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

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	Oregon's Forest Heritage	Students are introduced to Oregon forests and their history, and examine some changes in our state's forestland over time.
Week 3	Forest Basics	Students gain an understanding of both tree biology and the forest types in Oregon, and practice identifying and measuring trees.
Weeks 4-5	Environmental Importance of Oregon's Forests	Students explore the environmental importance of forests: for example, how they protect our water resources, provide habitat and store carbon.
Week 6	Economic Importance of Oregon's Forests	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.

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

**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).

STUDENT PAGE
LESSON 1

Basic Tree Biology[1]

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

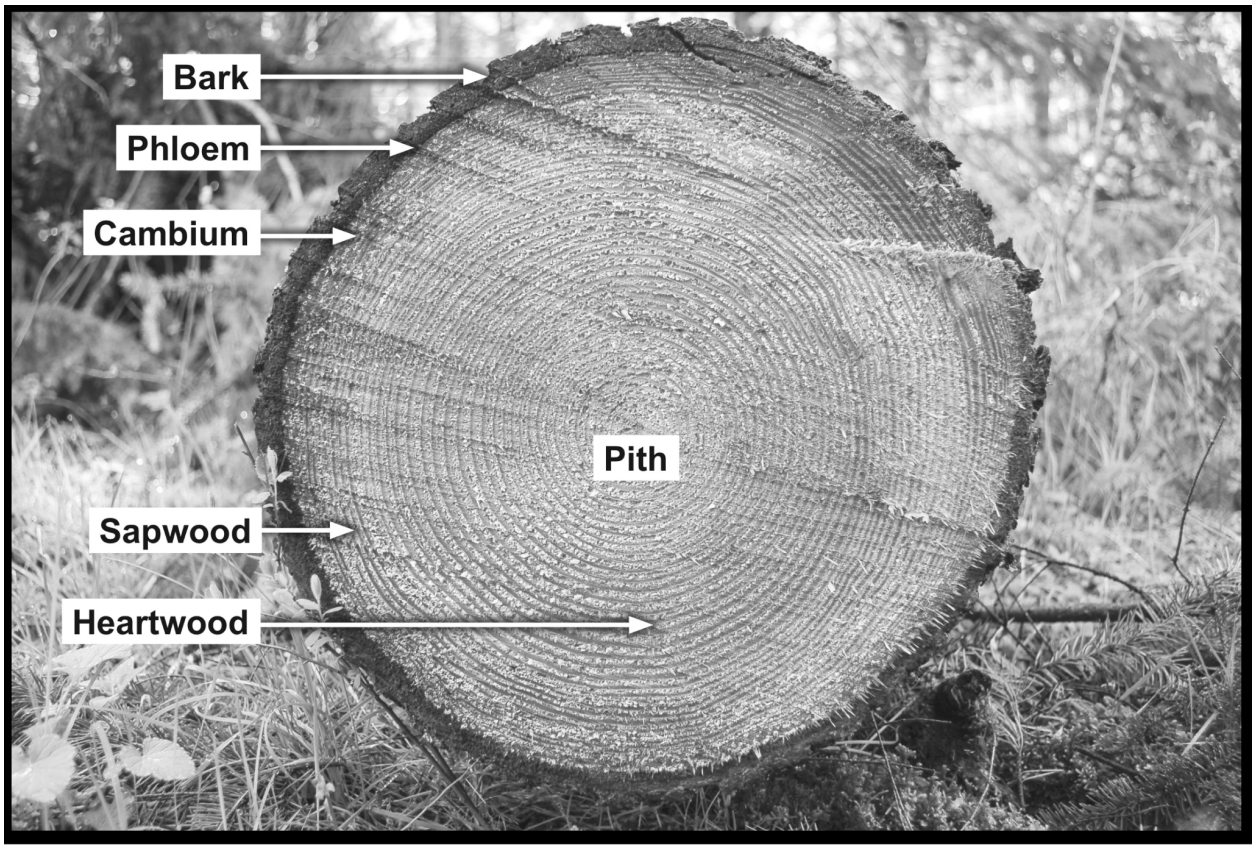
Trees have specialized parts that enable them to meet their basic needs. Following are a few of these parts:

- **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 (CO_2) 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 (CO_2)
- 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, CO_2, 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.

NAME(S): _____

Tree Biology – Questions[2]

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.
   Broadleaf Coniferous

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 Information[3]

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.

STUDENT PAGE
LESSON 2

NAME(S): _____

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 Types[4]

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," 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.

STUDENT PAGE

LESSON 3

NAME(S): _____

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 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* 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, available at 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.