can help safeguard their homes and communities against catastrophic wildfire damage. This includes:

- Clearing a 30-foot perimeter of defensible space around the home
- Removing dead material
- Pruning branches in the adjacent forest to remove fuel ladders
- Creating fire-resistant landscapes with plants such as Oregon grape, holly and Pacific rhododendron

Working together, residents can make their own properties – and their neighborhoods – much safer from wildfire. In addition, land use planning helps strike a balance between growth and conserving Oregon forestlands for both humans and wildlife.

³ Source: Adapted from “[Do Your Part](#).” Keep Oregon Green. [keeporegongreen.org](#).
Maps and information about maps from “[Wildland Urban Interface Change: 1990-2020](#).” SILVIS Lab (Spatial Analysis for Conservation and Sustainability). University of Wisconsin, Madison, [silvis.forest.wisc.edu](#).

Note on maps: The 2020 map was produced using different land cover datasets than the 1990 map, and should only be compared on a very general basis.

For more information, see the report [Living with Fire](https://learnforests.org/living-with-fire), available at learnforests.org.

Key Vocabulary

defensible space

flammable

non-flammable

wildland urban interface (WUI)*

**included in Glossary*

Preparation

Make copies of the student page and set up equipment for sharing teacher pages.

Procedure

1. Ask students whether they have heard the term “wildland urban interface.” Ask them what they think it means. What issues might it raise for forests and for humans?
2. If students don’t mention it, point out that one issue with the wildland urban interface is an increased vulnerability to wildfire.
3. Show students the two maps of Oregon’s wildland urban interface, and have them compare and contrast the maps. What Oregon communities are most at risk for wildfire? What is the wildfire risk of their own community?
4. Have students conduct an assessment of their school, home or community using the “Wildfire Safety Checklist” student page.
5. Invite students to share what they learned. Which items on the checklist have been addressed? What could students do to encourage parents or community members to tackle items that haven’t been addressed?

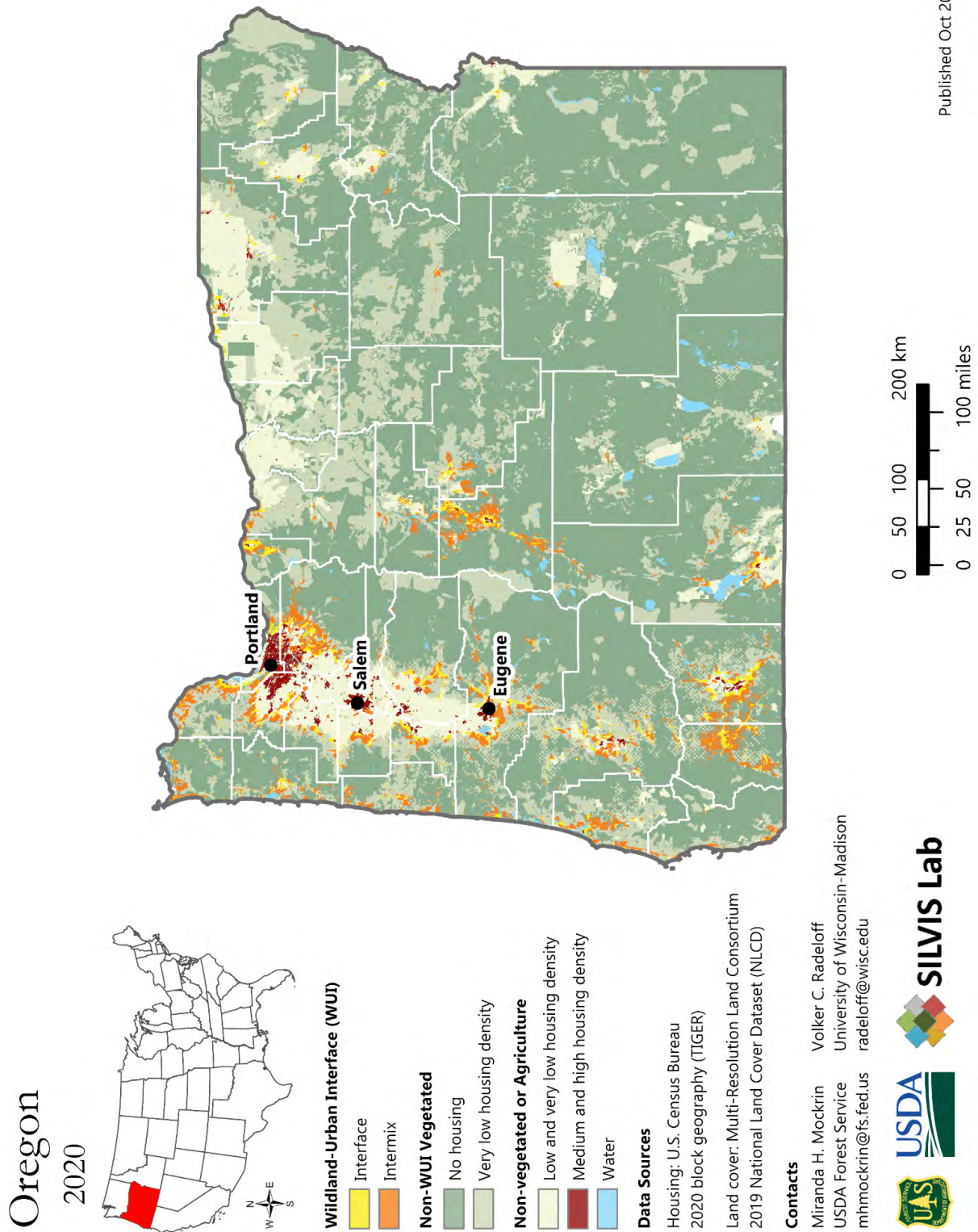
Assessment

Have students develop a recommendation plan for addressing one or more of the items on the checklist that still need attention.

Extension Ideas

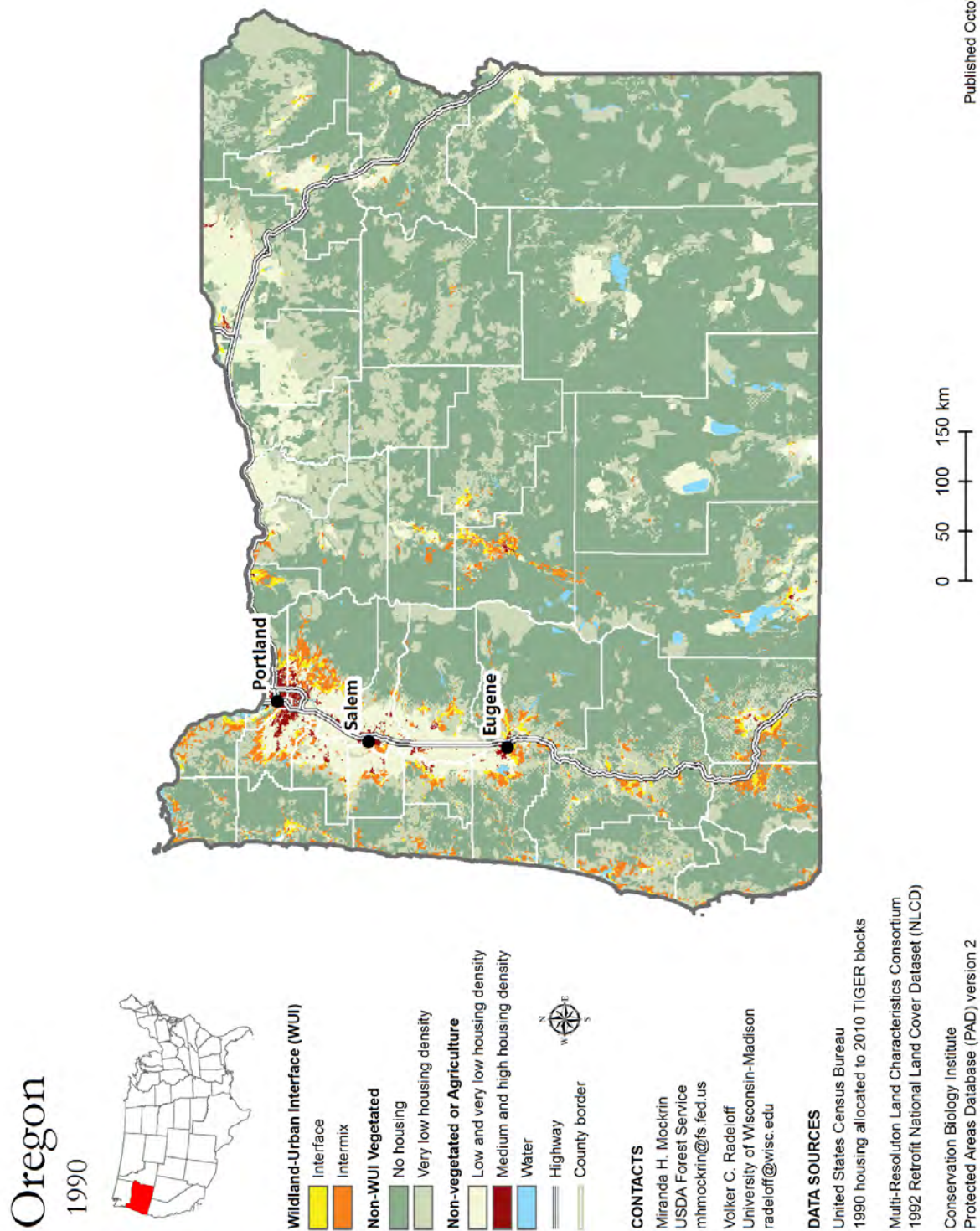
- Find out whether your community has a wildfire protection plan. (See [Community Wildfire Protection Plans](http://www.oregon.gov/odf) at www.oregon.gov/odf for links to some plans in Oregon.) If so, evaluate whether it is sufficient. If not, talk to community leaders about developing one.
- Challenge students to design a home or community that would exemplify living safely and responsibly in the wildland urban interface. Have them present their designs to the class. (From “The Nature of Fire,” Project Learning Tree’s *Exploring Environmental Issues: Focus on Forests* secondary environmental education module.)

Oregon Wildland Urban Interface, 2020⁴



⁴ Source of map: “[Wildland Urban Interface Change: 1990-2020](#),” SILVIS Lab (Spatial Analysis for Conservation and Sustainability). University of Wisconsin, Madison, silvis.forest.wisc.edu.

Oregon Wildland Urban Interface, 1990⁵



⁵ Source of map: "[The Wildland Urban Interface](#)." SILVIS Lab (Spatial Analysis for Conservation and Sustainability). University of Wisconsin, Madison, silvis.forest.wisc.edu.

LESSON 2

Wildfire Safety Checklist⁶

Wildfires are part of the Oregon landscape, and may even help maintain healthy forest ecosystems. There are many things you can do to make sure your property is more likely to survive a wildfire. Assess your home or school now and throughout the year to keep it wildfire-safe.

Around the Building

- ☐ Remove all flammable materials (firewood stacks, propane tanks, dry vegetation or construction materials) within 30 feet of any structure, including garages or sheds.
- ☐ Place any firewood stacks and propane tanks uphill of structures.
- ☐ Clear any flammable vegetation at least 10 feet away from wood piles or tanks.
- ☐ If there is a deck, clear all vegetation underneath it.
- ☐ For a deck or mobile home, provide a skirting or wire mesh all around to keep flammable materials from accumulating underneath.

The Roof

- ☐ Keep the roof and gutters free of all dead leaves and needles.
- ☐ Remove any dead branches overhanging the roof or within 10 feet of the chimney.
- ☐ Place a fire-proof screen with 1/4-inch or smaller mesh on chimney and stove pipe outlets.
- ☐ Check to make sure there are no loose or missing roof tiles.
- ☐ Cover any exterior attic and under-eave vents with metal mesh to prevent ember entry.

Vegetation and Landscaping

- ☐ Prune trees so that the lowest branches are 10 feet from the ground.
- ☐ Keep the lawn watered and maintained (or, if brown, cut it close to the ground).
- ☐ Wherever possible, use fire-resistant plants in the landscaping.

Emergency Access and Preparedness

- ☐ Identify at least two exit routes from the neighborhood.
- ☐ Make sure the property address is easily visible from the road.
- ☐ Make sure all road signs are clearly visible.
- ☐ Discuss and develop an escape plan with family members.
- ☐ Have a fire extinguisher, a ladder and tools such as rakes, shovels and axes available.

⁶ Sources: Adapted from "[Prevent Wildfires at Home](#)," Keep Oregon Green, [keeporegongreen.org](#). And from "[How to Prepare Your Home for Wildfires](#)," Firewise, [firewise.org](#).

3: Evaluating Articles on Forest Issues⁷

Overview

Students select an article from print or online sources related to Oregon forests, and analyze it using a series of questions such as “What claims does the article make?” and “What is the source of the evidence?”

Time Considerations

Preparation: 30 minutes or more, depending on whether teacher or students are locating articles

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Critically evaluate an article on a forest-related topic or issue.
- Recognize some common types of bias in an article.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.A. Natural Resources. All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.
- Science and Engineering Practice – Obtaining, Evaluating, and Communicating Information. Evaluate the validity and reliability of, and/or synthesize multiple claims, methods and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – 11-12.RST.1. Analyze what science and technical texts say explicitly as well as inferentially, citing evidence to support the analysis,

⁷ This lesson was adapted from “Media Coverage,” by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

- Reading Science and Technical Subjects – 11-12.RST.7. Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.

Oregon Forest Literacy Plan Concepts

- 3.D.1. People have differing perspectives on forests and forest management, which can be affected by cultural background and personal experiences, as well as by values, politics, science and economics. Their perspectives can change over time.
- 3.D.2. Forestry practices can be controversial, because of diverse perspectives as well as the complex nature of forest ecosystems.

Materials

- “Analyzing the Reporting of a Forest Topic” student page
- “Article Analysis” student page
- News stories, articles or reports on an issue related to Oregon forests (selected by students or by teacher; see Preparation)

Background Information⁸

Forest management issues - like many environmental problems - are often very complex, because they involve many different interacting components separated by both time and space. They're often also controversial precisely because they're too complex to have clear “right” and “wrong” solutions.

While the internet gives everyone access to a tremendous number of articles, reports, opinion pieces and websites on environmental issues, it can sometimes be difficult to determine which of these sources and accounts are reliable. They may be inaccurate or biased, or exaggerate certain aspects of an issue.

Students must learn to critically evaluate information sources to fully understand the issues. This activity is designed to help them practice evaluating claims related to forestry and forest management issues.

⁸ Source: “Media Coverage” by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Key Vocabulary

anecdote

bias

evidence

peer-reviewed

popular media

Preparation

- Decide whether students will find their own articles to analyze, or you will provide them. If you'll be selecting them, choose articles that vary in terms of their sources, perspectives and quality (such as a science journal article, a Wikipedia article, an advocacy organization webpage and an op-ed piece). If you want students to find their own articles, look for possible general sources on the chosen topic, such as organizations, government agencies and journals you can direct students to. Also decide any selection criteria you want students to follow, such as a minimum acceptable length and acceptable sources.
- Make copies of the “Analyzing the Reporting of a Forest Topic” student page, or provide on-screen access to it. Alternatively, you might prepare a brief lecture to present to students.

Procedure

1. Select a current issue related to Oregon forests for students to explore. Topics that are contentious, well-publicized and for which there is scientific uncertainty or different viewpoints would work well for this activity. Examples include the impacts of global climate change and how to address them; who should be responsible for managing wildland fires and how they should be managed; or economic pressures on the forest sector workforce.
2. Give students copies of the “Analyzing the Reporting of a Forest Topic” student page to read, or present a brief lecture on the key points of the reading.
3. Explain that students will be using this information to analyze articles related to Oregon's forests. Provide copies of the “Article Analysis” student page and one or more articles to analyze. If students will be finding their own articles, direct them to possible sources and explain any selection criteria you want them to follow.

4. Allow students time to evaluate each article by responding to the questions on the “Article Analysis” student page.
5. Have students meet in groups of three or four to discuss their evaluations.
6. Direct students to compare different articles they or another group analyzed. Challenge them to identify both strengths and weaknesses of the articles in communicating about the topic.

Assessment

Use student responses to the “Article Analysis” student page to assess their analyzing skill. Have them submit both the completed student page and a copy of the article they analyzed.

Acceptable responses will depend on the article.

Extension Ideas


- Challenge students to look for examples of “false balance” in news articles. (This is when journalists present opposing viewpoints of an issue in an effort to be fair and balanced, even though the preponderance of scientific evidence supports one viewpoint over another.) Discuss how false balances such as this may influence the reader’s perception of an issue.
- Encourage students to write articles or letters to the editor on a local forest-related issue.

Analyzing the Reporting of a Forest Topic⁹

Articles, reports and stories on forest topics can come from a variety of sources with a range of viewpoints. As you study a topic, it's important to know the source of the information, as well as to analyze how it's presented. The following questions will help you evaluate the credibility of a particular report.

Where was the report published or presented?

Try to get as close to the original source of information as possible. Although environmental information reaches the general public through many pathways, a common sequence is:



A scientific study appears in a peer-reviewed science journal (e.g., *Journal of Forestry*, *Science*, *Nature*). This information is usually reliable, but often inaccessible to the general public because of the technical writing style and the need for a subscription to read it.

A summary of the scientific study is prepared by a science writer and appears in a journal designed for and accessible to a more general readership (e.g., *Science News*, *Discover*, *Environment*, *Scientific American*). This information is usually reliable but less detailed, and is usually more accessible to the average reader.

Accounts of scientific findings are written by journalists for newspapers or popular magazine articles, or for TV news programs (e.g., *The New York Times*, *Newsweek*, or *Frontline*). The writers may or may not be experts on the topic, and may project their own interpretation on the findings. Also, limited space or time often means the findings are shortened and perhaps oversimplified. As a result, reliability may be somewhat diminished.

A radio show, podcast, website or other medium uses accounts from newspapers, magazines or news programs to share with their readers, listeners or viewers. For all the reasons indicated above, reliability may be further compromised.

Selected information from any of the above is used to produce an article that supports a particular agenda or viewpoint. Only information that supports that view is reported, and conflicting information is omitted or discredited. This report may take the form of an editorial, a promotional brochure or a tabloid article.

Note that the reliability of information fades as one gets further from the original source.

⁹ Source: "Media Coverage" by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

Evaluating Online Sources

- Domain names (the suffix of the URL) give some indication of the source of information and the motive for posting the information. Educational (.edu) and governmental (.gov) sites, for example, generally provide more reliable information than commercial (.com) sites, which may have a motivation other than providing useful information. Websites sponsored by organizations (.org) are a mixed bag. Many are excellent sources of unbiased information, while others clearly have an “agenda.”
- To be sure you’re not getting outdated information, examine the “last updated or modified” note at the bottom of the first page.
- The appearance of poor grammar, misspellings and other errors should be seen as an indication of lack of editorial control. Thus, any sites that exhibit these characteristics should be looked upon with suspicion.

What type of information was used to prepare the report?

Check whether the report includes complete and reliable information. Consider where the information came from and whether the author cites their sources. If only selected information that supports a particular point of view is presented, the claims should be looked upon with suspicion.

Also, be aware of the way the information is presented. A common strategy used by writers is to present data using only the extremes. Phrases such as “as many as” or “as few as” should serve as red flags, indicating that the writer is reporting extreme values to make a point. A more credible report would report numbers as a mean or average, with some indication of variation around that mean (i.e., range, standard deviation or confidence interval).

How credible is the “evidence” presented?

Different types of evidence carry with them different levels of credibility. In general, the following list ranks sources of evidence from most to least credible:

MOST CREDIBLE



- group of independent studies
- single scientific study
- collection of anecdotes
- single anecdote
- opinion

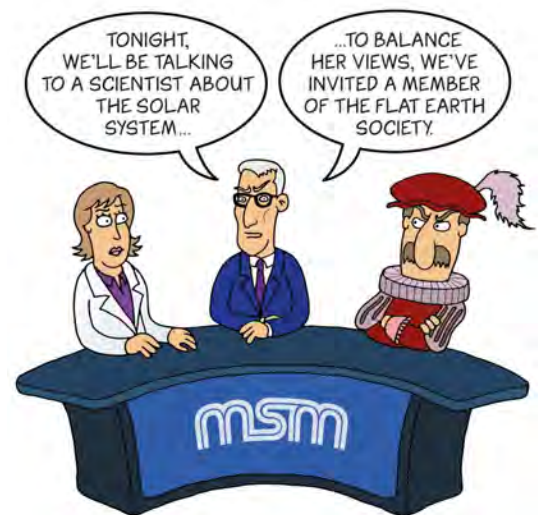
LEAST CREDIBLE

A peer-reviewed (or “refereed”) article is one that has been scrutinized by experts in the field prior to publication. As a result, such articles carry more weight than one that has not been peer-reviewed. Reliability also may be influenced by factors such as sample size, length of the study and even researcher bias. A claim gains credibility when it is confirmed by several independent studies.

Although many people rely solely on anecdotal information to formulate opinions, single accounts of isolated incidents are inherently unreliable.

Does the article present a “false balance”?

Journalists - unlike scientists - are trained to present both sides of a contentious issue. They will often include viewpoints of different sides in an effort to present a “fair and balanced” account. This may be done even when the preponderance of scientific evidence supports one viewpoint over another, or when a person presenting one of the viewpoints lacks suitable expertise. Often in these situations, viewpoints rather than evidence are emphasized, and the uninformed reader or listener may be left with the understanding that there is a legitimate debate when, in fact, little or none exists. This “false balance” is frequently seen in reports on environmental issues.



*Skeptical Science, John Cook,
[CC BY-SA 3.0](#), via Wikimedia Commons*

Evaluating Wikipedia Articles

Wikipedia is a popular online encyclopedia that provides a huge amount of information. But be aware that:

- anyone can write or edit Wikipedia articles, so there's no assurance that they're accurate.
- Wikipedia authors are anonymous, so you can't verify their credibility.

Wikipedia is not appropriate for scholarly work. However, it can be a good starting point for learning basic background about a topic and finding more appropriate sources of information.

To evaluate the credibility of a Wikipedia article:

- Look at the article itself to:
 - Check if it contains any “template messages” about issues with the article, such as a lack of references and sources, or the presence of unreliable information.
 - See if it cites sources that are authoritative and appropriate for the topic.
 - Determine if it is written in an unbiased way.
- Look at the article's Talk page to:
 - Check the article's quality grade. Many Wikipedia articles are graded according to the [WikiProject Article Quality Grading Scheme](#).
 - See whether there have been discussions about the article's validity, or whether it appears controversial.
- Look at the article's History page to:
 - Check the article's creation date and revision dates to assess whether the information is up to date.
 - See how many editors have contributed to the article - just one or two individuals, or many working collaboratively.
 - Find out whether the article has been subject to vandalism.

Do the conclusions or claims follow logically from the evidence?

Check whether the connection between “the evidence” and “the conclusions” (or “claims”) is logical and straightforward. If the connection is convoluted or illogical, less credibility should be assigned to the claims.

Reporters will sometimes provide anecdotes or stories as evidence. But be aware that one or two stories are not usually sufficient evidence for broad generalizations. For example, even though your friend's grandfather smoked a pack of cigarettes a day and lived to be 100, that's not sufficient evidence to say that smoking has no effect on health.

What bias or hidden agenda may be at play?

Bias is a leaning either in favor of or against an idea, person or thing, usually in a way that is prejudicial or unfair. When we exhibit bias, our conclusions are based on preconceived notions rather than on a critical evaluation of the evidence.

Reporters may exhibit bias through their emphasis, perspective, word choice or tone. To illustrate, here are two different headlines for the Three Little Pigs story, which give very different impressions of the story:

- Hungry Wolf Denied Dinner by Three Deceitful Pigs
- Three Brave Pigs Take a Stand Against Aggressive Wolf

To help determine whether there might be bias in a report, consider the source of the information. What individual or organization is responsible for producing the information? Are they credible and qualified to produce it? Why was it produced? Is the author trying to promote an idea or sell a product?

Article Analysis¹⁰

Analyze a current news story, article or report on a topic related to Oregon forests, using the following questions.

1. Different media carry with them different degrees of credibility. In what type of media does your report appear?
2. Is the author of the report given? Who is it? Is it an individual or an organization? If it's an individual, does the report say where they work?
3. If an organization has produced the report, what is the mission of the organization? If an individual has produced the report, what credentials or affiliations do they have?
4. Does the report attempt to persuade, advocate or inform? Explain.
5. What information was used to prepare the report? Check those that were used, and add others if necessary. Some possibilities include:
 - ☐ observation of actual occurrences
 - ☐ consultation with experts
 - ☐ discussion with non-experts
 - ☐ reports in scientific journals
 - ☐ reports or findings from a particular organization (scientific or other)
 - ☐ sources are not stated in article

¹⁰ Source: Adapted from "Media Coverage" by Dr. Wynn Cudmore. Northwest Center for Sustainable Resources, Chemeketa Community College.

6. Is this information properly referenced so you can check it out if you want to?

7. What is the date of publication? Is the information in the report (or the report itself) reasonably up to date? The importance of having recent information will vary with the topic under consideration.

8. Claims are positions or conclusions that are stated in the article. They should be supported by some kind of evidence – specific observations or data. What claims are made in your article? What evidence is used to support those claims? List the claims and the specific evidence supporting them in the space below:

Claim	Evidence

9. Do the claims in the report follow logically from the evidence given, or are “leaps in logic” required to reach the same conclusions as the author(s)? Could alternative claims be made from the same evidence?

10. Is there a basis for suspecting bias on the part of the sources, the author of the report or yourself? If so, check those you detect from the list of common biases below. For each of the biases you have detected, explain where in the article it appears.

☐ The author or source has a clear stake in the issue and will benefit in some way from the claims that are being made.

☐ Only selected information is being reported. (Are you aware of other information that would refute the claims being made?)

☐ You reject the claims of the article because you disagree with them, or you accept them because the claim happens to agree with your opinion.

☐ The publication has a well-known or suspected position on the issue.

11. Does the report appear to be objective, or does there appear to be a particular agenda being promoted? Explain.

12. Is there anything in the article you consider to be unnecessarily sensationalized to make a point or stimulate some emotion? Examples may include misleading or exaggerated titles, phrases that are meant to appeal to our emotions, or accompanying photographs.

4: Forest Pests

Overview

Students read about the mountain pine beetle and learn how some insects and other pests can damage forests. They research specific pests and quiz each other on methods for controlling these organisms and reducing their damage.

Time Considerations

Preparation: 20 minutes

Procedure: Two to three 50-minute class periods, with time between for student research

Learning Objectives

Students will be able to:

- Identify the major insect types (defoliators, bark beetles, etc.) present in Oregon's forests.
- Describe the major diseases that can affect Oregon's forests.
- Identify the major mammal species that harm the forest, and the characteristics of the damage they cause.
- Explain the various strategies used to control and reduce damage from forest pests.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Constructing Explanations and Designing Solutions. Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Oregon English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.7 and 11-12.WHST.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when

appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Oregon Forest Literacy Plan Concepts

- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and diversity, and maintaining a forested land base for the needs of present and future generations.
- 3.D.4. Current issues related to forest management include the effects of timber harvest, wildfire, climate change and land uses, as well as the perception of these effects.

Materials

- “When Beetles Battle Pines, It’s a Pitched Pine Beetle Battle” in [Forest Essays \(Level 7-12\)](#), available at learnforests.org
- “Damaging Forest Pests” student page
- “Pest Report” student page
- Index cards (4x6 or other size)

Background Information

This lesson introduces some of the insects, diseases and other forest pests that can affect forest health. Students should be aware that damage and decay are essential components of healthy forests. Insects that feed on trees become, in turn, food for other animals. And fungi that rot away trees also replenish the soil with essential nutrients that would otherwise be locked up in the wood. At low levels, insects, diseases and other organisms may even contribute to forest health. When levels are high enough to weaken or kill trees, they diminish forest health.

See the student page “Damaging Forest Pests” for a definition of forest health and basic information about these agents. In the next lesson, students will learn how global climate change affects forest health, including forest susceptibility to insects and disease.

Possible Forest Pests for Student Research

Insects

- Defoliators: western spruce budworm, Douglas-fir tussock moth, pine butterfly, hemlock looper, gypsy moth, tent caterpillar and sawfly

- Bark beetles: Douglas-fir bark beetle, pine engraver beetle and fir engraver beetle
- Sucking insects: aphids and scale insects
- Wood borers: emerald ash borer, flatheaded borer, roundheaded borer, ambrosia beetle, wood wasp larvae, carpenter ants and termites
- Terminal feeders: Sitka spruce weevil and midges
- Root feeders: white grubs, some weevils, termites and wireworms
- Gall makers: oak wasp gall and Cooley spruce gall adelgid

Diseases

- Biotic diseases: heart rot, white pine blister rust, Swiss needle cast, Dutch elm disease, blue stain and dwarf mistletoe

Mammals

- Deer, elk, bear, rabbit, mice, porcupine, beaver and mountain beaver (or “boomer”)

Key Vocabulary

abiotic*

biotic*

defoliator

disease

forest health*

gall maker

integrated pest management (IPM)

**included in Glossary*

Preparation

Make copies of the student pages, or provide on-screen access to them. (Alternatively, for the “Damaging Forest Pests” student page, you may choose to prepare a brief lecture based on the content.)

Procedure

- Ask students what they think the term “forest health” means, and ask them what factors might influence forest health.
- Give them copies of “When Beetles Battle Pines, It’s a Pitched Pine Beetle Battle” forest essay. Have them read the essay and then work in groups to answer the questions provided.

- Discuss what other insects, diseases or pests might impact forest health – both positively and negatively. Have students read the “Damaging Forest Pests” student page, or present the information to them in a brief lecture.
- Assign each student a forest pest to research (see the list of possibilities in the Background Information section). Using the “Pest Report” student page as a guide, they should find out how the species or disease affects trees and forests, under what conditions it is most damaging, and the methods forest managers use to control it. When possible, students should also locate a photo or illustration of the pest and another photo showing the impact on a tree or forest.
- Make a class set of Forest Pest Cards by giving each student an index card and having them summarize their findings on one side of the card and place their photos on the other side.
- Invite students to use the cards to quiz each other on the different pests and best methods of control. They may do this similar to a spelling bee or other game format.

Assessment

Use students’ “Pest Report” responses or their Forest Pest Cards to assess their learning.

Extension Ideas

- Encourage students to make a flier or poster “advertising” the hazards of one or more of the forest pests explored in the lesson.
- Develop a research project to determine the most effective method to protect seedlings or school garden plants from deer damage.
- Share the Oregon Forest Resources Institute report [Forest Threats](https://learnforests.org/forest-threats/), available at learnforests.org. Discuss the different threats to Oregon forests identified in the report and pinpoint some of the actions people are taking to mitigate them.
- Research diseases commonly found in Oregon’s forests and their impact on trees.
- Explore the topic of invasive species and how they affect Oregon’s forests. Conduct research to learn about invasive organisms that threaten our forests. See the Oregon Invasive Species Council website at <http://www.oregoninvasivespeciescouncil.org> for information and resources.

Damaging Forest Pests¹¹

A healthy forest is a balanced system of interacting and interdependent components. Defining forest health is difficult, because it means different things to different people. For those who see forests mainly for their economic benefit, a healthy forest is one that produces the most tangible goods. For those who mostly value their environmental benefit, a healthy forest may be one that is high in biodiversity and other measurements.

The Society of American Foresters describes forest health as “the perceived condition of a forest derived from concerns about such factors as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance.”

In addition to fire, a multitude of insects, diseases and mammals affect trees and forest health. Many are part of a natural forest cycle – and may even be beneficial. In fact, damage and decay are essential components of healthy forests. Insects that feed on trees become, in turn, food for other animals. And fungi that rot away trees also replenish the soil with essential nutrients that would otherwise be locked up in the wood.

At low levels, insects, diseases and other organisms may contribute to forest health. When levels are high enough to weaken or kill trees, they diminish forest health.

Insects

Insects constitute 90 percent of the species found in the animal kingdom. Many insects help forests thrive. For example, they are an important food source for forest birds and other animals, and may also help decompose dead wood and return nutrients to the soil.

But harmful insects, present at too high a level, destroy more timber in the United States than any other factor. Insects cause damage in various ways, depending on the type of insect. In addition to killing trees, insects may also cause limb and leaf dieback and stunt growth.

Defoliators attack the needles and leaves of trees. Their chewing mouthparts are designed to eat leaves, and they may completely remove all the leaves in a stand. Deciduous trees can

¹¹ Source: Adapted from “Forest Damage” online course draft, which was adapted for high school students by Rod Bardell from the Oregon State University Forestry Extension’s *Basic Forestry Short Course*.

usually withstand three consecutive years of attack without serious harm. Evergreen trees will often die after being defoliated just once.

Bark beetles enter trees through the bark and are considered more destructive than defoliators, posing a serious threat to timber trees. Although their life histories vary, most follow a similar pattern. First, a few attacking insects enter a tree. A healthy tree produces resinous pitch to drown and flush out (pitch out) the beetles that attempt to enter. If the tree is stressed or cannot resist the attack, the invading insect sends out a chemical message (pheromone) to attract neighboring bark beetles. Then thousands of bark beetles attack the tree, creating tunnels, called galleries, that destroy the cambium layer. Female beetles lay eggs in the galleries, and when they hatch the larvae “mine” their way out, killing the tree from within. Generally, the insects spend the winter in one host tree and start the process over in the spring.

Besides defoliating insects and bark beetles, there are a number of other insects that impact trees and forests in different ways. **Sucking insects** attack both foliage and stems. Their sucking mouthparts pierce tissues and siphon fluid from trees. **Wood borers** use abandoned tunnels and usually damage timber after the tree has been felled but before it has been harvested. **Terminal feeders** usually damage seedlings, which is very serious in nurseries and plantations, while **root feeders** attack young trees. **Gall makers** deposit larvae on a tree limb, causing a tree growth called a gall to form around them that provides protection and food for the growing insects. Galls are usually not harmful to trees.

Controlling Insect Pests

Forest managers can choose among many different methods for controlling insect pests and minimizing their damage. These include silvicultural controls, biological controls, chemical controls and integrated pest management.

Silvicultural controls aim to create unfavorable conditions for potential pests. Knowing the natural history of the invader (such as the host species, season of emergence, key predators and tolerance of extreme temperatures) can determine control measures. Forest managers may try:

- Selecting the “right tree for the right place.” That means knowing what insects are present and avoiding planting host trees, or planting trees that are resistant to the insects.
- Maintaining tree health by thinning.
- Performing sanitation or cutting to remove damaged or susceptible trees from a stand, and to reduce spread to other trees.
- Creating multiple-age stands, which are less susceptible to some insect attacks than even-age stands.

Biological controls work by either introducing known predators or through disturbing growth or reproductive cycles. Fungi, bacteria, viruses, parasites and predators (other insects, small mammals, reptiles, birds, etc.) are all biological control agents. Since exotic species from abroad can become invasive without natural predators in their new “home,” introducing natural predators from their native habitat may be the only way to control the invading insects.

Chemical controls (insecticides) are the most common and most controversial method of controlling insects, because they can have unintended consequences on the ecosystem. They are best used as treatment to control epidemic outbreaks.

Integrated pest management (IPM) uses a combination of controls (silvicultural, biological and chemical) to manage outbreaks. This method recognizes that insects are a natural and necessary part of the ecosystem, and focuses on keeping populations in check rather than on complete eradication.

Forest Diseases

Many diseases and disorders can also affect forests in Oregon. Some of these are abiotic diseases, which are caused by physical conditions of the forests, and some are biotic, which are caused by living organisms.

Abiotic diseases are growth problems that come from poor soil, drought, extreme climatic conditions or other environmental stresses. Some of the problems are caused by human activity, including increased urbanization, soil compaction, air and water pollution, or incorrect species selection.

Biotic diseases are caused by living organisms, usually from a fungal attack. Most are specific to a certain type of host tree. Examples in Oregon include heart and root rots, white pine blister, Swiss needle cast, wilts and dieback, blights and stains.

Dwarf mistletoe, a relative of the harmless “Christmas” mistletoe, is a very serious pest in Western coniferous forests. It is a parasitic, leafless seed plant whose roots (called sinkers) invade the bark of the host plant and its sapwood, draining the tree of water and nutrients.

Mammals

Deer and elk can seriously hamper reforestation projects by browsing or eating new growth, which damages seedlings and saplings. Deer are the most common browsers in Oregon, eating

young shoots and leaves until the tree reaches a height of 5 feet. They also damage bark when they rub their antlers against the trunk. Elk will sometimes pull recently planted seedlings out of the ground.

Bears consume a tree's cambium layer by tearing or biting the outer bark. Pole-sized trees are particularly susceptible due their thinner bark that allows for easier access.

Other woodland mammals can affect trees and forest health. Rabbits cause damage by eating all the way around (girdling) young tree shoots. Porcupines eat bark, exposing the cambium to insect attack and disease. Beavers cut down trees for food, lodges and dam construction. Squirrels, chipmunk and mice eat the seed crop. Pocket gophers and voles girdle seedlings, hampering replanting efforts.

Domestic mammals, particularly grazing and range animals, cause significant damage to planting sites. Cattle, sheep, goats and other grazers eat young shoots, seedlings, bark and seeds, interfering with regeneration as well as weakening or killing trees. Soil compaction and trampling by horses are also major problems, damaging young root systems and hampering regeneration.

Humans and their various activities can affect forests in many far-reaching ways. Although humans are not usually considered "pests," forest managers must often consider ways to reduce human impact on forest ecosystems. Damaging contact with the forest may include vandalism, drug labs and marijuana plantations, use of ATVs and off-road vehicles, and illegal dumping, as well as the broader effects of roads, homes and other development, air pollution and increased carbon dioxide emissions from burning fossil fuels.

Pest Report

Forest pest:

Pest species:

How it affects trees and forests:

What trees it affects most:

How it reproduces:

Under what conditions it thrives:

What people do to control it or reduce its impact:

Photo or illustration of pest:

Photo showing its effect on a tree or forest:

Sources of your information:

5: Climate Change and Oregon's Forests

Overview

Students research and prepare an infographic on how Oregon's forests are affected by climate change, and how the forests can be managed to help minimize the effects.

Note: See Lesson 5: Forests and Carbon in the "Environmental Importance of Oregon's Forests" module for an exploration of photosynthesis and carbon sequestration in trees.

Time Considerations

Preparation: 30 minutes

Procedure: One to two 50-minute class periods, plus time for research

Learning Objectives

Students will be able to:

- Read and understand scientific information on the effects of climate change on forest ecosystems.
- Identify ways forest managers and others are working to minimize the effects of climate change on Oregon's forests.
- Create an infographic to present the information to their peers.

Standards Connections

Oregon Science Standards

- HS.ESS3.5. Earth and Human Activity. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Oregon English Language Arts Standards

- Speaking and Listening – 11-12.SL.5. Make strategic use of digital media in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
- Reading Science and Technical Subjects – 9-10.RST.1. Analyze what science and technical texts say explicitly as well as inferentially, citing evidence attending to the precise details of explanations or descriptions.

Oregon Forest Literacy Plan Concepts

- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and diversity, and maintaining a forested land base for the needs of present and future generations.
- 3.D.4. Current issues related to forest management include the effects of timber harvest, wildfire, climate change and land uses, as well as the perception of these effects.

Materials

- “Key Resources on Climate Change in Oregon” student page
- “Research on Climate Change and Forests” student page
- “Climate Change Infographic” student page
- Sheets of poster paper and marker pens, or access to a presentation app

Background Information¹²

Climate change amplifies the effects of forest threats, such as fire and insects. Rising temperatures and prolonged droughts in some parts of Oregon are impacting forests in a number of ways, according to researchers from Oregon State University’s College of Forestry and Portland State University’s School of the Environment. This includes contributing to longer, more intense fire seasons, and increased insect and disease outbreaks.

Climate change may even reshape the makeup of Oregon’s forests in some areas, as conifer trees that need more moisture to live have a harder time surviving. In other regions of the state, such as northwestern Oregon, climate change models show increased moisture in the future.

¹² Source: “[Climate Change and Oregon's Forests](https://oregonforests.org/),” oregonforests.org.

More intense storms and extreme weather caused by climate change could also have lasting impacts on forest health. Trees with limbs that are snapped off in storms are more prone to insect and disease outbreaks. Freshly downed trees and branches attract bark beetles and could fuel a wildfire.

The good news is that the impacts of climate change can be lessened with active management, especially through forest restoration, thinning and fuels reduction for wildfire resiliency.

Forests also serve a vital biological role in mitigating the effects of climate change, because trees absorb and store carbon through photosynthesis. This carbon continues to be sequestered even after a tree is harvested and manufactured into wood products.

Key Vocabulary

adaptation

distribution*

effect

event

global climate change*

implication

mitigation

solution

**included in Glossary*

Preparation

Look over the “Key Resources on Climate Change in Oregon” student page and, if desired, identify which resources you’d like students to focus on for their research.

Procedure

1. Introduce the lesson by posing true-or-false statements to students about climate change (without telling them the answers), such as:
 - Climate change is something that will affect future generations, but is not happening now. (False)

- Forests will not be affected by climate change, because trees are very resilient. (False)
 - Wildfires will be more intense and more frequent in the future. (True)
 - Oregon forests may be more productive with climate change, as the trees are exposed to more CO₂ and longer growing seasons. (True)
2. Explain to students that they will do research to learn more about the ways Oregon's forests are affected by climate change, and about forest management strategies Oregonians are implementing to reduce the effects. Working in groups, they'll answer the questions on the "Research on Climate Change and Forests" student page and then create a visual presentation using the "Climate Change Infographic" student page to communicate the results of their research.
 3. Give students copies of the "Key Resources on Climate Change in Oregon" student page or provide online access. Also give them copies of the "Research on Climate Change and Forests" and "Climate Change Infographic" student pages.
 4. Divide the class into groups of three or four students. Provide poster paper and pens, or access to presentation software, for developing the infographic.
 5. Give students time to research and prepare their presentations, and to share them with the whole class.
 6. After the presentations, discuss students' findings about how the changing climate is affecting forests, and whether people could or should be doing more to reduce the effects.

Assessment

Use students' presentations to assess student learning.

Extension Ideas

- Students examine one of the references cited in one of the reports on the "Resources on Climate Change in Oregon" student page, and analyze the research underlying the conclusions presented.
- Students choose a topic related to climate change and forests and write a research paper on it.
- Students explore forest management strategies in more depth. See Project Learning Tree's activity guide [Southeastern Forests and Climate Change](#) for classroom activities on this topic, available at plt.org for free download. (Although it focuses on Southeastern forests, the activities in this guide are easily adapted to other forests.)

Possible Responses to the “Research on Climate Change and Forests” Student Page

1. What are three ways the changing climate has affected Oregon’s forests? Answers may include: warmer, drier conditions have occurred; severe wildfires happen more often and for a longer period of time each year; extreme weather events happen more often; pests and disease are becoming more of a problem.
2. What are three impacts from climate change Oregon’s forests might face in the future? Answers may include: Changes in the ranges of forest tree species; increased drought; more frequent and more intense forest fires due to greater fuel loads; stronger and more frequent storms; and greater incidence of invasive species and forest pests, which could jeopardize the health of native forest species.
3. What is one way Oregon’s forests can help reduce the effects of climate change? As trees grow, they remove carbon dioxide from the atmosphere and store carbon in their wood and in the soil, which reduces the amount of carbon in the atmosphere and, thus, its effect on climate.
4. What are three strategies foresters and other Oregonians have proposed (or are already doing) to either reduce climate change’s effect on forests or to increase forests’ ability to slow climate change? Answers may include: managing forests to reduce vulnerability to drought, insects and wildfire; altering the mix of forest tree species to better adapt to climate; using data to determine areas of forest stress; planting trees to create more forest; letting trees grow to peak carbon age; managing forests to increase their carbon storage; or using mill waste and wooden debris to produce energy.
5. What is something else Oregonians could or should do in relation to Oregon’s forests to respond to climate change? Answers may vary.

Key Resources on Climate Change and Oregon's Forests

[2021 Oregon State Agency Climate Change Adaptation Framework](#). Oregon Department of Land Conservation and Development (in collaboration with other agencies), oregon.gov/lcd. Recommendations for helping the state of Oregon plan for and respond to the impacts of climate change.

[2020 Biennial Report to the Legislature](#). Oregon Global Warming Commission, keeporegoncool.org. Recommended actions to help Oregon meet its climate mitigation goals.

[Carbon in Oregon's Managed Forests: Summary Report](#). Oregon Forest Resources Institute, oregonforests.org. A summary report on carbon sequestration and storage in Oregon's forests, including information on managing forests to increase their carbon storage and potential carbon markets.

[Climate Change and Carbon Plan](#). Oregon Department of Forestry, oregon.gov/odf. A plan for using Oregon's forests as part of the climate mitigation and adaptation solution.

[Climate Change Impacts on Forests](#). U.S. Environmental Protection Agency, epa.gov/climateimpacts. Summary of the impacts of climate change on U.S. forests.

[Oregon Climate Action Plan](#). Oregon Environmental Council, oeonline. Overview of the governor's 2020 executive order to address the climate crisis, directing state agencies to reduce greenhouse gas emissions in Oregon by at least 80% below 1990 levels by the year 2050. See also periodic progress reports (such as [Oregon Climate Action Plan Two-Year Progress Report](#)).

[Oregon Climate Assessments](#). Oregon Climate Change Research Institute, oregonstate.edu. A biennial assessment of climate change science and the likely effects on Oregon. In the 2023 assessment, the "Natural Resources" chapter describes effects on forests and other ecosystems, including increased incidence of wildfire.

[Oregon's Climate Protection Program](#). Oregon Department of Environmental Quality, oregon.gov/deq. Overview of the Climate Protection Program, which will set limits on greenhouse gas emissions from significant sources.

[Reducing Carbon Emissions](#). Oregon Department of Energy, oregon.gov/energy. An overview of the actions the department is taking to reduce carbon emissions.

[There's Carbon in Them Thar Hills](#). U.S. Forest Service Research and Development, usda.gov. Summary of a study to calculate the carbon flux in the forests of Oregon and Washington.

See [Climate Change Resources](#) for additional resources on
climate change in Oregon: oregon.gov/lcd.

Research on Climate Change and Forests

Look for answers to the following questions using information from at least two resources.

Resources used: _____

1. What are three ways the changing climate has affected Oregon's forests?
2. What are three impacts from climate change Oregon's forests might face in the future?
3. What is one way Oregon's forests can help reduce the effects of climate change?
4. What are three strategies foresters and other Oregonians have proposed (or are already doing) to either reduce climate change's effect on forests or to increase forests' ability to slow climate change?
5. What is something else Oregonians could or should do in relation to Oregon's forests to respond to climate change?

Climate Change Infographic

Create an infographic showing how climate change is affecting Oregon's forests, how Oregon's forests can help to slow climate change, and what Oregonians are doing. Your infographic should include the following elements, and visually represent the relationships between them.

- Air temperature
- Carbon in the atmosphere
- Carbon in trees and soil
- Length of growing season
- Oregon's forests
- Pests and disease
- Precipitation
- Storms
- Tree growth
- Wildfire

Add and label the forest management strategies from your research that foresters and other Oregonians have proposed. Show how each strategy affects the other elements in your infographic.

Add and label your idea for something else Oregonians could or should be doing, and show how it would affect the other elements in your infographic.

6: Community Views on Forest Management Issues

Overview

Students consider the pros and cons of one forest management practice that is sometimes controversial: clearcutting. They then develop and conduct an opinion survey on forest management issues, to learn about the views of people in their community.

Time Considerations

Preparation: 20 minutes

Procedure: One to two 50-minute class periods, plus time for conducting the survey

Learning Objectives

Students will be able to:

- Articulate pros and cons of one forest management practice: clearcutting.
- Identify other forest management practices for which the public may have a variety of opinions.
- Develop an opinion survey around those practices.
- Conduct the survey and analyze the results.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.ESS3.C. Human Impacts on Earth Systems. The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
- Science and Engineering Practice – Planning and Carrying Out Investigations. Plan and conduct an investigation 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 English Language Arts Standards

- Writing History, Science, and Technical Subjects – 9-10.WHST.5 and 11-12.WHST.5.
Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Oregon Mathematics Standards

- Number and Quantity – HS.NQ.B.3. Use reasoning to choose and interpret measurement units consistently in formulas, graphs, and data displays, as a way to understand problems and to guide the solution of multi-step problems.

Oregon Forest Literacy Plan Concepts

- 3.C.3. The type and intensity of forest management, including harvest, is dependent on the purposes for which the forest is managed, as well as forest type, ownership, size and location.
- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and diversity, and maintaining a forested land base for the needs of present and future generations.
- 3.D.2. Forest management can be controversial, because of diverse perspectives as well as the complex nature of forest ecosystems.
- 3.D.4. Current issues related to forest management include the effects of timber harvest, wildfire, climate change and land uses, as well as the perception of these effects.

Materials

- [Forest Fact Break: Clearcutting](#) video (1:51 minutes), available at learnforests.org
- Technology for sharing video
- [Forest Fact Sheet: Why Are Some Forests Clearcut?](#), available at learnforests.org
- “Sample Forest Management Opinion Survey” student page (optional)
- Strips of paper (approximately 3” x 18”)
- Colored marker pens
- Tape

Background Information

Managing Oregon forests is often a balancing act that requires foresters to consider the environmental, economic and social impacts of their decisions. Controversy over these decisions can sometimes arise, because stakeholders or the public may not know, understand or agree with them.

One forest management topic that most Oregonians have an opinion about is clearcutting, particularly because clearcuts are often readily visible. Many people believe clearcutting is not only unattractive, but that it actually harms the forest ecosystem and threatens water supplies. What they may not realize is that Douglas-fir seedlings, the species that predominates west of the Cascades, grow best in full sunlight, and that many of the forests seen today in western Oregon were established after clearcutting. Current Oregon laws include many measures that regulate the use of clearcutting on Oregon's private and public lands.

In this lesson, students will poll members of their community to learn what they think about various forest management issues. They may use this information as the basis for a project in Lesson 37: Service-Learning Project.

Survey Questions Compared

Question Type	Example	Advantages	Disadvantages
True/False or Yes/No	Do you enjoy visiting forests? Yes/No	<ul style="list-style-type: none">• Fast and easy to complete• Easy to tally and analyze	<ul style="list-style-type: none">• Only useful for items that have a yes/no or true/false response• Lacks detail and depth
Multiple Choice	Which of the following is the best way for you to learn new material? A. Lecture by teacher B. Assigned readings C. In-class videos D. In-class interactive exercises	<ul style="list-style-type: none">• Easy format for respondents to understand• Allows comparison of different options	<ul style="list-style-type: none">• Limited response options• May omit a respondent's preferred answer• Lacks detail and depth

Question Type	Example	Advantages	Disadvantages
Rank Order	Rank the following ice cream flavors by order of preference: ___ chocolate ___ vanilla ___ strawberry ___ cookies 'n' cream	<ul style="list-style-type: none"> • Enables respondents to indicate the relevant importance of choices • Allows comparison of different choices 	<ul style="list-style-type: none"> • More difficult to answer • Limits number of response options • May omit a respondent's preferred answer
Rating Scale	How strongly do you agree or disagree with this statement: Forests are critical to Oregon's future. 1=strongly agree 2=agree 3=neutral 4=disagree 5=strongly disagree	<ul style="list-style-type: none"> • Respondents can give more specific information about their thoughts • Provides a more precise measure than yes/no or true/false items 	<ul style="list-style-type: none"> • Each item must be scored separately • You have to have a specific question about each thing you want to know about • Respondents are more likely to give neutral responses
Open-ended	What is the most important issue facing Oregon today?	<ul style="list-style-type: none"> • Identifies issues and ideas most relevant to respondents • Generates new ideas about the topic • Clarifies respondents' positions • Provides depth and detail 	<ul style="list-style-type: none"> • Requires more time and communication skill to complete • May generate incomplete or irrelevant data • May be difficult to analyze and summarize

Key Vocabulary

clearcutting

open-ended

rank order

rating scale

Preparation

Depending on your class's time and interest, you may choose to have students create a survey from scratch or by building onto or modifying the "Sample Forest Management Opinion Survey" student page. They may also simply use the sample survey as is.

Procedure

1. Ask students what the term “clearcutting” means. Ask students for a show of hands on whether their view of clearcutting as a forest management practice is positive, negative or neutral.
2. Show the *Forest Fact Break: Clearcutting* video or have students read the *Forest Fact Sheet: Why Are Some Forests Clearcut?* Ask students whether their opinion about clearcutting changed after watching the video or reading the fact sheet. What additional information might they need for a more informed opinion?
3. Point out that many different forest management practices require weighing trade-offs and making decisions based on a variety of factors. Forest management can sometimes be controversial, as people with different perspectives on an issue may also be affected differently.
4. Ask students what they expect the people in their community would say about clearcutting or another forest management issue.
5. Invite students to learn more about their community’s ideas about forest management practices by creating and conducting a survey. Discuss the possible topics the survey might explore and, if you like, give students copies of the “Sample Forest Management Opinion Survey” as a starting point.
6. Discuss the different question formats that surveys employ and the advantages and limitations of each, including true/false, rating scale, multiple choice and open-ended questions. (See the Background Information for a comparison.)
7. Divide the class into small groups of three or four students, assigning each group one of the topics chosen. Groups should draft three or four possible questions on their topic, using a marking pen to write each question on a strip of paper.
8. Direct the groups to tape their question strips to the board. As a class, look at the questions to remove any duplicates, combine ones that make sense to do so, revise any that may need fine-tuning, and decide on a question order, moving the strips as necessary.
9. When a draft survey is complete, have students do a dry run by answering the questions themselves in order. Make any adjustments and then ask a couple volunteers to type it up. Give students copies of the final survey to administer to friends and family members.
10. After students have conducted the survey, have them tally and analyze the results in class. Discuss:
 - a. What does the survey tell us about our community’s views on forest management?
 - b. How were the results the same or different from what you expected?
 - c. Which of the results were particularly interesting?

- d. If you were a forest manager, how might you use these results in your work?
- e. Which do you think is more important in determining forest policy on forest management issues: public opinion or scientific findings? Why do you think so?
- f. Is there anything we can do to further educate our community about these forest management issues?

Assessment

Ask students to write a couple paragraphs describing the survey and what they learned from it. Use their writing to assess their learning.

Extension Ideas

- Have students prepare a report about their survey and findings to present to forest managers or other decision-makers in your area.
- Explore more deeply the practice of clearcutting by having students read [Not So Clear-Cut](#), available at oregonforests.org, and identify the conditions and rules for its use.

Sample Forest Management Opinion Survey

1. How familiar are you with the forests in our area?

Not at All Familiar

Very Familiar

1

2

3

4

5

2. In your opinion, what are the three most important things that you and others gain from Oregon's forests?

☐ Carbon storage

☐ Recreation

☐ Clean air

☐ Solitude

☐ Clean water

☐ Spiritual renewal

☐ Green spaces

☐ Wilderness

☐ Jobs

☐ Wood products

3. Clearcutting is a practice foresters sometimes use to harvest trees for wood products. It involves removing most of the trees in an area and then replanting seedlings over the whole area, and must follow Oregon laws. What is your opinion of clearcutting in Oregon? Please choose the best response.

☐ I am unfamiliar with clearcutting and do not have an opinion at this time.

☐ I don't see a problem with clearcutting and think forest owners should use it whenever they like, within the law.

☐ I think clearcutting has its place, but forest owners should use it only after considering other options.

☐ I don't think clearcutting should ever be used.

4. In Oregon, 60 percent of the forestland is owned by the federal government and 34 percent is privately owned. But 75 percent of Oregon's harvested timber comes from privately owned lands. What conclusion do you draw from this information?

5. According to a report by the Oregon Climate Change Research Institute, global climate change is already affecting Oregon forests and will continue to have profound effects on them. These impacts include changes in where and how trees grow, and increases in forest fires and pest outbreaks. How concerned are you about the effects of climate change on our forests?

Not at All Concerned

Very Concerned

1

2

3

4

5

6. What do you think is the most pressing issue facing Oregon forests today?

INSIDE OREGON'S FORESTS

A high school forestry curriculum



OUR RESPONSIBILITY TO OREGON'S FORESTS

- 1: Forest Sustainability
- 2: Interview a Forest Landowner
- 2: Service-Learning Project



Oregon Forest
Resources Institute

OUR RESPONSIBILITY TO OREGON'S FORESTS

1: Forest Sustainability

Overview

Students examine forest certification as one approach for ensuring forest sustainability, and then identify other ways to be stewards of Oregon forests.

Time Considerations

Preparation: 20 minutes

Procedure: One 50-minute class period

Learning Objectives

Students will be able to:

- Articulate what parameters they think would be important to include in a forest certification scheme.
- Identify the pros, cons, benefits and drawbacks of three forest certification systems.
- Communicate other ways that Oregonians can be stewards of our forests.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS4.D. Biodiversity and Humans. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Oregon English Language Arts Standards

- Reading Science and Technical Subjects – 11-12.RST.9. Synthesize information from a range of sources into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Oregon Forest Literacy Plan Concepts

- 3.C.7. Sustainable forest management takes into account environmental, economic and social dimensions of sustainability. It includes maintaining forest health, productivity and diversity, and maintaining a forested land base for the needs of present and future generations.
- 4.B.1. Everyone has a responsibility to treat forests with respect, and to be a conscientious steward of forests and forest resources.
- 4.B.2. Personal behaviors and actions directly impact the health and resiliency of our forests. Our consumer choices and investments, how we interact with the land (e.g., trails, campgrounds and forest habitat), how we use or conserve water, and how we use fire can either harm or help forests.

Materials

- “Forest Certification Systems Compared” student page
- Colored markers
- Access to websites for [Sustainable Forestry Initiative](https://forests.org) at forests.org, [American Tree Farm System](https://treefarmssystem.org) at treefarmssystem.org, and [Forest Stewardship Council](https://us.fsc.org) at us.fsc.org

Background Information¹

Nearly all forest landowners want to manage their lands to sustainably produce environmental, social and economic benefits. Forest certification is a market-based approach to recognizing sustainable forest management by labeling forests and the wood products from those forests as being certified. Having forestland certified under the American Tree Farm System (ATFS), the Sustainable Forestry Initiative (SFI) or the Forest Stewardship Council (FSC) lets people know that landowners are managing their forests sustainably and are in it for the long haul.

In the mid-1990s the Forest Stewardship Council (FSC) was created by the World Wildlife Fund and other conservation groups as a way to certify that wood products were sustainably managed

¹ Source: “[Forest Certification Demonstrates Sustainability](https://forests.org),” Oregon Forest Resources Institute, oregonforests.org.

to meet conservation goals. The American Forest and Paper Association (AFPA) followed with the development of the Sustainable Forestry Initiative (SFI), to demonstrate sustainability while meeting industrial wood-production goals.² The American Tree Farm System, which has been around since 1941, also developed a certification system to demonstrate sustainability while meeting a diverse set of family forestland goals.

Today these private, independent programs apply third-party standards to wood and manufactured products from the forest. This level of transparency gives consumers, architects, engineers and builders credible evidence that the products were produced through responsible forestry practices. Certified products earn the right to display an “eco-label” seal of approval. As of June 2022, more than 4.7 million total acres of private Oregon forestlands are certified by one of the three systems. SFI certifies about 3,889,000 acres; ATFS certifies about 719,000 acres; and FSC certifies about 172,000 acres.³

Key Vocabulary

afforestation

conservation value

forest certification

sustainable forest management*

tenure and use rights

**included in Glossary*

Preparation

Make copies of the student page or plan for students to have on-screen access to it.

Procedure

1. Ask students whether they’ve ever received a certificate for completing a program or taking a class, and ask them to describe what it means to “certify” something. List some of their ideas on the board. Ask whether they have heard of forests being certified, and what they think that might mean.

² SFI subsequently separated from the AFPA, reorganizing as a nonprofit organization governed by an independent board.

³ Source: [Oregon Forest Facts. 2023-24 Edition](#). Oregon Forest Resources Institute, learnforests.org.

2. Explain that forest certification is one approach to ensuring forest sustainability: When a particular forest meets certain criteria, the forest and products that come from it can be labeled as “certified” to help consumers make more sustainable purchases.
3. Have partners or small groups create a list of criteria they would include in a forest certification program. Challenge them to consider the social, economic and environmental aspects of the forest or forest product.
4. Invite groups to share elements from their list with the class.
5. Explain that there are currently three different forest certification systems that forest landowners use in Oregon. Give students a copy of the “Forest Certification Systems Compared” student page and direct them to use the student page to compare the three different systems. Allow them to look at the organizations’ websites to learn more about the three systems.
6. Discuss:
 - a. How does forest certification help Oregon forests?
 - b. What are the benefits of certification for forest landowners?
 - c. What are the benefits for consumers?
 - d. What might be drawbacks to certification?
7. Point out that forest certification is just one way that Oregonians can be stewards of our forests. Challenge students working in pairs or small groups to create a list of things that they and others can do to ensure the sustainability of forests.
8. Invite groups to share some of their ideas.

Assessment

Use student responses to the student page to assess their understanding of the material.

Extension Idea

Conduct a study of local stores to find out what certified wood products are available and whether they differ in quality, cost or other features from noncertified products. Use a data collection sheet, such as

Location (Store)	Wood type	Size	Cost	Certification system	Quality or other observations

Forest Certification Systems Compared

Follow the steps below to compare the standards and principles from the three forest certification systems commonly used in Oregon:

- Sustainable Forestry Initiative (SFI), forests.org
- American Tree Farm Certification System (ATFS), treefarmssystem.org
- Forest Stewardship Council (FSC), us.fsc.org

Note that in addition to the standards and principles, all three certification systems include detailed criteria and indicators to show whether a standard is met. Check the website for each system to learn more.

Directions

1. For each standard or principle, mark whether it focuses on environmental (EN), economic (EC) or social (SO) aspects of sustainable forestry.
2. Looking at the three different systems, use colored markers to color-code the standards and principles that are the same or similar.
3. In what ways are the goals of the three systems the same, and how do they differ?
4. What other differences do you note among the three systems?
5. What are the strengths and weaknesses (or pros and cons) of each system?
6. Why might someone choose one certification over another?

Sustainable Forestry Initiative (SFI) Principles⁴

Goal: To ensure that forestry practices are environmentally responsible, socially beneficial and economically viable.

Certificated organizations must implement and achieve the following forest management principles:

Principle 1: Sustainable Forestry. To practice sustainable forestry means meeting the needs of the present while promoting the ability of future generations to meet their own needs by practicing a land stewardship ethic that integrates reforestation and the managing, growing, nurturing and harvesting of trees for useful products, and for the provision of ecosystem services such as the conservation of soil, air and water quality and quantity, climate change adaptation and mitigation, biological diversity, wildlife and aquatic habitats, recreation and aesthetics.

Principle 2: Forest Productivity and Health. To provide for regeneration after harvest, maintain the health and productive capacity of the forest land base, and to protect and maintain long-term soil health and productivity. In addition, to protect forests from economically, environmentally or socially undesirable impacts of wildfire, pests, diseases, invasive species and other damaging agents, and thus maintain and improve long-term forest health and productivity.

Principle 3: Protection of Water Resources. To protect and maintain the water quality and quantity of water bodies and riparian areas, and to conform with forestry best management practices to protect water quality, to meet the needs of both human communities and ecological systems.

Principle 4: Protection of Biological Diversity. To manage forests in ways that protect and promote biological diversity, including animal and plant species, wildlife habitats, ecologically and culturally important species, threatened and endangered species (i.e., Forest with Exceptional Conservation Values) and native forest cover types at multiple scales.

Principle 5: Aesthetics and Recreation. To manage the visual impacts of forest operations, and to provide recreational opportunities for the public.

Principle 6: Protection of Special Sites. To manage lands that are geologically or culturally important in a manner that takes into account their unique qualities.

Principle 7: Legal Compliance. To comply with applicable federal, provincial, state, and local forestry and related environmental laws, statutes and regulations.

⁴ Source: [SFI 2022 Forest Management Standard](#). Sustainable Forestry Initiative, forests.org.

Principle 8: Research. To support advances in sustainable forest management through research, science and technology.

Principle 9: Training and Education. To improve the practice of sustainable forestry through training and education programs.

Principle 10: Community Involvement and Social Responsibility, and Respect for Indigenous Rights. To broaden the practice of sustainable forestry on all lands through community involvement and socially responsible practices, and through recognition and respect of Indigenous Peoples' rights and traditional forest-related knowledge.

Principle 11: Transparency. To broaden the understanding of forest certification to the Forest Management Standard by documenting certification audits and making the findings publicly available.

Principle 12: Continual Improvement. To continually improve the practice of forest management, and to monitor, measure and report performance in achieving the commitment to sustainable forestry.

Principle 13: Responsible Fiber Sourcing. To use and promote sustainable forestry across a diversity of ownership and management types in the United States and Canada that is both scientifically credible and socially, environmentally and economically responsible, and to avoid sourcing from controversial sources both domestically and internationally.

American Tree Farm System (ATFS) Standards of Sustainability⁵

Goal: To sustain forests, watershed and healthy wildlife habitats through the power of private stewardship by offering affordable forest certification for family forest landowners in the United States.

Forest landowners must demonstrate compliance with the following standards:

Standard 1: Commitment to Practicing Sustainable Forestry. Landowner demonstrates commitment to forest health and sustainability by developing a forest management plan, implementing sustainable practices, and seeking opportunities to expand their knowledge and understanding of sustainable forest management.

Standard 2: Compliance with Laws. Forest management activities comply with all relevant federal, state and local laws, regulations and ordinances.

Standard 3: Reforestation and Afforestation. Landowner completes timely restocking of desired species of trees on a regeneration harvest site and nonstocked areas where tree growing is consistent with land use practices and the landowner's objectives.

Standard 4: Air, Water and Soil Protection. Forest management practices maintain or enhance the ecosystems and ecosystem services provided by the forest, including air, water, soil and site quality.

Standard 5: Fish, Wildlife, Biodiversity and Forest Health. Forest management activities contribute to the conservation of biodiversity.

Standard 6: Forest Aesthetics. Forest management activities recognize the value of forest aesthetics.

Standard 7: Protect Special Sites. Special sites are managed in ways that recognize their unique historical, archeological, cultural, geological, biological or ecological characteristics.

Standard 8: Forest Product Harvests and Other Activities. Forest product harvests and other management activities are conducted in accordance with the landowner's objectives and consider other forest values.

⁵ Source: [2021 Standards of Sustainability](https://www.treefarmssystem.org/standards). American Forest Foundation, treefarmssystem.org.

Forest Stewardship Council (FSC) Principles⁶

Goal: To promote environmentally sound, socially beneficial and economically prosperous management of the world's forests.

The following principles apply to all FSC-certified forests around the world:

Principle 1: Compliance with Laws and FSC Principles. Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.

Principle 2: Tenure and Use Rights and Responsibilities. Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.

Principle 3: Indigenous Peoples' Rights. The legal and customary rights of indigenous peoples to own, use and manage their lands, territories and resources shall be recognized and respected.

Principle 4: Community Relations and Workers' Rights. Forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.

Principle 5: Benefits from the Forest. Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

Principle 6: Environmental Impact. Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest.

Principle 7: Management Plan. A management plan — appropriate to the scale and intensity of the operations — shall be written, implemented and kept up to date. The long-term objectives of management, and the means of achieving them, shall be clearly stated.

Principle 8: Monitoring and Assessment. Monitoring shall be conducted — appropriate to the scale and intensity of forest management — to assess the condition of the forest, yields of forest products, chain of custody, management activities, and their social and environmental impacts.

Principle 9: Maintenance of High Conservation Value Forests. Management activities in high conservation value forests shall maintain or enhance the attributes which define such forests.

⁶ Source: "[Mission and Vision](https://www.fsc.org/mission-and-vision)," Forest Stewardship Council, [us.fsc.org](https://www.us.fsc.org).

Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.

Principle 10: Plantations. Plantations shall be planned and managed in accordance with Principles and Criteria 1-9, and Principle 10 and its Criteria. While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

2: Interview a Forest Landowner

Overview

Students interview forest landowners to learn what they value about their forests, and the challenges they face in sustaining them.

This lesson was adapted from Project Learning Tree's "Who Owns America's Forests?" *Exploring Environmental Issues: Focus on Forests, Secondary Environmental Education Module*.

Time Considerations

Preparation: 15 minutes

Procedure: One to two 50-minute class periods

Learning Objectives

Students will be able to:

- Conduct an interview to explore forest landowners' motivations, priorities and choices in managing their forests.
- Articulate what individual forest landowners are doing to sustain their forests.
- Make inferences about how to support sustainable forestry on private forestland.

Standards Connections

New Generation Science Standards

- Disciplinary Core Idea – HS.LS4.D. Biodiversity and Humans. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Oregon English Language Arts Standards

- Speaking and Listening – 11-12.SL.1.C. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

Oregon Forest Literacy Plan Concepts

- 3.A.4. Oregon’s forests are managed under private (e.g., family and industrial), public (e.g., state and federal) and tribal ownership. Each type of ownership may have different management objectives, and is subject to different protection laws and policies. Management objectives may even differ within classes of ownership.

Materials

Optional: “Forest Landowner Interview” student page (see Procedure)

Background Information⁷

In Oregon, 62,000 individuals own between 10 and 5,000 acres of forestland. Classified as “family forestlands,” these acres have often been handed down through generations.

Most of these landowners are not professional foresters; they’re doctors, teachers, accountants and clergy. They’re also quite possibly your neighbors. That’s because a lot of family forestland is located close to residential areas in the foothills just outside Oregon’s primary metropolitan areas.

The amount of timber coming from family forestlands varies greatly depending on demand in the market. Family forestlands accounted for about 12% of Oregon’s annual timber harvest in 2022. Yet not all family forestlands are managed for timber production. Family forest landowners also manage forests for recreational use, fish and wildlife habitat, or just pure aesthetics.

A recent survey of family forest landowners indicated that they, like most Oregonians, desire to keep their property as forestland. But caring for the forest costs money. In many cases, family forest landowners use their land to earn a living. If the cost of managing the forest gets too expensive, they will turn to alternatives including, unfortunately, potentially selling the family forest.

⁷ Source: “[The Life of a Working Forest](https://oregonforests.org/the-life-of-a-working-forest/).” Oregon Forest Resources Institute, oregonforests.org.

Key Vocabulary

regulation

resource

Preparation

- Decide whether students will conduct interviews individually in the community, or as a group in class with a panel of landowners you invite. To find possible forest landowners in your area to interview, contact your local chapter of the [Oregon Small Woodlands Association](http://oswa.org) (oswa.org) or your local [OSU Forestry and Natural Resources Extension](http://forestry.oregonstate.edu) agent (forestry.oregonstate.edu) and ask for a Master Woodland Manager.
- You may choose to have students use the questions provided on the student page or develop their own. If they'll be developing their own questions, allow extra time for them to do so.

Procedure

1. Introduce the lesson by asking students what they think they could learn from local forest landowners about the challenges they face in sustaining their forests.
2. Explain that students will interview forest landowners to find out about their motivations, priorities and choices; what they value about their forests; and what they do to sustain their forests. Depending on what you've decided, these may be individual interviews students conduct in the community, or a group interview in class with a panel of landowners.
3. You may have students use the sample interview questions on the "Forest Landowner Interview" student page, or have them develop a different set of questions based on their interests, or on local issues. If they're developing questions, have each student prepare one to three possibilities and then choose the best ones as a class.
4. Provide copies of the final interview questions to use in conducting the interviews and for taking notes.
5. After the interviews, lead a class discussion about the findings:
 - a. What did students learn from the interviews about either individual owners or the choices and challenges they face?
 - b. What confirmed students' prior understanding about forestland ownership? What was a surprise to them?
 - c. From the interviews, what can students infer about what forest landowners are doing to sustain their forests?

- d. What can we do – as individuals and a society – to support efforts to sustain forests in Oregon?

Assessment

- Students write a response to one of the following prompts:
 - Based on what you learned from the interview, what is the biggest challenge private forest landowners in our area face? Use specific examples from the interview to support your view.
 - Based on what you learned from the interview, what can Oregonians do to increase the sustainability of our forests? Use specific examples from the interview to support your view.

Extension Idea

Compare Oregon forest landowners with those across the United States by looking at data from the National Woodland Owner Survey, which is conducted periodically by the US Forest Service. For more information see “[National Woodland Owner Survey](http://www.fia.fs.usda.gov/nwos)” (available at www.fia.fs.usda.gov/nwos).

Forest Landowner Interview⁸

Forest Landowner's Name: _____

1. Describe the forestland you own: Where is it located? What types of trees, water, resources and built structures does it have? What is the surrounding area like?
2. How long have you owned this land? How did you acquire it?
3. Why do you own this forestland? What do you value most about it?
4. How do you use this land?
5. How do you make decisions about managing this forestland?
6. What are the biggest challenges you face in managing this forestland?

⁸ Source: Adapted from "Who Owns America's Forests?" *Exploring Environmental Issues: Focus on Forests, Secondary Environmental Education Module*. Project Learning Tree.

7. How has this forestland changed over the past 10, 20 or 50 years? In what ways has it stayed the same?
8. What do you see happening to this land in the next 10, 20 or 50 years?
9. What are your biggest concerns about the future of this land?
10. What actions, if any, are you taking to ensure the long-term sustainability of your forestland?

3: Service-Learning Project

Overview

In this lesson, students plan and carry out a service-learning project related to Oregon forests.

Time Considerations

Preparation: One hour or more

Procedure: The duration of this lesson depends on the specific project, and may range from one class period to an entire term

Learning Objectives

Students will be able to:

- Identify and assess a need in their community.
- Develop and implement an action plan.
- Practice problem-solving skills.

Standards Connections

Oregon Science Standards

- Disciplinary Core Idea – HS.LS4.D. Biodiversity and Humans. Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Other relevant standards depend on the specific project.

Oregon Forest Literacy Plan Concepts

- 4.A.2. Everyone should have the opportunity to identify and explore their personal and cultural relationships with forests, and to spend time in forests. Accommodations such as

paved paths, multi-language signage, and proximity to public transportation help to ensure access to forests for all.

- 4.A.3. There are many ways we can deepen our relationship with forests, including learning about forests, recreating in forests, volunteering for projects in and around forests, and recognizing the ways forests enhance our lives.
- 4.B.1. Everyone has a responsibility to treat forests with respect, and to be a conscientious steward of forests and forest resources.

Materials

- “Service-Learning Planning Template” teacher page
- “Sample Service-Learning Projects” teacher page
- Any materials needed for the planned project

Background Information

Service-learning is a teaching method that combines service to the community with meaningful and relevant learning experiences. According to the National Youth Leadership Council, high-quality service-learning actively engages students in meaningful and personally relevant service activities. It is an intentional instructional strategy used to meet learning goals or content standards.

To be effective, service-learning incorporates ongoing reflective activities that prompt deep thinking and analysis about one’s relationship to society. It provides students with a strong voice in planning, implementing and evaluating their service-learning experiences. It also gives students the opportunity to demonstrate what they learned from the project or how the service affected them.

Preparation

- Use the “Service-Learning Planning Template” teacher page to map out possible service-learning projects, taking into account your community’s needs. Identify your instructional goals, any assessment you plan to incorporate into the project, and any time or space constraints. See the “Sample Service-Learning Projects” teacher page for possible projects.
- Check other resources for project ideas and opportunities, such as [SOLVE Oregon](https://solveoregon.org) at solveoregon.org.
- Consider having students invite community leaders, stakeholders or local media for a presentation about the completed project.

Procedure

1. Explain to students that service-learning is an opportunity to apply what they learn in school to the real world. Ask for their ideas of service-learning projects that would both help the community in some way and enable them to apply their learning about forestry. See the “Sample Service-Learning Projects” teacher page for ideas.
2. As a class, look at the list of project ideas and combine or eliminate any, as appropriate. Discuss what sector of the community each project remaining on the list would serve, how the project might meet the community’s needs, and what knowledge and skills students would be able to demonstrate. Vote on one project, or use another method for determining which to undertake.
3. As a class, develop an action plan for the selected project. The plan should include a timeline, materials needed, budget, community resources and steps required to carry out the project. It should also include a way for students to demonstrate their learning.
4. Implement the action plan, making sure that all students have meaningful roles. Encourage students to problem-solve any issues that arise.
5. After the project, take time for students to reflect on their learning and celebrate their accomplishments.

Assessment

Build into the project a way for students to demonstrate what they have learned, and then use that to assess their learning.

Service-Learning Planning Template

Forest-related project idea:

Service

Community need:

Learning

Connections to curriculum, Oregon Standards and Conceptual Framework

- ☐ Arts:
- ☐ English/Language Arts:
- ☐ Mathematics:
- ☐ Science:
- ☐ Social Sciences:
- ☐ Other:

Concept Development

- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

Skill Development

- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

Project Plan

Timeline:

Preparation:

Action:

Reflection:

Demonstration of learning:

Community resources:

Books, other resources:

Notes:

Sample Service-Learning Projects

Forest Stream Monitoring. Students monitor a nearby forest stream and riparian zone for the local watershed council. They map the area using GPS units, take ongoing water quality samples, keep photo journals, analyze their results and develop a multimedia presentation of their findings.

Invasive Species Removal. Students remove invasive plants from a nearby forest area, after assessing the prevalence of invasive species. They learn about the impact of invasive species on forest ecosystems, practice identifying some of the most prevalent invasive species, learn the best methods for removal, document the effectiveness of the treatment and communicate with others in the community about the problem of invasive species.

Forest Interpretive Trail. Students develop an interpretive trail for the community that goes through a local forest. Students learn about the local ecosystem, research interesting facts about plants, animals or historical figures, work with government agencies and businesses, and create signs or a brochure for the trail.

Forest Species Living Lab. Students design an outdoor forest species living lab for their school community. They research Oregon native plants and what they need to thrive, organize fundraising efforts for suitable plants and needed supplies, create planning maps of the lab site, and then plant and care for the plants.

Forest Field Day. Students plan and carry out a field day to teach elementary students about the local forest ecosystem. They research topic areas, plan activities and demonstrations, practice teaching their lessons and present them to elementary students.

Tree Planting and Monitoring. Students work with a local park or government agency to plant trees and then monitor the trees' development over time. They plan what, where and how many trees to plant, organize fundraising efforts to buy the trees, and carry out their planting plan. Then, over time, they collect data on the newly planted trees to monitor their growth and impact.